Original Paper

Research on the Relationship among Digital Inclusive Finance, Agricultural and Rural Modernization and Rural Residents' Income Based on PVAR Model

Jiatong Wang[1*]

[1] Beijing Wuzi University, Beijing, 101149, PR China

[*] Jiatong Wang, Beijing Wuzi University, Beijing, 101149, PR China

Abstract

Based on the panel data of 30 provinces and municipalities from 2011 to 2021, this paper constructs PVAR model to study the relationship among digital inclusive finance, agricultural and rural modernization and rural residents' income. It is found that: Firstly, digital inclusive finance is the unidirectional Granger cause of agricultural and rural modernization, and there is a bidirectional Granger causality between digital inclusive finance and rural residents' income. There is also a bidirectional Granger causality between agricultural and rural modernization and rural residents' income, and there is a direct or indirect influence mechanism among them. Secondly, digital inclusive finance has a strong self-enhancement mechanism, while rural residents' income and agricultural and rural modernization have self-enhancement in a short term. At the same time, digital inclusive finance obviously promotes rural residents' income increase, and the two factors promote each other in the short term. Rural residents' income increase can promote agricultural and rural modernization in the short term, while the development of digital inclusive finance lags behind in promoting agricultural and rural modernization. Finally, the biggest impact of digital inclusive finance, agricultural and rural modernization and rural residents' income comes from themselves, and the coordination among them needs to be strengthened.

Keywords

digital inclusive finance, agricultural and rural modernization, income of rural residents, PVAR model

1. Introduction

The lifeblood of modern economy is finance, and the blood of economic operation is also finance. Promoting the modernization of agriculture and rural areas cannot be separated from financial support. In 2018, the Strategic Plan for Rural Revitalization (2018-2022) pointed out that it is necessary to strengthen financial support for agriculture, to improve the rural financial system, to adapt it to the characteristics of agriculture and rural areas, and to allocate more financial resources in the key and weak areas of rural development, so as to meet the diversified financial needs of rural areas. Facing the rapid development of Internet technology, traditional financial business in rural areas is faced with financial exclusion caused by factors such as high transaction costs and credit costs (Meng et al., 2023). Digital inclusive finance is a product of the organic combination of traditional financial business and digital technology, which has innovated and developed the operation mode of traditional finance. The advantages of digital inclusive finance including convenience, sharing, high coverage, low cost provide an effective solution to solve the problems of financial exclusion in rural areas, and encourage rural residents to innovate and start businesses, thus improving their income level and providing effective financial support for active and effective agricultural boosting and rural modernization in the new era. Therefore, this paper studies the relationship among digital inclusive finance, agricultural and rural modernization and rural residents' income, and analyzes its coordination level.

2. Literature Review

First of all, some scholars have found that the development of digital inclusive finance can increase the income of rural residents: Li T et al. (2021), based on county-level data, found that the development of digital inclusive finance can significantly increase the income of rural residents. Moreover, the development of digital inclusive finance has a more significant positive impact on the central and western regions. With the enhancement of residents' education level, its positive impact is also more significant, while with the rise of rural financial level, its positive impact will gradually weaken. Yin Zhentao et al. (2021), based on CHFS data, found that the development of financial technology can increase farmers' income, encourage farmers to start businesses, narrow the income gap between urban and rural areas, and then improve the happiness of rural residents. Shi Lingling et al. (2022), found that the income-increasing effect of digital inclusive finance is more obvious among poor groups, and its intermediary mechanism is industrial upgrading and economic development. Secondly, some scholars have found that the development of digital inclusive finance has brought positive effects on agricultural and rural modernization. Specifically, by studying the provincial panel data from 2011 to 2020, Wang Min et al. (2023), found that digital inclusive finance has a very significant role in promoting rural revitalization, and digital inclusive finance has a more significant positive effect in areas with high consumption level and high human capital. It is also found that digital inclusive finance promotes rural

revitalization by increasing mechanization penetration rate, stimulating entrepreneurship and increasing income. Luo Zhenjun et al. (2023), by using SARAR model to conduct empirical research, found that digital inclusive finance and its three dimensions of coverage breadth, using depth and digitalization degree all have significant promotion effects on agricultural and rural modernization, and digital inclusive finance can promote agricultural and rural modernization through economic growth, increasing investment in rural fixed assets and increasing household income. Finally, promoting the sustainable growth of rural residents' income is the inevitable requirement and central task of promoting the strategy of rural revitalization and realizing the modernization of agriculture and rural areas. The improvement of rural residents' income level can bring about the improvement of consumption level, and the potential of consumption market in rural areas can be brought into play, which can better promote the economic growth in rural areas (Chen Ling et al., 2022) and promote the modernization of rural areas. Luo Zhenjun et al. (2023), found that increasing household income in rural areas is one of the mechanisms to promote agricultural and rural modernization in digital inclusive finance, which shows that increasing residents' income can improve the level of agricultural and rural modernization.

After the above literature review, it is found that the existing literature proves that there is indeed a correlation between digital inclusive finance, agricultural and rural modernization and the income level of rural residents. However, scholars pay more attention to the unidirectional and static relationship between the two factors, and fewer scholars pay attention to the interactive relationship among the three factors. Therefore, this paper examines and analyzes the interaction among digital inclusive finance, agricultural and rural modernization and rural residents' income by constructing a PVAR model to study the mutual influence among different variables from a dynamic perspective.

3. Research Design

3.1 Variable Selection

Based on the provincial panel data of 30 provinces in China mainland (except Tibet) from 2011 to 2021, this paper calculates the agricultural and rural modernization index of each province. All the secondary index data come from China Statistical Yearbook, Provincial Statistical Yearbook, China Labor Statistical Yearbook and National Bureau of Statistics. The Digital Inclusive Finance Index comes from the Institute of Digital Finance of Peking University.

Agricultural and rural modernization level (Rur): This paper draws lessons from Chen Huiqing et al. (2022) to construct an index evaluation system of agricultural and rural modernization from five aspects: rural agriculture, ecology, culture, governance and life. After standardizing the original data, entropy method is used to weight each index, and a natural logarithm is taken. Among them, the selection of each index is shown in Table 1. Digital Inclusive Finance Level (Dif): This paper draws

lessons from the practice of Zhang Xun et al. (2019), and adopts the logarithmic value of Peking University Digital Inclusive Finance Index (Guo Feng et al., 2020) as an indicator to measure the level of digital inclusive finance. Rural residents' income level (Inc): The logarithmic value of per capita disposable income of rural residents is used to measure the income level of rural residents in various regions. Table 2 is descriptive statistics of each variable.

Table 1. Index Evaluation System of Agricultural and Rural Modernization Level

first-class index	second-class index	attribute
agricultural modernization	Effective irrigation ratio of farmland	+
	Per capita grain output	+
	Total power of agricultural machinery	+
	Gross output value of agriculture, forestry, animal husbandry and fishery	+
ecological modernization	Fertilizer use per unit sown area	-
	Forest coverage ratio	+
	Proportion of harmless treatment of domestic garbage	+
	Financial expenditure on environmental protection	+
cultural modernization	Per capita possession of public library collections	+
	Financial expenditure on education	+
	Financial expenditure on science and technology	+
	Telephone penetration rate	+
governance modernization	Proportion of old-age insurance participation	+
	Financial expenditure on urban and rural community affairs	+
	Number of village committee units per 10,000 people in villages	+
	Number of health workers per 10,000 people in villages	+
farmers' life modernization	Engel coefficient	-
	Proportion of administrative villages with centralized water supply	+
	Rural electricity consumption	+
	The proportion of wage income to total income of rural residents	+

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Rur	330	3.202	0.324	2.417	4.061
Dif	330	5.283	0.669	2.909	6.129
Inc	330	9.410	0.414	8.361	10.559

3.2 Model Buliding of PVAR

Panel Vector Autoregressive Model (PVAR) integrates traditional VAR model with panel data, taking into account individual and time effects, and mainly analyzes the interaction among variables for panel data. In order to analyze the dynamic relationship among the level of digital inclusive finance, the income level of rural residents and the level of agricultural and rural modernization, this paper draws lessons from the practice of Song Na et al. (2023), to construct the following panel vector autoregressive model (PVAR):

$$Y_{it} = X_0 + \sum_{j=1}^{p} X_j Y_{i,t-j} + X_p Y_{i,t-p} + \mu_i + \theta_i + \varepsilon_{it} \tag{1}$$

In the above formula, Y_{it} represents three different vectors: digital inclusive finance level, rural residents' income level and agricultural and rural modernization level, i and t represent regions and years respectively, j represents lag order, μ_i is individual effect, θ_i is time effect, and ε_{it} is random error term.

4. Analysis of Empirical Results

4.1 Unit Root Test and Optimal Lag Order of Panel Data

In order to avoid the error of impulse response and variance decomposition results caused by the deviation of model estimation results, before PVAR test, unit root test must be carried out for each variable to ensure the stationarity of the variable sequence. In this paper, LLC, IPS, ADF and PP are selected to test the unit root of three variables and their first-order differences dRur, dDif and dInc. Table 3 shows the test results, which proves that the first-order difference sequences of the three variables have passed the stationarity test.

Table 3. Unit Root Test Results

Variable	LLC	IPS	Fisher-ADF	Fisher-PP	Results
Rur	-12.734***	-0.459	162.896***	52.659	not smooth
Dif	-4.144***	-6.326***	253.671***	1380.035***	smooth
Inc	-19.629***	-0.528	151.556***	87.636**	not smooth
dRur	-5.280***	-5.665***	90.825***	282.104***	smooth
dDif	-13.251***	-6.386***	355.686***	1071.199***	smooth
dInc	-23.531***	-4.440***	133.692***	119.819***	smooth

Note: *, **, *** are significant at the levels of 10%, 5% and 1%

At the same time, this paper determines the optimal lag order of PVAR model according to the criteria in MAIC, MBIC and MQIC. From Table 4, it can be seen that the optimal lag order of this model is the first order.

Table 4. Optimal Lag Order Selection

lag	MBIC	MAIC	MQIC
1	-153.871*	-47.059*	-88.839*
2	-123.170	-35.208	-69.615
3	-90.561	-21.448	-48.481
4	-66.758	-16.494	-36.155
5	-44.198	-12.782	-25.071
6	-20.281	-7.715	-12.630

4.2 Robustness Test and Granger Causality Test

After determining the optimal lag order of the model, the robustness test of the model should be carried out to ensure that the results of impulse response and variance decomposition are accurate. Figure 1 shows the robustness test results. It can be seen from the figure that all variables are in the unit circle, indicating that PVAR model is robust.
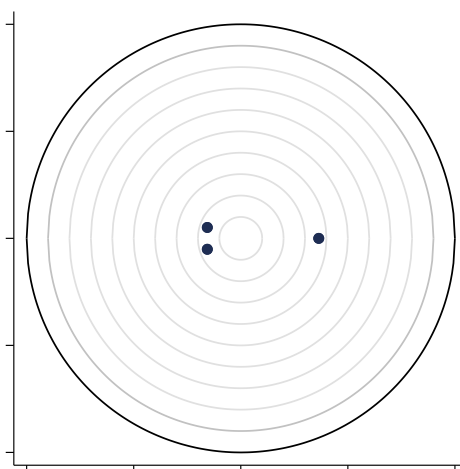
Figure 1. Robustness Test

In order to test the causal relationship among digital inclusive finance, agricultural and rural modernization and rural residents' income, this paper conducts Granger causality test on three variables, and the results are shown in Table 5. The results show that the digital inclusive finance is the unidirectional Granger cause of agricultural and rural modernization at the significance level of 1%; There is a bidirectional Granger causality between digital inclusive finance and rural residents' income; There is also a bidirectional Granger causality between rural residents' income and agricultural and rural modernization.

Table 5. Granger Causality Test Results

Variable	Null hypothesis	chi2	P	Outcome
dRur	dDif does not Granger cause dRur	13.238***	0.000	refuse
	dInc does not Granger cause dRur	22.524***	0.000	refuse
dDif	dRur does not Granger cause dDif	0.414	0.520	accept
	dInc does not Granger cause dDif	3.425*	0.064	refuse
dInc	dRur does not Granger cause dInc	3.033*	0.082	refuse
	dDif does not Granger cause dInc	96.099***	0.000	refuse

4.3 Impulse Response and Variance Decomposition

In order to further understand the specific dynamic relationship among digital inclusive finance, agricultural and rural modernization as well as rural residents' income, this paper makes an impulse response analysis on the three. However, since the above analysis shows that the three factors are not

mutually Granger caused, only the variables with Granger causality are analyzed. Through 300 Monte-Carlo simulations, the time span is 0-10 periods, and the results are shown in Figure 2.

It can be seen from Figure 2 (1), (5) and (9) that the income of rural residents, agricultural and rural modernization and digital inclusive finance reached positive maximum in the current period when they were impacted by themselves. Digital inclusive finance has a significant self-reinforcing effect, and its impact on itself is always positive, but it will gradually tend to zero with time. After the income of rural residents and the modernization of agriculture and rural areas give themselves a positive impact in the current period, the impact effect decreases and becomes negative impact in the first or second period, and then increases slightly. After returning to a positive value, the impact effect gradually dissipates, reflecting their short-term promotion effect on themselves. It shows that digital inclusive finance has a strong self-enhancement mechanism and circular accumulation effect, while rural residents' income and agricultural and rural modernization have self-enhancement in a short term. From figure (2) and (3), it can be seen that the positive shock effect of digital inclusive finance on rural residents' income reached its peak in the first phase, and then gradually decreased until the shock effect dissipated in the fourth phase, which shows that digital inclusive finance can promote rural residents' income increase. The shock effect of agricultural and rural modernization on rural residents is unstable, which is positive in the current period, and then fluctuates up and down around 0 until it dissipates. From figure (4), it can be seen that the shock effect of rural residents' income on digital inclusive finance rises, reaching the maximum in the first phase, and then fluctuating slightly until the impact is 0 in the second phase. It can be seen that increasing rural residents' income can promote the development of digital inclusive finance in the short term. From figure (7) and (8), it can be seen that the positive impact of rural residents' income on agricultural and rural modernization also reached its peak in the first phase, then dropped sharply to negative value, and fluctuated up and down around 0 value until the impact dissipated. That is, increasing rural residents' income can promote the development of agricultural and rural modernization in the short term. The impact of digital inclusive finance on agricultural and rural modernization is negative in the first phase and positive in the second phase, which shows that there is a time lag in the promotion of digital inclusive finance development on agricultural and rural modernization.
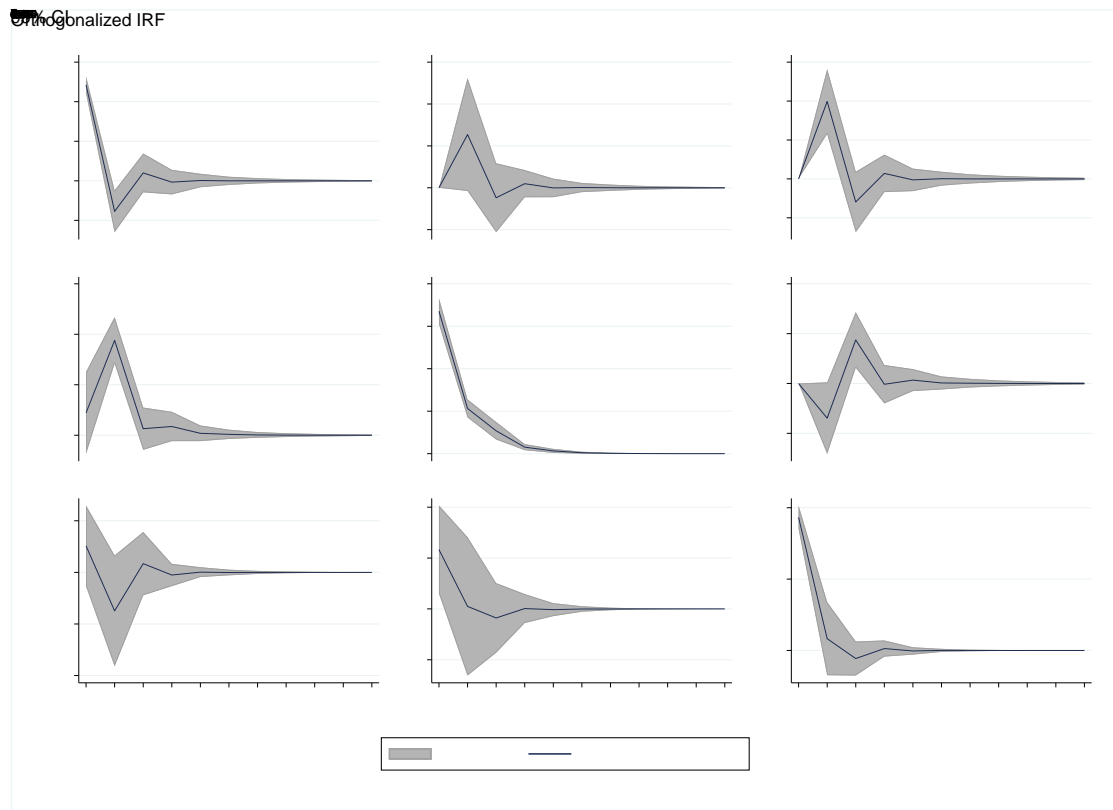
Figure 2. Impulse Response

In order to further analyze the long-term interaction among digital inclusive finance, agricultural and rural modernization and rural residents' income, this paper uses variance decomposition to study, and Table 6 shows the results of variance decomposition.

From the results of variance decomposition, digital inclusive finance, agricultural and rural modernization and rural residents' income all have self-strengthening mechanisms, and the fluctuations of the three all come from themselves to a great extent. First of all, observing the variance decomposition of dRur, agricultural and rural modernization was impacted totally by itself in the first stage, then gradually declined and remained stable after the fifth period. The impact of digital inclusive finance and rural residents' income appeared in the second period, while the contribution rate of digital inclusive finance was less, reaching the maximum value of 1.67% in the fifth period. The contribution rate of rural residents' income reached the maximum of 23.08% in the fourth period and remained unchanged after that. Secondly, by investigating the variance decomposition of dDif, the contribution rates of agricultural and rural modernization and rural residents' income are relatively small, with the contribution rate of the former rising to 2.59% in the third period and the contribution rate of the latter rising to 3.12% in the fourth period. The contribution rate of digital inclusive finance to itself decreased slowly from 97.06% in the first phase to 94.29% in the fourth phase. Finally, investigating the variance

decomposition of dInc, the contribution rate of agricultural and rural modernization and digital inclusive finance is also relatively small, with the contribution rate of the former rising to 1.88% in the third period and the contribution rate of the latter rising to 8.33% in the fifth period. However, the contribution rate of rural residents' income to themselves decreased slowly from 98.76% in the first period to 89.79% in the fifth period.

Table 6. Variance Decomposition Results

Forecast Horizon	dRur			dDif			dInc		
	dRur	dDif	dInc	dRur	dDif	dInc	dRur	dDif	dInc
1	1	0	0	0.0294	0.9706	0	0.0071	0.0053	0.9876
2	0.7753	0.0067	0.2181	0.0260	0.9433	0.0307	0.0182	0.0828	0.8989
3	0.7534	0.0166	0.2300	0.0259	0.9430	0.0311	0.0188	0.0827	0.8986
4	0.7526	0.0166	0.2308	0.0259	0.9429	0.0312	0.0188	0.0832	0.8980
5	0.7525	0.0167	0.2308	0.0259	0.9429	0.0312	0.0188	0.0833	0.8979
6	0.7525	0.0167	0.2308	0.0259	0.9429	0.0312	0.0188	0.0833	0.8979
7	0.7525	0.0167	0.2308	0.0259	0.9429	0.0312	0.0188	0.0833	0.8979
8	0.7525	0.0167	0.2308	0.0259	0.9429	0.0312	0.0188	0.0833	0.8979
9	0.7525	0.0167	0.2308	0.0259	0.9429	0.0312	0.0188	0.0833	0.8979
10	0.7525	0.0167	0.2308	0.0259	0.9429	0.0312	0.0188	0.0833	0.8979

5. Conclusions and Suggestions

Based on the panel data of 30 provinces and municipalities from 2011 to 2021, this paper studies the relationship among digital inclusive finance, agricultural and rural modernization and rural residents' income, and draws the following conclusions. First, Granger causality test results show that digital inclusive finance is the unidirectional Granger cause of agricultural and rural modernization, and there is a bidirectional Granger causality between digital inclusive finance and rural residents' income, and there is also a bidirectional Granger causality between agricultural and rural modernization and rural residents' income. It shows that there is a direct or indirect influence mechanism among the three factors. Secondly, the impulse response results show that digital inclusive finance has a strong self-enhancement mechanism, while rural residents' income and agricultural and rural modernization have self-enhancement in a short time. At the same time, digital inclusive finance obviously promotes rural residents' income increase, and the two factors promote each other in the short term. Rural residents' income increase can promote agricultural and rural modernization in the short term, while the development of digital inclusive finance lags behind in promoting agricultural and rural modernization. Finally, the variance decomposition results show that the biggest impact of digital inclusive finance,

agricultural and rural modernization and rural residents' income comes from themselves, and the coordination among them needs to be strengthened.

According to the above conclusions, this paper puts forward the following suggestions: First, we should continue to vigorously develop digital inclusive finance, especially strengthening the development of digital inclusive finance in rural areas and the cumulative circular effect of digital inclusive finance. Meanwhile, government departments should strengthen the construction of digital infrastructure in rural areas, alleviate the "digital divide" and "financial exclusion", and provide a good material foundation for the development of digital finance in rural areas. Secondly, the financial sector should popularize digital financial knowledge for rural residents, improve their digital financial literacy, let residents know about related financial products and services, and let related financial products really help rural residents solve their financial problems, so as to encourage residents to innovate and start businesses, increase their income, and further promote the modernization of agriculture and rural areas. Finally, we should coordinate the common development of digital inclusive finance and agricultural and rural modernization. Agricultural and rural modernization is an organic combination of the modernization of the whole agricultural industrial chain and the modernization of all aspects of the countryside, both of which need low-threshold and inclusive financial support. The development of digital inclusive finance can just solve this problem.

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