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Research article

Does inclusive finance improve income: A study in rural areas

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Abstract: Increasing rural income is the common requirement of poverty alleviation and a rural revitalization strategy. As a financial system arrangement, inclusive finance plays an important role in rural income. This paper analyzes the influence of inclusive finance development affecting rural income. Taking 13 regions in Xinjiang as samples, we used a fixed-effects and mediating-effect model to conduct empirical tests. We found that inclusive finance development can significantly promote rural income in Xinjiang. The role of inclusive financial development in the rural income in deep poverty areas is weaker than that in non-deep poverty areas. Meanwhile, with the proposal of the Belt and Road Initiative, the role of inclusive financial development in rural income has been significantly enhanced. Taking the per capita economic output as the mechanism variable, we found that it is a vital channel for inclusive finance to improve rural income.

Keywords: inclusive finance; rural income; per capita economic output; rural area
Mathematics Subject Classification: 62P20, 62P25, 90A19, 90A80

1. Introduction

Poverty is a long-standing problem in the development of human society [1]. There are more than 280 million people living below the international poverty line of US $2 per day, and there are 120 million people living in extreme poverty struggling with a living standard of less than US $1 a day in the world according to the World Bank. Most of the poor are from rural areas in Asia and Africa [2]. Therefore, increasing the rural income is the key to poverty eradication. Inclusive finance is often considered as a key factor in making inclusive growth, as a lower access threshold to finance can lift people out of income poverty. A

lower access threshold to formal finance and digital finance has also significantly promoted household consumption, and it may have a greater impact on rural and poor families [3,4].

Since its reform and opening-up, China has taken many practical and effective measures to improve the rural living environment and promote rural income growth. According to the concept and methods of poverty governance, China has successively experienced four stages, i.e., "relief-type poverty alleviation" (1978–1985), "development-type poverty alleviation" (1986–2000), "industrial-type poverty alleviation" (2001–2013) and "targeted poverty alleviation" (2014–2020). By the end of 2020, China had completed the goal of poverty alleviation as scheduled, as "98.99 million rural poor people have been lifted out of poverty, 832 poverty-stricken counties have been removed, 128,000 poverty-stricken villages have been listed, and regional poverty has been solved [5,6]. The arduous task of eliminating absolute poverty has been completed." After a long-term poverty struggle, China has eliminated extreme poverty, and the absolute poverty in rural areas has been solved, but relative poverty still exists [7]. How to eliminate relative poverty and prevent poverty return has become a new focus of discussion. To consolidate the achievements of poverty alleviation, further improve the income of rural residents and realize the modernization of agriculture and rural areas, China has launched a new round of governance in rural areas around the five major development goals of "industrial prosperity, ecological livability, civilized rural style, effective governance, and rich life" [8]. On the road to poverty alleviation in China, both poverty alleviation and rural revitalization cannot be separated from rural income increase [9]. On the one hand, rural income increase is a direct manifestation of poverty alleviation achievements, and it is related to consolidating poverty alleviation achievements and preventing poverty return. On the other hand, rural income increase in rural areas is one of the organic links between poverty alleviation and a rural revitalization strategy. Therefore, paying attention to rural income is an important epitome of paying attention to poverty governance in China.

As the core of contemporary economic activities, financial activities play an important role in the development of the modern economy [10–15]. Under the traditional financial development framework, only a minority of people can enjoy financial services, and small and marginal groups such as small and micro enterprises, farmers and low-income people are often excluded [16,17]. As the antithesis of financial exclusion, inclusive finance has had a subversive impact on the traditional financial theory. Since it was formally put forward by the United Nations at the International Year of Microcredit in 2005, breaking the class-fixed idea that financial services only serve the rich. Inclusive finance provides vulnerable groups with financial services such as deposits, loans, insurance and payment by lowering the threshold of financial services, as this will allow more marginalized groups to enjoy the right to financial services [18,19]. At the same time, affected by the dual economy of urban and rural areas, the financial development in rural areas of China is relatively slow, which restricts the development of the rural economy and the improvement of rural residents' income. The inclusive finance system arrangement has been vigorously advocated and promoted by the Chinese government due to the breakthrough of the financial service boundary, and it has begun to allocate financial resources to key areas and weak links of the rural economy [20]. Therefore, the impact of the development of inclusive finance on rural income cannot be ignored.

Xinjiang accounts for about one-sixth of China's total land area. It is a core and hub area of the areas encompassing the Belt and Road Initiative. Its economic development is relatively backward and there are contiguous deep poverty areas. The southern Xinjiang area is recognized as one of the "three regions and three states" of China's deep poverty areas. Its consolidation of poverty alleviation

achievements and promotion of rural revitalization is of great significance to the high-quality development of China's economy. Under the continuous poverty control, the living environments of poor people in Xinjiang have been significantly improved. Relevant data show that the per capita disposable income of rural residents in Xinjiang has increased from 2593 yuan in 2005 to 15575 yuan in 2021[1]. At the same time, the construction of inclusive finance in Xinjiang has also been vigorously developed. A financial service system covering agriculture, rural areas and farmers has been established, the threshold for the use of financial services has been lowered and agricultural credit services and insurance business have been increased. Under this backdrop, studying the effect of inclusive finance development on the rural income of Xinjiang is not only conducive to the performance evaluation of inclusive finance for poverty alleviation in Xinjiang, but it also provides a reference for preventing the phenomenon of returning to poverty and provides experience for the further construction of inclusive finance after poverty alleviation in poor areas so that inclusive finance development can benefit more rural residents and promote sustainable prosperity.

The possible marginal contributions of this paper are as follows. First, based on the data of 13 areas in Xinjiang from 2005 to 2019, the development of inclusive finance in various regions of Xinjiang was quantified from the comprehensive index, the availability index of inclusive finance and the usage index of inclusive finance. Second, analyzing the effect of inclusive finance development on the rural income of Xinjiang can bridge existing research gaps. Third, the samples were divided according to the poverty level and the time when the Belt and Road Initiative was proposed, which refined the regional heterogeneity and time heterogeneity of inclusive finance development improving rural income. Fourth, using the mediating-effect model, we empirically tested whether the level of per capita economic output is the channel mechanism of inclusive finance development to the rural income of Xinjiang.

The remainder of this paper is structured as follows. The second section introduces the relevant literature review on the measurement of inclusive finance and the development of inclusive finance and rural income. The third section introduces the mechanism analysis and relevant research assumptions about the effects inclusive finance on rural income. The fourth section introduces the research methods and samples of this study, including the variables used and the data collection and processing. The fifth section discusses the empirical results of the effect of inclusive finance development on the rural income of Xinjiang and examines the channel mechanism of the effect of inclusive finance development on the rural income of Xinjiang. The sixth section summarizes the research conclusions and gives some recommendations.

2. Literature review

Inclusive finance refers to providing appropriate and effective financial services to all social strata and groups with financial service needs at an affordable cost [21–23]. This paper reviews the existing literature primarily regarding inclusive finance measurement and the impact of inclusive finance on rural income.

First, scholars have performed a lot of research studies and made many contributions to the measurement of the development level of inclusive finance [24–26]. Most of the previous studies measured the development level of inclusive finance by building an inclusive finance development index system [27]. Beck used eight indicators, such as the proportion of deposits and loans in the gross domestic product (GDP), the number of per capita accounts and the distribution of financial outlets

[1]http://tjj.xinjiang.gov.cn/tjj/tjgb/ist.shtml

and ATMs, as the evaluation metrics for inclusive finance [28]. Sama divided Beck's index system into three dimensions: accessibility, effectiveness and practicality [29]. Arora constructed the inclusive finance index in three dimensions: banking service scope, transaction convenience and transaction cost. To present the development of inclusive finance more accurately and comprehensively, different from Sarma's work, which adopted a single indicator in each dimension, it covers as many indicators as possible in each dimension [30]. Gupte et al. further broadened the inclusive finance indicator system and constructed the inclusive finance indicator system in four dimensions: service coverage, product usage, transaction convenience and transaction cost [31]. However, the construction of the above-mentioned indicator system takes more consideration of the comprehensiveness and integrity of inclusive finance and neglects the per capita enjoyment of inclusive finance. Zhang and Wang considered the population factor when studying China's inclusive finance, included the per capita access to financial services into the indicator system and built a two-dimensional indicator system of availability and use [32]. Besides, in terms of synthetic methods, Gupte et al. and Sarma used the construction method of the United Nations Human Development Index (HDI) to measure the development level of inclusive finance [31,33]. Cámara and Tuesta used two-stage principal component analysis to determine the weight distribution of each dimension [34]. Mialou et al. used factor analysis to obtain the weight of the inclusive finance index [35]. Kebede et al. used two-stage unsupervised machine learning to measure inclusive finance [36]; the first stage is to analyze its dimensions, and the second stage is to analyze the whole inclusive finance index.

Second, scholars have not reached a consensus on the impact of inclusive finance development on rural income [7,37]. On the one hand, some scholars, for example, believe that inclusive finance development has a significant effect on rural income. It can suppress the occurrence of poverty and significantly improve the quality of life of residents of rural areas by promoting the development of green ecological industries, promoting land urbanization [38–40], supporting farmer entrepreneurship [41] and promoting the upgrade of industrial structures [20]. Li et al. unveiled a positive spatial spillover effect of inclusive finance on farmers' income based on a spatial dependence perspective [42]. Kazi et al. found that the bank deposit business in Bangladesh can benefit poor people and play a role in increasing rural income [43]. Mushtaq and Bruneau used data from 62 countries to point out that the availability and financing effectiveness of inclusive finance can help rural residents increase their income [44]. Coulibaly and Yogo found, in the research on developing countries, that increasing the number of bank branches can effectively reduce the number of workers in the poverty line [45]. On the other hand, some scholars believe that, due to some factors, inclusive finance cannot effectively increase income. Jeanneney and Kpodar pointed out that there is financial uncertainty in financial development, and that this uncertainty is unfavorable for the poor [46]. Kling et al. identified that inclusive finance worsens income inequality, while low-income households would benefit from inclusive finance [47]. Besides, Seven and Coskun pointed out that banks and stock markets have not played a significant role in increasing the income of low-income people, and that financial development is not beneficial to low-income people in emerging countries [48]. Neaime and Gaysset pointed out that the imperfect banking structure makes inclusive finance unable to alleviate poverty in some areas [49]. Acheampong et al. believe that the lack of a financial resource allocation structure for vulnerable groups leads to the failure of inclusive finance to drive up the incomes of vulnerable groups [50].

Finally, it can be seen that the research results on the relationship between inclusive finance development and rural income are relatively abundant. Under different research objects, different contents and different perspectives, there are great differences in the research conclusions. The

relationship between inclusive finance development and rural income cannot be generalized. As a key poverty alleviation region in China, Xinjiang has a poor ecological environment for rural cooperative finance, a large development gap between North and South Xinjiang and a lack of grassroots financial institutions [51]. Xie believes that the development of rural non-governmental finance in Xinjiang can play a role in promoting the rural income of Xinjiang [52].

To sum up, the above documents show that inclusive finance has an important impact on rural income, but there are still some shortcomings. There is less research on inclusive finance development in rural areas in Xinjiang, and most of their research objectives were at the provincial, prefectural or county level in China [53]. For example, Liu et al. confirmed the statistically significant impact of inclusive finance on farmers' income only at the national level in China [20]. Li et al., using 1624 counties in mainland China, revealed that inclusive finance boosts rural residents' income [42], but with differences at the area level and at various quantiles of rural residents' income.

3. Mechanism analysis and research hypothesis

The profit-seeking nature of capital makes finance services exclusive, especially excluding rural areas and low-income groups. Inclusive finance originates from finance exclusion. By reducing the threshold effect of financial services, it provides access and formal financial services to people excluded from formal financial services [54], eliminating finance exclusion and improving the opportunities for rural economic entities to obtain financial services and increase income [55]. Therefore, the analysis of the effect of inclusive finance on rural income cannot be separated from finance exclusion. On the basis of the view that inclusive finance is to alleviate finance exclusion, the research of Aghion and Howitt is used for reference [56], and the factor of "rural financial exclusion" has been added to the AK model (Endogenous growth theory) to explain the relationship between inclusive finance and rural income through a theoretical model.

Assuming that there are N economic individuals in the rural economy of a certain region and the capital stock owned by an economic individual i in period t is e_i units, the total capital stock in the rural area of this region is

$$K_t = \sum_{i=1}^{N} e_i \tag{1}$$

Using a simple AK model, the production function of an economic individual i is defined as

$$y_i = \tau_i k_i \tag{2}$$

where the parameter τ_i represents the productivity of the economic individual i. k_i denotes amount of capital devoted to economic production by economic individuals. It is assumed that there are individual differences in productivity. For N rural economic individuals, this parameter satisfies

$$\underbrace{\tau_1 > \tau_2 > \cdots > \tau_i > \cdots > \tau_{m-1}}_{1 \le i \le m-1 Highly productive individuals} > \underbrace{\tau_m}_{Marginal producer} > \underbrace{\tau_{m+1} > \cdots > \tau_i > \cdots > \tau_N}_{m+1 \le i \le N Low productivity individuals} \tag{3}$$

Equation (3) shows that, with the increase of i, the productivity of the corresponding economic individual decreases. The right side of τ_m corresponds to low-income individuals with low productivity, and the left side corresponds to high-income individuals with high productivity. Assuming that each economic individual is rational and will choose the amount of capital, k_i, to maximize the income, the income equation is

$$\pi_i = \tau_i k_i - r(k_i - e_i) \tag{4}$$

$$s.t. k_i \leq v e_i \tag{5}$$

Equation (4) is the individual income equation, π_i is the individual income and r is the market interest rate. Equation (5) is the credit constraint equation, and v is the rural finance exclusion factor, which is used to reflect the strength of rural credit exclusion. The value is between $[1, +]$. The smaller the value, the stronger the finance exclusion in rural areas, that is, the lower the development level of inclusive finance. $v = 1$ indicates strict financial exclusion. At this time, rural economic individuals cannot obtain credit. $v = +$ indicates a perfect finance market. At this time, rural economic individuals do not have credit constraints.

Equations (4) and (5) show that the maximum income depends on the relationship between the productivity of rural economic individuals and the market interest rate. That is, at the time of $\tau_i > r$, the more k_i, the greater the return, and the maximum selected borrowing capital is ve_i; when $\tau_i = r$, its income is only related to e_i, independent of k_i. When $\tau_i < r$, there is no need for borrowing and lending, and lending one's capital will lead to greater income. To maintain the balance of the rural finance market, the total capital use must be equal to the total capital stock K_t, which can be realized by making the productivity of a marginal producer meet $\tau_m = r$. Then, the total capital use can be expressed as the marginal producer's capital use plus the maximum amount of capital that can be used by the left individuals of τ_m, that is,

$$K_t = k_m + v \sum_{0}^{m-1} e_i \tag{6}$$

Considering that the marginal producer belongs to the case of $\tau_i = r$, there is $k_m \in [0, ve_i]$; the equilibrium of the rural finance market can be expressed as

$$\sum_{0}^{m-1} e_i \leq K_t \leq \sum_{0}^{m} e_i \tag{7}$$

Further, due to inclusive finance development, rural finance exclusion has been gradually alleviated, that is, v continues to increase. Suppose that the individual with higher productivity on the left side of τ_m has no extra borrowing capacity, and that there are also individuals with lower productivity. At this time, with the increase of v, the marginal producer will move to the left side and an individual with lower productivity than the marginal producer will become a new marginal producer. According to this, combining Eqs (2) and (6) yields the total output:

$$Y_t = \tau_m k_m + \sum_{0}^{m-1} \tau_i k_i = \tau_m k_m + v \sum_{0}^{m-1} \tau_m e_m \tag{8}$$

Equation (8) combined with the capital clearing conditions of Eq (6) yields

$$Y_t = \tau_m K_t + v \sum_{0}^{m-1} (\tau_i - \tau_m) e_i \tag{9}$$

Find the partial derivative of v from the above formula to get

$$\frac{\partial Y_t}{\partial v} = \sum_{0}^{m-1} (\tau_i - \tau_m)\, e_i \tag{10}$$

In Eq (3), for all individuals with $i < m$, $\tau_i > \tau_m$, so $\partial Y_t / \partial v$ is always greater than zero. Equation (10) shows that the development of inclusive finance can enable low-income rural individuals with low productivity to have more capital to generate income by alleviating finance exclusion, that is, inclusive finance can promote rural income. In terms of Xinjiang, with the proposal and development of inclusive finance, financial services continue to cover remote areas and rural areas, effectively alleviating the finance exclusion in rural areas. This not only broadens the scope of financial services and enables more rural residents to enjoy them, but it also encourages rural residents to use inclusive finance by lowering the threshold for accessing financial services. It also stimulates rural area residents to adopt inclusive finance so that low-income people in rural areas of Xinjiang can increase their income through the use of financial services. In addition, inclusive finance includes both the financial system and financial resources, and the allocation requirements for financial resources vary from one area to another. Thus, inclusive finance is not homogeneously distributed, as it has regional differences. For instance, there are significant variations in the rural economic development status and resource endowment between deep poverty areas and non-deep poverty areas in Xinjiang. However, the intensity of inclusive finance's role in improving rural income will be adjusted to the actual situation of different areas, and the effectiveness of its role will also vary from one area to another [52]. Finally, Xinjiang, as a core node area of the areas included in the Belt and Road Initiative, has embarked on new stages of development in all aspects with the introduction of the Belt and Road cooperation initiative. This is also evident in inclusive financial development and rural income. The rising financial needs of the Belt and Road construction have deepened the residents' awareness of inclusive finance and increased their motivation to utilize inclusive finance, thus improving rural income.

Therefore, the following hypotheses are proposed:

Hypothesis 1: *The development of inclusive finance can directly promote rural income.*

Hypothesis 2: *The effect of inclusive finance on rural income has regional heterogeneity and time heterogeneity.*

Inclusive finance has two impacts on rural areas. On the one hand, with the gradual spread of inclusive finance to rural areas, the rural poor groups at the edge of financial services are becoming absorbed by alleviating finance exclusion, which directly promotes rural income [20]. On the other hand, the essence of inclusive finance is financial. Its development not only increases savings and investment, but it also promotes technological innovation, thus promoting the per capita economic output [57–62]. The improvement of per capita economic output promotes consumption, employment and investment in rural areas through the “trickle-down effect”, and improves the quality of life and income level of rural residents [63]. Therefore, Hypothesis 3 is proposed in this paper:

Hypothesis 3: *The inclusive finance can improve rural income in rural areas by promoting per capita economic output.*

4. Research design

4.1. Model setting

Fixed-effects models and random-effects models have the advantage of incorporating individual

effects compared to OLS (Ordinary least squares) models. The fixed-effects model is applied when the individual effects are correlated with the dependent variable [64–70]. The random-effects model is applied when the individual effects are not correlated with the independent variables [71]. Whereas, by observing the F-statistic, a fixed-effects model is applied in this work. The endogeneity is mitigated to some extent by controlling for omitted variables that do not vary over time but vary with individuals, making the estimation results more biased toward unbiased estimation. To investigate the effect of inclusive finance development on rural income, a model was constructed as follows.

$$pri_{it} = \alpha_0 + \alpha_1 ifi_{it} + \sum \delta_j Z_{j \cdot it} + \mu_i + \varepsilon_{it} \tag{11}$$

In Eq (11), i and t denote areas and years, respectively. pri_{it} is an evaluation indicator for the effect of rural income. ifi_{it} is an indicator of inclusive financial development in Xinjiang. $Z_{j \cdot it}$ is a control variable. μ_i is a fixed effect for each region in Xinjiang. ε_{it} is a random disturbance term.

4.2. Variable definitions

Core explanatory variables. The inclusive finance composite index (ifi) is adopted to measure the inclusive finance development level in Xinjiang. Also, to identify the effect of each dimension of inclusive finance on rural income, the index of inclusive finance availability ($ifi1$) and the index of usage ($ifi2$) are considered as the other two core explanatory variables. Combining the actual conditions and the definition of inclusive finance, we created two basic dimensions incorporating the availability of demographic factors and the use of the degree of participation in economic activities, with a total of eight indicators selected to compose an index system for inclusive financial development in Xinjiang (see Table 1). Among them, the availability dimension reflects the range of financial services available to economic individuals. Since traditional finance only serves a specific class, its service personnel, amount of capital and the property insurance needs enjoyed are bounded. In order to reflect the universality of inclusive finance and distinguish it from traditional finance, we apply two indicators, i.e., the number of financial industry service personnel per 10,000 people covered by financial institutions and the number of financial institutions per square kilometer, to reflect the coverage of financial industry service personnel in terms of per capita enjoyment and area distribution. The two indicators, i.e., deposit balance per capita and loan balance per capita, are used to reflect the amount of funds enjoyed per capita in terms of both deposits and loans. The indicator of insurance density measured by the per capita insurance premium indicator reflects the level of insurance penetration and the development of the insurance industry. The usage dimension reflects the importance of inclusive finance in economic development under the implementation of inclusive finance policies, and it was designed to measure the contribution of inclusive finance in economic construction. We apply two indicators, deposit balance/GDP and loan balance/GDP, to reflect the importance of the amount of funds used in economic development in terms of both deposits and loans. Insurance income/GDP is used as an indicator of insurance depth to reflect the position of the insurance industry in the overall national economy.

Table 1. Inclusive finance development evaluation system.

Dimension	Indicator description	Indicator	Symbol
Availability	Number of financial industry service personnel	Number of financial institutions employed per 10,000 people covered (persons/million)	X1
		Number of people employed in financial institutions per square kilometer	X2
	Per capita deposit and loan balance	Deposit balance per capita (10,000 yuan/person)	X3
		Loan balance per capita (10,000 yuan/person)	X4
	Insurance density	Insurance premium per capita (1,000 yuan/person)	X5
Usage	Ratio of deposit and loan balance to GDP	Deposit balance/GDP (%)	X6
		Loan balance/GDP (%)	X7
	Insurance depth	Insurance income/GDP (%)	X8

Before conducting the index measurement, each index is first standardized by applying the extreme difference standardization technique to eliminate the magnitude, and then a synthesis of the HDI is adopted for the measurement of the Xinjiang inclusive finance index, which is constructed as follows.

$$IFI = 1 - \frac{\sqrt{（\omega_1 - \omega_1 * x_1）^2 + （\omega_2 - \omega_2 * x_2）^2 + \cdots + （\omega_n - \omega_n * x_n）^2}}{\sqrt{{\omega_1}^2 + {\omega_2}^2 + \cdots + {\omega_n}^2}} \tag{12}$$

In Eq (12), *IFI* is the inclusive finance index (i.e., the calculation process ensures that the index interval is [0,1]), with larger values characterizing a better degree of inclusive finance development. ω_i is the weight determined by applying the coefficient of variation technique. In this study, Eq (2) was used to calculate the inclusive finance accessibility index ($ifi1$) and the inclusive finance usage index ($ifi2$) for 13 areas in Xinjiang from 2005–2019. The above-described method was then repeated, using the two-dimensional indexes to yield an inclusive financial comprehensive index (ifi) for each area in Xinjiang; the average value of the inclusive financial composite index (ifi) for Xinjiang and each area was also calculated (see Table 2)[2].

Table 2. Inclusive finance composite index of Xinjiang, 2005–2019.

Items	2005	2006	2007	2008	2009	2010	2011	2012
Total area	0.198	0.181	0.177	0.182	0.234	0.242	0.226	0.218
All areas except the four southern areas	0.212	0.193	0.190	0.196	0.250	0.256	0.231	0.221
Four southern areas	0.034	0.029	0.026	0.055	0.046	0.025	0.019	0.021
Items	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Total area	0.218	0.239	0.253	0.300	0.381	0.421	0.414	0.399
All areas except the four southern areas	0.221	0.252	0.267	0.327	0.414	0.448	0.440	0.427
Four southern areas	0.021	0.032	0.039	0.031	0.039	0.055	0.053	0.052

Table 2 shows the overall inclusive finance composite index in Xinjiang to be rising, from 0.198 in 2005 to 0.399 in 2019. In terms of different periods, Xingjiang's inclusive finance composite index fluctuated below 0.2 from 2005 to 2008, but, after 2008, benefiting from the reform and development of China's financial sector, the inclusive finance composite index exceeded 0.2 and reached a maximum of 0.421 in 2017. In terms of areas, the inclusive finance composite index in the four southern Xinjiang areas is much lower than the overall average of Xinjiang and the average of other areas, which indicates that inclusive finance development in Xinjiang has a distinct regional orientation,

[2]Xinjiang Uygur Autonomous Region is divided into non-deep poverty areas and deep poverty areas according to whether they are deep poverty areas or not. The deep poverty areas are the four southern Xinjiang areas, including the Aksu area, Kizilsu Kirgiz Autonomous Prefecture, Kashgar area and Hotan area. Other areas are non-deep poverty areas.

with a higher degree of inclusive finance development in non-deep poverty areas.

Dependent variable. We selected the net income per rural resident as the evaluation index for the rural income of Xinjiang. The net income per capita of rural residents can more accurately identify the effect of rural income increase. Stable growth of net income per rural resident is both a basis for stable poverty eradication and the rightful meaning of affluent living under the rural revitalization strategy.

Mechanism variables. Per capita economic output level ($pergdp$). Per capita economic output is the source of power to overcome poverty. It not only boosts the employment and income of the poverty-stricken population, but it also contributes to a higher level of social welfare. We utilized the GDP per capita to express the per capita economic output level [72].

Control variables. *Marketization level* ($market$). The marketization process has brought deep changes to the traditional rural economy. The better the marketization, the closer is the individual rural economy to the hypothesis of rational man, and the better the rural resource allocation system. We applied the ratio of urban non-state economy employment to urban employment to measure the marketization level. *Agricultural mechanization level* ($power$). Agricultural mechanization liberates agricultural labor and improves labor efficiency, which can both directly increase agricultural income and increase non-farm income through labor transfer. We employed the total power of agricultural machinery per capita to determine the agricultural mechanization level. *Unemployment rate* ($unem$). Creating employment opportunities and increasing the employment level of the poor is an effective way to reduce rural poverty. Reducing the number of people on unemployment and the unemployment rate is one way to reflect it. We applied the urban registered unemployment rate as a proxy variable of the unemployment rate. *Industrial structure* ($inst$). The industrial structure selected in this work includes two indicators: the ratio of the output value of the primary industry to GDP and the ratio of the output value of the tertiary industry to GDP [73]. On the one hand, the production and life of rural residents are closely related to the primary industry. The primary sector plays an important role in poverty reduction. On the other hand, the tertiary sector has a direct impact on the lives of rural residents. For example, the development of rural tourism can effectively improve rural production and living standards. Moreover, the low employment threshold of the tertiary sector makes it easier for the poor to enter, and it has a dampening effect on the occurrence of poverty.

4.3. Data sources and processing

Since Karamay City is a non-poor area and the statistics of rural per capita net income are missing, the sample selected in this work is the panel data of 13 areas (cities and states) in Xinjiang from 2005 to 2019. The data were obtained from the China Statistical Yearbook, the Xinjiang Statistical Yearbook and the statistical yearbooks of various regions (cities and states). The statistical bulletins of Xinjiang and all cities and states in the period under examination were also referenced, in which the net income per capita of rural residents and GDP per capita were deflated by the CPI index of each region in 2005 as the base period. The descriptive statistics of each index are shown in Table 3.

Table 3. Description statistics.

Items	Symbol	Mean	Std	Max	Min
Net income per capita of rural residents	$income$	0.607	0.301	1.474	0.130
Inclusive finance composite index	ifi	0.271	0.154	0.927	0.022
Inclusive finance accessibility index	$ifi1$	0.145	0.147	1.000	0.006
Inclusive finance usage index	$ifi2$	0.361	0.156	0.998	0.066
Marketization level	market	0.232	0.123	0.615	0.030
Per capita economic output level	$pergdp$	2.455	1.584	6.649	0.271
Agricultural mechanization level	$power$	0.865	0.539	2.813	0.070
Unemployment rate	$unem$	2.862	0.829	5.500	0.560
Primary industry	$inst1$	0.227	0.108	0.452	0.008
Tertiary industry	$inst3$	0.409	0.121	0.726	0.167

5. Results and discussion

5.1. Benchmark results and discussion

We utilized the Hausman test to investigate the optimal choice of the model before conducting the estimation model selection. This paper reveals that the optimal results were observed after the individual fixed effects were controlled; thus, a fixed-effects model was employed to empirically inspect the effect of inclusive financial development on rural income of Xinjiang. Furthermore, the variance inflation factor was tested to be 2.52, which is lower than the empirical value of 10, and the data covariance problem can be omitted. Table 4 reports the baseline regression results, where Columns (1) to (5) in Table 4 investigate the effect of the inclusive financial composite index on the rural income of Xinjiang through stepwise regression. As the estimated coefficients of inclusive financial development gradually decreased due to the gradual inclusion of control variables, R^2 increased from 0.674 to 0.867, suggesting that the addition of control variables renders the sample robust, and that inclusive financial development can explain the rural income of Xinjiang. Columns (6) and (7) in Table 4 examine income increase effects of the inclusive financial accessibility index and usage index on rural areas, respectively. Column (6) of Table 4 reveals that the estimated coefficient of the inclusive finance composite index was 1.114, which passes the 1% significance level test, i.e., inclusive finance development is associated with a significant effect of rural income increase. Promoting inclusive financial development in Xinjiang can contribute to the increase in income of rural residents, and Hypothesis 1 was tested. The estimated coefficients of the inclusive financial accessibility index and the inclusive financial usage index in Columns (7) and (8) of Table 4 were found to be 1.360 and 0.744, respectively (both passing the 1% significance level test), implying that both inclusive financial accessibility and usage can generate rural income increase. It shows that inclusive finance promotes the increase of rural income is the comprehensive result of the inclusive financial accessibility index and usage index, reflecting that inclusive financial development in Xinjiang focuses on comprehensiveness. The more content that is covered by inclusive finance, the larger the coverage, the more people using it and the deeper the involvement in economic activities, the more effective it will be in increasing rural income.

Table 4. Benchmark results.

Items	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ifi	1.983***	1.396***	1.020***	1.004***	1.002***	1.114***	-	-
	(19.32)	(14.35)	(11.13)	(10.98)	(10.98)	(9.38)		
$ifi1$	-	-	-	-	-	-	1.360***	-
							(15.56)	
$ifi2$	-	-	-	-	-	-	-	0.744***
								(5.51)
$market$	-	1.499***	1.024***	0.966***	0.950***	0.911***	0.320***	1.163***
		(10.72)	(7.97)	(7.34)	(7.22)	(6.81)	(2.69)	(7.95)
$power$	-	-	0.303***	0.289***	0.276***	0.276***	0.349***	0.309***
			(8.87)	(8.30)	(7.68)	(7.70)	(12.90)	(7.60)
$unem$	-	-	-	−0.023*	−0.018	−0.017	−0.027***	−0.020
				(−1.83)	(−1.41)	(−1.33)	(−2.65)	(−1.33)
$inst1$	-	-	-	-	−0.257	−0.255	−0.226	−0.381*
					(−1.46)	(−1.45)	(−1.62)	(−1.91)
$inst3$	-	-	-	-	-	−0.251	0.393***	0.020
						(−1.46)	(3.65)	(0.10)
Constant	0.069**	−0.120***	−0.170***	−0.074	−0.014	0.064	0.001	−0.065
	(2.35)	(−4.14)	(−6.83)	(−1.28)	(−0.20)	(0.72)	(0.02)	(−0.66)
Observations	195	195	195	195	195	195	195	195
R-squared	0.674	0.801	0.862	0.864	0.866	0.867	0.916	0.830
State Fixed	YES	YES	YES	YES	YES	YES	YES	YES

Note: t-values in parentheses; ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

5.2. Benchmark results and discussion

Following the classification of poverty areas in Xinjiang, the full sample was divided into non-deep poverty areas and deep poverty areas to investigate the effect of inclusive finance development on rural income under different poverty levels. Moreover, the Chinese government proposed the Belt and Road Cooperation Initiative in 2013 and implemented it [74]. As the critical area for the implementation of the Belt and Road Initiative, the inclusive financial development and the per capita economic output of rural areas in Xinjiang are bound to be affected. Therefore, we classified the sample into two time periods, i.e., 2005–2012 and 2013–2019, to investigate how inclusive financial development contributes to rural income before and after the implementation of the Belt and Road Initiative. The regression results are reported in Table 5 by area and by period. Columns (1)–(6) from Table 5 reveal that a significant regional difference is observed in the effect of the inclusive finance composite index and its dimensional indexes on the rural income of Xinjiang. The estimated coefficients of the inclusive financial composite index for non-deep poverty areas and deep poverty areas were found to be 1.295 and 0.495, respectively, demonstrating that the effect of inclusive financial development on rural income is weaker in deep poverty areas than in non-deep poverty areas, which confirms Hypothesis 2. Meanwhile, when comparing the estimated coefficients of two dimensions of inclusive finance availability and usage, one observes that the coefficient of inclusive finance availability in deep poverty areas (1.497) is larger than that in non-deep poverty areas (1.375), whereas the coefficient of inclusive finance usage in deep poverty areas (0.357) is smaller than that in non-deep poverty areas (1.497). One interesting explanation is that, for non-deep poverty areas in Xinjiang, the "activation effect" of inclusive finance is more effective than the "transport effect". Rural residents in non-deep poverty areas can spontaneously use financial services to satisfy their interests. In contrast, in deep poverty areas, the effect of inclusive financial development on rural income is still at the stage of financial service construction leading. It mainly depends on the input of financial services to boost the income of rural residents. Moreover, because of their endowments and

environmental constraints (such as education level, remote living location and insufficient financial knowledge), rural residents in deep poverty areas are not able to use financial services efficiently, further using financial services to generate income for themselves [75]. That is, inclusive financial development in deep poverty areas has not yet fully entered the stage of creating wealth by "activation effect". Columns (7) and (8) of Table 5 reveal significant heterogeneity in the effect of inclusive financial development on rural income before 2013, while the estimated coefficient of inclusive financial development after 2013 increased from 0.097 before 2013 to 0.692 (the significance level increased 1%), implying that, with the Belt and Road Initiative, implementation strengthened the effect of inclusive financial development on rural income, and Hypothesis 2 is verified. The inclusive financial system has been optimized and enhanced through the implementation of the Belt and Road Initiative. On the one hand, the Belt and Road construction has quickened financial industry development and strengthened the basic conditions for the development of inclusive finance. On the other hand, while the banking industry supports the Belt and Road construction, it also actively bears the social responsibility of popularizing the urban and rural areas and benefiting the people.

Table 5. Heterogeneity regression results.

Items	Non-deep poverty areas			Deep poverty areas			Before 2013	After 2013
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ifi	1.295***	-	-	0.495***	-	-	0.097	0.692***
	(8.94)			(4.40)			(0.55)	(6.41)
$ifi1$	-	1.375***	-	-	1.497***	-	-	-
		(13.06)			(4.70)			
$ifi2$	-	-	0.926***	-	-	0.357***	-	-
			(5.33)			(3.20)		
$market$	0.843***	0.432***	1.152***	0.398**	0.073	0.347*	0.371***	0.630***
	(5.06)	(2.92)	(6.21)	(2.14)	(0.40)	(1.75)	(3.13)	(3.94)
$power$	0.261***	0.370***	0.290***	0.316***	0.267***	0.368***	0.541***	0.129**
	(6.30)	(11.40)	(5.94)	(5.37)	(4.32)	(6.09)	(9.58)	(2.20)
$unem$	−0.047**	−0.026	−0.045*	−0.021***	−0.028***	−0.023***	-0.027***	−0.003
	(−2.26)	(−1.50)	(−1.85)	(−3.07)	(−4.34)	(−3.10)	(−2.64)	(−0.16)
$inst1$	−0.507*	0.115	−0.735**	−0.227	−0.528***	−0.245	−0.017	-0.842***
	(−1.81)	(0.48)	(−2.24)	(−1.34)	(−3.19)	(−1.34)	(−0.08)	(−3.45)
$inst3$	−0.591***	0.156	−0.314	0.581***	0.624***	0.625***	−0.472**	0.354*
	(−2.62)	(1.03)	(−1.14)	(4.02)	(4.50)	(4.03)	(−2.43)	(1.86)
Constant	0.325**	−0.032	0.177	−0.143	0.075	−0.183	0.239*	0.286**
	(2.62)	(−0.33)	(1.24)	(−1.23)	(0.64)	(−1.43)	(1.83)	(2.63)
Observations	135	135	135	60	60	60	104	91
R-squared	0.877	0.915	0.834	0.962	0.963	0.956	0.764	0.831
State Fixed	YES	YES	YES	YES	YES	YES	YES	YES

Note: t-values in parentheses; ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

5.3. Benchmark results and discussion

Endogeneity problems may emerge in the baseline regression because of the presence of omitted variables, which biases the estimation results. We adopted the instrumental variables technique to tackle endogeneity. The first-order and second-order lagged terms of the inclusive finance model were jointly adopted as instrumental variables and re-estimated by using IV-2SLS model estimation and controlling for clustering robust standard errors for the baseline regression results (Column (1) of Table 6). The endogeneity was also alleviated by using D-K standard error techniques that can solve cross-sectional heteroskedasticity, intra-sectional serial correlation and inter-sectional autocorrelation (Column (2) of Table 6). In addition, all explanatory variables were lagged by one

period to mitigate endogeneity in the benchmark regression results (Column (3) of Table 6). Table 6 reports that the p-values of the under-identification test (K-P test) were all less than 0.01, rejecting the null hypothesis, while the p-values of the overidentification test (Hansen J test) were more than 0.01 and did not reject the null hypothesis, indicating that the instrumental variables were selected as valid. Table 6 also reveals that the coefficient of ifi remained significantly positive after the endogeneity check; the results are in line with the former ones after the endogeneity check.

Table 6. Endogeneity problem results.

Items	IV-2SLS	D-K standard error	Lagged by one period
	(1)	(2)	(3)
ifi	1.032***(6.53)	1.114***(8.09)	0.796***(5.20)
$market$	0.936***(4.83)	0.911***(5.26)	1.203***(9.04)
$power$	0.249***(5.75)	0.276***(5.57)	0.329***(8.01)
$unem$	−0.012(−0.91)	−0.017(−1.31)	−0.008(−0.59)
$inst1$	−0.336**(−2.05)	−0.255*(−2.10)	−0.215(−1.08)
$inst3$	0.002(0.01)	−0.251(−1.05)	−0.548**(−2.59)
Constant		0.064(0.82)	0.151(1.44)
Observations	169	195	182
State Fixed	YES	YES	YES
K-P test	38.12	-	-
K-P test-P-value	5.29e-09	-	-
Hansen J-test	5.423	-	-
Hansen J-test P-value	0.02	-	-

Note: t-values in parentheses; ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

5.4. Robustness check results and discussion

To further examine the robustness of the estimated results, we adopted the following three techniques for robustness checking. First, to prevent biased results due to a small sample size, the robustness check was performed by sampling 1000 times using the bootstrap sampling technique (Column (1) of Table 7). Second, the baseline regression may be subject to estimation bias from omitted variables that change over time, so we performed two-way fixed-effects analysis for individual and time to perform robustness checks (Column (2) of Table 7). Finally, we adopted the entropy weight technique to synthesize a novel inclusive financial index re-estimate baseline regression result (Column (3) of Table 7). Table 7 implies that there is no significant difference in the direction of significance and sign of the coefficients of the key variables, which identifies that the baseline regression results are robust.

Table 7. Robustness check results.

Items	Bootstrap sampling technique	Two-way fixed technique	Replacing the dependent variable measurement
	(1)	(2)	(3)
ifi	1.114***(7.28)	0.464***(3.01)	1.237***(8.53)
$market$	0.911***(5.01)	0.431***(3.92)	0.282***(2.94)
$power$	0.276***(7.21)	0.080**(2.57)	0.158***(5.54)
$unem$	−0.017(−1.35)	0.011(1.09)	0.006(0.69)
$inst1$	−0.255*(−1.75)	0.597***(3.87)	0.519***(4.05)
$inst3$	−0.251(−1.05)	−0.482***(−3.09)	−0.556***(−4.82)

Continued on next page

Items	Bootstrap sampling technique	Two-way fixed technique	Replacing the dependent variable measurement
	(1)	(2)	(3)
Constant	0.064(0.56)	0.097(1.33)	0.064(1.06)
Observations	195	195	195
R-squared	0.867	0.935	0.953
Year Fixed	-	YES	-
State Fixed	YES	YES	YES

Note: t-values in parentheses; ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

5.5. Mechanism results and discussion

The previous research hypothesis proposes that inclusive finance can boost rural income increase by promoting per capita economic output. Moreover, numerous scholars have demonstrated the positive contribution of improved per capita economic output to rural income. The following model was constructed to test the impact of inclusive financial development on the rural income of Xinjiang from the perspective of the per capita economic output level:

$$income_{it} = \alpha + \beta_1 ifi_{it} + \sum \beta_{2j} Z_{j\cdot it} + \mu_i + \varepsilon_{it1} \tag{13}$$

$$pergdp_{it} = \alpha + \gamma_1 ifi_{it} + \sum \gamma_{2j} Z_{j\cdot it} + \mu_i + \varepsilon_{it2} \tag{14}$$

The selection and interpretation of the variables in Eqs (13) and (14) are the same as in Eq (11). $pergdp$ indicates the per capita economic output. The mechanism results are listed in Columns (1) and (2) of Table 8. The results of Column (1) of Table 8 have been analyzed in the baseline regression for interpretation and will not be repeated here. Column (2) of Table 8 reveals that the coefficient of inclusive finance was 2.797, which passes the 1% significance level test, implying that inclusive finance development significantly boosts per capita economic output. That is, the inclusive financial development influences the rural income of Xinjiang by affecting the per capita economic output. Hypothesis 3 is verified.

Table 8. Mechanism results.

Items	(1)	(2)
	$income$	$pergdp$
ifi	1.114***(9.38)	2.797***(4.20)
$market$	0.911***(6.81)	5.736***(7.65)
$power$	0.276***(7.70)	0.957***(4.77)
$unem$	−0.017(−1.33)	0.050(0.69)
$inst1$	−0.255(−1.45)	−3.731***(−3.79)
$inst3$	−0.251(−1.46)	−4.840***(−5.02)
Constant	0.064(0.72)	2.219***(4.46)
Observations	195	195
R-squared	0.867	0.733
State Fixed	YES	YES

Note: t-values in parentheses; ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

6. Conclusions and policy recommendations

Based on theoretical analysis and a dataset of 13 areas in Xinjiang from 2005–2019, we investigated the effect of inclusive finance development on the rural income of Xinjiang by constructing inclusive finance development and rural income indexes. The findings revealed that the inclusive finance composite index fluctuated below 0.2 before 2008, while it followed an increasing trend after 2008. Nevertheless, there is a difference in inclusive finance development levels in different areas. Inclusive finance development levels in the four southern Xinjiang areas were found to be lower than those in other areas. Inclusive finance development has significantly contributed to the rural income of Xinjiang. The inclusive finance composite index has generated a stronger effect on rural income than unilateral dimensions. We found regional heterogeneity and temporal heterogeneity in the effect of inclusive finance development on rural income [76]. Regarding deep-poverty areas, the effect of inclusive financial development on rural income in the four southern Xinjiang areas was found to be weaker than that in non-deep poverty areas. With the Belt and Road Initiative, the effect of inclusive finance development on rural income has gained more effectiveness. Mediating mechanisms suggest that the per capita economic output is an effective channel for inclusive finance development to increase the rural income of Xinjiang.

Inclusive finance development can drive rural income increase in Xinjiang. To fully exploit the effect of inclusive finance development on rural income, the following policy recommendations were formulated in light of the findings.

(1) Policymakers should, in conjunction with the Belt and Road Initiative and rural revitalization strategy, continuously reinforce inclusive finance construction and develop a comprehensive financial service system and insurance business practices covering rural areas so that those rural residents can have fairer access to financial services and more reasonable prices for financial services. Simultaneously, policymakers need to intensify digital financial diffusion [77–79] so that inclusive finance meets contemporary trends and further contributes to the betterment of the lives of rural residents.

(2) Policymakers should consolidate the financial soft environment in deeply impoverished areas while building a comprehensive coverage of financial services in rural areas. Moreover, the financial awareness and financial management awareness of rural residents should be bolstered to broaden the boundaries of the population by using inclusive finance and release the demand for financial services.

(3) Inclusive finance's rural income increase must be concerned with the direct effect, i.e., through lowering the threshold and cost of applying financial services, as well as with the increase of the coverage and content of financial services to improve the inclusiveness of financial services and make the rural income increase effect of inclusive finance more obvious by actively alleviating financial exclusion. Also, policymakers should concentrate on per capita economic output as an indirect channel. Financial services should be built with in-depth integration of regional resource endowment, industrial layout and folk customs. Inclusive finance will be further oriented to boost consumption, employment and investment in rural areas through the per capita economic output so that those rural residents can move toward a richer life.

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Conflict of interest

The authors state no conflict of interest.

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