The Impact of Informatization on Farmers' Disposable Income——— Theoretical model and empirical testing

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Abstract. The issue of "increasing farmers' income" is a focal point of agricultural and rural development. With the continuous advancement of information technology, exploring whether informatization can promote farmers' income growth holds significant theoretical and practical implications. By employing a simple mathematical framework, this study constructs models of capital and labor flows between urban and rural sectors under the backdrop of informatization. It analyzes the reasons for the impact of increased societal informatization on farmers' income. Utilizing panel vector autoregressive models with data from 25 provinces, the study empirically examines whether informatization can indeed contribute to increasing farmers' income, considering three dimensions of informatization. Subsequently, it investigates the impact of informatization on farmers' income in the eastern, central, and western regions of China. The findings indicate that, nationally, the increased application of information technology in industries can promote farmers' income growth. However, for the eastern region, the improvement in informatization alone does not necessarily lead to increased farmers' income. In contrast, for the central and western regions, increased application of information technology in commerce and the enhancement of information network infrastructure can facilitate farmers' income growth.

Keywords: Informationization; Farmers' income increase; Urban-rural Dual Structure; PVAR model

1 INTRODUCTION

“Farmers' income increase" has always been a top priority in agricultural issues. In February 2023, the Central Committee of the Communist Party of China issued the "Opinions on Doing a Good Job in the Key Tasks of Comprehensive Rural Revitalization in 2023", proposing relevant measures to expand channels for increasing farmers' income and wealth, highlighting the importance of stabilizing and increasing farmers' income in promoting agricultural, rural, and comprehensive rural revitalization, and accelerating the modernization of agriculture and rural areas. With the rapid development and penetration of information technology, rural areas are gradually entering the

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information age. The widespread application of emerging technologies such as the internet, big data, and the Internet of Things in rural areas has made it more convenient for farmers to access knowledge, market information, financial services, and other aspects, greatly promoting the production and sales of agricultural products. However, it has also brought about the problem of widening income disparities between urban and rural areas. Therefore, exploring whether informationization can promote farmers' income increase is of great practical significance.

The impact of informationization on farmers' income can be summarized as follows:

Increase in Income:

- Information technology and resources enable rapid and accurate market information dissemination, reducing production costs and risks, thus allowing farmers to adjust cropping structures and increase income[1].
- Promotion of cooperation and resource optimization in the agricultural industry through information sharing and technological advancements further enhances income[2].
- Information technology facilitates accurate detection of soil, water, and weather conditions, enabling farmers to adjust planting methods promptly to ensure crop yields and income growth[3][4][5][6].
- The popularization of information technology also enhances rural human capital accumulation, contributing to income growth.

Decrease in Income:

- Weak information processing capabilities in agricultural and rural information systems lead to information closure, resulting in policy failures.
- Disparities in information and network technology ownership and application between rural and urban areas hinder rural investment and industrial development.[7]
- Internet applications create new jobs but also destroy old ones, leading to unemployment issues in rural areas, exacerbated by farmers' transition to non-agricultural employment without finding better opportunities[8][9][10].
- Insufficient and imbalanced agricultural information resources can result in blind spots in farmers' production, causing harm[11][12].

Overall, while existing research lacks analysis of the macro-level impact of social informatization on farmers' income, this paper contributes by theoretically deducing and examining the influencing mechanisms and pathways using panel data.

2 THEORETICAL FRAMEWORK CONSTRUCTION

Assuming that all other technological levels in society remain constant, the increase in the level of informatization reflects technological progress. Due to disparities between rural and urban areas in terms of ownership, application, and innovation of information and network technologies, the process of informatization leads to the redirection of investments from rural to urban areas and the migration of labor from rural to urban areas.

Based on the above assumptions, we can equate the level of societal informatization to technological level and assume that at time t, the technological level in rural areas is represented by $A_{1,t}$, in urban areas by $A_{2,t}$; the technological adaptation level in rural areas is represented by $\theta_{1,t}$, in urban areas by $\theta_{2,t}$; the labor force in rural areas is represented by $L_{1,t}$, in urban areas by $L_{2,t}$; the capital invested in the rural sector is represented by $K_{1,t}$, and in the urban sector by $K_{2,t}$. The output functions for the rural and urban sectors are defined as:

$$\begin{aligned} Y_{1,t} &= A_{1,t}\theta_{1,t}K_{1,t}^{\alpha}L_{1,t}^{1-\alpha} \\ Y_{2,t} &= A_{2,t}\theta_{2,t}K_{2,t}^{\alpha}L_{2,t}^{1-\alpha} \end{aligned} \tag{1}$$

Measuring the change in income by per capita output.

$$\begin{aligned} y_{1,t} &= A_{1,t}\theta_{1,t}\left(\frac{K_{1,t}}{L_{1,t}}\right)^{\alpha} \\ y_{2,t} &= A_{2,t}\theta_{2,t}\left(\frac{K_{2,t}}{L_{2,t}}\right)^{\alpha} \end{aligned} \tag{2}$$

Assuming that the proportion of labor force transferred from rural to urban areas at t is δ_t, according to the urban-rural dual structure model, the labor flow between urban and rural areas directly depends on the income difference between them:

$$f(y_{2,t-1} - y_{1,t-1}) = \delta_t > 0 \tag{3}$$

Based on the above assumption, we can derive the urban-rural labor flow equation as follows:

$$\begin{aligned} L_{1,t-1} - f(y_{2,t-1} - y_{1,t-1})L_{1,t-1} &= L_{1,t} \\ L_{2,t-1} + f(y_{2,t-1} - y_{1,t-1})L_{1,t-1} &= L_{2,t} \end{aligned} \tag{4}$$

Assuming that the proportion of capital transferred from rural to urban areas at t is μ_t, it is easily understood that this depends on the difference in information adaptability between urban and rural areas, and investors' perception of this difference in information adaptability is lagged:

$$g(\theta_{2,t-1} - \theta_{1,t-1}) = \mu_t > 0 \tag{5}$$

Based on the above assumptions, we can derive the urban-rural capital flow equation as follows:

$$\begin{aligned} K_{1,t-1} - g(\theta_{2,t-1} - \theta_{1,t-1})K_{1,t-1} &= K_{1,t} \\ K_{2,t-1} + g(\theta_{2,t-1} - \theta_{1,t-1})K_{1,t-1} &= K_{2,t} \end{aligned} \tag{6}$$

The adaptability of cities and rural areas to technology is obviously positively correlated with the level of technology.

$$\begin{aligned} \theta_{1,t} &= h(A_{1,t}) \\ \theta_{2,t} &= h(A_{2,t}) \end{aligned} \tag{7}$$

By comparing the ratio of $\frac{y_{1,t}}{y_{1,t-1}}$ with 1, we can judge the impact of informatization on farmers' income.

$$\frac{y_{1,t}}{y_{1,t-1}} = \frac{A_{1,t}h(A_{1,t})\left(\frac{K_{1,t-1}-g(\theta_{2,t-1}-\theta_{1,t-1})K_{1,t-1}}{L_{1,t-1}-f(y_{2,t-1}-y_{1,t-1})L_{1,t-1}}\right)^{\alpha}}{A_{1,t-1}h(A_{1,t-1})\left(\frac{K_{1,t-1}}{L_{1,t-1}}\right)^{\alpha}} = \frac{A_{1,t}h(A_{1,t})}{A_{1,t-1}h(A_{1,t-1})}\left(\frac{1-g(\theta_{2,t-1}-\theta_{1,t-1})}{1-f(y_{2,t-1}-y_{1,t-1})}\right)^{\alpha} \quad (8)$$

3 EMPIRICAL TESTING ON A NATIONAL SCALE

3.1 Data Processing and Explanation

Following the approach of mainstream literature, this study considers the three elements of informatization to be the proportion of the information industry in the national economy (i.e., the level of development of the information industry measured from the output perspective), the degree of application of information technology in industries, and the level of national information infrastructure.

Indicator selection is based on the research by Lu Lina (2007)[13]. The number of broadband access users per province ($popu$) is chosen as the proxy variable for the level of information infrastructure construction; the income from information technology services ($service$) serves as the proxy variable for the level of development of the information industry; the proportion of enterprises conducting transactions through e-commerce ($eratio$) is used as the proxy variable for the degree of application of information technology in industries. Farmers' annual disposable income1 ($income$) is used to reflect whether farmers have increased their income. This study constructs a panel dataset based on the above indicators from 25 provinces in China from 2014 to 2022. The data is sourced from the "China Statistical Yearbook."

$\ln income_{it}$, $\ln popu_{it}$,$\ln \text{service}_{it}$, $\ln eratio_{it}$ respectively represent the logarithm of farmers' per capita annual income, broadband access users, income from information technology services, and the proportion of enterprises conducting transactions through e-commerce in the i th province in the t th year. The model introduces fixed effects to reflect the heterogeneity between cross-sections, and employs the "Helmert procedure" method to eliminate fixed effects, ensuring orthogonality between the transformed variables and lagged explanatory variables.

3.2 Establishment of PVAR Model

Homogeneous panel unit root tests (LLC test) were employed. The results, as shown in Table 1, indicate that the null hypothesis is rejected for all four variables.

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[1] The term "farmers' income" in the following context all refers to farmers' disposable income.

Table 1. LLC Test

Variable	P-value	Conclusion
$\ln income_{it}$	0.0000	Stationary
$\ln popu_{it}$	0.0000	Stationary
$\ln \mathrm{service}_{it}$	0.0408	Stationary
$\ln eratio_{it}$	0.0000	Stationary

For the selection of lag orders in the model, the results are shown in Table 2:

Table 2. Selection of Optimal Lag Orders

Lag	AIC	BIC	HQIC
1	-8.86148	-6.53325*	-7.9156
2	-8.82702	-5.84033	-7.61369
3	-9.58626*	-5.73061	-8.02581*
4	-8.39563	-3.32805	-6.3722

Although the above table indicates that a lag of 3 is the optimal lag order, considering the short time series of panel data, a lag order of 1 is ultimately chosen.

Granger causality tests are conducted on the PVAR model, with the results shown in Table 3. It can be observed that, nationally, there is bidirectional causality between $h\_lneratio$ and $h\_lnincome$.However, there is no Granger causality relationship between the coverage rate of information networks, the level of development of the information industry, and farmers' income.

Table 3. Granger Causality Test under National Scope

Null Hypothesis	P-Value	Conclusion
h_lnpopu is not a Granger cause of $h\_lnincome$	0.144	Accepted
$h\_lneratio$ is not a Granger cause of $h\_lnincome$	0.007	Rejected
$h\_lnservice$ is not a Granger cause of $h\_lnincome$	0.579	Accepted
$h\_lnincome$ is not a Granger cause of h_lnpopu	0.658	Accepted
$h\_lneratio$ is not a Granger cause of h_lnpopu	0.307	Accepted
$h\_lnservice$ is not a Granger cause of h_lnpopu	0.885	Accepted
$h\_lnincome$ is not a Granger cause of $h\_lneratio$	0.071	Rejected
h_lnpopu is not a Granger cause of $h\_lneratio$	0.048	Rejected
$h\_lnservice$ is not a Granger cause of $h\_lneratio$	0.428	Accepted
$h\_lnincome$ is not a Granger cause of $h\_lnservice$	0.080	Rejected
h_lnpopu is not a Granger cause of $h\_lnservice$	0.309	Accepted
$h\_lneratio$ is not a Granger cause of $h\_lnservice$	0.086	Rejected

Impulse Response

This study sets the duration of the shock impact to 10 periods, and through 200 Monte Carlo simulations, the impulse response functions of the four variables can be obtained. Since the Granger causality test only showed bidirectional causality between the proportion of enterprises conducting transactions through e-commerce and farmers' income, the following analysis focuses on the impulse response results for this relationship, as shown in Figure 1.

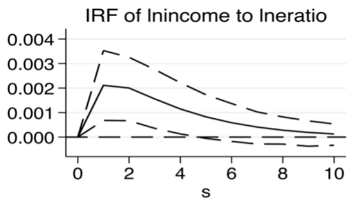

Fig. 1. Impulse Response Graph of $h\_lnincome$ to $h\_lneratio$

It can be observed that in response to a positive shock in the application level of information technology in commerce, farmers' income shows no immediate response in the same period. It initially rises in the first period, indicated by a positive value, reaching its peak in the second period. Subsequently, this shock gradually diminishes but remains positive. Nationally, an increase in the application level of information technology in commerce promotes increased income for farmers.

4 EMPIRICAL TESTING IN EASTERN, CENTRAL, AND WESTERN REGIONS

The Stationarity tests results indicate that the eastern region did not pass the LLC test, so first-order differencing was applied. The original data for the western and central regions all passed the stationarity test. Based on the AIC, BIC, and HQIC criteria, the optimal lag order for the eastern and western regions is 1, while for the central region, it is 2.

4.1 Granger Causality Test

Table 4. shows the results of the Granger causality tests conducted separately for the three regions:

Table 4. Granger Causality Test in Eastern, Central, and Western Regions

Null Hypothesis	**Eastern Regions**		**Central Regions**		**Western Regions**	
	P-Value	Conclusion	P-Value	Conclusion	P-Value	Conclusion
h_lnpopu is not a Granger cause of $h\_lnincome$	0.231	Accepted	0.000	Rejected	0.002	Rejected
$h\_lneratio$ is not a Granger cause of $h\_lnincome$	0.115	Accepted	0.002	Rejected	0.100	Rejected
$h\_lnservice$ is not a Granger cause of $h\_lnincome$	0.614	Accepted	0.292	Accepted	0.858	Accepted

h_lnincome is not a Granger cause of *h_lnpopu*	0.530	Accepted	0.001	Rejected	0.006	Rejected
h_lneratio is not a Granger cause of *h_lnpopu*	0.149	Accepted	0.000	Rejected	0.084	Rejected
h_lnservice is not a Granger cause of *h_lnpopu*	0.687	Accepted	0.133	Accepted	0.328	Accepted
h_lnincome is not a Granger cause of *h_lneratio*	0.674	Accepted	0.000	Rejected	0.100	Rejected
h_lnpopu is not a Granger cause of *h_lneratio*	0.791	Accepted	0.524	Accepted	0.031	Rejected
h_lnservice is not a Granger cause of *h_lneratio*	0.523	Accepted	0.005	Rejected	0.551	Accepted
h_lnincome is not a Granger cause of *h_lnservice*	0.230	Accepted	0.223	Accepted	0.070	Rejected
h_lnpopu is not a Granger cause of *h_lnservice*	0.005	Rejected	0.008	Rejected	0.160	Accepted
h_lneratio is not a Granger cause of *h_lnservice*	0.171	Accepted	0.283	Accepted	0.137	Accepted

Eastern Region

Except for *h_lnpopu* having a unidirectional Granger causality relationship with *h_lnservice*, none of the other variables show Granger causality relationships. That may because the information infrastructure development level in the eastern region has already reached a high standard, with no significant increase during this period.

Central Region

(1) There is a bidirectional causality relationship between *h_lnincome* and *h_lneratio*, meaning that an increase in the application level of e-commerce in transactions will promote increased income for farmers, and increased income for farmers will, in turn, affect the application level of e-commerce in transactions.

(2) There is a bidirectional causality relationship between *h_lnpopu* and *h_lnincome*. The proliferation rate of information networks will promote increased income for farmers, and an increase in farmers' income will, in turn, promote the proliferation of information networks.

(3) Regarding internal relationships of informatization levels, there is a unidirectional causality relationship between *h_lneratio* and *h_lnpopu*, *h_lnservice* and *h_lneratio*, *h_lnpopu* and *h_lnservice*.

Western Region

(1) There is a bidirectional causality relationship between *h_lnpopu* and *h_lnincome*. An increase in the proliferation rate of information networks will promote increased income for farmers, and increased income for farmers will, in turn, promote the proliferation of information networks.

(2) There is a bidirectional causality relationship between *h_lnincome* and *h_lneratio*, meaning that an increase in the application level of information technology in industries will promote increased income for farmers, and increased income for farmers will, in turn, affect the application level of information technology in industries.

(3) The increase in farmers' income has a promoting effect on the proliferation coverage of information networks, the development level of the information industry, and the application level of information technology in commerce.

(4) There is a unidirectional causality relationship from h_lnpopu to $h\_lneratio$, and from $h\_lneratio$ to h_lnpopu.

4.2 Impulse Response

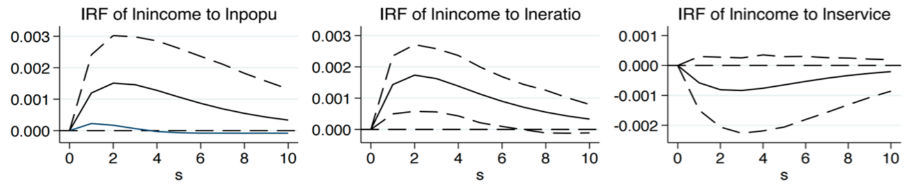

Fig. 2. Eastern Region Impulse Response Graph

The impulse response for the eastern region is depicted in Figure 2. It can be observed that the effects of the three factors on farmers' income are small and fluctuate continuously, which aligns with the results of the Granger causality test.

The impulse response results for the **central region** are shown in Figure 3:

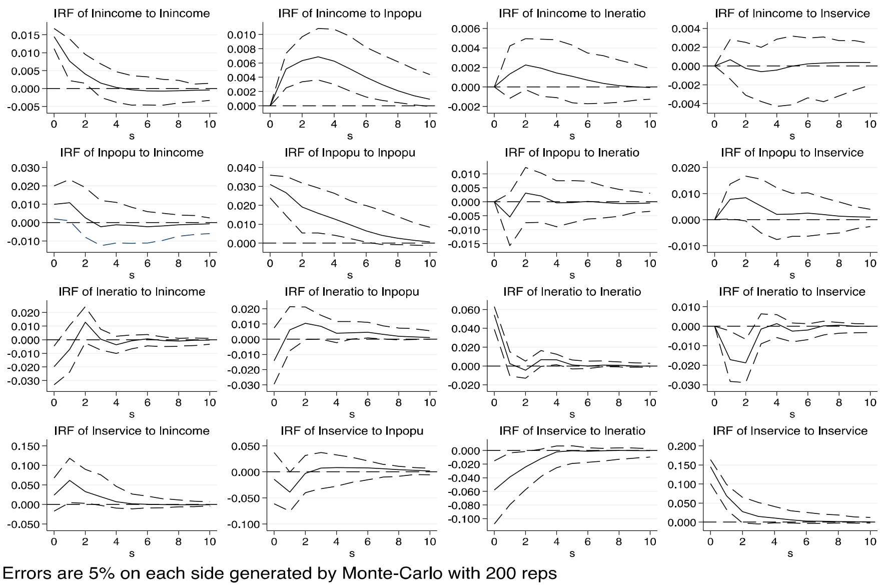

Fig. 3. Central Region Impulse Response Graph

(1) In response to a positive orthogonal shock in the coverage level of information networks, farmers' income is unaffected in the same period. Subsequently, in the first

period, it experiences a positive shock, which strengthens and reaches its peak in the third period before gradually declining and converging towards the $y = 0$ axis. Its values remain positive throughout, indicating a positive promotion effect of the coverage level of information networks on farmers' income.

(2) In response to a positive orthogonal shock in the application level of information technology in industries, farmers' income shows no immediate response in the same period. It begins to rise in the first period, reaching its peak in the second period, then weakens and tends towards 0. Its values remain positive throughout, indicating a positive promotion effect of the application level of information technology in industries on farmers' income.

(3) In response to a positive orthogonal shock in the development level of the information industry, farmers' income is unaffected in the same period. Subsequently, it starts fluctuating around the $y = 0$ axis, becoming negative in the third and fourth periods. This may be due to the rapid development of the information sector leading to a large amount of investment withdrawing from rural areas and entering urban areas. With weak agricultural development, farmers' income decreases.

The impulse response results for the **western region** are shown in Figure 4:

(1) In response to a positive orthogonal shock in the coverage level of information networks, farmers' income is unaffected in the same period. Subsequently, it receives a positive shock in the first period, which continuously strengthens until reaching its peak in the fourth period before declining and converging towards the $y = 0$ axis. Its values remain positive throughout, indicating a positive promotion effect of the coverage level of information networks on farmers' income.

(2) In response to a positive orthogonal shock in the application level of information technology in industries, farmers' income shows no immediate response in the same period. It begins to rise in the first period, reaching its peak in the second period, then weakens and tends towards 0.

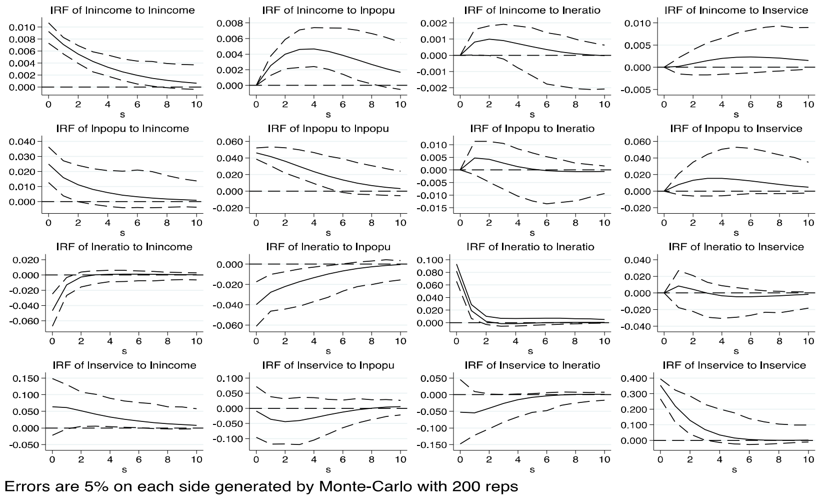

Fig. 4. Western Region Impulse Response Graph

5 CONCLUSION

This study divides informatization into three main elements: the development level of the information industry, the application level of information technology in industries, and the construction level of information infrastructure. Empirical results indicate that, at the current stage of development in China, advancing the process of informatization promotes increased income for farmers. Moreover, there exists a bidirectional Granger causality relationship between the application level of information technology in industries and farmers' income. When separately examining provinces in the eastern, central, and western regions, it is found that the construction level of information infrastructure significantly positively influences farmers' income in the central and western regions. However, when examining nationwide data, the construction level of information infrastructure cannot be confirmed to have a significant impact on farmers' income through Granger causality testing. Empirical testing in the western and central regions suggests that both the construction level of information infrastructure and the application level of information technology in industries can promote increased income for farmers. Moreover, both factors exhibit bidirectional Granger causality relationships with farmers' income, with the increase in the construction level of information infrastructure having a particularly significant impact on increasing farmers' income.

From a national strategic perspective, the government can focus on promoting the application of information technology in industries. For the eastern region, where informatization does not necessarily promote increased income for farmers, measures should be taken to stimulate rural investment. Governments in the central and western regions should focus appropriately on information infrastructure construction.

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