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Impact of Internet Use on Farmers' Organic Fertilizer Investment: A New Perspective of Access to Credit

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Abstract: Encouraging farmers to increase the use of organic fertilizer will be conducive to promoting the green transformation of farmers' production and realize sustainable agricultural development. As a long-term investment, the accuracy of farmers' access to organic fertilizer information and the supporting role of credit are important factors that affect their organic fertilizer application decisions. However, the existence of information asymmetry in the organic fertilizer market and the credit constraints in the financial market, which restricts the enthusiasm of farmers to apply organic fertilizer. In recent years, the rapid development of the Internet in China's rural areas has effectively alleviated the degree of information asymmetry in rural areas, and improved farmers' access to credit, which provides a new opportunity for farmers to increase the application rate of organic fertilizer. This study takes 1030 apple growers in the main apple production areas of China as the research object, and employs Tobit model, IV-Tobit model and mediation effect model to explore the impact of internet use on farmers' organic fertilizer investment. The results show that internet use can promote farmers' organic fertilizer investment. After addressing the endogeneity issue and the robustness test, the conclusion is still robust. Heterogeneity analysis shows that internet use has a more significant impact on organic fertilizer investment in the older generation and the large-scale group of farmers. The mechanism analysis shows that internet use affects farmers' organic fertilizer investment through improving access to credit. Therefore, it is necessary to continuously improve the construction of rural digital infrastructure, accelerate the development of the Internet in rural areas, and actively guide financial resources to agriculture, so as to effectively promote the green transformation of agricultural production.

Keywords: internet use; organic fertilizer investment; access to credit; apple growers

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1. Introduction

Chemical fertilizer is an important input factor in agricultural production, which plays an indispensable role in the rapid development of China's agricultural economy. However, excessive application of chemical fertilizer has also brought about a series of ecological and environmental problems such as soil acidification, water pollution and greenhouse effect, which seriously threaten the sustainable development of agriculture [1]. Therefore, the Chinese government has issued a series of policies and measures to encourage and guide farmers to replace chemical fertilizer with organic fertilizer. Although organic fertilizer has many advantages such as cultivating soil fertility and improving the yield and quality of agricultural products [2], most farmers still prefer to apply chemical fertilizer rather than organic fertilizer to maintain crop yields [3]. The reasons behind this are as follows: First of all, the supply market of organic fertilizer is uneven in quality. In recent years, with the strong support of the Chinese government, the number of organic fertilizer factories has soared, but due to the low entry threshold of enterprises in the supply market of organic fertilizer, there have been problems such as uneven quality of organic fertilizer and substandard fertilizer efficiency. Due to incomplete information on organic

fertilizer, farmers will bear more risks when purchasing organic fertilizer. They often buy organic fertilizer at a high price, but are unable to increase their income due to substandard fertilizer efficiency. Although the government has addressed some of the market constraints through public bidding and unified procurement, there is still mistrust between farmers and fertilizer producers, which may encourage farmers to choose low-priced chemical fertilizer [4]. Secondly, organic fertilizer, as a long-term investment, is characterized by a low short-term rate of return, and it requires more investment costs compared to chemical fertilizer, which is difficult to maintain only the limited household capital accumulation. In this case, farmers can only look to external financing sources such as banking institutions. However, due to the serious incompleteness of loan information, it is difficult for small farmers who lack sufficient collateral to obtain loans from traditional financial institutions, which will limit their incentive to adopt organic fertilizer [5,6].

In recent years, the Internet has developed rapidly in rural China. According to the latest Statistical Report on the Development of Internet in China released by the China Internet Network Information Center (CNNIC), there were 0.293 billion internet users in rural China by the end of June 2022, accounting for 27.9 percent to total internet users in China (See http://www.cnnic.net.cn/n4/2022/0914/c88-10226.html (accessed on 14 September 2022) for details (in Chinese)). Studies have shown that the Internet can break through information barriers, reduce transaction costs, and promote farmers' market participation, thereby increasing their profitability and productivity [7–9]. In addition, with the help of information technology, borrowers and lenders can better understand the market risks and improve their efficiency and effectiveness in dealing with potential information asymmetry and moral hazards, thereby improving the availability of credit for farmers [10,11]. With the continuous development of the Internet, its impact on the production and life of farmers is more and more profound. Theoretically, the Internet can effectively alleviate the information asymmetry between the organic fertilizer market and the credit market, thereby improving farmers' access to organic fertilizer market information and access to credit, which will help encourage farmers to increase organic fertilizer investment. So, can internet use promote farmers' organic fertilizer investment? That's an interesting question. Accurately answering this question is of great significance for promoting the green transformation of farmers' production and realizing the sustainable development of agriculture.

Turning to the factors affecting farmers' organic fertilizer application behavior, existing literature argues that individual characteristics of farmers, such as age, education level [12], risk attitude [13], environmental cognition [1] and household-level characteristics, such as non-agricultural employment [14], social capital [2], cooperative member [15], technical training [16] and land scale [3] are important factors affecting the application of organic fertilizer for farmers. Otherwise, some studies explored the factors affecting farmers' organic fertilizer application from the perspectives of financial credit [17], land rights stability [18] and social norms [19], etc. Although substantial research on the benefits of internet use to rural households, the impact of internet use on the organic fertilizer application has received much less attention. To our knowledge, only one literature has focused on the impact of internet use on organic fertilizer application. Ma et al. [20] found that internet use can significantly improve the probability of vegetable farmers' organic fertilizer application. Considering that the relevant research is still in its infancy, whether internet use has an impact on organic fertilizer investment of different types of growers such as apples, citrus, and rice has yet to be further verified. In addition, considering that organic fertilizer is a capital-intensive technology with a high degree of demand for capital, few studies analyze the impact of internet use on organic fertilizer investment and its mechanism from the perspective of access to credit, which provides research space for this study.

In light of this, this study attempts to answer the following questions: Does internet use promote organic fertilizer investment by apple growers? If so, will this promotion effect be generated through the credit behavior of farmers? Furthermore, does this promotion effect differ across generations and planting scales of farmers? To answer these questions,

this study makes use of the micro-survey data of 1030 apple growers collected by the China Agricultural Research System (CARS) in the main apple production areas of Shaanxi Province, China in 2020. Based on the theoretical analysis of the relationship between internet use and farmers' organic fertilizer investment, this paper empirically examines the influence and mechanism of internet use on farmers' organic fertilizer investment, and further examines the heterogeneity of internet use on farmers' organic fertilizer investment behavior of different generations and planting scales.

This study's contribution to the literature is three-fold. Firstly, considering that apple trees have the characteristics of large fertilization amount and high fertilization intensity, and most farmers in the investigated area have applied organic fertilizer, this paper focuses on the investment intensity of organic fertilizer, which can better reflect the difference of organic fertilizer application than whether to apply organic fertilizer. Secondly, analyzing the mechanism of internet use on farmers' organic fertilizer investment behavior from the perspective of farmers' access to credit, which is helpful to enrich the research on the relevant fields of farmers' organic fertilizer adoption behavior, and provides a new direction for the research on the determinants of farmers' organic fertilizer adoption behavior. In addition, the conclusions of this study can provide useful reference for the government to formulate differentiated policies on internet support for farmers' organic fertilizer investment. Thirdly, the main apple production areas in China are mainly located in mountainous and hilly areas, where the construction of information infrastructure is relatively lagging behind, and the negative impact of information constraints on apple growers' production decisions is more obvious, so it is more conducive to capturing the marginal impact of the Internet on apple growers' organic fertilizer investment behavior, and the research findings are more scientific and reliable.

The rest of this study is organized as follows. In Section 2, we present the theoretical analysis and proposes the hypothesis. Section 3 presents the data source, variable measurements and econometric models. The empirical results are reported and discussed in Section 4. Finally, we summarize the study and discuss policy implications in Section 5.

2. Theoretical Framework

2.1. Direct Impact of Internet Use on Farmers' Organic Fertilizer Investment

This study draws on the theoretical framework of Zheng et al. [21], and incorporates "information" as an input factor into the production function of farmers. The function is given as follows:

$$Y_t = g(K_t)F(M_t, L_t, N_t) \quad (1)$$

In Equation (1), Y_t is the apple output in period t, M_t is the apple planting area in period t, L_t represents the family labor endowment in period t, N_t is capital input in period t, such as organic fertilizer, pesticide, new crop varieties, etc., K_t is the accumulated information during t. $g(\cdot)$ is knowledge function, $F(\cdot)$ is agricultural production functions. $g(\cdot)$ and $F(\cdot)$ are concave functions. To simplify the analysis, apple acreage and labor input costs remain unchanged during production. At this point, changes in output will depend on variable capital factor inputs and the amount of information accumulated.

The hypothesis of Yoav and Shchori-Bachrach [22] is applicable to the knowledge function $g(\cdot)$, which is the marginal contribution of knowledge is positive and shows a decreasing trend. As knowledge grows, the knowledge function converges to an upper limit $\overline{g}$, the marginal productivity of information increment tends to reach zero. Assuming that farmers obtain agricultural production information through traditional information channels (including television, radio, newspapers, etc.) and internet information channel, the cumulative amount of information in the t period can be expressed as follows:

$$K_t = K_{t-1} + H_t + A_t \quad (2)$$

In Equation (2), K_{t-1} is the amount of information accumulated in the previous issue, H_t is the amount of information obtained by farmers through traditional information

channels in period t. A_t is the amount of information obtained by farmers through internet information channel in period t. Considering that it takes a certain amount of time and even money for farmers to collect information, the cost of acquiring information in period t is $C_t = C(A_t)$. In this case, the farmer's profit function π can be expressed as follows:

$$\pi = g(K_t)F(M, L, N_t) - PN_t - C(A_t) \tag{3}$$

In Equation (3), P denotes the price of capital factors in period t. Combine Equations (2) and (3), and obtain the first-order derivation of N_t and K_t, respectively:

$$\pi_{N_t} = g(K_t)F' - P \tag{4}$$

$$\pi_{K_t} = g'F(M, L, N_t) - C' \tag{5}$$

In Equations (4) and (5), π_{N_t} and π_{K_t} represent the partial derivatives of profit with regard to N_t and K_t. From the previous section, it is clear that there is a potential correlation between the amount of knowledge accumulated K_t and the amount of capital input N_t. Therefore, taking the partial derivative of Equation (4), the equation can be obtained as follows:

$$\frac{dN_t}{dK_t} = g'F' + g(K_t)F'' = 0 \Rightarrow -\frac{g'F'}{g(K_t)F''} > 0 \tag{6}$$

The result of Equation (6) means that as long as the marginal productivity of the knowledge production function g' is positive, the more information accumulated by farmers, the more conducive it will be to increase organic fertilizer investment. Especially in the complex environment of various varieties and uneven quality of organic fertilizer, the internet information channel has more advantages than the traditional information channels, which can effectively break through the information barriers, significantly improve the quality and quantity of farmers' information acquisition, thereby helping to optimize the production decisions and promote the investment in organic fertilizer. Assuming that the threshold information level K^*, when $g(K_t) = \overline{g}$, $K_t = K^*$ is within the range of K, more and more farmers will increase their investment in organic fertilizer, until K_t exceeds K^*. Therefore, we propose the first research hypothesis as follows.

Hypothesis 1 (H1). *Internet use has a positive impact on farmers' organic fertilizer investment.*

2.2. Impact of Internet Use on Farmers' Organic Fertilizer Investment: The Mediating Role of Access to Credit

Due to the widespread financial exclusion in rural areas, farmers' long-term financing needs cannot be effectively met, which restricts their enthusiasm for investment in organic fertilizer [23]. However, with the development of Information and Communication Technology represented by the Internet, it can affect the access to credit for farmers in two ways. Firstly, the Internet can reduce transaction costs and stimulate the use of digital finance, represented by mobile money [24,25]. Since the scattered residence of farmers and the small amount of loan, traditional financial institutions seldom set up physical bank outlets in rural areas for the consideration of cost and revenue [26]. Farmers usually need to go to a bank branch in a town or county to handle related business, which significantly increases their time and transportation costs. However, with the help of the Internet, farmers can complete loan applications, transfers and remittances through the mobile terminals [27]. For instance, Munyegera and Matsumoto [28] showed that mobile money effectively eased financial access constraints for rural households in Uganda and stimulated remittance and borrowing transactions between farmers. Secondly, the Internet can reduce the degree of information asymmetry associated with financial market [29]. At present, China's rural credit system is not perfect, and financial institutions often need to spend a lot of time and effort to collect information about individual farmers. The increase in the cost of information search has made financial institutions generally reluctant to lend to such groups, further

aggravating the information asymmetry between borrowers and lenders [30]. While the risk assessment based on big data can effectively alleviate the information asymmetry when lending, thereby improving farmers' access to credit [31]. For instance, when farmers trade on Tmall, they will leave digital traces including transaction behavior, logistics paths and supply chain relationships. At this time, the traditional financial institutions and fintech companies can use these data to more accurately picture them to reduce the possibility of moral hazard and adverse selection problems [32]. With the easing of financing constraints, farmers will increase their investment in organic fertilizer [17]. Therefore, we propose the second research hypothesis as follows.

Hypothesis 2 (H2). *Internet use can improve the credit constraints faced by rural households and thus promote farmers to increase organic fertilizer investment.*

3. Materials and Methodology

3.1. Data Source

The data used in this study were collected by the China Agricultural Research System (CARS) through a field survey of apple growers in Shaanxi Province from November to December 2020. To ensure the representativeness of the research sample, the research team selected three major apple-producing counties (districts) using the typical sampling method, namely Baota and Luochuan counties in Yan'an City and Fengxiang District in Baoji City. In these three counties (districts), three sample towns were randomly selected, three to four sample administrative villages were randomly selected from each sample township, and 30 to 40 sample apple farmers were randomly selected from each sample administrative village for face-to-face questionnaire surveys. A total of 1030 valid samples were obtained from the survey.

3.2. Variable Measurement

3.2.1. Dependent Variable

The dependent variable of this study is farmers' organic fertilizer investment. The variable refers to "Last year, how much did your apple orchard's organic fertilizer investment cost?" Here, organic fertilizer refers to commercial organic fertilizer and farmyard manure (purchased and home-produced). In addition, we convert home-produced farmyard manure according to the market price in the surveyed area and count the value into the input cost of organic fertilizer use.

3.2.2. Independent Variable

Internet use is the key independent variable. Drawing on the measure of Zheng et al. [21], this survey directly asked whether farmers use internet to obtain agricultural information (including information of production materials such as fertilizers and pesticides, agricultural product price information, meteorological disaster information, etc.). Among the sample farmers, there are 668 households using the Internet to obtain agricultural information and 362 households that have never used the Internet to obtain agricultural information.

3.2.3. Control Variables

This study chose the control variables from three categories: personal characteristics of household head including age, education, health status and village cadre; family characteristics including apple-planting years, number of agricultural labor, total household income, agricultural technology training, cooperative membership, orchard area, orchard plots and the external environmental conditions, that is, the distance from home to the nearest agricultural production material stores.

The definition and the statistical description are shown in Table 1.

Table 1. Variable definition and statistical description.

Variables	Definition	Mean	S.D.
Organic fertilizer investment	Logarithm of organic fertilizer expenditure (yuan/ha)	8.61	2.30
Internet use	No = 0; Yes = 1	0.65	0.48
Age	Age of household head (years)	54.94	9.37
Education	Education years of household head (years)	7.29	3.44
Health status	Very unhealthy = 1; Less healthy = 2; General = 3; More healthy = 4; Very healthy = 5	3.93	1.08
Village cadre	No = 0; Yes = 1	0.11	0.32
Apple planting year	Family apple planting years (years)	21.42	9.56
Labor	Number of family agricultural labor	1.80	0.82
Income	Logarithm of total household income	11.11	0.94
Training	No = 0; Yes = 1	0.61	0.49
Cooperative membership	No = 0; Yes = 1	0.15	0.36
Orchard area	Total area of apple orchard (ha)	0.68	0.55
Orchard plots	Total number of plots of apple orchard (plots)	2.82	1.64
Distance to market	The distance from home to the nearest agricultural production material stores (kilometers)	4.72	5.93

Note: For the measurement of the organic fertilizer investment variable, we adopted the strategy of adding 1 to the variable and then taking the logarithm.

3.3. Model Selection

3.3.1. Tobit Model

Considering that the fertilizer investment data have a value of 0, it belongs to the restricted continuous merged data. We employ the Tobit model to explore the impact of internet use on organic fertilizer investment. The model is built as following:

$$Y_i = \alpha_0 + \alpha_1 Internet_i + \alpha_2 X_i + \varepsilon_i \quad (7)$$

In Equation (7), Y_i represents the investment amount of organic fertilizer per unit area of farmer i on the research plot; $Internet_i$ represents the use of farmer i whether use internet, if used is 1, not used is 0; X_i is the control variable; α_0 is a constant term; α_1 and α_2 is the estimated parameter of the relevant variable; ε_i is the random disturbance term.

3.3.2. Mediating Effect Model

We employ the mediation effect model to verify the role of access to credit in influencing, via the Internet, farmers' organic fertilizer investment. Following the approach of Baron and Kenny [33], the stepwise mediation model is as follows:

$$Med_i = \beta_0 + \beta_1 Internet_i + \beta_2 X_i + \mu_2 \quad (8)$$

$$Y_i = \gamma_0 + \gamma_1 Internet_i + \gamma_2 Med_i + \gamma_3 X_i + \mu_3 \quad (9)$$

In Equations (8) and (9), Med_i is the intermediary variable; β_0 and γ_0 is a constant term; β_1, β_2, γ_1, γ_2 and γ_3 is the estimated parameter of the relevant variable; μ_2 and μ_3 is the random disturbance term; the explanation of other variables is the same as Equation (7).

4. Results and Discussion

4.1. Baseline Results: Impact on Organic Fertilizer Investment

As shown in Table 2, column 1 only controls the core explanatory variable, and column 2 introduces relevant control variables to test the robustness of the model. The regression result shows that internet use has a significant positive impact on farmers' organic fertilizer investment, and the estimated coefficient passes the significance level test of 1%, which preliminarily confirmed the H1. The regression results of the OLS model in column 3 show

that internet use can significantly promote farmers' organic fertilizer investment, which indicates that the regression result is robust.

Table 2. Estimated results of internet use on farmers' organic fertilizer investment.

Variables	(1)	(2)	(3)
	Tobit	Tobit	OLS
Internet use	0.542 ***	0.519 ***	0.487 ***
	(0.174)	(0.192)	(0.181)
Age		0.005	0.004
		(0.009)	(0.009)
Education		−0.027	−0.024
		(0.027)	(0.026)
Health status		0.069	0.063
		(0.077)	(0.072)
Village cadre		−0.12	−0.121
		(0.210)	(0.199)
Apple planting year		−0.008	−0.007
		(0.007)	(0.007)
Labor		0.092	0.085
		(0.107)	(0.101)
Income		0.329 ***	0.312 ***
		(0.105)	(0.098)
Training		0.221	0.211
		(0.165)	(0.156)
Cooperative membership		0.300 *	0.281 *
		(0.168)	(0.160)
Orchard area		−0.766 ***	−0.750 ***
		(0.158)	(0.148)
Orchard plots		0.031	0.029
		(0.042)	(0.040)
Distance to market		0.014	0.013
		(0.013)	(0.012)
Number of observations	1030	1030	1030

Note: *, and *** indicates significance at the 5%, and 1% levels, respectively; robust standard error in parentheses.

Based on the analysis of control variables in column 2, it is found that the impact of total household income on farmers' organic fertilizer investment has a significant positive impact at the statistical level of 1%, which means that the higher the income level, the smaller the financial constraint problem faced by farmers, which will be conducive to promoting organic fertilizer investment [34]. The influence of cooperative members on farmers' organic fertilizer investment has a significant positive impact at the statistical level of 10%. The possible reason is that the interaction between members can increase farmers' understanding of organic fertilizer, thereby promoting organic fertilizer investment [15]. The impact of orchard area on farmers' organic fertilizer investment has a significant negative impact at the statistical level of 1%. The possible reason is that organic fertilizer has labor-capital intensive characteristics, so the larger the orchard area, the greater the pressure on labor endowment constraints and capital constraints faced by farmers [35], which will inhibit organic fertilizer investment.

4.2. Endogenous Problem Handling

Whether or not to use the Internet may be endogenous due to omission of key variables, reverse causation and other factors. To address the endogeneity issue, this study draws on previous studies [36] and use the "Internet use ratio" as the instrumental variable measured by the proportion of farmers' internet use from the same village. The reason for using this

instrumental variable is based on the peer effect, that is, if the ratio of internet use among other farmers in the village is higher, the greater the likelihood that the farmer will use the Internet, satisfying the instrumental variable relevance; the ratio of internet use among other farmers in the village generally does not directly affect the farmer's organic fertilizer investment, satisfying the instrumental variable exogeneity. On this basis, the IV-Tobit model is employed to test for endogeneity and the regression result is shown in Table 3.

Table 3. Endogenous test results.

Variables	The First Stage: Internet Use	The Second Stage: Organic Fertilizer Investment
Internet use		2.866 ** (1.272)
Internet use ratio	0.536 *** (0.112)	
Wald test of exogeneity: (*p*-value)	3.91 **	
Control variables	Controlled	Controlled
Number of observations	1030	

Note: **, and *** indicates significance at the 5%, and 1% levels, respectively; robust standard error in parentheses.

As can be seen from Table 3, the results of the first stage regression show that the impact of internet use ratio on farmers' internet use has a statistically significant positive impact at the 1% level, satisfying the instrumental variable correlation. The value of the endogeneity test is significant at the 5% statistical level, indicating that internet use is an endogenous explanatory variable. The results of the second stage of regression show that after correcting the possible endogenous bias, internet use still has a significant positive impact on farmers' organic fertilizer investment, which is consistent with baseline regression.

4.3. Robustness Test

Although the IV-Tobit model is employed to solve the endogenous problem as much as possible, the impact of internet use on farmers' organic fertilizer investment may be disturbed by "self-selection" due to the limitations of data and variables, leading to a selective bias in the regression results. To this end, we employ the Propensity Score Matching Method (PSM) method to construct a counterfactual analytical framework of internet use on farmers' organic fertilizer investment to overcome the potential selectivity bias problem of the model, and the estimation results are shown in Table 4. Although the Average Treatment Effect on the treated (ATT) values obtained by the three matching methods are slightly different, they all have a significantly positive effect at the 1% statistical level, which indicates that after overcoming the potential selectivity bias of the model, internet use still has a significant role in promoting farmers' organic fertilizer investment, and effectively verifies the robustness of the regression results.

Table 4. Estimation results of the PSM method.

Matching Methods	Treated Group	Control Group	ATT	S.E.	*T* Stat
k-nearest neighbor matching (k = 4)	8.802	7.871	0.932 ***	0.237	3.93
Caliper matching (Caliper = 0.02)	8.803	7.984	0.819 ***	0.230	3.55
Kernel matching (window width = 0.06)	8.802	8.020	0.782 ***	0.221	3.54

Note: *** indicates significance at the 1% level.

4.4. Heterogeneity Analysis

Although the impact of internet use on farmers' organic fertilizer investment has been examined above, the above results can only reflect the average effect at the whole sample level, and cannot reflect the differences between different groups. To do this, we

will examine the heterogeneity of internet use on farmers' organic fertilizer investment in different generations and planting scales. The reason why different generations are chosen as groupings is that with the continuous advancement of urbanization in China, the structure of rural labor force has also undergone tremendous changes, a large number of young and middle-aged farmers have moved to the cities to work, and the gradual "aging" of agricultural labor has become a common phenomenon. Therefore, there will be obvious differences between the new and old generation of farmers in organic fertilizer investment decision-making, which cannot be generalized. It is necessary to study the intergenerational differences in the impact of internet use on the organic fertilizer investment of new and old generations of farmers according to different intergenerational groups. The basis for choosing different planting scales as groupings is that the larger the planting scale, the greater the dependence of farmers on agriculture, therefore the enthusiasm of using the Internet to increase organic fertilizer investment will be different.

Firstly, drawing on Karl Mannheim's criteria for the intergenerational division of Chinese farmers, we divide the old generation of farmers into farmers who started farming before 1977, while the new generation of farmers includes farmers who started farming after 1977, that is, farmers aged ≤43 are the new generation and those aged >43 are the old generation [37]. On this basis, we employ the Tobit model to estimate, and the regression results are presented in Table 5. It can be seen from Table 5 that internet use has a significant positive impact on organic fertilizer investment for the old generation of farmers, but the impact on organic fertilizer investment for the new generation of farmers is not significant. The possible reason is that while the new generation of farmers are more likely to accept the Internet as a new thing, they are more likely to use the Internet for higher-paying off-farm work, so the impact of internet use on organic fertilizer investment is not significant. For the older generation of farmers, who rely more on land, they are more likely to use the Internet to search for organic fertilizer information, thereby promoting organic fertilizer investment.

Table 5. Heterogeneity analysis results.

Variables	Intergenerational Differences		Planting Scale		
	New Generation Farmers	Old Generation Farmers	Small-Scale	Medium-Scale	Large-Scale
Internet use	0.468 (0.634)	0.490 ** (0.199)	0.460 ** (0.223)	0.566 (0.387)	0.625 * (0.344)
Control variables	Controlled	Controlled	Controlled	Controlled	Controlled
Number of observations	116	914	275	410	345

Note: *, and ** indicates significance at the 10%, and 5% levels, respectively; robust standard error in parentheses.

Secondly, we take the 0.33 and 0.65 quantiles of planting scale as the cut points, and divide the sample farmers into three groups: small-scale, medium-scale, large-scale. On this basis, we employ the Tobit model to estimate, and the regression results are presented in Table 5. As can be seen from Table 5, internet use has a significant positive impact on organic fertilizer investment in small-scale and large-scale groups, but it has no significant effect on organic fertilizer investment in medium-scale groups. Furthermore, from the perspective of influence coefficient, with the expansion of planting scale, the influence of internet use on organic fertilizer investment gradually increased. The possible reason is that with the expansion of planting scale, farmers will rely more on agriculture. In order to ensure the long-term return of land, farmers will choose to increase organic fertilizer investment to maintain land productivity. Therefore, the larger the planting scale, the more motivated farmers will be to use the Internet to search for organic fertilizer information, which is conducive to promoting organic fertilizer investment.

4.5. Mechanism Analysis

In terms of intermediary variable selection, we based on the question "In 2019, did your family take out a bank loan for agricultural production?" to characterize farmers' access to credit, with options "0 = No and 1 = Yes". Furthermore, we employ the mediation effect model to examine the mediating role of access to credit. The regression results are presented in Table 6.

Table 6. Mediation effect estimation results.

Variables	Access to Credit	Organic Fertilizer Investment
Internet use	0.252 ** (0.123)	0.499 ** (0.195)
Access to credit		0.413 ** (0.201)
Control variables	Controlled	Controlled
Number of observations	1030	1030

Note: ** indicates significance at the 5% level.

As can be seen from the second column of Table 6, internet use has a significant positive impact on farmers' access to credit. Specifically, financial institutions can use the internet technology to effectively screen the information of farmers and screen out farmers who truly meet the loan conditions. This effectively reduces the degree of information asymmetry between financial institutions and farmers, and improves the willingness of financial institutions to lend to farmers [38,39]. For farmers, the use of the Internet can effectively reduce the transaction costs caused by information transmission and search, thereby increasing the willingness to borrow [40,41]. For example, Mushtaq et al. [42] assessed the role of Information and Communication Technologies (ICT) in poverty reduction by fostering financial inclusion. They found that positive association of ICT diffusion with financial inclusion and a negative relationship with poverty and inequality. Moreover, the ICT dimensions when used as instruments for financial inclusion accelerate economic growth and reduce poverty and inequality. It can be seen from the third column of Table 6 that after adding the credit access variable into the benchmark regression model, both internet use and access to credit have a significant positive impact on farmers' organic fertilizer investment. This shows that farmers can effectively ease their credit constraints by using the Internet. As the level of credit increases, it will help promote organic fertilizer investment [43,44]. For instance, Abdul-Rahaman et al. [45] found that adopters of the mobile money technology applied 18% and 13% more fertilizer and herbicides, respectively, than nonadopters. Therefore, H2 is verified.

5. Conclusions and Policy Implications

Based on 1030 micro data from the main apple production areas of Shaanxi, China, this study employs the Tobit model to empirically test the impact of internet use on farmers' organic fertilizer investment. The IV-Tobit model is employed to address the endogeneity issues associated with internet use. Furthermore, the mediation effect model is employed to explore the mediating role of access to credit. In addition, heterogeneity analysis was conducted to explore the different effects of internet use on organic fertilizer investment among different farmers.

The empirical results showed the following: First, internet use has a significant role in promoting farmers' organic fertilizer investment. After using the IV-Tobit model to address the endogeneity issue and the Propensity Score Matching Method (PSM) method to check the robustness, the conclusion is still robust. Second, internet use promotes organic fertilizer investment by improving farmers' access to credit. Specifically, the emergence of the Internet not only greatly reduces the cost of searching for farmers' information for financial institutions, but also changes the way farmers reach financial, thereby improving

farmers' access to credit. With the easing of credit constraints, farmers will be encouraged to increase investment in organic fertilizer. Heterogeneity analysis shows that internet use has a significant positive impact on organic fertilizer investment for the old generation of farmers, but the impact on organic fertilizer investment for the new generation of farmers is not significant; the effect of internet use on farmers' organic fertilizer investment is significantly positive in the small-scale and large-scale groups, but not significant in middle-scale groups. Furthermore, with the expansion of planting scale, the influence of internet use on organic fertilizer investment gradually increased.

Based on the above findings, it can be judged that the Internet may be an important driving force in the future to facilitate the green transformation of farmers' production and achieve sustainable agricultural development. Therefore, this study proposes the following policy recommendations. First, government departments should continue to promote the construction of digital villages and accelerate the digital transformation of agriculture and rural areas. While continuously improving the construction of digital infrastructure such as 5G base stations and gigabit broadband in rural areas, attention should also be paid to the training of rural households in internet use skills, especially for the old generation of farmers, and strive to improve their internet application capabilities. Second, we should pay attention to the supporting role of credit in agricultural green production. Credit constraints are an important factor affecting farmers' organic fertilizer investment, and government departments should actively guide financial resources to tend to agriculture. At the same time, with the help of internet information technology, the construction of farmers' credit systems is constantly improving, thereby promoting the farmers' access to credit. Finally, actively cultivate new agricultural business entities. As the main force of modern agriculture, the development and expansion of new agricultural business entities will help to lead the transformation of green agricultural production. Therefore, it can be cultivated through policy support, tax relief, technical training and other means.

Of course, there are still some limitations in this study. First, limited by cross-sectional data, it fails to grasp the dynamic impact of the internet use and farmers' organic fertilizer investment behavior. Second, the conclusion is based on farmers in China's main apple production areas, but it remains to be verified whether similar conclusions can be drawn for different types of crops, even in other countries.

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