Does digital inclusive finance promote agricultural production for rural households in China? Research based on the Chinese family database (CFD)

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Abstract

Purpose – The development of digital inclusive finance appears to be able to solve the difficulty of traditional finance, which cannot completely cover agriculture and farmers and provides better financial services and products to Chinese farmers. Thus, it improves the farmers' enthusiasm for agricultural production. The purpose of this paper is to clarify whether this goal is indeed being achieved.

Design/methodology/approach – This paper theoretically analyzes the mechanism that influences the effect of digital inclusive finance on rural households' agricultural production decisions and conducts an empirical study based on a sample from the Chinese family database (CFD).

Findings – First, the development of digital financial inclusion in general can encourage rural households to reduce agricultural production. Second, the negative effect of digital inclusive finance on households' agricultural output is realized by widening the gap between the efficiency of non-agricultural economic activities and the efficiency of agricultural production. The wider the gap is, the lower the enthusiasm of households for agricultural production. Third, the mediating effect of "digital financial inclusion – difference in efficiency – agricultural output" has a significant negative effect on households with low agricultural production efficiency, but not households with high agricultural production efficiency. Digital inclusive finance has no significant effect on the difference in efficiency between the two economic activities of high-efficiency households, but a greater difference in efficiency between the two economic activities corresponds to higher enthusiasm of households for agricultural production.

Originality/value – To the best of our knowledge, this paper is the first to analyze the impact of digital financial inclusion on Chinese farmers' agricultural production. The findings of this study can provide policy-related insights to help local governments promote the development of digital finance in China's agricultural economy.

Keywords Digital inclusive finance, Rural families, Agricultural output, Production decision

Paper type Research paper

1. Introduction

Since the 1990s, as the core of information and communication technology (ITC), the internet has flourished, penetrated all aspects of the economy, shaped the economic form of all industries and formed a new digital economy model. As a result, human society has shifted from the processing of "atoms" to the processing of the "bits" (Tapscott, 1994; Negroponte, 1995; Hojeghan and Esfangareh, 2011). Internetization provides a necessary method to overcome the limitations of agricultural production and operation of farmers and improve the level of agricultural production (Pool, 2001; Markelova *et al.*, 2009; Chang and Just, 2009; Wiggins and Llambí, 2010; Poulton and Kydd, 2010). Currently, China's rural Internetization

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process is rapidly progressing; however, its promotion effect on agricultural production remains limited overall [1].

The "self-employed by farmers" method based on the household responsibility system has been the main production organization form of Chinese agriculture. The widening gap in per capita net income between rural and urban households has long been one of the core issues in China's unbalanced economic development, which is accompanied by a large number of young farmers aged 18–45 who continue to migrate from the countryside to seek urban employment [3] (Figure 1). Traditional finance has disadvantages such as insufficient coverage, scarce types of finance, high costs and credit difficulties in rural and agricultural fields. The development of digital inclusive finance is believed to have the ability to compensate for the shortcomings (Mishkin and Strahan, 1999; Berger and Udell, 2006; Manyika *et al.*, 2016; Fu and Huang, 2018). According to the *G20 High-level Principles on Digital Financial Inclusion*, digital inclusive finance generally refers to all activities that promote financial inclusion through the integration of digital technology and financial industry. Digital inclusive finance is rooted in widespread financial exclusion (Demirgü-Kunt and Levine, 2009; Li and Feng, 2020). Digital financial inclusion and digital finance are similar concepts with different focuses [2]. Digitalization has transformed the traditional financial system and spawned new Internet-based financial formats [3]. The emerging new type of finance has strong resource availability, more efficient resource allocation and more convenient payment methods (Mishkin and Strahan, 1999; Manyika *et al.*, 2016; He and Li, 2020). Digital inclusive finance appears to be a method for China to promote agricultural development and narrow the widening urban-rural income gap. However, is this situation accurate?

Currently, research concerning digital inclusive finance remains in its infancy, and scholars have paid much attention to digital finance. Regarding the effect of digital finance on agriculture, scholars have conducted research exploring the agricultural industry chain

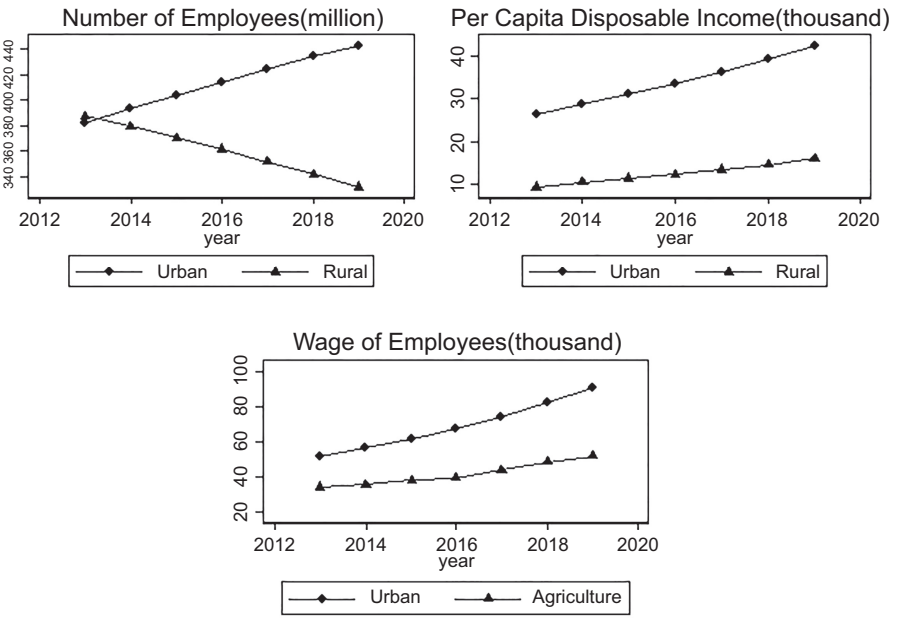

Figure 1.
China's urban and rural employees, income and wages in 2013–2019

Data Source(s): National Bureau of Statistics of China, http://data.stats.gov.cn/

(Berger and Udell, 2006; Wang and Jiang, 2017), new types of agricultural production and operation entities (Jiang and Li, 2015) and P2P online lending (Pierrakis and Collins, 2013; Mollick, 2014; Xu and Lin, 2014); theoretical exploration is performed in conjunction with e-commerce (Wang and Jiang, 2017; Wang and Jiang, 2017). Although problems remain, such as insufficient regulation, digital technology has played a positive role in making finance more "inclusive", which improves farmers' incomes and promotes inclusive economic growth (Grossman and Tarazi, 2014; Song, 2017; Park and Mercado, 2018; Xie *et al.*, 2018; Fu and Huang, 2018; Yi and Zhou, 2018). The research literature on digital inclusive finance mainly focuses on four aspects: theoretical induction of the types and modes of digital inclusive finance (Zhao, 2016; Zheng, 2019); measurement and characteristic analysis of digital inclusive finance (Xu, 2012; Zhang *et al.*, 2017; Jiang *et al.*, 2019; Guo *et al.*, 2019); study of the factors that affect the development of digital inclusive finance (Wu *et al.*, 2018; He and Li, 2020) and analysis of the positive effect of digital inclusive finance on stimulating innovation and entrepreneurship (Zhang *et al.*, 2019; Xie *et al.*, 2018), increasing household consumption (Yi and Zhou, 2018), improving the financial needs of farmers (Fu and Huang, 2018), promoting inclusive growth and narrowing the urban-rural income gap (Song, 2017; Ren and Li, 2019; Li and Feng, 2020).

Although the existing literature has revealed that digital financial inclusion plays a positive role in increasing farmers' income and narrowing the urban-rural gap, a lack of the research literature remains on two issues: First, does digital financial inclusion improve the agricultural output of farmers? Second, how does digital financial inclusion affect the agricultural production decisions of farmers? Thus, this paper studies the mechanism that influences the effect of digital inclusive finance on the agricultural production decisions of rural households from theoretical and empirical perspectives and draws the following conclusions. First, overall, digital financial inclusion can significantly encourage rural households to reduce agricultural production. Second, digital inclusive finance has a great effect on the efficiency of non-agricultural economic activities than on agricultural production. A greater difference between the two economic activities corresponds to lower enthusiasm of farmers for agricultural production. Third, according to their agricultural production efficiency, the rural households were divided into the low agricultural production efficiency group and high agricultural production efficiency group. This mediating effect has a significant impact on the households in the low-efficiency group, but not those in the high-efficiency group. The reason is that digital inclusive finance has no significant effect on the efficiency of the two economic activities in the high-efficiency group.

The structure of this paper is as follows: Section 2 presents the theoretical analysis and analyzes the mechanism that influences the effect of digital inclusive finance on agricultural production decisions from the perspective of agricultural families; Section 3 presents the empirical design; Section 4 presents the empirical research results and analysis and Section 5 presents the conclusion.

2. Theoretical analysis

It is assumed that only one person in a typical farmer household owns one unit of the labor force, and the farmer household distributes the labor force in agricultural and non-agricultural activities to obtain the maximum income. The proportion of labor devoted to agricultural production is ξ, and the proportion of labor devoted to non-agricultural economic activities is η.

Wang *et al.* (2020) believed that the sense of acquisition meant the satisfaction generated by the subject after it had obtained certain benefits, which should be the most important indicator of the impact evaluation of digitalization on the subject of agriculture. Undoubtedly, monetary income is the main source of the sense of acquisition of farmers in participating in the digitization process, and there should be no difference in influence of monetary income

from different sources on the farmers' sense of acquisition. The utility maximization formula of a typical household is as follows [3]:

$$\begin{aligned} &\text{Max}: U = A(\xi) + N(\eta) \\ &s.t. \xi + \eta = 1 \end{aligned} \tag{1}$$

Referring to the existing literature (Baumol, 1967; Matsuyama, 1992; Zhong *et al.*, 2020), this paper does not include capital in the input factors; referring to Yi and Liu (2015), it takes digital inclusive finance and labor as production input factors. It is assumed that the income functions follow the form of the C-D production function as follows:

$$A = a_a \mu^{\sigma} \xi^{\alpha} \tag{2}$$

$$N = a_n \mu^{\upsilon} \eta^{\alpha} \tag{3}$$

where it is assumed that $0 < \alpha < 1$, which subjects A and N to the law of diminishing returns. σ and υ are the influence coefficients of digital financial inclusion on agricultural and non-agricultural economic incomes. a_a and a_n are not nonnegative efficiency factors.

The first-order maximization condition is as follows:

$$\frac{a_n \mu^{\upsilon}}{(1-\xi)^{1-\alpha}} - \frac{a_a \mu^{\sigma}}{\xi^{1-\alpha}} = 0 \tag{4}$$

Thus, the proportion of labor distributed between agricultural production and non-agricultural activities depends on the labor efficiency of the two economic activities.

Based on formula (4), ξ can be obtained as follows:

$$\xi = \frac{1}{1 + \sqrt[1-\alpha]{G(\mu)}} \tag{5}$$

where $G(\mu) = a_n \mu^{\upsilon - \sigma / a_a}$ is the ratio of the efficiency of labor input in different economic activities.

By substituting formula (5) into formula (2), the agricultural output at the time of utility maximization can be obtained as follows:

$$A = \left(\frac{\sqrt[\alpha]{a(\mu)}}{1 + \sqrt[1-\alpha]{G(\mu)}} \right)^{\alpha} = \left(\frac{\sqrt[\alpha]{a_a \mu^{\sigma}}}{1 + \sqrt[1-\alpha]{(a_n / a_a) \mu^{\upsilon - \sigma}}} \right)^{\alpha} \tag{6}$$

Formula (6) shows that the labor efficiency of agricultural activities $a = a_a \mu^{\sigma}$ positively affects the agricultural output of farmer households, the difference between the labor efficiency of non-agricultural activities and the labor efficiency of agricultural activities $G(\mu)$ inversely affects the agricultural output of farmer households. The overall effect of μ on A depends on the effect of μ on the numerator and denominator.

To facilitate the analysis, we assume that $A_1 = \sqrt[\alpha]{a(\mu)} / (1 + \sqrt[1-\alpha]{G(\mu)})$. The elastic coefficients of A and μ can be obtained as follows:

$$e_{A\mu} = \frac{\partial (A_1)^{\alpha}}{\partial \mu} \cdot \frac{\mu}{(A_1)^{\alpha}} = \alpha \cdot \frac{\partial A_1}{\partial \mu} \cdot \frac{\mu}{A_1} = \alpha \left(c - \frac{d}{1 + n^{-1} \mu^{-d}} \right) \tag{7}$$

where $a = a_a^{1/\alpha}$, $n = (a_n / a_a)^{1/(1-\alpha)}$, $c = \sigma / \alpha$, $d = (\upsilon - \sigma)/(1-\alpha)$.

Formula (7) shows that if $\upsilon - \sigma < 0$, since $a > 0$, $n > 0$, $c > 0$ and $d < 0$, μ is positively correlated with $e_{A\mu}$, and households will increase the agricultural economic output.

If $\upsilon - \sigma = 0$, $e_{A\mu} = \alpha[c - d/(1 + n^{-1})]$ can be derived, which shows that μ is not correlated with $e_{A\mu}$, households will maintain their existing agricultural output. If $\upsilon - \sigma > 0$, since $a > 0$, $n > 0$, $c > 0$ and $d > 0$, μ is negatively correlated with $e_{A\mu}$, and households will decrease the agricultural economic output.

For a long time, the average profit margin of China's agricultural production and operation was 2–8% (Meng and Dong, 2019; Li and Feng, 2020), which is far lower than that of non-agricultural economic activities. As a result, farmers, especially the new generation of farmers, are unwilling to engage in agricultural production and operation. However, China has a significant number of wealthy farming households that earn more from agriculture than from agricultural economic activity. According to this economic reality, the following theoretical hypothesis is proposed to be empirically tested:

If the agricultural production efficiency is lower than non-agricultural economic activities, digital financial inclusion will encourage rural households to reduce agricultural production by increasing the difference between the efficiency of non-agricultural economic activities and the efficiency of agricultural production. If the agricultural production efficiency is higher than non-agricultural economic activities, digital financial inclusion will encourage rural households to increase agricultural production by reducing the difference between the efficiency of non-agricultural activities and the efficiency of agricultural production.

3. Empirical design

3.1 Empirical models

According to the theoretical hypothesis to be empirically tested, it is necessary to empirically test whether digital inclusive finance can affect the agricultural production arrangement of farmers by affecting the difference between non-agricultural economic activity efficiency and agricultural production efficiency. Therefore, the following mediating effect test model is established:

$$\mathrm{Lny} = \alpha_1 + c \cdot \mathrm{Efina} + \sum \gamma_i \mathrm{Control}_i + \varepsilon_1 \tag{8}$$

$$\mathrm{Lngap} = \alpha_2 + a \cdot \mathrm{Efina} + \sum \gamma_j \mathrm{Control}_j + \varepsilon_2 \tag{9}$$

$$\mathrm{Lny} = \alpha_3 + c' \cdot \mathrm{Efina} + b \cdot \mathrm{Lngap} + \sum \gamma_\tau \mathrm{Control}_\tau + \varepsilon_3 \tag{10}$$

In this paper, the latest mediating effect test method of Zhao *et al.* (2010) and Sobel statistics (Sobel, 1987) are used as the mediating test index.

3.2 Data and variables

The main data are derived from the "Chinese Family Database" (CFD) of Zhejiang University and "China Household Finance Survey" (CHFS) of the Survey and Research Center for China Household Finance of Southwestern University of Finance and Economics. This database is the most representative sample survey database of rural households in China. The survey data of 2015 and 2017 can cover all variables in this study. Moreover, the survey data of 2015 and 2017 are representative at the provincial and rural region levels. Therefore, this study adopts the survey data of 2015 and 2017 for empirical research [4]. The settings of the specific variables are described in the following section.

3.2.1 Explained and explanatory variables. To control the effect of family farming members, this study adopted the logarithmic value of the average output of the family farming members as the explanatory variable (*Lny*). The total agricultural output of a household is the sum of the output of agriculture, forestry, husbandry and fishing.

Digital financial inclusion (*Efina*) adopts the "Digital Inclusive Financial Index", which was published by the Peking University Institute of Digital Finance and compiled based on

the massive data of the Ant Financial Services Group. The index measures nine areas of digital inclusive finance: coverage, usage depth, payment, insurance, monetary fund, investment, credit, credit investigation and digitization level; this index is the most representative indicator to measure the development degree of digital inclusive finance and online-finance in China and has been widely used by Chinese scholars (Fu and Huang, 2018; Yi and Zhou, 2018; Zhang *et al.*, 2019; Guo *et al.*, 2019). This index is divided into the provincial level, prefecture level, city level and county level. As the data of CFD are representative at the provincial level, the provincial aggregated index is adopted as the explanatory variable.

3.2.2 Mediation and control variables. The agricultural production efficiency index is obtained for per capita agricultural net income by deducting the per capita cost of agricultural operations from the per capita sales income of agricultural products. The income of rural households from various non-agricultural economic activities is highly uncertain.

Due to the effect of administrative system and geographical factors, even in the internet era, China's economy has profound regional and provincial characteristics [5]. In addition, the scholars found that the migration of Chinese population was characterized by distinct intraprovincial migration (Lu and zhou, 2013; Wang and Gao, 2019). The per capita disposable income of urban families can well represent the expected income of agricultural families that participate in non-agricultural economic activities such as working and doing business. Therefore, the per capita disposable income of urban households at the provincial level is used as an indicator of the efficiency of non-agricultural economic activities. The difference in efficiency between the two economic activities (*Lngap*) is measured by the logarithm of the difference between the per capita disposable income of urban residents and the per capita net income of rural households.

Since China abolished the agricultural tax in 2006, the government has increased subsidies for agriculture, boosting farmers' enthusiasm for agricultural production. In the regressions, we control the effect of agricultural subsidies, and the agricultural subsidy variable (*Lnsub*) assumes the logarithm value of the sum of monetary subsidies and the market value of physical subsidies as the indicator.

Family characteristics should also be controlled in the regressions (Duong and Izumida, 2002). The variables related to family characteristics included the age (*Age*), education (*Edu*), marital status (*Marry*) and health status (*Health*) of the household head. The variable of education was set as follows: 0 represents illiteracy, 1 represents primary school education, 2 represents junior high school education, 3 represents high school education, 4 represents vocational high school education, 5 represents junior college education, 6 represents undergraduate education, 7 represents master's education and 8 represents doctor's education; marital status is assigned a value of 1 if the head of the household is married and 0 otherwise; the health status was rated from very poor to very good (from 1 to 5).

3.2.3 Other fixed-effect variables. The production type (*Kind*) includes food crops, cash crops, tree planting and harvesting, livestock and poultry raising, aquaculture and fishing and other types. There are 40 combinations with values from 0 to 39.

To control for regional fixed effects, such as economic development and culture, the regional characteristics variable (*Region*) was assigned values from 1 to 3 according to the traditional division of the eastern, central and western regions.

3.3 Statistical description

3.3.1 Statistical characteristics of the variables. After the data tables were combined and the default value samples were deleted, in total, 12,306 rural households were sampled. The statistical characteristics of each variable are shown in Table 1.

3.3.2 Development of digital financial inclusion. According to the "Digital Inclusive Financial Index", from 2011 to 2018, digital financial inclusion in China rapidly developed

Variable	*N*	Mean	Std. Dev	Min	Max
lny	12,306	8.1261	1.4921	−0.9808	16.1181
Efina	12,306	237.4950	47.1285	145.9300	336.6500
L.Efina	12,306	201.8941	39.4812	118.0100	286.3700
lngap	12,306	3.2938	0.4386	−2.1371	7.1882
lnsub	12,306	3.9049	3.0594	0	12.8992
Age	12,306	54.4764	11.1927	3	91
Edu	12,306	2.5223	0.938	0	8
Health	12,306	2.8397	1.0350	1	5
Marry	12,306	0.6408	0.4798	0	1
Kind	12,306	6.5413	0.4800	0	39
Region	12,306	2.3003	0.7964	1	3

Table 1.
Statistical characteristics of the variables

with an average annual growth rate of 43.88%, but the growth rate showed a decreasing trend each year.

The development of digital financial inclusion in each province of mainland China from 2013 to 2016 is shown in Figure 2. Shanghai, Beijing, Zhejiang, Jiangsu and Fujian are among the top five most developed provinces and generally show a spatial descending sequence of east, central and west with a clustering regional distribution pattern.

Next, the digital finance inclusion index was divided into four numerical intervals with equal values, and the average agricultural output of each group is shown in Table 2. With the development of digital inclusive finance, the difference between the efficiency of non-agricultural economic activities and the efficiency of agricultural production shows an overall trend of expansion, while the agricultural output shows an overall trend of decline.

4. Empirical analysis

4.1 Benchmark test

To prevent potential endogeneity from affecting the regression efficiency, this study adopts the two-stage least square method for the benchmark model estimation, and the instrumental variables adopt the lagging one-phase item of the digital financial inclusion index. The benchmark regression results of all samples are shown in columns (1)–(3) in Table 3 [6].

Column (1) shows that the total effect of digital inclusive finance on agricultural output is significantly negative, which is consistent with the statistical findings for intervals of digital inclusive finance in Table 2. There is a significant negative correlation between the development of digital inclusive finance and farmers' agricultural output. Column (2) shows that there is a significant positive correlation between digital inclusive finance and the difference between the efficiency of non-agricultural economic activities and the efficiency of agricultural production. The development of digital inclusive finance significantly widens the difference between the efficiency of the two economic activities. The development of digital inclusive finance promotes the efficiency of non-agricultural economic activities more than the efficiency of agricultural production. In the regression results in column (3), the coefficient of the difference in efficiency between the two economic activities is significantly negative, which indicates that the expansion of the difference in efficiency significantly encourages farmers to reduce agricultural production. The Sobel statistics were significantly negative, which indicates that digital inclusive finance can encourage farmers to reduce agricultural production activities by widening the difference between the two economic activity efficiencies. However, the coefficient of digital financial inclusion

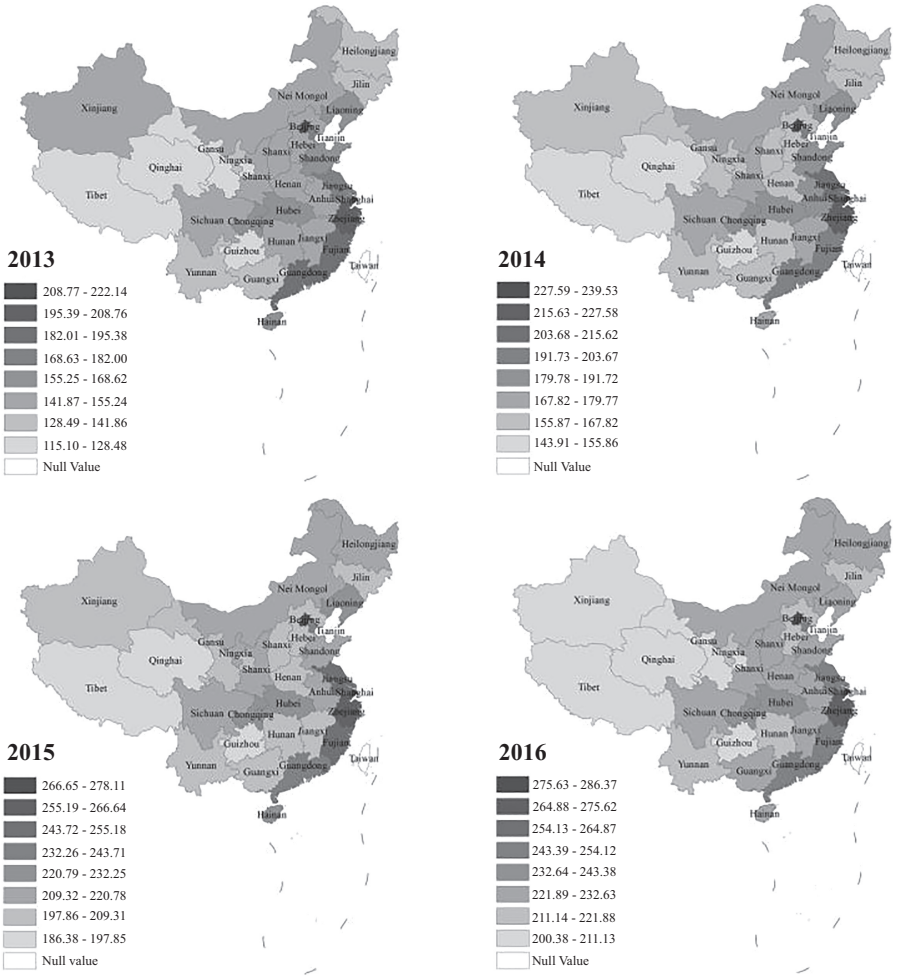

Figure 2.
Development of digital inclusive finance in the provinces of China from 2013 to 2016

Data Source(s): Peking University Institute of Digital Finance

Table 2.
Group description of digital financial inclusion and agricultural output

Efina	Average Lngap	Average lny	*N*
[145, 193)	3.0213	8.2401	3,476
[193, 241)	3.3817	8.1834	707
[241, 289)	3.3588	8.1335	6,587
[289, 337]	3.7076	7.6863	1,103

is no longer significant, which indicates that this mediating effect is a complete mediating effect.

According to the characteristics of the data structure, the data are considered unbalanced short panel data with a one-year gap, and a regression is performed by using the instrumental

Table 3. Total sample regression

	(1) 2SLS *Lny*	(2) 2SLS *Lngap*	(3) 2SLS *Lny*	(4) IV_RE *Lny*	(5) IV_RE *Lngap*	(6) IV_RE *Lny*
Efina	−0.0052*** (0.0014)	0.0092*** (0.0010)	−0.0012 (0.0013)	−0.0057*** (0.0014)	0.0092*** (0.0011)	−0.0015 (0.0013)
Lngap			−0.4355*** (0.0090)			−0.3927*** (0.0098)
Lnsub	0.0952*** (0.0045)	−0.0289*** (0.0044)	0.0826*** (0.0042)	0.0826*** (0.0044)	−0.0289*** (0.0037)	0.0747*** (0.0041)
Age	−0.0111*** (0.0013)	0.0066*** (0.0010)	−0.0082*** (0.0012)	−0.0101*** (0.0013)	0.0066*** (0.0010)	−0.0077*** (0.0012)
Edu	0.1103*** (0.0145)	−0.0811*** (0.0130)	0.0750*** (0.0134)	0.1096*** (0.0149)	−0.0811*** (0.0122)	0.0789*** (0.0140)
Health	−0.1398*** (0.0130)	0.0651*** (0.0104)	−0.1115*** (0.0122)	−0.1291*** (0.0129)	0.0651*** (0.011)	−0.1056*** (0.0121)
Marry	0.0460 (0.0421)	0.1416*** (0.0312)	0.1076*** (0.0398)	0.0519 (0.0388)	0.1416*** (0.0351)	0.1084*** (0.0365)
Kind	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
_Con	5.0979*** (1.9427)	1.0678*** (0.2953)	5.5629*** (2.0238)	5.1166*** (1.0604)	1.0678 (0.8892)	5.4254*** (0.9925)
Sobel		−0.0040*** (0.0005)			−0.0036*** (0.0004)	
N	12,360	12,306	12,306	12,360	12,360	12,360
Wald χ^2/F	49.18***	46.51***	95.48***	2128.06***	2186.19***	4002.20***
R^2	0.1589	0.1488	0.2715	0.1582	0.1488	0.2708

Note(s): *, ** and *** denote the 10%, 5% and 1% statistical significance levels, respectively; the values shown in brackets are the standard errors, and the values in the brackets in the 2SLS regression are the robust standard errors

variable method of the random effect model for comparison. As shown in columns (4)–(6) in Table 3, the regression results of the comparison test are basically consistent with the corresponding regression results of the benchmark test in terms of the coefficient values and significance.

4.2 Grouping test

According to the theoretical analysis section, σ and υ are important influencing factors of agricultural economic efficiency and non-agricultural economic efficiency. The model comes to a different conclusion whether $\upsilon - \sigma < 0$. The empirical study of grouping according to the difference between non-agricultural economic efficiency and agricultural economic efficiency can explain the difference in influence of digital inclusive finance on different income groups. According to whether the per capita net income of agricultural production exceeds the per capita disposable income of urban households, the samples are divided into the low-efficiency group and high-efficiency group. The regression results of the mediation effect test of the two groups are shown in Tables 4 and 5.

According to the regression results of the low-efficiency group, as shown in Table 4, the complete mediating effect by which digital inclusive finance encourages farmers to reduce the agricultural output by increasing the difference in efficiency of the two economic activities is still supported. In contrast to the benchmark regression results, the main effect coefficients in columns (1) and (4) are lower than those in the benchmark regression results. In columns (2) and (5), the regression coefficient of the difference between the efficiency of digital inclusive finance and that of the two economic activities is also lower than that in the benchmark regression results. Moreover, in the regression results in column (3) and column (6), the coefficient symbol of digital inclusive finance changed, and the difference in efficiency of the two economic activities remains significantly negative and greatly improved. This finding indicates that in the low-efficiency group, the effect of digital inclusive finance on the difference in efficiency of the two economic activities is lower than that in the benchmark regression results, but the difference in efficiency of the two economic activities has a greater impact on farmers' agricultural output, which causes a greater mediating effect.

As shown in Table 5, the mediating effect symbol in the high-efficiency group is opposite to the symbol in the low-efficiency group, which is consistent with the theoretical analysis, but the mediating effect does not pass the significance test. As shown in Table 5, the symbol of the mediating effect in the high-efficiency group is opposite to that in the low-efficiency group, which indicates that if the efficiency promoting the effect of digital inclusive finance on agricultural production is greater than the efficiency of non-agricultural economic activities, households increase agricultural production, which is consistent with the theoretical analysis, but the mediating effect does not pass the significance test.

As shown in columns (2) and (5), digital inclusive finance has no significant effect on the difference in efficiency of the two economic activities in the high-efficiency group, while columns (3) and (5) show that the difference in efficiency of the two economic activities has a significant negative impact on the agricultural output of farmers. Thus, when the agricultural production efficiency exceeds the efficiency of non-agricultural economic activities by a great amount, the farmers are more positive about agricultural production.

4.3 Grouping test by year

Next, the samples grouped by years are tested.

The regression results of the samples in 2015 are shown in Table 6. The mediating effect of the low-income group passed the significance test, while the mediating effect of the

Table 4. Regression results of the low-efficiency group

	(1) 2SLE *Lny*	(2) 2SLE *Lngap*	(3) 2SLE *Lny*	(4) IV_RE *Lny*	(5) IV_RE *Lngap*	(6) IV_RE *Lny*
Efina	−0.0043*** (0.0013)	0.0066*** (0.0003)	0.0032** (0.0013)	−0.0045*** (0.0014)	0.0066*** (0.0003)	0.0025* (0.0013)
Lngap			−1.1258*** (0.0627)			−1.0343*** (0.0317)
Lnsub	0.0926*** (0.0044)	−0.0107*** (0.0014)	0.0807*** (0.0045)	0.0807*** (0.0044)	−0.0107*** (0.0012)	0.0730*** (0.0042)
Age	−0.0086*** (0.0013)	0.0003 (0.0003)	−0.0082*** (0.0012)	−0.0078*** (0.0013)	0.0003 (0.0003)	−0.0077*** (0.0012)
Edu	0.0931*** (0.0142)	−0.0278*** (0.0040)	0.0617*** (0.0138)	0.0946*** (0.0149)	−0.0278*** (0.0039)	0.0658*** (0.0142)
Health	−0.1224*** (0.0128)	0.0143*** (0.0033)	−0.1063*** (0.0123)	−0.1134*** (0.0127)	0.0143*** (0.0035)	−0.1017*** (0.0122)
Marry	0.0864*** (0.0415)	0.0199** (0.0101)	0.1088*** (0.0399)	0.0825** (0.0377)	0.1989* (0.011)	0.1089*** (0.0365)
Kind	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
_Con	4.7004*** (1.9664)	2.1260*** (0.1116)	7.0938*** (2.0644)	4.6810*** (1.0402)	2.1261*** (0.2782)	6.846^6*** (0.9925)
Sobel		−0.0075*** (0.0006)			−0.0068*** (0.0004)	
N	11,873	11,873	11,873	11,873	11,873	11,873
F	40.57***	87.55***	69.30***	1788.41***	4114.77***	3,029.53***
R^2	0.13865	0.2583	0.2189	0.1391	0.2583	0.2184

Note(s): *, ** and *** denote the 10%, 5% and 1% statistical significance levels, respectively; the values shown in brackets are the standard errors, and the values shown in brackets in the 2SLS regression are the robust standard errors

Table 5.
Regression results of the high-efficiency group

	(1) 2SLE *Lny*	(2) 2SLE *Lngap*	(3) 2SLE *Lny*	(4) IV_RE *Lny*	(5) IV_RE *Lngap*	(6) IV_RE *Lny*
Efina	0.0031 (0.0055)	−0.0081 (0.0082)	0.0007 (0.0049)	−0.0004 (0.0053)	−0.0084 (0.0087)	−0.0012 (0.0045)
Lngap			−0.2991*** (0.0373)			−0.3092*** (0.0219)
Lnsub	−0.0018 (0.0138)	−0.0264 (0.0211)	−0.0096 (0.0116)	−0.0093 (0.0116)	−0.0245 (0.0201)	−0.1336 (0.0097)
Age	−0.0078* (0.0045)	−0.0056 (0.0073)	−0.0095** (0.0037)	−0.0056 (0.0043)	−0.0064 (0.0072)	−0.0068 (0.0037)
Edu	0.0448(0.0415)	−0.0435 (0.0687)	0.0318 (0.0334)	0.0713 (0.0441)	−0.0542 (0.0741)	0.0491 (0.0372)
Health	−0.0362 (0.0486)	0.0737(0.0734)	−0.0142 (0.0419)	−0.0485 (0.0439)	0.0585 (0.0753)	−0.0439(0.0368)
Marry	−0.1057 (0.1591)	0.4842 (0.3193)	0.0391 (0.0419)	0.1414 (0.1453)	0.2598 (0.2617)	0.0749 (0.1203)
Kind	YES	YES	YES	NO	NO	NO
Region	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
_Con	11.1013*** (1.0001)	−2.0733 (1.5475)	10.4812*** (0.8869)	10.9673*** (1.1001)	2.1261*** (0.2782)	10.3899*** (0.9925)
Sobel		0.0024 (0.0025)			0.0026 (0.0027)	
N	487	487	487	487	487	487
Wald χ^2/F	6.52***	1.95**	13.31***	112.14***	10.41***	353.54***
R^2	0.3290	0.1294	0.5081	0.2141	0.0247	0.4490

Note(s): *, ** and *** denote the 10%, 5% and 1% statistical significance levels, respectively; the values shown are the standard errors, and the values shown in brackets in the 2SLS regression are the robust standard errors

Table 6. Group regression results in 2015

	Low				High	
	(1)	(2)	(3)	(4)	(5)	(6)
	2SLE	2SLE	2SLE	2SLE	2SLE	2SLE
	Lny	*Lngap*	*Lny*	*Lny*	*Lngap*	*Lny*
Efina	−0.0102*** (0.0024)	0.0064*** (0.0010)	−0.0049** (0.0023)	0.0151* (0.0085)	−0.0135 (0.0140)	0.0106* (0.0062)
Lngap			−0.8304*** (0.0708)			−0.3346*** (0.0335)
Lnsub	0.0556*** (0.0088)	−0.0109*** (0.0041)	0.0465*** (0.0084)	−0.0197 (0.0167)	−0.0363 (0.0320)	−0.0318** (0.0130)
Age	−0.0045* (0.0025)	−0.0007 (0.0009)	−0.0050** (0.0023)	−0.0178** (0.0071)	0.0120 (0.0114)	−0.0138** (0.0059)
Edu	0.0786*** (0.0301)	−0.0375*** (0.0110)	0.0474* (0.0276)	0.0215 (0.0635)	0.1379 (0.1206)	0.0676 (0.0467)
Health	−0.1097*** (0.0239)	0.0081 (0.0088)	−0.1029*** (0.0220)	0.0224 (0.0620)	0.1152 (0.1063)	0.0610 (0.0488)
Marry	0.0586 (0.0786)	0.0679*** (0.0205)	0.1150 (0.0737)	−0.1634 (0.2230)	0.7811** (0.3440)	0.0980 (0.2033)
Kind	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
_Con	8.5343*** (0.5256)	2.4132*** (0.2050)	10.5382*** (0.5383)	9.4608*** (1.5947)	−2.8744 (2.6781)	8.3538*** (1.2260)
Sobel		−0.0053*** (0.0009)			0.0045 (0.0047)	
N	4016	4016	4016	390	390	390
F	19.42***	14.04***	39.02***	3.70***	2.93***	12.12***
R^2	0.1292	0.0957	0.2425	0.2352	0.1924	0.5137

Note(s): *, ** and *** denote the 10%, 5% and 1% statistical significance levels, respectively; the values shown in brackets are the standard errors, and the values shown in brackets in the 2SLS regression are the robust standard errors

high-efficiency group did not pass the test. In contrast to the regression results of all samples, although the coefficient of digital inclusive finance in column (3) was reduced, it was still significantly negative, which indicates that the mediating effect of the low-efficiency group was only a part of the effect and can only explain 52% of the total effect. In the high-efficiency group, the total effect of digital inclusive finance on agricultural output is positive, but does not affect the efficiency difference between the two economic activities. Thus, digital inclusive finance may directly or indirectly affect the agricultural output through other intermediary factors.

In the grouping regression results of the 2017 samples in Table 7, the negative mediating effect of the low-efficiency group is significant, while the mediating effect of the high-efficiency group remains insignificant. The total effect of digital inclusive finance on farmers' agricultural output was significantly negative, which indicates that over time, the negative effect of digital inclusive finance on the high-efficiency group began to appear. The coefficient of the efficiency difference between the two economic activities remains significantly negative, which indicates that when the agricultural production efficiency of farmers exceeds the efficiency of non-agricultural economic activities by a larger amount, the farmers are more active in agricultural production, which is consistent with the above total sample regression results and regression results of the high-efficiency group in 2015.

4.4 Robustness test and research limitations

Since the sample is representative at the provincial level, the robustness test examines whether the mediating effect at the provincial level remains significant. The regression results of the mean values of all variables in the low-efficiency group calculated by provincial stratified sampling weights are shown in Table 8, and the mediation effect is still supported.

In summary, the analysis of each regression result shows that digital financial inclusion encourages farmers to reduce agricultural production by increasing the efficiency difference between non-agricultural economic activities and agricultural production when the efficiency of agricultural production is lower than that of non-agricultural economic activities. However, the theoretical hypothesis is not supported in the high agricultural production efficiency group.

Since there is no relevant survey of digital finance in the database, the provincial index is adopted, and the robustness test shows that the conclusions remain valid for the provincial average index of households. However, the possibility remains that provincial indicators may mask substantial differential effects of both income differences and digital service provision at the household level. The solution to this problem depends on the improvement of the survey in the future and development of effective regression methods to evaluate the macro indicators and micro individual indicators.

The grouping study in this paper and the robustness test on the average index of households at the provincial level alleviated the severity of this problem. The application of IV regression methods largely avoided the effect of potential endogeneity on the research conclusion. Moreover, the findings of this paper can well explain China's economic operation reality, including the continuous expansion of the urban-rural income gap and continuous migration of the rural labor force to cities, from the perspective of digital financial development (as shown in Figure 1). Therefore, in terms of the overall effect at the provincial level, the relevant research conclusions on the impact of digital inclusive finance on the agricultural production decisions of farmers have considerable credibility.

Table 7. Group regression results in 2017

	Low			High		
	(1)	(2)	(3)	(4)	(5)	(6)
	2SLE	2SLE	2SLE	2SLE	2SLE	2SLE
	Lny	*Lngap*	*Lny*	*Lny*	*Lngap*	*Lny*
Efina	−0.0109*** (0.0028)	0.0050*** (0.0005)	−0.0019 (0.0028)	−0.0234** (0.0105)	0.0156 (0.0164)	−0.0191** (0.0084)
Lngap			−1.8147*** (0.1430)			−0.2743*** (0.0494)
Lnsub	0.1076*** (0.0075)	−0.0113*** (0.0016)	0.0871*** (0.0072)	0.0427 (0.0369)	−0.0437 (0.0652)	0.0307 (0.0301)
Age	−0.0040* (0.0022)	0.0006** (0.0003)	−0.0028 (0.0021)	−0.0152 (0.0092)	−0.0257 (0.0221)	−0.0222** (0.0087)
Edu	0.0784*** (0.0244)	−0.1690*** (0.0043)	0.0478** (0.0232)	−0.0110 (0.0535)	−0.1547 (0.1743)	−0.0534 (0.0533)
Health	−0.1133*** (0.0225)	0.0119*** (0.0036)	−0.0917*** (0.0215)	−0.2080 (0.1378)	0.2615 (0.3233)	−0.1363 (0.1228)
Marry	0.0592 (0.0738)	−0.0187* (0.0101)	0.0253 (0.0696)	−0.6526 (0.3056)	0.7316 (0.9313)	−0.4519 (0.2866)
Kind	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
_Con	3.8568*** (0.8722)	2.1667*** (0.1401)	7.7886*** (0.8992)	18.8742*** (3.0071)	−5.822 (4.7453)	17.4185*** (2.7207)
Sobel		−0.0090*** (0.0011)			−0.0042 (−0.0046)	
N	7,857	7,857	7,857	97	97	97
F	28.29***	38.62***	52.73***	5.27***	2.20***	9.85***
R^2	0.1433	0.1894	0.2373	0.6060	0.3949	0.7543

Note(s): *, ** and *** denote the 10%, 5% and 1% statistical significance levels, respectively; the values shown in brackets are the standard errors, and the values shown in brackets in the 2SLS regression are the robust standard errors

Table 8.
Robustness test

	(1) OLS *Lny*	(2) OLS *Lngap*	(3) OLS *Lny*	(4) 2SLS *Lny*	(5) 2SLS *Lngap*	(6) 2SLS *Lny*
Efina	−0.2431 (0.0178)	0.0080** (0.0032)	−0.0096 (0.0142)	−0.0178 (0.0195)	0.0069** (0.0033)	−0.0044 (0.0157)
Lngap			−1.8432*** (0.6188)			−1.9342*** (0.6229)
Age	0.1128 (0.0910)	0.0152 (0.0189)	0.1409* (0.0718)	0.0927 (0.0961)	0.0184 (0.0195)	0.1284* (0.0759)
Edu	1.1091 (0.6943)	−0.2558 (0.1707)	0.6377 (0.6227)	1.0817 (0.6957)	−0.2514 (0.1718)	0.5954 (0.6622)
Health	−0.1518 (0.7403)	0.2885** (0.1329)	0.3799 (0.8037)	−0.2563 (0.7368)	0.3051** (0.1343)	0.3337 (0.8064)
Marry	−3.0939 (2.6468)	0.5252 (0.7445)	−2.1260 (2.3361)	−3.0258 (2.6789)	0.5143 (0.7413)	−2.0310 (2.3619)
Region	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
_Con	0.7086 (3.3580)	0.1648 (1.0017)	1.0123 (2.8940)	0.8143 (3.3171)	0.1480 (1.0179)	1.1006 (2.8182)
Sobel		−0.0147* (0.0077)			−0.0134* (0.0078)	
N	57	57	57	57	57	57
F	4.46***	14.21***	7.15***	4.38***	14.15***	7.26***
R^2	0.4596	0.7040	0.5681	0.4562	0.7032	0.5662

Note(s): *, ** and *** denote the 10%, 5% and 1% statistical significance levels, respectively; the values shown in brackets are the robust standard errors

5. Conclusion

Since the beginning of the new century, ICT has flourished in China in forming new information and communication industries and shaping the economic outlook of traditional industries. With the application of digital technology in the financial field, the rural population, which is scarcely covered by traditional finance, can also enjoy more and better financial services and products. For a long time, Chinese agriculture had generally lower profit than other industries, and many rural people left the countryside and migrated to cities to participate in secondary and tertiary industries, which is a major feature of China's rapid economic growth during this period. In this context, digital financial inclusion appears to have become a new tool to promote the development of agricultural economy and narrow the widening income gap between urban and rural areas.

This paper uses rural families as the research object theoretically analyzes the mechanism that influences the effect of digital inclusive finance on agricultural production decisions of households, empirically tests the theoretical hypotheses by using the "chinese family database" and draws the following conclusions. First, in general, the development of digital financial inclusion increases the willingness of farmers to reduce agricultural production. Second, digital inclusive finance has a greater effect on the efficiency of non-agricultural economic activities than on agricultural production. A greater difference between the two economic activities corresponds to less enthusiasm of farmers for agricultural production. Third, according to the agricultural production efficiency, the rural households were divided into the low agricultural production efficiency group and high agricultural production efficiency group. The mediating effect had a significant impact on the households in the low-efficiency group, but not those in the high-efficiency group. The reason is that digital inclusive finance has no significant effect on the efficiency of the two economic activities in the high-efficiency group. In addition, the difference in efficiency of the two economic activities has a significant negative impact on the agricultural output of high-efficiency farmers, which indicates that when the agricultural production efficiency increasingly exceeds the efficiency of non-agricultural economic activities, farmers are more active in agricultural production. In summary, the development of digital financial inclusion has not narrowed the long-standing urban-rural family income gap in China; in contrast, digital inclusive finance has increased this gap for the rural households with low agricultural production.

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Declarations: This paper is the authors' original paper, which has never been published in any form. The authors declare that they have no competing interests.

Availability of data and material: The main data used to support the findings of this study are derived from the "Chinese Family Database" (CFD) of Zhejiang University and the "China Household Finance Survey" (CHFS) of the Survey and Research Center for China Household Finance of Southwestern University of Finance and Economics. The digital financial inclusion index adopts the "Digital Inclusive Financial Index", which was published by the Peking University Institute of Digital Finance.

The metrology software used is Stata 13. The do-files can be supplied, readers can repeat the research on the VPN platform at "Chinese Family Database" (CFD) of Zhejiang University.

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Notes

1. According to the 2017 China rural Internet application report published by Shanghai University of Finance and Economics, the 2017 rural Internet development research report published by China Internet Network Information Center (CNNIC) and the 2017 China rural Internet finance development report published by a think tank.
2. Chinese scholars use digital finance to refer to Internet finance and online finance in English literature. Digital finance tends to emphasize its "digital" features, while digital inclusive finance emphasizes the features of financial inclusion brought by digital technology.
3. The utility function is generally set to the form $U = [A(\xi) + N(\eta)]^{\tau}$, $0 < \tau < 1$ of diminishing utility. However, $[A(\xi) + N(\eta)]^{\tau}$ and $A(\xi) + N(\eta)$ have identical maximization conditions. To simplify the model, the utility function adopts the linear form.
4. Regarding agricultural output and agricultural production costs, the questionnaire used in 2013 greatly differed from the questionnaire in 2015 and 2017 and lacked the provincial stratified sampling weight required in this study. Therefore, the survey data from 2013 were discarded in this study.
5. According to a report by Economic Daily on March 28, "'Online vassal Economy' is the enemy of anti-counterfeiting".
6. As the instrumental variables are the lagging terms of digital financial inclusion, the coefficients of the instrumental variables in the first-stage regressions are highly significant in each regression model; thus, we do not report the first-stage regression results in the regression table.

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