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Can Digital Finance Promote Rice Production? Evidence from Sichuan Province, China

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Abstract: The rapid development of digital finance has effectively reduced financial challenges in rural regions and created new prospects for agricultural production. This article examines the impact of digital financial development on rice production in Sichuan Province using the 2011–2021 Peking University Digital Financial Inclusion Index and data from 20 prefecture-level cities, as well as a fixed effects model. The mechanism of action is also discussed. The findings reveal that the advancement of digital finance plays an important role in boosting the expansion of rice production, and that digital finance influences rice output by increasing farmers' willingness to participate in insurance and increasing the availability of credit. A heterogeneity analysis reveals that digital finance has a substantial effect on mountainous and economically poor areas. As a result, this article suggests that the breadth and depth of usage of rural digital finance, as well as the development of rural digital financial services in underdeveloped areas, should be expanded.

Keywords: digital finance; agricultural output; mechanism of action

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1. Introduction

Food security is a crucial issue affecting the Chinese national economy and people's livelihoods, and it serves as the foundation for national stability and progress. The National Bureau of Statistics reported that China produced 1390.82 billion kilograms of grain overall in 2023, up 1.3% or 17.76 billion kilograms from the previous year. The annual grain output has reached a record peak, with more than 1.3 trillion kilograms being produced for nine consecutive years. Such production has not only achieved basic food self-sufficiency through related efforts but also significantly enhanced food security. Sichuan is the most populous and agriculturally productive province of China. It has been renowned as the "land of abundance" since antiquity [1,2].

According to People's Daily, General Secretary Xi Jinping emphasized the need to seriously adhere to the red line of arable land during his visit to Sichuan in June 2022 [3], protecting this valuable area for grain production, tightening grain output, and constructing a higher-level "Tianfu Granary" in the new age. Data from the Sichuan Provincial Statistical Yearbook show that in 2022, the total output of rice, corn, soybeans, and other large spring grain crops in Sichuan Province was 29.601 million tons, accounting for more than 80% of the total annual grain output. Among them, rice is the most important crop in the spring grain harvest in Sichuan Province, with an annual rice planting area of 28 million mu and a rice output of 14.623 million tons, accounting for about 40% of the total grain output. The harvest has a crucial impact on the overall grain production for the entire year. Thus, ensuring the production and quality of rice plants is of utmost importance.

The emergence of digital finance, propelled by advancing technologies, has become a significant catalyst for China's economic expansion in the era of digitalization. Digital finance is an innovative business model that combines cloud technologies such as the internet and big data with traditional banking. It offers a new approach to boost food production and guarantee food security. Traditional rural finance has many problems,

and it is difficult to provide financial services that match agricultural production. Digital finance can effectively lower the threshold of financial services in rural areas through mobile internet, big data, cloud technology, and other methods [4]. With its strong penetration, this approach is conducive to overcoming the bottleneck of traditional financial services for rural development and stimulating the "long tail effect", which is highly important for meeting the demand for food production funds. At the same time, digital technology can also provide digital and intelligent services for food production, provide chemical support, and promote grain production efficiency [5]. Current research on digital finance in agriculture mainly focuses on the impact of digital finance on the level of agricultural mechanization, its relationship with the agricultural industrial structure, and the integrated development of agriculture, rural areas, and farmers [6,7]. In addition, digital finance can also improve farmers' access to credit, promote farmers' entrepreneurship, and reduce the income gap among residents [8,9]. Research on the impact of digital finance on food production has revealed that the development of digital finance can improve the resilience of China's food system, thereby providing opportunities to improve China's food security [10]. Some scholars have also proposed that the development of digital finance will be beneficial for activating the competitive factor market, improving the level of agricultural resource allocation, and promoting the high-quality development of agriculture in China's main grain-producing areas [11]. The literature shows that digital finance has a positive effect on agricultural development and ensuring food security [5,12]. However, there is scant literature on the impact of digital finance on food production. Research on the mechanisms through which digital finance affects food production is even rarer. Therefore, based on the digital financial inclusion index compiled by Peking University and the statistical yearbook database of prefecture-level cities in Sichuan Province, this paper uses a double fixed effects model to empirically study the impact of digital finance on rice production in Sichuan Province and explores the mechanism of action. First, based on the panel data of 20 prefecture-level cities in Sichuan Province from 2011 to 2021, the impact of digital finance on rice production in Sichuan Province is analyzed. Second, this article demonstrates the specific path through which digital finance affects rice production from the perspective of expanding the credit scale and farmers' participation in insurance. Finally, the total sample is further divided into plain areas, mountainous areas, economically developed areas, and economically underdeveloped areas to demonstrate the regional heterogeneity of digital finance, to study the impact of digital finance on rice production in Sichuan Province, and to provide a basis for formulating digital finance differentiation, for which developmental policies provide support.

2. Literature Review and Research Hypotheses

2.1. Literature Review

Digital finance has developed vigorously in recent years, and many studies have been conducted on the connotation and measurement of digital finance and the relationship between digital finance and economic growth. The measurement of digital finance mainly includes the comprehensive index method and the core indicator method. The composite index method typically uses survey data, underlying transaction data, or text mining data to construct a composite index. The core indicator method uses core indicators such as online loan amounts and third-party payments to measure the development level of digital finance [13]. Existing studies have shown that digital finance promotes economic growth, mainly by promoting innovation and entrepreneurship, providing capital support, and improving allocation efficiency [14,15]. The development of digital finance driven by internet technology makes borrowing and lending more convenient, significantly reduces the borrowing constraints of the innovative entrepreneurial group, and promotes regional entrepreneurship. Therefore, it has the transmission mechanism of "digital financial development—technological innovation and regional entrepreneurship—economic growth". At the same time, digital finance can also rely on the powerful data collection, processing, and sharing capabilities of the big data platform to quickly match the supply and

demand sides in the transaction process, reduce the transaction costs due to information asymmetry, improve the allocation efficiency of resources, and promote economic growth. In addition, the development of digital finance can also promote residents' consumption, increase the demand for formal consumer credit in rural areas, and increase the income of rural households; this impact has heterogeneity and threshold effects [8,16,17]. In terms of agricultural development, digital financial development can promote the substitution of capital factors for labor factors in agricultural production [18] and improve not only agricultural mechanization by promoting both the development of the agricultural machinery operation service market and investment in agricultural fixed assets [19] but also agricultural production efficiency. In addition, digital finance can not only ease rural credit constraints and improve financial availability [20] but also relax information constraints on farmers with regard to starting businesses and engaging in nonagricultural employment, thereby promoting the transfer of agricultural labor to nonagricultural sectors. In turn, the progress of the nonagricultural sector provides agricultural production with conveniences in terms of energy, power, machinery, equipment, fertilizers, and seeds [21].

Research on grain production has focused mainly on identifying its influencing factors, such as factor inputs [22], climatic conditions [23], and government support for agricultural policies [24]. Research on finance's promotion of grain production has focused mainly on the relationship between fiscal and financial support for agricultural policies and grain production. It is believed that fiscal and financial support for agriculture can effectively alleviate rural credit constraints and reduce the cost of agricultural factor inputs, which in turn will help farmers expand the scale of grain planting and promote increased grain production [25]. In addition, some scholars have paid attention to the impact and path of county-level financial agglomeration on farmers' income [26]. China's agricultural development is highly concentrated in the county. County financial agglomeration promotes regional economic growth. Economic growth produces the main positive effect of promoting improvements in the levels of income of the residents, so the county financial agglomeration directly allows the farmers to increase their income. In addition, agricultural mechanization can indirectly increase the farmers' income. However, there are currently no studies focusing on the impact of digital finance on food production. However, some research has shown that there is an important relationship between digital finance and agricultural production factor inputs. Since digital finance has inclusive value in agricultural production, the greater the level of digital finance development there is, the more likely it is that traditional farming methods will shift to semi-mechanized and mechanized methods. Digital finance can also expand the scale of cultivation by facilitating the transfer of farmland by large growers, ultimately increasing output and production value. The development of digital finance can effectively alleviate the financing constraints faced by large planting households with the intention of expanding their scale of operation and satisfy their capital needs for productive investment, thus promoting their transfer to farmland [27]. The study proves that the transferring households have realized large-scale operation through the transfer of farmland, which has a significant effect in improving the efficiency of resource allocation and increasing food production [28].

2.2. Research Hypothesis

Agriculture, unlike other industries, is greatly affected by climate; thus, climate change has exacerbated the vulnerability of agricultural production [29]. Farmers have problems with inaccurate and untimely access to agricultural information during the agricultural production process, which leads to crop yield reductions due to natural disasters or losses due to market fluctuations [30]. Information asymmetry theory points out that a party with relatively poor information is more likely to be at a disadvantage. Digital finance relies on advanced technologies such as the internet and big data to effectively alleviate information asymmetry and promote information dissemination and sharing [31]. On the other hand, digital financial platforms can provide farmers with climate-related information more conveniently and extensively and expand information acquisition channels through

data flow and information flow [32]. Farmers can use digital financial platforms to obtain accurate and timely information; better understand information such as climate forecasts, market dynamics, and planting technologies; and rationally plan planting and management strategies based on local conditions to avoid climate risks and ensure the production of rice and other grains. On the other hand, the use of digital finance effectively reduces the cost of information searches [33]. Digital finance can overcome the barriers of time and space, achieve a high efficiency and low cost through data integration and disintermediation, satisfy farmers' demand for climate information, and mitigate the moral hazard and adverse selection problems caused by information asymmetry [32]. Additionally, digital finance can improve the accessibility of borrowing to farmers in both traditional lending and private lending to ensure that farmers with financial needs receive capital when they change their production behavior by adopting climate adaptive behaviors to cope with climate change [34]. Meanwhile the adoption of adaptive measures by farmers has a significant positive impact on food production, with higher food production by farmers who take measures compared to those who do not have adaptive behaviors [35]. At the same time, the development of digital finance can help guide the flow of digital industries and social capital to rural areas, thereby promoting the substitution of capital for labor in the agricultural production process [18] and enabling various rural economic organizations to achieve digitalization and intelligent chemical production. The introduction of agricultural remote sensing equipment, irrigation facilities, and other machinery has compensated for the shortage of agricultural labor and promoted agricultural production efficiency [5]. The above-mentioned information leads to the following hypothesis:

Hypothesis 1. *Digital financial development helps increase rice production.*

The problem of difficult and expensive financing has always existed in the "three rural areas". On the one hand, the urban–rural dual structure has led to the structural mismatch of financial resources between urban and rural areas. Subsequently, the financial needs of rural areas cannot be effectively met [36], and the financial constraints have affected the normal production activities of rural residents. On the other hand, funds in the rural financial market are mostly invested in agribusinesses, agricultural cooperatives, etc., and ordinary small farmers still face financing difficulties [37]. In particular, farmers engaged in agricultural production lack collateral and credit information compared to non-agricultural farmers. Agriculture is affected by natural, geographical, and other uncertainties, which increases the credit cost and credit risk of financial institutions [38], making the financial constraints faced by farmers engaged in agricultural production even more severe. Digital finance has powerful functions and is widely used. Various electronic information technologies, such as the internet, big data, and cloud computing, can be used to reduce the entry threshold of financial services and the total cost of financial transactions, improving the coverage and service efficiency of financial services [39],which can effectively overcome the high cost of financing and information asymmetry in rural areas and alleviate the problems of difficult and expensive financing in the agricultural sector. It has become an important driving force to improve people's livelihoods and promote agricultural development [32]. First, digital finance can provide financial services at a lower cost. Digital financial institutions need only to invest a large amount of money in system construction, product research and development, etc., in the initial stage. After such investment is officially put into use, the marginal cost is low, and the coverage can overcome the limitations of time and space [40]. Second, with the help of digital finance, especially digital payments, financial institutions can integrate a large amount of fragmented and unstructured network user information to provide credit support and improve credit availability for rural residents who lack mortgages and guarantees [41]. Finally, digital finance can expand rural funding sources. There is a large supply and demand gap in the rural credit market. Online lending in digital finance relies on digital technology to match the supply and demand of borrowers and lenders, improve the

efficiency of fund use, and increase rural funding sources [42]. By meeting the financing needs of rural residents, digital finance enables rural residents to introduce advanced agricultural production technologies [43], purchase large-scale agricultural machinery and equipment [19], and ultimately expand the scale of agricultural production and increase rice production output [44]. The abovementioned information leads to the following hypothesis:

Hypothesis 2. *Digital finance increases rice production by expanding the credit scale.*

Agricultural insurance transfers agricultural risks and improves the effectiveness of farmers' grain planting, thereby enhancing farmers' confidence in agricultural production, motivating farmers to expand planting areas and increasing food production. It plays an important role in ensuring agricultural production and national food security [45]. The digital finance that has emerged in recent years has used modern information technologies such as the internet to improve the financial availability of rural residents and provide opportunities for the development of agricultural insurance [46]. First, due to the rapid development of digital finance, farmers can access relevant knowledge related to risk management through the mobile internet, which helps them to correctly understand the functions of agricultural insurance, improve their financial literacy, and enhance their willingness to participate in insurance. At the same time, digital technology can overcome the time and space limitations of farmers purchasing agricultural insurance, change the way in which farmers participate in agricultural insurance, and improve the convenience of farmers participating in insurance [47]. Second, digital finance based on digital technologies such as cloud computing and big data can effectively alleviate the information asymmetry between the supply and demand sides of agricultural insurance [48]. With the development of digital finance, insurance companies can collect information on policyholders through big data and artificial intelligence technologies. On the one hand, they can accurately profile policyholders, capture the needs of farmers in a timely manner, and innovatively develop personalized agricultural products that better meet the needs of farmers' insurance products [46]. On the other hand, the development of digital finance has improved both the pricing ability of agricultural insurance and the problem of adverse selection [49]. It can also provide massive amounts of data for the risk control management of insured persons and improve the service quality of the risk management of insurance institutions [50]. At the same time, combined with satellite images, disaster areas can be quickly identified, thereby reducing assessment costs and improving claim settlement efficiency. The abovementioned information leads to the following hypothesis:

Hypothesis 3. *Digital finance increases rice production by increasing farmers' willingness to participate in insurance.*

On the one hand, according to Metcalfe's Law, the value of a network is proportional to the square of the number of internet users. Therefore, the greater the number of users who use the network, the greater the utility each user obtains, and the more the "value added" continues to grow exponentially [51]. As the degree of digitalization in our country continues to increase and user stickiness continues to increase, the average cost and marginal cost of digital finance built on mobile phones and the internet will gradually decrease due to the increase in network users. The benefits generated and brought about by digital finance will continue to increase. With exponential growth, the law of diminishing returns in the traditional economy has changed. On the other hand, although the inclusive nature of digital finance can give underdeveloped areas a "late-mover advantage" and catch up with developed areas at a faster pace, there is still an imbalance in the development of digital finance in China. Digital finance is based on the internet and big data, blockchain, and other technologies; thus, it will first be produced and applied to economically developed large cities [52]. With the development of digital finance, the coverage breadth, depth of use, and digital degree of digital finance will expand in underdeveloped areas. Only when there is a significant improvement among disadvantaged groups will the role of digital finance in

promoting economic development be significantly improved [53]. Therefore, when digital finance develops to a certain level, its impact on regional economic development will reach an inflection point. In the agricultural field, when the network foundation in rural areas becomes increasingly complete and the digital information technology accessibility of underdeveloped groups continues to increase, the cost of digital financial services will continue to decrease, financial coverage will be effectively expanded, and long-tail groups will have greater access to financial services. This process will continue to improve and promote the diversification of funding sources for agricultural production, thereby ensuring food production and promoting an increase in food output [54]. The abovementioned information leads to the following hypothesis:

Hypothesis 4. *There is a threshold effect on the impact of digital financial development on rice yield.*

Digital finance is an emerging form of finance formed by integrating modern technology into traditional finance, and under the coat of big data, cloud computing, and other digital technologies, the essence of its realization of capital financing has not changed. At the same time, compared with traditional finance, digital finance, based on its own characteristics, has unique types of risk, including information technology risk, "long-tail risk" and fraud risk [55]. Therefore, preventing digital financial risks and strengthening financial regulation is an inevitable choice to achieve financial stability [56]. The intensity and direction of financial supervision may affect the development direction of digital finance and play a key role in the healthy development of digital finance [57]. Financial supervision mainly affects the development of digital finance and the increase in rice production in two ways. On the one hand, insufficient financial supervision may lead to vicious competition between traditional financial institutions and digital financial institutions, which will lead to the disorderly expansion of digital finance, resulting in data privacy security risks, technical operational risks, consumer rights risks, etc. [58], ultimately through risk contagion and spillover effects. Thus, systemic financial risks are increased, and the role of digital finance in promoting food production is weakened [59]. On the other hand, appropriate financial regulatory measures such as cracking down on and punishing illegal activities and deepening the application of internet technology will help relevant financial institutions to efficiently and accurately identify and resolve systemic financial risks and prevent some companies from exploiting the low threshold of digital finance to conduct illegal activities. Financial arbitrage encourages financial business innovation [60], protects not only healthy competition but also the inclusive development of digital finance, and improves the ability to explore new paths when the food system faces risks. The abovementioned information leads to the following hypothesis:

Hypothesis 5. *Financial regulation has a positive regulatory effect on the process of increasing rice yields empowered by digital finance.*

3. Empirical Design

3.1. Sample Selection and Data Sources

This article selects panel data from 20 prefecture-level cities in Sichuan Province from 2011 to 2021 (as the Aba Prefecture rice planting data are missing, the Aba Prefecture data are excluded), for a total of 220 samples, to study and analyze the impact of digital finance on rice production in Sichuan Province. The data as shown in Table 1 mainly include two parts, namely, rice production-related data and digital financial data. Sichuan Province digital finance general index in 2011, 2013, 2015, 2017, 2019, and 2021. As shown in Figure 1, the development of regional digital finance can be clearly seen. Among them, digital finance-related data (including a comprehensive index and three sub-indicators, namely, breadth of coverage, depth of use, and degree of financial digitization) come from the Peking University Digital Financial Inclusion Index. Rice production and related statistical data come from the "Sichuan Statistical Yearbook (2011–2021)", the "Sichuan

Rural Yearbook (2011–2020)", and prefecture-level city statistical yearbooks; a small portion comes from prefecture-level city statistical bulletins. The data are collected and organized. Interpolation is used to supplement a small amount of missing data.

Table 1. Digital financial index of 21 prefecture-level cities in Sichuan Province from 2011 to 2021.

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Chengdu	80.20	122.82	161.17	173.19	205.30	225.06	253.89	266.77	281.09	292.20	316.69
Zigong	49.94	89.93	124.10	139.50	167.16	185.71	212.31	221.01	231.98	243.18	273.04
Panzhihua	52.63	76.86	113.84	153.14	172.42	193.48	217.55	225.88	235.21	245.38	273.58
Luzhou	46.31	78.76	116.70	135.98	158.78	182.82	207.27	215.94	225.84	238.42	265.84
Deyang	56.70	95.91	127.81	147.37	171.69	196.99	221.87	226.56	240.27	248.40	272.89
Mianyang	58.66	95.46	135.89	148.50	174.21	190.97	226.76	232.48	242.83	252.85	280.98
Guangyuan	40.68	83.95	111.84	130.43	156.34	181.91	203.88	210.94	222.93	232.50	261.48
Suining	40.37	78.29	112.34	126.38	156.25	182.56	205.82	214.18	223.19	233.14	264.69
Neijiang	43.11	79.63	117.25	125.21	156.69	178.81	204.56	214.42	223.62	235.26	226.99
Leshan	51.97	92.04	128.28	138.15	170.10	191.20	216.02	225.54	236.03	246.43	234.47
Nanchong	41.19	82.29	117.35	134.74	157.63	182.47	207.78	215.24	225.04	236.10	271.24
Meishan	42.09	87.22	115.49	133.95	164.06	185.75	211.23	221.31	232.52	244.01	269.78
Yibin	49.03	85.81	119.48	132.85	161.30	181.23	210.00	218.66	229.14	241.20	270.40
Guang'an	42.46	78.76	111.53	126.76	157.61	183.04	204.75	212.38	224.05	234.32	265.63
Dazhou	35.08	71.48	105.28	122.16	151.32	175.81	198.32	206.48	217.88	229.79	257.83
Ya'an	43.68	87.24	126.21	135.30	162.82	184.79	209.93	213.84	223.82	236.95	264.17
Bazhong	25.77	69.57	100.74	116.74	145.97	171.04	195.33	201.35	211.35	222.67	256.60
Ziyang	45.44	79.02	112.92	129.34	156.38	184.25	212.00	221.02	221.20	229.38	256.97
Aba	37.13	76.69	100.43	133.04	154.13	181.67	210.85	206.86	214.61	226.69	254.47
Ganzi	33.65	78.04	108.77	119.52	148.32	174.64	199.64	209.21	214.61	223.47	251.98
Liangshan	24.37	65.89	107.69	135.77	148.00	171.61	195.99	202.63	210.41	221.61	249.31

3.2. Model Construction

To analyze the impact of digital financial development on rice yield, this paper selects rice yield as the explained variable, uses the corresponding development level of digital finance as the explanatory variable, and uses the amount of agricultural fertilizer applied, crop sowing area, etc., as control variables to construct the following panel regression model:

$$outp_{it} = \alpha_0 + \alpha_1 df_{it} + \alpha_2 X + \lambda_i + \eta_t + \varepsilon_{it} \quad (1)$$

where $outp_{it}$ represents the rice production level of region i in year t; df_{it} is the digital finance index of region i in year t, which is subdivided into three types, namely the coverage breadth, depth of use, and digitalization degree of digital finance; X is the set of control variables; λ_i represents the individual fixed effect; η_t is the time fixed effect; and ε_{it} is the random disturbance term.

$$M_i = \alpha_0 + \alpha_1 df_{it} + \alpha_2 X + \lambda_i + \eta_t + \varepsilon_{it} \quad (2)$$

where M_i is the mediating variable.

In addition to the fixed effects model and the intermediary effect model that test the direct and indirect transmission mechanisms, respectively, the possible nonlinear dynamic effects of digital finance on economic growth should also be considered. This article uses the threshold model to test this, with the following settings:

$$outp_{it} = \beta_0 + \beta_1 df_{it} \times I(cd \le d) + \beta_2 df_{it} \times I(cd > d) + \beta_3 X + \lambda_i + \eta_t + \varepsilon_{it} \quad (3)$$

where d is the threshold value of the credit scale, cd is the level of the credit scale, and $I()$ is the indicator function. This value depends on whether the credit size level meets the threshold conditions in the brackets. If so, the value assigned is 1; otherwise, the value assigned is 0.

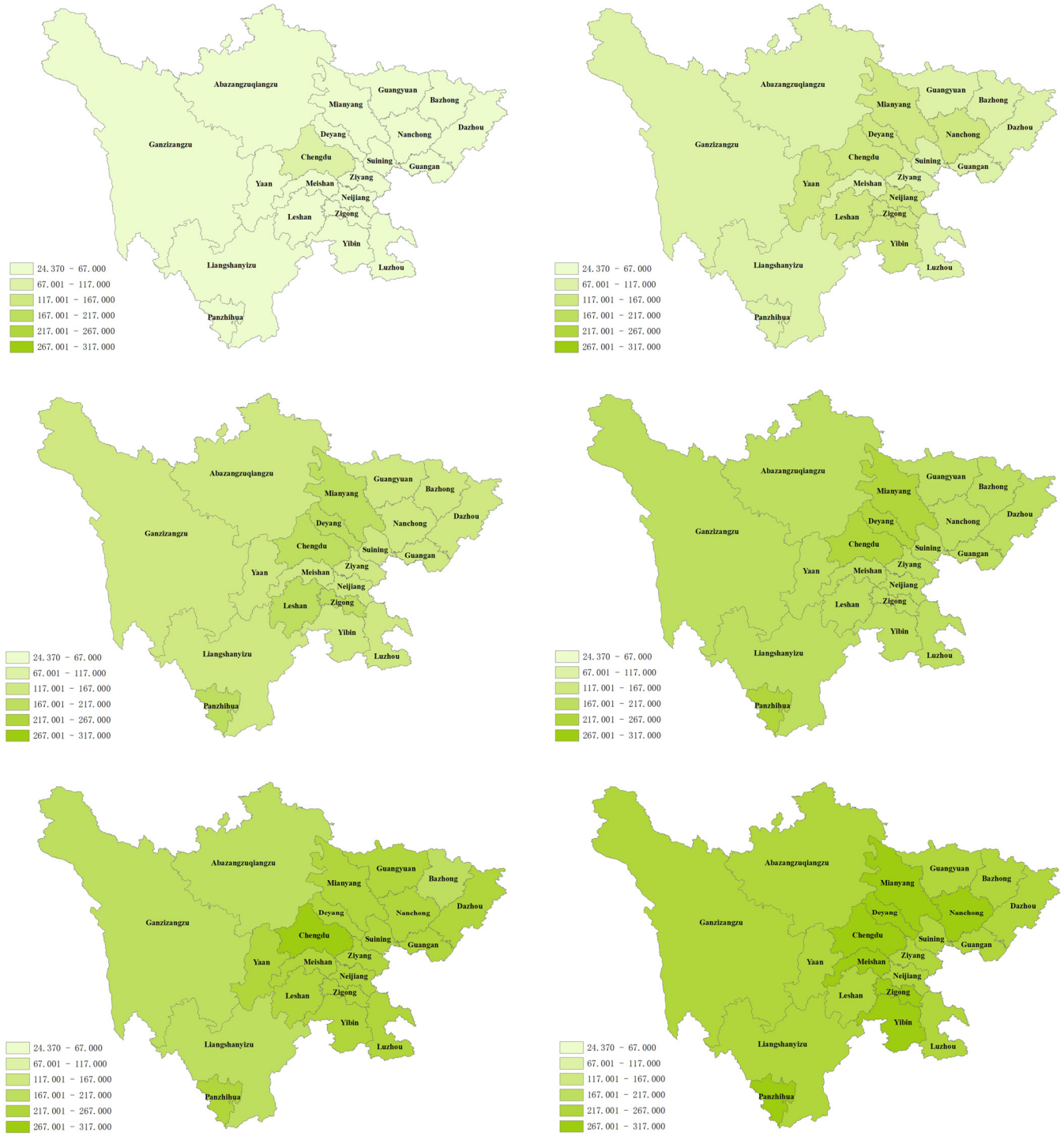

Figure 1. Sichuan Province digital finance general index in 2011, 2013, 2015, 2017, 2019, and 2021.

To test how the development of digital finance affects rice yield levels against the background of financial supervision, this paper uses financial supervision as a moderating variable based on Model (1) and introduces the interaction term between financial supervision and digital financial development. Its coefficient expresses the impact of financial supervision on rice yields. The impact of digital financial development on residents' consumption upgrades is as follows:

$$outp_{it} = \alpha_0 + \alpha_1 df_{it} + \alpha_2 df_{it} \times sup + \alpha_3 sup + \alpha_4 X + \lambda_i + \eta_t + \varepsilon_{it} \quad (4)$$

where *sup* represents financial supervision, and the other symbols have the same meanings as those described above.

3.3. Variable Definition

1. Explained variable ($lnoutput$): rice output. The annual total rice output of prefecture-level cities (autonomous prefectures) in Sichuan Province is selected and taken in logarithmic form as the explained variable to study the impact of digital finance on rice output in Sichuan Province.

2. Explanatory variables: digital finance (df). This article selects the Peking University Digital Finance Index as the explanatory variable. Specifically, a comprehensive index is selected to reflect the overall development level of digital finance. The digital financial index can be divided into three sub-indicators. ① Digital financial coverage breadth (de_bre) refers to the proportion of users with third-party payment accounts bound to bank cards and the account coverage rate. Digital finance is based on the internet model. The internet is not restricted by geography. The number of electronic accounts reflects the extent to which users receive digital financial services. In addition, according to China's regulations, only third-party accounts bound to bank cards can truly cover users. Otherwise, if they are not bound, they will only have the function of small-amount transfers, and the corresponding values will be limited. ② Digital financial usage depth (df_dep) refers to the actual usage of digital financial services. The types of financial services included credit, payment, monetary funds, insurance, and other services. The usage of digital finance covers the actual number of users (the number of people using the corresponding service per 10,000 users) and the level of activity (the number and amount of transactions per capita). ③ The degree of financial digitalization (df_deg) reflects the convenience and efficiency of digital finance in a region. The main reasons why users use digital financial services include their low cost, convenience, credit, etc., which also reflect the low-threshold and low-cost advantages of digital finance. The lower the cost of digital financial services (for example, the lower interest rates on consumer loans and small and microenterprise loans), the more convenient they are (for example, the number of mobile payment accounts for a high proportion of the total number of payments), and the greater the degree of credit is (for example, the number of deposit-free payment accounts for a high proportion of the total number), which can better reflect the value of digital finance. Referring to the method of Guo Feng [39], to facilitate inspection and analysis, the original data are divided by 100 for quantification.

3. Intermediary variables: credit scale (*cd*) and farmers' willingness to participate in insurance (*prem*). Credit support can help farmers solve financial difficulties, provide necessary funds for grain production activities, and promote the scale and standardization of grain production through the use of agricultural loans from financial institutions. By transferring agricultural risks, agricultural insurance can enhance farmers' confidence in agricultural production, encourage farmers to expand planting areas, and thereby increase grain production. This is represented by agricultural insurance premium income.

4. Adjusting variable: the fiscal and financial supervision expenditure data of prefecture-level cities are used to measure the logarithm of the level of financial supervision (*sup*). Referring to the research of Wu Yue et al. [54], these data usually cover the implementation of laws and regulations, financial development planning, and the prevention of financial risks and can more comprehensively reflect the development level of local financial supervision.

5. Control variables: to control the impact of related factors on agricultural output levels as much as possible, this article sets the following control variables based on the relevant literature. Crop sown area (*lnarea*): the crop sown area reflects the actual sown area of crops and should be positively correlated with rice yield levels. Effective irrigation area (*lnirri*): the proper irrigation of crops is beneficial to the growth of crops and increases crop yields. Agricultural chemical fertilizer application amount (*lnfer*): in the agricultural production process, chemical fertilizers can eliminate the damage caused by pests and diseases to crops and increase rice output. Rural electricity consumption (*lnelec*): the increase in electricity consumption can, to a certain extent, reflect the increase in the power

of rural machinery and equipment and the corresponding progress at the technical level. Agricultural machinery power (*lnmach*): agricultural mechanization helps farmers achieve large-scale development, improves farmers' production efficiency, and promotes food production. The logarithm not only does not change the nature or correlation of the data but also prevents the influence of extreme outliers and mitigates heterogeneity. Therefore, according to the relevant literature, logarithmic processing is performed on variables other than numerical financial data to maintain data smoothness. The descriptive statistical results of each variable are shown in Table 2.

Table 2. Descriptive statistics.

Variables	Obs	Mean	Std. Dev.	Min	Max
lnoutput	220	3.913	1.442	−2.168	5.478
df	220	172.018	67.729	24.370	316.693
df_bre	220	157.688	67.560	9.450	328.187
df_dep	220	173.255	67.048	25.440	295.966
df_deg	220	217.095	80.470	18.020	316.423
lnarea	220	6.013	0.677	4.236	6.852
lnirri	220	4.782	0.595	2.980	5.919
lnfer	220	2.232	0.929	−1.273	3.182
lnelec	220	1.932	0.747	−0.094	3.638
lnmach	220	5.262	0.441	4.107	6.037

4. Empirical Results Analysis

4.1. Analysis of Benchmark Results

This paper uses a fixed effects model to regress Model (1) to test the impact of digital finance on agricultural output levels. The results are shown in Table 3. Column (1) in the table shows the overall effect of digital finance on rice yield. For every unit increase in digital finance, the level of agricultural output increases by 0.406 units. Thus, digital finance can significantly increase rice yields, and Hypothesis 1 is verified. Columns 2–4 verify the impact of the three sub-indicators of digital finance on rice production. The results show that the coefficient of the impact of digitalization on agricultural output is 0.155, which is significant at the 1% level. That is, for every 1% increase in digitalization, rice production will increase by 15,500 tons. The degree of digitalization has an impact on agricultural rice output. There are significant positive impacts. In addition, the impact coefficient of utilization depth on agricultural output is 0.242, which is significant at the 5% level. That is, for every 1% increase in the depth of digital financial use, rice production will increase by 24,200 tons. However, the positive effects of the breadth of digital financial coverage on rice yield did not pass the significance test. This outcome shows that digital finance mainly promotes an increase in rice production through the degree of digitalization and the depth of use. This may be because deepening digitalization can facilitate transaction methods, improve payment efficiency, help more farmers obtain financial services, and promote agricultural production. In-depth improvements in use can help reduce the threshold and risks of obtaining financial resources, providing farmers with more opportunities to obtain financial resources. The funds provide more choices and ease the constraints of credit funds for agricultural production, thus promoting food production. Although digital finance has the characteristic of wide coverage, since digital finance relies on the development of digital technology, it is difficult for digital finance methods to cover remote areas with poor information infrastructure quickly. Therefore, although the breadth of coverage can increase rice production, the effect is not obvious.

Table 3. Baseline regression results.

	(1)	(2)	(3)	(4)
Variables	**lnoutput**	**lnoutput**	**lnoutput**	**lnoutput**
df	0.406 **			
	(0.163)			
df_bre		0.085		
		(0.117)		
df_dep			0.242 *	
			(0.138)	
				0.155 ***
				(0.0564)
lnarea	0.521 ***	0.519 ***	0.550 ***	0.490 ***
	(0.112)	(0.113)	(0.114)	(0.112)
lnirri	−0.701 ***	−0.688 ***	−0.734 ***	−0.692 ***
	(0.0991)	(0.101)	(0.103)	(0.0987)
lnfer	0.121	0.133	0.113	0.114
	(0.129)	(0.131)	(0.131)	(0.129)
lnelec	0.182 **	0.173 **	0.190 ***	0.209 ***
	(0.0715)	(0.0730)	(0.0723)	(0.0720)
lnmach	0.526 ***	0.502 ***	0.483 ***	0.501 ***
	(0.116)	(0.118)	(0.116)	(0.114)
Constant	0.692	0.905	0.931	1.037
	(0.725)	(0.740)	(0.721)	(0.711)
Observations	220	220	220	220
Number of city	20	20	20	20
R-squared	0.454	0.437	0.444	0.458
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, standard errors in parentheses.

Regarding the control variables, the crop sown area, rural electricity consumption, and total power of agricultural machinery can significantly increase rice yields, and all the results pass the 5% significance test. Thus, improving grain production efficiency and expanding crop sowing areas are two important ways to ensure China's grain output. When it is difficult to increase grain yield per unit area, expanding the crop sowing area can effectively increase grain output. The development of agricultural machinery can effectively replace agricultural labor, improve food production efficiency, and promote increased food production. The irrigated area of cultivated land has a significant negative effect on grain production. The reason may be that water resources are an important strategic resource for ensuring food security. While proper irrigation is a necessary condition to ensure stable grain production, too much or too little irrigation will affect the growth of crops, which will result in the loss of food production. The impact of chemical fertilizer application on grain production is not significant. The main reason is that the impact of chemical fertilizer input on grain production has entered the stage of diminishing marginal returns, and its impact is no longer significant.

4.2. Robustness Check

To ensure the reliability of the benchmark regression results, this article uses four methods to conduct robustness testing, namely lagging one period in digital finance, replacing the explained variable, changing the research sample, and adjusting the sample interval. First, considering the time lag of digital finance's effects on grain output and the reverse causality between the two, the digital finance index is replaced by a digital finance index lagged by one period. The regression results are shown in Column (2) of Table 4, which are consistent with the benchmark. Thus, the regression conclusions remain consistent. Second, to replace the explained variable, this paper divides the annual rice production by the number of agricultural employees; that is, the per capita rice production, and it

performs a robustness test after taking the logarithm. The results are shown in Column (2) of Table 4. The regression coefficient of digital finance is significantly positive. Third, excluding the central city, considering that Chengdu is the provincial capital of Sichuan Province, and due to the particularity of factors such as political status and resources, it is quite different from other prefecture-level cities in Sichuan Province, resulting in biased regression results. The samples from Chengdu city are excluded. The regression results show that the significance level and sign of the core variables are not significantly different from those mentioned above, which verifies the rationality and robustness of the empirical results of this article. Fourth, the sample interval is adjusted. Considering that the industry generally regarded the opening of Yu'ebao in 2013 as the first year of China's digital financial development, and referring to the relevant practices of Zhuang Xudong et al. [61], this article eliminates the sample data of the previous two years and sets the sample subrange to 2013. The sample is re-estimated after 2021. The regression results in Column 4 of Table 4 show that the estimated coefficient of digital finance is significantly positive at the 5% level, indicating that after adjusting the sample, digital finance still has a significant positive effect on rice production.

Table 4. Robustness check.

	(1)	(2)	(3)	(4)
Variables	**lnoutput**	**lnper_output**	**lnoutput**	**lnoutput**
df	0.478 **	0.382 *	0.409 **	0.405 **
	(0.238)	(0.213)	(0.176)	(0.167)
lnarea	0.579 ***	0.426 ***	0.523 ***	0.577 ***
	(0.113)	(0.145)	(0.116)	(0.117)
lnirri	−0.866 ***	−0.924 ***	−0.714 ***	−0.871 ***
	(0.106)	(0.129)	(0.104)	(0.112)
lnfer	0.279 **	−0.101	0.0972	0.331 **
	(0.133)	(0.168)	(0.144)	(0.143)
lnelec	0.189 **	0.425 ***	0.182 **	0.150 *
	(0.0748)	(0.0932)	(0.0746)	(0.0814)
lnmach	0.466 ***	0.547 ***	0.527 ***	0.464 ***
	(0.116)	(0.151)	(0.119)	(0.125)
Constant	0.956	−2.192 **	0.757	0.678
	(0.737)	(0.945)	(0.745)	(0.833)
Observations	200	220	209	180
Number of cities	20	20	19	20
R-squared	0.500	0.445	0.457	0.495
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, standard errors in parentheses.

4.3. Endogeneity Test

Digital finance will increase grain production. At the same time, an increase in grain production will increase farmers' income, which may increase farmers' expenditures on digital networks and encourage farmers to further seek digital financial services, thereby promoting the development of digital finance. Therefore, there is a reverse causality problem. This article uses lagged digital financial indicators for one period as the explained variable, which alleviates the endogeneity problem of reverse causality to a certain extent. However, the above-mentioned benchmark regression may still have other omitted variable biases. For example, local governments have implemented certain policies to support agriculture. These policies may be related to digital finance, which will affect the estimated results. To address other possible estimation biases, this paper uses the instrumental variable method to further verify the impact of the digital financial index on rice yield. Research shows that although the main form of digital finance is online, its development is still affected by geographical factors, and the farther away from Hangzhou, China, the birthplace of the financial technology company Alipay, the more difficult it is to

promote [62]. Distance will affect economic behavior but will not change with economic development [63]. Secondly, the distance between prefecture-level cities and Hangzhou is directly related to the level of digital financial development in the city and will not affect the financial needs of local residents, which meets the requirements of setting instrumental variables [16]. Therefore, this paper draws on the method of Zhang Xun et al. [17] and adopts methods for each region. The distance between the first-level city and Hangzhou is used as an instrumental variable for regression. Since the digital financial index changes with the year and the distance is a constant, this paper interacts the geographical distance with the year to obtain a new time-varying instrumental variable. The results are shown in Column (1) of Table 5. The first stage shows that the estimated coefficients of the instrumental variables and the corresponding explanatory variables are significant and negative, indicating that the greater the distance from Hangzhou, the lower the level of digital financial development. According to the results of the Cragg–Donald Wald F statistic and the Lagrange multiplier (LM) statistic, the selection of the instrumental variable passes the weak instrumental variable test and the nonidentifiable test, suggesting that the selected instrumental variable is reasonable and effective. The second-stage regression results in Column (2) show that the estimated coefficient of digital finance is still significant, demonstrating that after controlling for endogeneity issues, digital finance can still promote an increase in rice production, further confirming Hypothesis 1.

Table 5. Endogeneity test.

	(1)	(2)
Variables	**First Stage**	**Second Stage**
df		0.6434 ***
		(3.46)
dist_hangzhou	−0.0021 ***	
	(−5.53)	
lnarea	−1.2401 ***	0.8227 ***
	(−6.73)	(4.06)
lnirri	1.0045 ***	−0.6172 ***
	(4.60)	(−2.69)
lnfer	−0.4465 ***	1.3521 ***
	(−4.96)	(15.35)
lnelec	0.2463 **	0.3085 ***
	(2.27)	(2.58)
lnmach	0.7537 ***	−0.7956 ***
	(4.70)	(−4.00)
Constant	4.1528 ***	1.3832 **
	(4.21)	(2.10)
Anderson canon. corr. LM statistic	27.628 ***	
Cragg–Donald Wald F statistic	30.590	
Stock–Yogo weak ID test critical values (10%)	16.38	
Observations	220	220
R-squared		0.844

*** $p < 0.01$, ** $p < 0.05$, *t*-statistics in parentheses.

4.4. Threshold Effect Analysis

To test the nonlinear relationship between digital financial development and rice yield in Model (3), we first repeatedly sample 300 times based on the bootstrap method. The results show that the impact of digital finance on rice yield is affected by the developmental stage of the credit scale. Credit scale can dynamically strengthen the effects of digital finance on promoting rice yield, which also once again verifies the rationality of choosing credit scale as an intermediary variable. The specific results are shown in Table 6 and Figure 2.

Table 6. Threshold effect test results.

Explained Variable	Threshold Variable	Threshold	Prob	Bootstrap	Threshold Estimator		
					1	2	3
df	*cd*	Single	0.0833	300	3045.7400		
		Double	0.0667	300	3045.7400		1295.9600
		Triple	0.4300	300	3045.7400	2006.7800	1295.9600

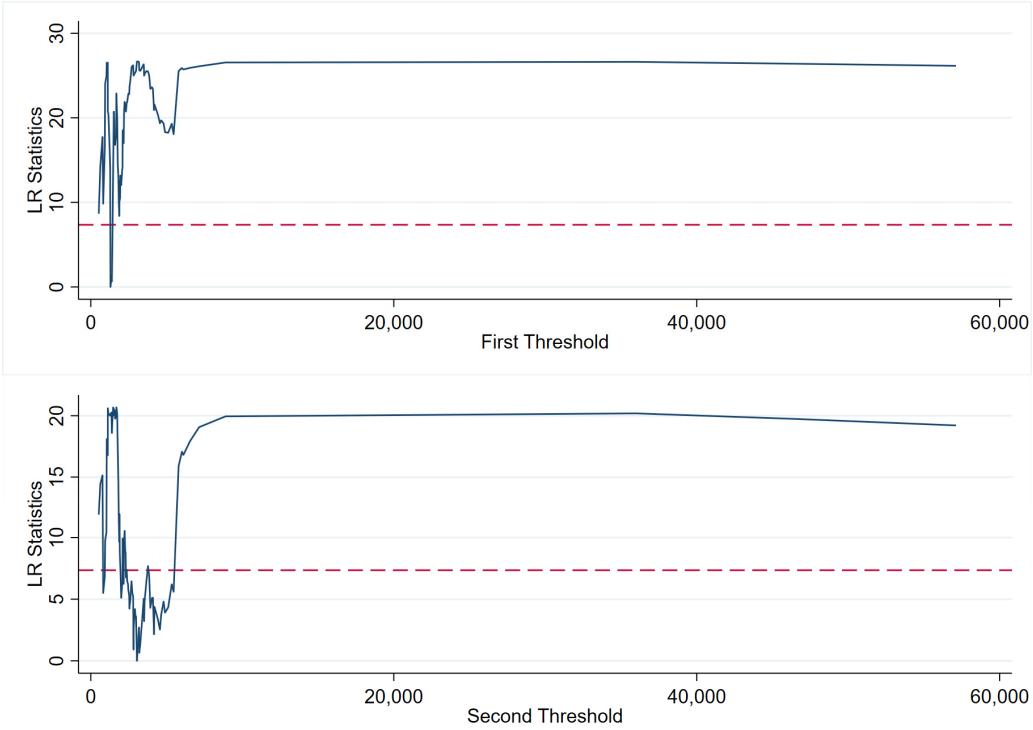

Figure 2. Threshold estimation results diagram.

The above results show that when the credit scale is used as the threshold variable, the single threshold effect and the double threshold effect pass the 10% significance test, rejecting the original hypothesis. However, the *p* value of the triple threshold effect is 0.4300, indicating that there is no triple threshold effect. This shows that digital finance has a nonlinear relationship with rice yield. Therefore, this article uses a double threshold model to test the threshold effect of digital finance and rice yield. After passing the threshold effect test, the single-threshold and double-threshold estimates are estimated and tested. Table 7 shows the threshold value of the impact of digital finance on rice yield and its 95% confidence interval. The threshold values are 1295.9600 and 3045.7400, respectively.

Table 7 shows that there are two thresholds for the impact of digital finance on rice yield. When cd $\leq$ 1295.9600, digital finance has a weak negative effect on rice yield. When 1295.9600 < cd $\leq$ 3045.7400, the influence coefficient of digital finance increases significantly and passes the 1% significance test. The credit scale increases, and the impact of digital finance on rice production also increases. When the credit scale crosses the threshold at the value of 3045.7400, the regression coefficient of the core explanatory variable on the explanatory variable increases significantly, showing that the impact of digital finance on rice production has nonlinear characteristics. Furthermore, the contribution of digital finance to rice production further increases, suggesting that as the credit scale continues to expand in the future, the contribution of digital finance to rice production will gradually increase. The impact of digital finance on rice production has the nonlinear characteristic

of increasing marginal benefits. The greater the level of digital finance, the greater the promotion effect on rice production, which further confirms Hypothesis 1.

Table 7. Threshold effect test regression results.

	(1)
Variables	**lnoutput**
lnarea	0.5730 ***
	(3.38)
lnirri	−0.5960 ***
	(−3.79)
lnfer	0.2192 *
	(1.96)
lnelec	0.1049
	(0.91)
lnmach	0.3023 *
	(2.04)
Df (cd ≤ 1295.9600)	−0.2624 **
	(−2.51)
Df (1295.9600 < cd ≤ 3045.7400)	−0.1017 ***
	(−2.95)
Df (cd > 3045.7400)	−0.0519 *
	(−1.92)
Constant	1.1951
	(1.13)
Observations	220
Number of cities	20
R-squared	0.525

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, standard errors in parentheses.

4.5. Analysis of the Mechanisms of Action

To explore the impact mechanism through which digital finance increases rice production, according to Model (2), we analyze the "digital finance → expanding credit scale → increasing rice production" and "digital finance → increasing farmers' willingness to participate in insurance → alleviating income and increasing rice production" flows. The two intermediary mechanisms are empirically tested as shown in Table 8. The estimated coefficient of digital finance on credit scale is significantly positive at the 1% level; that is, when the level of digital finance changes by 1 unit, the credit scale will expand by 25,009 units, indicating that digital finance can expand the credit scale. Digital finance, due to its convenient services, strong real-time monitoring capabilities, instant lending or collection, small information asymmetry, and fast review speed, is conducive to credit institutions reducing credit risks [64] and issuing more loans. Digital financial institutions adjust the number of digital financial products and services based on the actual situation of farmers by assessing production conditions and social credit, providing farmers with more loan channels, effectively alleviating farmers' credit constraints, helping rural residents resolve financial difficulties in a timely manner, and enabling them to have more financial resources to invest in rice production and increase rice yields.

Similarly, the results in Column (2) show that digital finance has a significant positive impact on farmers' willingness to participate in insurance. First, in the context of promoting the development of digital finance, farmers can more easily access risk management education through mobile internet, improve their own risk management awareness, and increase their willingness to participate in insurance [47]. Second, the popularization of digital technology enables farmers to break through the time and space limitations of purchasing insurance and improve the convenience of participating in insurance. Third, digital financial services based on digital technologies such as big data and cloud computing can effectively alleviate the information asymmetry between the supply and demand sides of agricultural insurance [48,65], improve the service quality of risk management of

insurance institutions, and make agricultural insurance more sustainable and effective. At the same time, farmers with agricultural insurance protection are more likely to increase their investment in agricultural technology and improve productivity. Therefore, digital finance can promote an increase in rice production by increasing farmers' willingness to participate in insurance; thus, Hypotheses 2 and 3 are verified.

Table 8. Mechanism of action test results.

	(1)	(2)
Variables	**cd**	**Prem**
df	25,009 ***	327.5 ***
	(55.60)	(63.54)
lnarea	3097	91.29 **
	(3799)	(43.41)
lnirri	−10,126 ***	−74.18 *
	(3375)	(38.57)
lnfer	23,311 ***	211.4 ***
	(4397)	(50.24)
lnelec	−6987 ***	−32.14
	(2434)	(27.81)
lnmach	3461	1.909
	(3933)	(44.94)
Constant	−38,549	−700.1 **
	(24,686)	(282.1)
Observations	220	220
Number of cities	20	20
R-squared	0.379	0.481
City FE	YES	YES
Year FE	YES	YES

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, standard errors in parentheses.

4.6. Test of the Moderation Effect

To verify the moderating effect of financial supervision intensity, this paper uses Equation (4) to perform a regression on the entire sample. The regression still uses the fixed effects model. The results are shown in Table 9. In Table 9, the intensity of financial regulation is not significant. The reason may be that an increase in financial supervision intensity not only promotes rural financial institutions to strengthen risk management and control but also weakens the technological spillover of digital finance to rural financial institutions. The interaction between the two effects makes the direct impact of financial supervision intensity on rice production nonsignificant. The coefficient of the interaction term between financial supervision and digital finance is significantly positive. According to Shen Yu's [66] judgment on regulating the interaction term, financial supervision positively regulates the positive relationship between digital finance and rice yield. The greater the level of financial supervision, the stronger the positive effects of digital finance in promoting rice production.

Table 9. Moderating effect test results.

	(1)
Variables	**lnoutput**
df	−0.0774 *
	(0.0445)
df × *lnsup*	0.0381 *
	(0.0209)
lnsup	0.00807
	(0.0168)

Table 9. *Cont.*

	(1)
Variables	**lnoutput**
lnarea	0.466 **
	(0.200)
lnirri	−0.677 **
	(0.263)
lnfer	0.214
	(0.129)
lnelec	0.192
	(0.141)
lnmach	0.388 **
	(0.184)
Constant	1.522
	(1.445)
Observations	220
Number of cities	20
R-squared	0.437

** $p < 0.05$, * $p < 0.1$, standard errors in parentheses.

4.7. Heterogeneity Analysis

4.7.1. Regional Heterogeneity

Due to the complex topography of Sichuan Province, the development status and resource endowments of each city are different, and there may be regional heterogeneity in the impact of the level of digital financial development in each city on the increase in rice production. Therefore, this article divides the entire sample into two subsamples: plains and mountains. The specific estimation results are shown in Columns (1–2) of Table 10. In mountainous areas, the effects of digital finance on increasing rice production are significant at a level of 5%, and for every 1% change in the level of digital finance, rice production in mountainous areas will increase by 16,320 tons. In plain areas, the impact of digital finance on rice yields is not significant, and the estimated coefficient is smaller than that in mountainous areas. The possible reason is that the level of economic development in mountainous areas is low, and resources and technology are relatively scarce. However, the development of digital finance can provide farmers with a more convenient financial support platform, which is conducive to farmers' diversified access to agricultural production funds and has a marginal impact on the increase in rice production. The effect is more significant. For example, farmers in mountainous areas can engage in financial loans through digital platforms, avoiding cumbersome processes; they can directly use e-commerce platforms to conduct direct transactions with consumers; and they can also directly enjoy unique financial products. In plain areas, farmers have first-mover advantages in terms of geographical location, talent, technology, and resources, as well a relatively complete traditional financial foundation. Therefore, the marginal effects of digital finance on increasing rice production are relatively small.

Table 10. Heterogeneity test results.

	(1)	(2)	(3)	(4)
	Plain Area	**Mountainous Region**	**Developed Areas**	**Less-Developed Area**
Variables	**lnoutput**	**lnoutput**	**lnoutput**	**lnoutput**
df	0.1632	0.3465 **	0.0930	1.228 ***
	(1.6279)	(2.4502)	(0.123)	(0.389)
lnarea	0.8434 ***	−0.0995	−0.0313	0.366 **
	(4.9473)	(−0.3028)	(0.197)	(0.155)

Table 10. *Cont.*

	(1)	(2)	(3)	(4)
	Plain Area	**Mountainous Region**	**Developed Areas**	**Less-Developed Area**
Variables	**lnoutput**	**lnoutput**	**lnoutput**	**lnoutput**
lnirri	0.1041	−1.0269 ***	0.129	−0.858 ***
	(1.0127)	(−5.5477)	(0.144)	(0.138)
lnfer	−0.2181	−0.4928	−0.229	0.241
	(−1.4519)	(−1.0329)	(0.151)	(0.202)
lnelec	0.0192	0.2690 **	−0.0982	0.337 ***
	(0.1542)	(2.3972)	(0.0875)	(0.111)
lnmach	0.0863	0.4220	0.0721	0.482 **
	(0.5271)	(1.5181)	(0.104)	(0.215)
Constant	−1.4989	7.4462 *	4.511 ***	1.340
	(−1.6736)	(2.1189)	(1.431)	(1.194)
Observations	88	132	110	110
Number of cities	8	12	10	10
R-squared	0.750	0.596	0.111	0.637
City FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, standard errors in parentheses.

4.7.2. Heterogeneity Analysis Based on Urban Characteristics

Since the economic development status of each city is not the same, the impact of digital finance on rice production is different in cities of different levels and requires further analysis. Based on the GDP of prefecture-level cities, this article divides the sample cities into economically developed areas and underdeveloped areas for analysis. As shown in Columns 3–4 in Table 10, digital finance does not significantly increase rice production in economically developed areas. The reason is that the urban financial system in economically developed areas is more developed, and financial factors are obtained in various ways. Improving the distortion of financial resource allocation is no longer the key driving force for increasing grain production. In economically underdeveloped regions where financial resources are relatively scarce and the degree of distortion is high, digital finance has a wider space to increase the total financial supply and optimize the allocation of financial factors, thus playing the role of "providing timely assistance" and showing a more significant positive impact. This is reflected in the regression results; that is, for every 1% change in the level of digital finance, the rice yield in economically underdeveloped regions will increase by 12,280 tons.

5. Conclusions and Suggestions

Farmers often encounter the problem of difficult and expensive financing during the production process. Digital finance relies on technologies such as the internet to provide ideas for solving financing problems in the agricultural production process. Based on panel data from 20 prefecture-level cities in Sichuan Province from 2011 to 2021, this article analyzes the impact and mechanism of digital finance on rice production in Sichuan. The research revealed that (1) the development of digital finance can significantly improve the level of agricultural output, and the promotion effect is still significant according to the robustness and endogeneity tests. Furthermore, (2) the promotion effect of digital finance on rice production occurs because digital finance can expand the scale of credit, effectively alleviate credit constraints, and increase farmers' willingness to participate in insurance, thereby ensuring food production. Finally, (3) there is regional heterogeneity in the impact of digital finance on agricultural output levels. Digital finance can significantly increase rice production in mountainous areas and economically underdeveloped areas.

In view of the current status of rice production in Sichuan Province and the characteristics of digital financial development, several conclusions can be drawn from the above analysis. First, we must continue to strengthen the construction of rural digital infrastructure, improve the coverage of rural digital finance, and promote the development of rural digital finance. At the same time, more attention should be given to the education and training of digital skills for rural residents to comprehensively improve farmers' basic financial knowledge and enhance their digital literacy and application capabilities. Second, the development of digital finance should be continuously promoted, and the supply of financial products should be optimized. Financial institutions, especially township banks, must accelerate the digitization of traditional financial services, innovate financial product types, and meet the diversified needs of farmers by increasing the types of financial product supply, for example, by providing special agricultural loan products and increasing subsidies for agricultural machinery and equipment. Moreover, when promoting the development of digital finance, we must not only broaden the coverage of digital finance and enhance the depth of use of digital finance but also start to improve the degree of financial digitization to support the development of the agricultural economy more accurately and effectively. Compared with cities, rural areas need more channels through which to obtain funds and low-risk products that guarantee basic production and life. Digital financial products should control risks as much as possible. Agriculture-related digital financial services should also try to lower the threshold for use and simplify business processes to make them more accessible. These services are easier to use for vulnerable groups. Finally, the development of the agricultural economy cannot be separated from finance. We should pay attention to the development of digital finance and strengthen the importance of digital finance in the development of the agricultural economy. Therefore, we need to pay attention to new information technologies such as big data and blockchain, and we should also strengthen big data. The government should cultivate talent in information technology fields such as artificial intelligence and cloud computing, provide human resources for technological breakthroughs, focus on the sharing and accumulation of agricultural-related financial data in agricultural production, add functions such as digital payment and settlement, and continuously improve the capabilities of agricultural-related digital financial services and levels, thereby allowing digital finance to better leverage its advantages and continuously promote the development of the agricultural economy.

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