agriculture

Article

Impacts of Capital Endowment on Farmers' Choices in Fertilizer-Reduction and Efficiency-Increasing Technologies (Preferences, Influences, and Mechanisms): A Case Study of Apple Farmers in the Provinces of Shaanxi and Gansu, China

Yihan Chen [1], Wen Xiang [2] and Minjuan Zhao [1,*]

[1] College of Economics and Management, Northwest A&F University, Xianyang 712100, China; cyihan@nwafu.edu.cn

[2] Institute for Interdisciplinary and Innovate Research, Xi'an University of Architecture and Technology, Xi'an 710055, China; xiangwen@xauat.edu.cn

* Correspondence: minjuan.zhao@nwsuaf.edu.cn

Abstract: On the basis of data collected from 1208 apple farmers in the provinces of Shaanxi and Gansu, this study utilizes the weighted-frequency method to investigate the priority sequence of farmers' preferences in choosing fertilizer-reduction and efficiency-increasing technologies. Subsequently, ordered-probit models, a mediating-effect model, and a moderating-effect model are employed to empirically analyze the influence of capital endowment on farmers' choices related to fertilizer-reduction and efficiency-increasing technologies and their underlying mechanisms. The study further examines how agricultural-technology extension moderates these mechanisms. The main findings are: (1) The priority sequence of farmers' choices concerning fertilizer-reduction and efficiency-increasing technologies is as follows: organic fertilizer substitution, new efficient fertilizers, soil testing and formula fertilization, green manure cultivation, straw mulching, fertilizer-reduction application, and deep mechanical application. (2) Capital endowment significantly enhances farmers' choices in fertilizer-reduction and efficiency-increasing technologies. (3) The mechanism analyses indicate that capital endowment can promote farmers' choices in fertilizer-reduction and efficiency-increasing technologies by improving their information-acquisition capabilities. (4) Moderation effects reveal that agricultural-technology extension methods, such as technical training, financial subsidies, and government publicity, significantly and positively moderate the relationship between information-acquisition capabilities and farmers' choices in fertilizer-reduction and efficiency-increasing technologies. The moderating effects of educational attainment and generational differences on different agricultural-technology extension methods are heterogeneous. Technical training, financial subsidies, and government publicity can effectively enhance the positive impact of information-acquisition capabilities on farmers with a higher educational attainment. Financial subsidies can effectively strengthen the positive impact of information-acquisition capabilities on the older generation of farmers. Therefore, it is recommended to prioritize the accumulation of farmers' capital endowment, improve their information-acquisition capabilities, and intensify agricultural-technology extension efforts, especially taking into account farmers' educational attainment and generational differences.

Keywords: capital endowment; fertilizer-reduction and efficiency-increasing technologies; information-acquisition capabilities; agricultural-technology extension

check for updates

Citation: Chen, Y.; Xiang, W.; Zhao, M. Impacts of Capital Endowment on Farmers' Choices in Fertilizer-Reduction and Efficiency-Increasing Technologies (Preferences, Influences, and Mechanisms): A Case Study of Apple Farmers in the Provinces of Shaanxi and Gansu, China. *Agriculture* **2024**, *14*, 147. https://doi.org/10.3390/agriculture14010147

Academic Editors: Pan Dan and Fanbin Kong

Received: 10 December 2023
Revised: 14 January 2024
Accepted: 17 January 2024
Published: 19 January 2024

1. Introduction

Fertilizer, as a crucial agricultural input, has played a significant role in contributing to the economic growth of agriculture in China [1]. However, the quantity of fertilizer applied in agriculture has surpassed the optimal range that balances economic and environmental efficiency [2,3]. The per-unit-area application of fertilizer in China remains 1.67 times higher than the internationally accepted fertilizer application limit of 225 kg/ha [4], and the nitrogen-use efficiency is only 0.25 in China compared with 0.42 worldwide [5]. The chronic excessive and inefficient application of fertilizer has not only escalated the costs of agricultural production but has also led to a progressively severe environmental pollution crisis, thereby impeding the sustainable development of agriculture in China [6,7]. Addressing the challenges of augmenting agricultural efficiency and farmers' income while simultaneously improving the quality of agricultural products and enhancing the ecological environment of the soil necessitates a concerted effort toward reducing the use and increasing the efficiency of fertilizers. Initiated in 2015 with the introduction of the "Action Plan for Zero Growth in Fertilizer Use by 2020" by the Ministry of Agriculture and Rural Affairs, this commitment was reaffirmed in the central government's "Number One Document" in 2021, emphasizing the ongoing promotion of the reduction in the use and improvement in the efficiency of fertilizers. Further, in 2022, the national government enacted the "Action Plan for the Battle Against Agricultural and Rural Pollution (2021–2025)", outlining the imperative to further the reduction in the use and the improvement in the efficiency of fertilizers while specifying the technical pathways and measures necessary to achieve these objectives. It is evident that the reduction in the use and improvement in the efficiency of fertilizers represent focal points of attention for both the political and academic spheres, constituting an essential prerequisite for agricultural emissions reduction and the realization of green, high-quality development.

In this context, technologies related to fertilizer reduction and increasing efficiency are essentially green agricultural technology, and they are of wide concern. They not only stabilize crop yields but also enhance the overall benefits by saving production costs, improving the quality of agricultural products, and mitigating environmental pollution [8]. Comprising various subtechnologies, they constitute a technical package encompassing a series of green agricultural production techniques. Through the implementation of innovative fertilizers, adjustment of fertilization structures, and improvement of fertilization methods, this technology aims to boost the utilization efficiency of fertilizers and curtail the volume of fertilizer applied. Despite a series of incentive measures taken by the Chinese government over the years to promote green agricultural technology, there have been limited improvements in the technical supply and extension, particularly when dealing with numerous small-scale farmers [9]. Existing research indicates that farmers exhibit limited enthusiasm and low adoption rates for green production technologies [10]. The decision-making process of farmers regarding the adoption of fertilizer-reduction and efficiency-increasing technologies is pivotal in determining the effectiveness of technology extension, constituting the foundation and a key challenge for the green transformation of agricultural production [11]. Effectively promoting technologies for reducing fertilizer usage and improving efficiency has become an urgent issue to address, and it is vital for ensuring the sustainable and green development of agriculture in China.

Academic explorations of farmers' choices of technology and the influencing factors generally unfold along four main dimensions: (1) A comprehensive analysis of the various factors: research undertaking a quantitative analysis of the diverse factors influencing farmers' choices of technology, considering both internal and external factors [12] as well as the perspectives of micro-individuals and macropolicies [13–15]. (2) A focus on specific factors: Some studies have honed in on specific factors affecting farmers' decisions concerning technology, such as technological awareness [16–19], technological environment [20], risk preferences [21,22], migration for work [23], market conditions [24], policy incentives, and others [25–27]. (3) Classification based on technological attributes: research has categorized the impact of different technological attributes on farmers' technology choice, including single attribute characteristics [28] and multi-attribute features [29]. (4) Deviations in technology choice according to the type of farmer: studies have explored variations in the choice of technology among different types of farmers [30]. While the existing literature provides insight from various perspectives, the influences on farmers' technological choices can be synthesized as being rooted in the transformation and dynamic balance of different elements based on varying capital endowments. These differences in capital endowments are likely to manifest as distinct comprehensive effects. Therefore, it is crucial to offer both theoretical explanations and empirical validations from the perspective of capital endowment regarding the impact on farmers' technology choices.

Regarding the interplay between capital endowment and farmers' behavior, studies in the existing literature predominantly commence with an examination of the level of capital endowment. This exploration delves into its implications for various aspects of farmers' conduct, including, but not limited to, green production behaviors [31,32], land-utilization patterns [33], and the adoption of technology [34]. A consensus has largely been reached that recognizes capital endowment as a critical factor shaping farmers' decisions and behavior. Farmers may opt to forego these activities when their capital endowment falls short of meeting the prerequisites for certain behaviors. Among them, farmers' education, social networks, age, and ethnicity are the deep-rooted factors that affect farmers' green production behavior [35]. Risk attitude, government publicity and education, household size, land fragmentation, farm income ratio, farm size, and health are the most important factors influencing farmers' environmentally friendly pesticide-application behavior (FEPAB) [36]. Capital endowment, including natural, economic, human, and social capital, has a significant influence on farmers' green production behavior [37]. At the same time, some scholars have traced the capital endowment, planting scale, family income, and technical specialization of fruit farmers as having a significant impact on the adoption and exercise of environmentally friendly technology (EFT) [38]. Simultaneously, a relatively rich body of research has emerged, probing relationships such as "information-acquisition capability and technology selection" and "agricultural-technology extension and technology selection" [9,39,40]. For example, previous studies used survey data from households in the Loess Plateau in 2017 to evaluate the impact of the ability to acquire information on the decision-making process for the adoption of soil and water conservation (SWC) technology by farmers [41]. The results indicated that information acquisition exerts a positive and significant impact on farmers' recycling choices, whereby a greater information-acquisition intensity increases the likelihood of recycling plastic film residues [42]. Both agricultural-technology extension and social networks can significantly promote farmers' adoption of conservation tillage technology, and the promotion effect of agricultural-technology extension is greater [43]. However, scholarly attention has predominantly focused on understanding the emergence and decision-making mechanisms of one or two influencing factors on farmers' selection of technology. There remains a relative scarcity of comprehensive examinations of the interplay among these three factors. Therefore, several questions arise: How is the logical nexus established between capital endowment, information-acquisition capability, and agricultural-technology extension concerning farmers' choices in adopting fertilizer-reduction and efficiency-increasing technologies? Are there discernible differences in the decision-making mechanisms of farmers' technological choices under varying constraints of capital endowment? What are the underlying transmission mechanisms and operative principles? The academic community has yet to arrive at a conclusive consensus. Theoretically, a farmer's robust information-acquisition capability implies a more symmetrical access to agricultural production and management information, coupled with a wealth of technological knowledge and experience. This is likely to diminish uncertainties in the technology adoption process, thereby amplifying the catalytic role of capital endowment in affecting their behaviors of technology adoption. Additionally, as an external intervention, agricultural-technology extension serves to fortify farmers' information-acquisition capabilities, enhance their comprehensive assessment of technological benefits, and propel their inclination toward technology adoption. In summary, through an in-depth analysis of the impact and operational mechanisms of capital endowment on farmers' decisions regarding the selection of fertilizer-reduction and efficiency-increasing technologies, as well as an exploration of the moderating effects of agricultural-technology extension, including potential disparities in the efficacy of various extension methods across diverse farmer groups, this study introduces a fresh perspective and an avenue for advancing the cause of green technology in agriculture.

In consideration of this context, this paper focuses on the following questions: Does capital endowment exert an influence on farmers' choices regarding the adoption of fertilizer-reduction and efficiency-increasing technologies? If so, can the impact of capital endowment be strengthened by enhancing information-acquisition capabilities? In the affirmative, can this mechanism be adjusted through agricultural-technology extension? Additionally, does the moderating effect of different agricultural-technology extension methods exhibit heterogeneity? To address these inquiries, the study utilized data from 1208 valid surveys conducted among apple farmers in the provinces of Shaanxi and Gansu to supplement the existing studies from the following aspects: First, in terms of the research content, building upon an examination of farmers' preferences in prioritizing choices related to fertilizer-reduction and efficiency-increasing technologies, this paper used the order-probit model to confirm the promoting effect of capital endowment on farmers' choices of fertilizer-reduction and efficiency-increasing technologies, supplemented the existing evidence on the factors influencing farmers' choices of fertilizer-reduction and efficiency-increasing technologies, and provides a new perspective for promoting farmers' choices of technology. Second, from the perspective of farmers' information-acquisition ability, this paper analyzes the mechanism by which capital endowment affects farmers' choices of fertilizer-reduction and efficiency-increasing technologies and tests the regulating effect of agricultural-technology extension. Thirdly, from the perspective of research, this paper analyzes the heterogeneity of the influence of the adjustment effect of agricultural-technology extension on the behavior related to the choices of fertilizer-reduction and efficiency-increasing technologies of farmers with different education levels and generations, so as to provide a decision-making basis for formulating effective fertilizer-reduction policies.

2. Theoretical Analysis and Research Hypotheses

2.1. Direct Influence of Capital Endowment on Farmers' Choices in Fertilizer-Reduction and Efficiency-Increasing Technologies

Capital endowment refers to all the resources and capabilities, whether inherent or acquired, that are possessed by farmers. It reflects farmers' capacity for engaging in agricultural production and constitutes a significant factor influencing human behavior or intent [44]. Because of the constraints imposed by capital endowment, the decision-making process of most farmers involves making rational choices after considering their family endowment [45]. In other words, different constraints in capital endowment lead to variations in individual farmers' decisions. Theoretically, a higher level of capital endowment means that farmers not only have more decision-making information and choices but also a stronger ability to carry out various life or production practices. They can reasonably weigh up and screen relevant technical information, quickly learn and accept new production technologies and behaviors, and, thus, enhance their willingness to adopt technologies.

Considering the different dimensions of capital, as categorized by scholars [46], this paper elaborates on the impact of capital endowment on farmers' behavior concerning their choices of fertilizer-reduction and efficiency-increasing technologies across five dimensions: natural capital, material capital, human capital, economic capital, and social capital. Specifically, natural capital refers to the indispensable resources and environmental elements in farmers' production decisions [47]. It plays a vital role in social security, providing the foundation necessary for farmers' survival. Farmers with abundant natural capital tend to choose methods of agricultural production conducive to long-term development [48], and farmers who are mainly engaged in agricultural production live in villages for longer periods of time. It can obtain greater effects with improvements to the village environment, so the probability of selecting technology related to fertilizer reduction and efficiency increase is greater. Material capital refers to the materials and equipment that farmers rely on for technology selection. It reflects, to some extent, their quality of life and material conditions. The richer the material capital, the more improved the material conditions and production facilities for agricultural production. This enhancement contributes to increased production efficiency and convenience. At the same time, farmers with a high level of material capital have better living and production conditions and pay more attention to improving their quality of life. Human capital refers to the knowledge and production capabilities farmers possess when making choices about the adoption of technology [49]. Higher levels of human capital deepen the understanding of the importance of fertilizer-reduction and efficiency-increasing technologies and the harmfulness of environmental pollution. Abundant human capital can allocate some labor to engage in new technologies, ensuring the existing agricultural production income while reducing uncertainty and risk, making it easier to adopt such technologies. Economic capital refers to a major reflection of the financial strength and economic status of farmers' households. It determines the capacity to invest in new technologies and withstand technological risks, influencing the farmers' decision-making process [50,51]. The greater the economic capital, the more substantial the financial support farmers have in production decisions, making them more inclined to adopt new technologies. Social capital refers to farmers' network relationships and mobilizable resources, including social networks, trust, participation, reputation, and norms. These elements influence the collective awareness and actions of social members through complex social relationships [52–54]. Farmers with a higher level of social capital can obtain relevant information more quickly and accurately, which has certain advantages in alleviating information asymmetry. Serving as informal channels for information and resources, farmers promote the adoption of fertilizer-reduction and efficiency-increasing technologies through interactions, learning, and communication. It can be observed that farmers with enriched levels of capital endowment across various dimensions are more likely to choose fertilizer-reduction and efficiency-increasing technologies.

On this basis, the following research hypotheses are proposed:

H1. *Capital endowment has a significant positive effect on farmers' choices in fertilizer-reduction and efficiency-increasing technologies.*

H2. *Different dimensions of capital endowment have significant positive effects on farmers' choices of fertilizer-reduction and efficiency-increasing technologies.*

2.2. Mediating Effect of Information-Acquisition Capability in the Relationship between Capital Endowment and Farmers' Choices of Fertilizer-Reduction and Efficiency-Increasing Technologies

Information-acquisition capability refers to farmers' ability to effectively identify, digest, and apply relevant agricultural information. Prior research suggests that stronger information-acquisition capabilities confer advantages to farmers in terms of searching for information, market negotiation, and other aspects, leading to reduced information costs [55]. Farmers with enhanced information-acquisition capabilities tend to possess more symmetrical information for agricultural production and management, enriched technological knowledge, and a greater potential to alleviate uncertainties in the process of technology adoption, thereby facilitating the adoption of new technologies [56]. However, information-acquisition capability is contingent upon both the basic conditions of farmers and external factors and environments. Because of varying levels of capital endowment, farmers exhibit differences in sensitivity to agricultural technology and related information [57,58]. It is evident that the level of capital endowment is a primary manifestation of farmers' information-acquisition capabilities. This not only directly influences farmers' decisions but also determines the acquisition capability to differentiate information among farmers. Consequently, it leads to diverse choices in the adoption of fertilizer-reduction and efficiency-increasing technologies. Specifically, as the level of capital endowment increases, farmers with better agricultural production resources and capabilities find it easier to meet various demands, making them more inclined to choose new technologies. Abundant capital endowment broadens the diversification of farmers' information acquisition, enhancing their information-acquisition capabilities. Farmers with strong information-acquisition capabilities can access more information about new technologies, reducing the difficulty in utilizing technology and, consequently, promoting the decision-making process for the selection of fertilizer-reduction and efficiency-increasing technologies. Therefore, farmers with enriched capital endowments tend to have more opportunities to acquire technical information and possess stronger information-acquisition capabilities, making them more likely to choose fertilizer-reduction and efficiency-increasing technologies.

On this basis, the following research hypothesis is proposed:

H3. *Information-acquisition capability plays a mediating role in the relationship between capital endowment and farmers' choices in fertilizer-reduction and efficiency-increasing technologies.*

2.3. Moderating Effect of Agricultural-Technology Extension on the Relationship between Information-Acquisition Capability and Farmers' Decisions in the Selection of Fertilizer-Reduction and Efficiency-Increasing Technologies

Agricultural-technology extension, as a government-supported initiative to reduce the use of and increase the efficiency of fertilizer, plays an important role in enabling farmers to access information and enhance their skills. It serves as a crucial mechanism to facilitate farmers' adoption of technology. Extensive research has been conducted on the correlation between agricultural-technology extension and farmers' adoptive behavior. Existing studies suggest that agricultural-technology extension, employing strategies such as demonstration, lectures, training programs, and technical subsidies [34,59,60], not only enhances farmers' agricultural production capacity [61] but also boosts their information-acquisition capabilities [32,62], cognitive levels, and risk tolerance [63,64]. Consequently, it contributes to the adoption of new technologies by farmers [65]. With its diverse approaches, broad outreach, accurate information dissemination, and strong inclusiveness, agricultural-technology extension acts as a positive force for farmers. It mitigates information asymmetry and barriers, reduces information searching and the corresponding costs [40], and widens information channels. This makes it more convenient for farmers to acquire technical information, reinforcing their proactive selection of new technologies. Presently, the government primarily promotes agricultural production technologies through three main avenues: technical training, financial subsidies, and government publicity. This diverse approach introduces heterogeneous information to farmers, influencing their adoption of technology, with varying effects [66]. Therefore, this paper categorizes agricultural-technology extension into three dimensions. Specifically, technical training provides farmers with technical information and professional guidance. Expanding the depth and breadth of farmers' technical knowledge enhances their awareness of the advantages and disadvantages of fertilizer application, as well as policies for fertilizer reduction and efficiency. This optimization of fertilization habits improves agricultural production capacity, ultimately increasing farmers' acceptance of technology. Financial subsidies, by compensating farmers for positive externalities in their environmental behavior, help to reduce farmers' input costs, increase expected returns, and stimulate farmers' enthusiasm for choosing new technologies. Government publicity conveys policy information and green development concepts to farmers, contributing to raising environmental awareness among farmers and, consequently, increasing farmers' adoptive behavior toward technology.

On this basis, the following research hypothesis is proposed:

H4. *Technical training, financial subsidies, and government publicity exhibit moderating effects on the relationship between information-acquisition capability and farmers' decisions in the selection of fertilizer-reduction and efficiency-increasing technologies.*

On this basis, a theoretical framework was constructed, as illustrated in Figure 1.

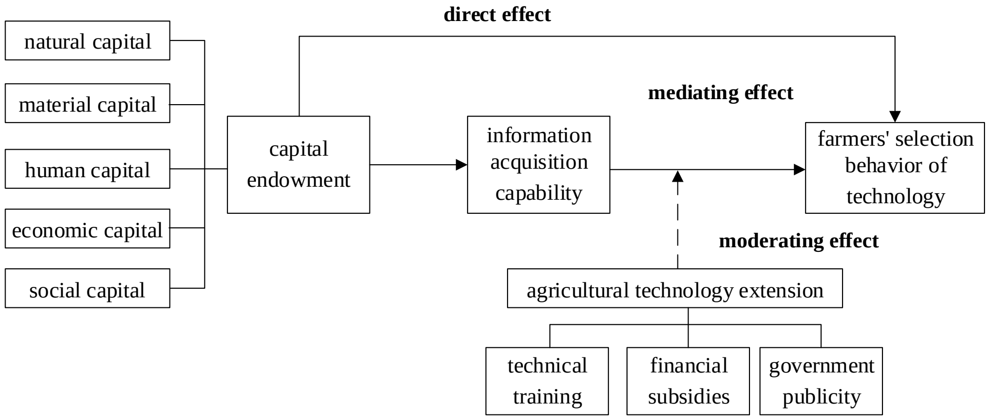

Figure 1. Theoretical framework of capital endowment on farmers' selection of fertilizer-reduction and efficiency-increasing technologies.

3. Data Source, Model Construction, and Variable Selection

3.1. Source of Data and Sample Description

The data for this study were collected during a survey on the selection of fertilizer-reduction and efficiency-increasing technologies among apple farmers conducted by our research team from March to June 2022 in the provinces of Shaanxi and Gansu. The selection of the Shaanxi and Gansu provinces, located on the Loess Plateau, as the research areas and apple farmers as the research subjects were mainly based on the following considerations: First, in 2008, the Ministry of Agriculture's "Apple Advantageous Regional Layout Plan (2008–2015)" pointed out that the Loess Plateau, as one of China's optimal apple-producing areas, has an apple-planting area of approximately 18.3042 million mu, accounting for the largest proportion (58.44%) of the country's apple-planting area. Second, according to the latest data released by the National Bureau of Statistics, the apple-planting area in 2022 was 9.2410 million mu in the Shaanxi province and 3.8460 million mu in the Gansu province, ranking them as the top two apple-planting areas in the country. The amount of fertilizer applied is large and is on the rise, with the average amount of fertilizer applied to apples per mu in the Shaanxi and Gansu provinces in 2021 being 74.8 kg and 31.1 kg, respectively, and excessive fertilization is common. Agricultural nonpoint-source pollution is a serious problem. Third, most research objects are rice, corn, wheat, or other field crops, and there are few research results that analyze perennial cash crops, such as fruits and vegetables. In addition, compared with food crops, China's fruit trees, vegetables, and other theoretical scientifically based fertilization studies and technological research and development are seriously insufficient, so it is more urgent to choose fertilizer-reduction and efficiency-increasing technology. Therefore, the selection of the survey areas has a certain representativeness and typicality. The questionnaires were primarily conducted with farmers through one-on-one interviews with household heads or key family members involved in decision making related to production. The content included information on farmers' capital endowment, production, and management; sales situation; application practices related to fertilizers and pesticides; and farmers' choices concerning fertilizer-reduction and efficiency-increasing technologies. Farmers orally answered the questions raised by the researchers. Prior to the formal survey, the research team conducted a presurvey in the Zhuanglang county, Jingning county, Xifeng district, and Qingcheng county in the Gansu province. On the basis of the findings of the presurvey, modifications and improvements were made to the survey questionnaire.

The research team made full preparations before the field investigation, including designing the questionnaire, holding expert discussions, and conducting a pre-investigation. The survey employed a multistage sampling method involving the following four stages: First stage: selection of the representative areas in the Loess Plateau region (the area to the north of the Weihe River within Shaanxi, the southern area of northern Shaanxi, and the Longdong and Longnan regions in Gansu). Second stage: Considering factors such as the geographical distribution and the apple-farming practices within the two provinces, four counties (districts) in Shaanxi and four counties (districts) in Gansu were chosen as sample counties. Specifically, these included Xunyi County, Baishui County, Baota District, and Luochuan County in Shaanxi, and Xifeng District, Qingcheng County, Zhuanglang County, and Jingning County in Gansu. Third stage: two townships involved in the apple industry's development and technology application were randomly selected from each of the eight designated counties (districts). Fourth stage: four villages were randomly selected from each township, and 16–19 households were then randomly chosen from each village as the final survey subjects. A total of 1230 questionnaires were distributed to farmers in this survey. After excluding some questionnaires with missing data and inconsistencies, the final valid sample set consisted of 1208 questionnaires, resulting in a questionnaire validity rate of 98.21%. Meanwhile, to test the stability and reliability of the questionnaire, Cronbach's alpha coefficient and the Stata15.1 software were used to test the reliability of the samples. The results show that the overall α coefficient was 0.7108, indicating that the questionnaire had good internal consistency.

As can be seen from Table 1, the sample of farmers mainly presented the following characteristics: First, males accounted for 94.21% of the farmers sampled. The age of the farmers was generally older, with farmers aged 50 and above accounting for 77.15%, and the average age was 55.13 years old. Overall, the educational level was low, and the average number of years of education attained was approximately 7.42 years. The average number of household participants in the labor force was approximately three. The planting scale was mainly small, with 74.92% of farmers having a planting scale of less than 10 mu, and the average planting scale was 9.59 mu; the planting years were generally long, and the average number of planting years was 21.46 years. The annual family income was mostly below CNY 80,000, accounting for 59.69%, and the percentage of farmers with an agricultural income accounting for more than half of the annual income of the family was 43.29%. The research samples in this paper basically conform to the basic situation of agricultural producers in China and have good representativeness. Second, 50.08% of farmers judged the amount of fertilizer applied according to their own experience; 27.73% of farmers fertilized more than the application standard, and only 9.11% of farmers fertilized according to the application standard, indicating that the method used by the farmers in the sample to judge the amount of fertilizer is greatly affected by production habits, and the potential for a reduction in fertilizer use by farmers is relatively large. Third, 9.44% of the farmers did not choose any fertilizer-reduction and efficiency-increasing technologies; 17.30% of the farmers chose one of the fertilizer-reduction and efficiency-increasing technologies; 24.42%, 20.61%, and 14.40% of the farmers chose two, three, and four fertilizer-reduction and efficiency-increasing technologies; and 13.82% of the farmers chose five or more fertilizer-reduction and efficiency-increasing technologies. Although the proportion of farmers who chose at least one fertilizer-reduction and efficiency-increasing technology was high, fertilizer reduction and efficiency involves systematic engineering, which needs to be combined with a variety of technologies to play a better role. Therefore, the degree of adoption of the fertilizer-reduction and efficiency-increasing technologies by farmers still needs to be further improved.

Table 1. Basic statistical characteristics of sample farmers.

Variable	Category	Sample Size	Ratio	Variable	Category	Sample Size	Ratio
Sex	Male	1138	94.21%	Income	≤40,000	358	29.64%
	Female	70	5.79%		80,000 to 80,000	363	30.05%
Age	≤40 years	85	7.04%		80,000 to 120,000	215	17.80%
	41–50 years	271	22.43%		>120,000	272	22.52%
	51–70 years	791	65.48%	Fertilizer application	Less than standard	158	13.08%
	>70 years	61	5.05%		According to standard	110	9.11%

Table 1. *Cont.*

Variable	Category	Sample Size	Ratio	Variable	Category	Sample Size	Ratio
Education	Primary school and below	486	40.23%		More than standard	335	27.73%
	Junior school	514	42.55%		According to experience	605	50.08%
	Senior school	178	14.74%	Technical quantity	Unselected	114	9.44%
	High school and above	30	2.48%		1 kind	209	17.30%
Scale	≤5 mu	411	34.03%		2 kinds	295	24.42%
	5–10 mu	495	40.92%		3 kinds	249	20.61%
	10–15 mu	157	13.00%		4 kinds	174	14.40%
	>15 mu	145	12.00%		5 kinds or more	167	13.82%

3.2. Model Construction

3.2.1. Weighted-Frequency Method

In accordance with the National Sustainable Agricultural Development Plan (2015–2030) jointly released by multiple departments, and drawing from relevant studies [67,68], this study focused on two aspects: altering the methods and structure of fertilizer's application. Seven technology packages for fertilizer reduction and increasing efficiency were selected, including reduced fertilizer application, green manure cultivation, new efficient fertilizers, organic fertilizer substitution, soil testing and formula fertilization, straw mulching, and mechanical deep application. Farmers' preferences for these seven technologies were analyzed by ranking them based on their demand. The final comprehensive score for the intensity of the demand for each strategy was calculated by accumulating the frequency of each rank for every technology. The method is outlined below:

$$Z_k = \sum_{n=1}^{N} w_n R_n \tag{1}$$

where Z_k represents the comprehensive demand score for the kth strategy, and R_n and w_n represent the cumulative frequency and respective weight for the strategy ranked in the nth position. To mitigate potential errors arising from subjective weighting, this study employed an equal-interval weighting method, where $w_n = (7 - n)/6$. The descending arrangement of Z_k enables the identification of the priority sequence for farmers' preferences in selecting fertilizer-reduction and efficiency-increasing technologies.

3.2.2. Ordered-Probit Model

The dependent variable in this study represents the quantity of farmers' choices of fertilizer-reduction and efficiency-increasing technologies, with values ranging from 0 to 7 (0, 1, 2, 3, 4, 5, 6, 7), demonstrating a noticeable progressive relationship. This makes it suitable for analyzing the intensity of farmers' selection of fertilizer-reduction and efficiency-increasing technologies. Therefore, the ordered-probit model was selected for regression estimation with the specific mathematical expression as follows:

$$Y_i^* = aX_i + \varepsilon_i \tag{2}$$

In Equation (2), Y_i^* represents the unobservable latent variable, X_i represents the capital endowment and control variables, and ε_i is the random error term following a standard normal distribution. Although Y_i^* is unobservable, there exists an observable variable, Y, corresponding to it, defined by $r_0 < r_1 < r_2 < r_3 < r_5 < r_6$, that serves as a critical point for abrupt changes in Y_i^*. Therefore, the relationship between Y_i^* and Y can be described as follows:

$$Y_i = \begin{cases} 0 \text{ (Not adopted)} & Y_i^* \le r_0 \\ 1 \text{ (One adopted)} & r_0 < Y_i^* \le r_1 \\ 2 \text{ (Two adopted)} & r_1 < Y_i^* \le r_2 \\ 3 \text{ (Three adopted)} & r_2 < Y_i^* \le r_3 \\ 4 \text{ (Four adopted)} & r_3 < Y_i^* \le r_4 \\ 5 \text{ (Five adopted)} & r_4 < Y_i^* \le r_5 \\ 6 \text{ (Six adopted)} & r_5 < Y_i^* \le r_6 \\ \cdots\cdots & \\ j \text{ (}j\text{ adopted)} & r_{j-1} < Y_i^* \end{cases} \quad (3)$$

This implies that the probabilities for Y = 0, 1, 2, 3, 4, 5, 6, and 7 are as follows:

$$prob(Y = 0|X_i) = P\left(Y_i^* \le r_0 \middle| X_i\right) = \Phi(r_0 - aX_i) \quad (4)$$

$$prob(Y = 1|X_i) = P\left(r_0 < Y_i^* \le r_1 \middle| X_i\right) = \Phi(r_1 - aX_i) - \Phi(r_0 - aX_i) \quad (5)$$

$$prob(Y = j|X_i) = P\left(r_{j-1} < Y_i^* \middle| X_i\right) = 1 - \Phi\left(r_{j-1} - aX_i\right) \quad (6)$$

In Equations (4)–(6), Φ represents the cumulative probability function of the standard normal distribution. The coefficients a and r_i can be estimated using MLE, where a represents the marginal impact of the independent variable on the latent variable, indicating its influence on the probability of the dependent variable for different values of the independent variable.

3.2.3. Testing for Mediation Effects

This study adopts the testing method for mediation effects proposed by Zhonglin Wen et al. [69], utilizing a stepwise regression approach to establish regression models for the independent variable on the dependent variable, the independent variable on the mediator variable, and the independent and mediator variables on the dependent variable. The specific testing process is as follows:

$$Y = cX + \varepsilon_1 \quad (7)$$

$$M = aX + \varepsilon_2 \quad (8)$$

$$Y = c^{'}X + bM + \varepsilon_3 \quad (9)$$

In Equations (7)–(9), Y represents the dependent variable, indicating farmers' behaviors in choosing fertilizer-reduction and efficiency-increasing technologies; X is the core independent variable, reflecting capital endowment; and M is the mediator variable, representing the information-acquisition capability. The mediation effect is assessed through the following steps: First, the significance of the coefficient c in Equation (7) is examined. If it is significant, the mediation effect is considered; otherwise, it suggests a masking effect. Second, the significance of the coefficients a and b in Equations (8) and (9) is sequentially tested. If both are significant, a mediation effect exists. If at least one is not significant, further verification is required using the bootstrap method.

3.3. Variable Selection

3.3.1. Dependent Variables

The focal point of this study was the farmers' engagement in choosing fertilizer-reduction and efficiency-increasing technologies. The quantity of technologies chosen by farmers serves as an indicator to gauge their selection behavior [70]. Farmers usually do not select all of the subtechnologies in the technology package at once but gradually select each subtechnology in the technology package through "learning by doing" or "social learning" [71]. The ordered-probit model assigns a value of 0 to not adopting any fertilizer-reduction and efficiency-increasing technology, 1 to adopting only one technology, etc. The selection of all fertilizer-reduction and efficiency-increasing technologies is denoted by a value of 7 [14].

3.3.2. Core Independent Variables

The core independent variable in this study was capital endowment, primarily assessed across five dimensions: natural capital, material capital, human capital, economic capital, and social capital. For natural capital, considerations included the village's topography, land size, land quality, and the fragmentation level of the cultivated land. Material capital encompassed the number of agricultural machines, housing conditions, and the quantity of household appliances. Human capital included the education level, health status, gender structure, and the percentage of the labor force. Economic capital comprised the proportion of income from apple planting, income stability, and financing capability. Social capital encompassed social networks, trust, participation, reputation, and norms. After standardizing these indicators using the entropy method to calculate the weights, the levels of capital endowment in each dimension were objectively determined, and the comprehensive score of the capital endowment was further calculated.

3.3.3. Mediating Variables

In this study, information-acquisition capability was chosen as the mediating variable, drawing primarily on existing research [41]. Farmers' information-acquisition capability was assessed using four questions: "Can you easily access relevant information about new technologies?"; "Do you have sufficient ability to understand the newly acquired technologies?"; "Can you accurately identify the risks associated with the new technologies obtained?"; and "Can you quickly recognize the benefits brought by new technologies?". Respondents provided their answers on a Likert five-point scale, with options ranging from "Strongly Disagree" = 1; "Disagree" = 2; "Neutral" = 3; "Agree" = 4; and "Strongly Agree" = 5. The average value of the responses to these four questions is then used as the numerical representation of the level of information-acquisition capability.

3.3.4. Moderating Variables

Agricultural-technology extension was selected as the moderating variable in this study, measured from three aspects: technical training, financial subsidies, and government publicity. It was represented by three questions: "In the past five years, have you participated in training related to fertilizer-reduction and efficiency-increasing technologies?"; "In the past five years, have you received financial subsidies related to fertilizer-reduction and efficiency-increasing technologies?"; and "In the past five years, has the government conducted publicity on fertilizer-reduction and efficiency-increasing technologies?" The variable was assigned a value of 1 if applicable and 0 otherwise.

3.3.5. Control Variables

Various factors such as age, cadre identity, years of cultivation, risk aversion, understanding of fertilizer-reduction and efficiency-increasing policies, and membership in cooperatives were selected as the control variables affecting farmers' choices in fertilizer-reduction and efficiency-increasing technologies. Additionally, to control for differences in geographical location, climate conditions, and precipitation among different regions, variables of the virtual region were included to eliminate the impact of the region on farmers' choices in fertilizer-reduction and efficiency-increasing technologies. Specific assignments and the descriptive statistical analysis are detailed in Table 2.

Table 2. Variable definition and descriptive statistics.

Variable	Definition	Mean	Max	Min	Std.
Farmers' choices in fertilizer-reduction and efficiency-increasing technologies	The number of farmers' choices in fertilizer-reduction and efficiency-increasing technologies/numbers	2.621	7	0	1.656
Capital endowment	The entropy weighting method calculates the value	0.466	0.766	0.148	0.094
Natural capital	The entropy weighting method calculates the value	0.083	0.174	0.007	0.032
Village's topography	Flat land = 1; Sloping land = 2; Mountain = 3; Tableland = 4; Mountain platform = 5	1.477	3	1	0.819
Land size	Actual apple-planting area/acres	9.594	120	0.5	9.368
Land quality	Very poor = 1; Relatively poor = 2; Moderate = 3; Relatively good = 4; Good = 5	3.406	5	1	0.886
Fragmentation level of cultivated land	The area of land operated divided by the number of plots	4.918	80	0	5.353
Material capital	The entropy weighting method calculates the value	0.053	0.129	0.006	0.019
Number of agricultural machinery	The quantity of farm machinery owned by a household	2.088	8	0	1.515
Housing conditions	Stone kiln = 1; Adobe house = 2; Brick = 3; Brick = 4; Reinforced concrete = 5	3.624	5	1	0.920
Quantity of household appliances	The number of household appliances owned by the household	5.815	12	0	2.197
Human capital	The entropy weighting method calculates the value	0.061	0.097	0.019	0.137
Education level	The actual number of years of education	7.426	17	0	3.531
Health status	Very poor = 1; Poor= 2; Average = 3; Good = 4; Very good = 5	4.043	5	1	1.085
Gender structure	The proportion of male members in the total population of the household	0.548	1	0	1.575
Percentage of the labor force	Proportion of actual household labor force to total household population	0.758	1	0	0.224
Economic capital	The entropy weighting method calculates the value	0.130	0.312	0.000	0.066
Proportion of income from apple planting	Annual apple revenue as a percentage of total annual revenue	0.466	1	0	0.323
Income stability	Very unstable = 1; Rather unstable = 2; Moderate = 3; Relatively stable = 4; Very stable = 5	2.343	5	1	1.208
Financing capability	How easy is it to borrow money? Very difficult = 1; Rather difficult = 2; Moderate = 3; Relatively easy = 4; Very easy = 5	2.853	5	1	1.163
Social capital	The entropy weighting method calculates the value	0.140	0.223	0.009	0.044
Social networks	How are you moving around with friends and neighbors? Never = 1; Occasionally = 2; Generally = 3; Relatively frequently = 4; Frequently = 5	3.853	5	1	1.171
Social trust	How much do you trust your friends and neighbors? Very distrustful = 1; Distrustful = 2; Generally trusting = 3; More trusting = 4; Very trusting = 5	4.270	5	1	0.801

Table 2. *Cont.*

Variable	Definition	Mean	Max	Min	Std.
Social participation	Do you take part in village activities? Never = 1; Occasionally = 2; Generally = 3; Relatively frequently = 4; Frequently = 5	3.767	5	1	1.192
Social reputation	Do village people who have important matters to decide consult you? Never = 1; Occasionally = 2; Generally = 3; Relatively frequently = 4; Frequently = 5	3.156	5	1	1.375
Social norms	Do you consider the opinions of your friends and neighbors when adopting technology? Strongly disagree = 1; Disagree = 2; Neutral = 3; Agree = 4; Strongly agree = 5	3.508	5	1	1.187
Information-acquisition capability	Arithmetic mean	3.405	5	1	0.826
Agricultural-technology extension					
Technical training	Have you participated in training related to fertilizer-reduction and efficiency-increasing technologies in the past 5 years? Yes = 1; No = 0	0.623	1	0	0.485
Financial subsidies	Have you received financial subsidies related to fertilizer-reduction and efficiency-increasing technologies in the past 5 years? Yes = 1; No = 0	0.499	1	0	0.500
Government publicity	Has the government conducted publicity on fertilizer-reduction and efficiency-increasing technologies in the past 5 years? Yes = 1; No = 0	0.651	1	0	0.477
Age	Actual age of the head of household/Years	55.134	81	26	9.363
Cadre identity	Have you ever served as a village cadre? Yes = 1; No = 0	0.108	1	0	0.319
Years of cultivation	Actual planting years/Years	20.26	50	0	9.783
Risk aversion	Risk aversion index: 0–1	0.776	1	0	0.336
Understanding of fertilizer-reduction and efficiency-increasing policies	No knowledge = 1; Limited knowledge = 2; Moderate =3; Considerable knowledge = 4; Extensive knowledge = 5	2.515	5	1	1.251
Membership in cooperatives	Yes = 1; No = 0	0.203	1	0	0.402
Region	Shaanxi = 1; Gansu = 0	0.493	1	0	0.500

4. Model Estimation

4.1. Analysis of Farmers' Choices and Preferences concerning Fertilizer-Reduction and Efficiency-Increasing Technologies

In this study, an analysis of farmers' willingness, adoption rates, and demand preferences for seven fertilizer-reduction and efficiency-increasing technologies was conducted. As shown in Table 3, first, the farmers' overall willingness to select the seven fertilizer-reduction and efficiency-increasing technologies only exceeded 50%. This indicates that the sampled farmers had a relatively low willingness to select fertilizer-reduction and efficiency-increasing technologies, and there were differences in the willingness to select different technologies. Specifically, the willingness to select organic fertilizer substitution technology was 74.42%, while the willingness to select green manure cultivation was 52.40%. Second, among the fertilizer-reduction and efficiency-increasing technologies, the farmers currently have a higher adoption rate for organic fertilizer substitution and new efficient fertilizers, while the adoption rate for soil testing and formula fertilization is the lowest. Thirdly, the farmers' preferences for the priority order of fertilizer-reduction and efficiency-increasing technologies were as follows: organic fertilizer substitution, new efficient fertilizers, soil testing and formula fertilization, green manure cultivation, straw mulching, reduced fertilizer application, and deep mechanical fertilization. Ranking first, as a technology in demand, 484 households chose organic fertilizer substitution as their preferred technology, accounting for 40.07% of the sample's choice in this position, followed by new efficient fertilizers, accounting for 33.03% of the sample's choice in this position.

Table 3. Analysis of farmers' choices and preferences concerning fertilizer-reduction and efficiency-increasing technologies.

Preferences	Reduced Fertilizer Application	Green Manure Cultivation	New Efficient Fertilizers	Organic Fertilizer Substitution	Soil Testing and Formula Fertilization	Straw Mulching	Deep Mechanical Fertilization
First	176	115	399	484	314	232	114
Second	46	308	150	34	97	35	58
Third	6	242	5	306	193	79	66
Fourth	89	161	229	29	227	423	64
Fifth	396	198	39	90	126	93	460
Sixth	441	44	350	117	93	96	28
Seventh	54	140	36	148	158	250	418
Willingness %	56.21	52.4	70.28	74.42	58.03	52.48	56.46
Adoption rates %	28.81	35.51	69.04	75	9.77	23.43	28.23
Composite score	468.33	686.83	713.17	780.33	695.5	572.33	396.33
Preference order	6	4	2	1	3	5	7

4.2. Direct Impact of Capital Endowment on Farmers' Choices in Fertilizer-Reduction and Efficiency-Increasing Technologies

Multicollinearity tests were conducted on all variables using Stata 15.1. The obtained VIF values ranged from 1.05 to 7.82, with an average of 5.68. All values were below 10, indicating the absence of severe multicollinearity among the selected variables and meeting the independence requirement. The stepwise-regression method was employed to examine the impact of the overall capital-endowment index on the farmers' choices in fertilizer-reduction and efficiency-increasing technologies in Model (1). In Model (2), the dimensions of capital endowment were included to assess their influence on farmers' choices in fertilizer-reduction and efficiency-increasing technologies. Models (3) and (4) utilized the ordered-logit method for robustness checks. The testing and regression results for each model are outlined in Table 4.

Analyzing the results from Models (1) and (3), there is a significant positive correlation between capital endowment and farmers' choices of fertilizer-reduction and efficiency-increasing technologies, which was observed at the 1% significance level. Thus, it can be concluded that capital endowment has a direct significant and positive effect on farmers' choices in fertilizer-reduction and efficiency-increasing technologies. This implies that farmers with higher levels of capital endowment are more likely to choose these technologies. This finding supports Hypothesis H1. As a reflection of farmers' production capacity and technological proficiency, capital endowment fulfills the resource requirements such as labor, materials, and funds when farmers engage in technology selection, facilitating their decision-making process. Consequently, higher levels of capital endowment make it easier for farmers to meet the demands of and supply the resources necessary for agricultural production, resulting in an increased likelihood of opting for fertilizer-reduction and efficiency-increasing technologies.

Table 4. Estimation results of capital endowment on farmers' choices in fertilizer-reduction and efficiency-increasing technologies.

Variable	Oprobit		Ologit	
	(1)	(2)	(3)	(4)
Capital endowment	2.2236 *** (0.3420)		3.7466 *** (0.5873)	
Natural capital		−2.5936 ** (0.9985)		−4.1191 * (1.7502)
Material capital		7.9715 *** (1.6955)		13.6842 *** (2.9173)
Human capital		3.9119 (2.3018)		6.9968 (3.9796)
Economic capital		2.6667 *** (0.4993)		4.1800 *** (0.8765)
Social capital		1.5866 * (0.7250)		2.8338 * (1.2397)
Age	−0.0074 * (0.0034)	−0.0051 (0.0034)	−0.0125 * (0.0058)	−0.0088 (0.0060)
Cadre identity	0.1093 (0.0962)	0.1073 (0.0979)	0.1890 (0.1703)	0.1857 (0.1730)
Years of cultivation	0.0074 * (0.0033)	0.0082 * (0.0033)	0.0121 * (0.0057)	0.0138 * (0.0058)
Risk aversion	−0.3092 ** (0.0906)	−0.2624 ** (0.0912)	−0.4925 ** (0.1589)	−0.4221 ** (0.1609)
Understanding of fertilizer reduction and efficiency-increasing policies	0.1031 *** (0.0249)	0.0845 ** (0.0252)	0.1842 *** (0.0431)	0.1544 *** (0.0436)
Membership in cooperatives	0.4153 *** (0.0753)	0.3957 *** (0.0755)	0.7137 *** (0.1327)	0.6769 *** (0.1334)
Region	0.4309 *** (0.0629)	0.4633 *** (0.0692)	0.7660 *** (0.1101)	0.7880 *** (0.1208)
N	1208		1208	
LR chi^2	218.41	255.78	215.75	248.25
Pseudo R^2	0.0482	0.0564	0.0476	0.0547
Prob > chi^2	0.0000	0.0000	0.0000	0.0000

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Examining the results from Models (2) and (4), there are significant differences in the impact of various dimensions of capital endowment on the farmers' selection behavior toward fertilizer-reduction and efficiency-increasing technologies. Natural capital exhibited a negative impact on the farmers' selection of these technologies at a 10% significance level, indicating that farmers with higher levels of natural capital are less inclined to select these technologies. One plausible explanation is that richer natural capital corresponds to better land conditions for agricultural production, and the adoption of new technologies involves uncertainty. Consequently, farmers with abundant natural capital may exhibit a lower probability of selecting fertilizer-reduction and efficiency-enhancement technologies. The impact of human capital on the farmers' selection did not demonstrate statistical significance, suggesting that the influence of different dimensions of capital endowment on various fertilizer-reduction and efficiency-increasing technologies varies. As this study did not separately analyze different technologies and, instead, tested them collectively based on the total number of technologies chosen by farmers, this may have influenced the final results. Material capital, economic capital, and social capital positively affected the farmers' choices of fertilizer-reduction and efficiency-increasing technologies at significance levels of 1%, 1%, and 10%, respectively. This implies that farmers with higher levels of material capital, economic capital, and social capital are more likely to select fertilizer-reduction and efficiency-increasing technologies. A potential interpretation is that a higher level of material capital signifies better operational capacity and production conditions for farmers, facilitating the satisfaction of basic needs in agricultural activities. With increased economic capital, financial constraints are reduced, encouraging farmers to allocate more funds and time to agricultural production. Social capital reflects farmers' ability to access external resources through informal channels, reducing learning costs and establishing "soft constraints" that influence farmers' choices. Consequently, the farmers' selection behavior related to fertilizer-reduction and efficiency-increasing technologies exhibited a significant negative correlation with natural capital and a significant positive correlation with material capital, economic capital, and social capital, partially confirming Hypothesis H2.

Examining the control variables, the age of the household head showed a significant negative correlation at the 10% level with farmers' choices in fertilizer-reduction and efficiency-increasing technologies. This suggests that compared with younger farmers, older farmers have greater differences in their information-acquisition and learning ability. In addition, they rely more on traditional production experience, are used to conservative production methods, and are less likely to choose new technologies. The number of years spent in farming was subjected to significance testing and exhibited a positive coefficient, indicating that farmers with more experience in planting are more inclined to select fertilizer-reduction and efficiency-increasing technologies. The propensity for risk aversion, having passed the significance test with a negative coefficient, implies that farmers who favor risk are more likely to adopt this technology. The level of awareness regarding fertilizer-reduction and efficiency-increasing policies positively affected the adoption of these technologies at the 1% significance level. This suggests that farmers with a better understanding of relevant policies are more likely to adopt fertilizer-reduction and efficiency-increasing technologies. Joining a cooperative had a positive impact on the selection of fertilizer-reduction and efficiency-increasing technologies at the 1% significance level. Farmers who are members of cooperatives possess ample social capital [61]. This organizational structure not only enhances farmers' negotiation abilities and reduces production costs but also widens their information sources, mitigating information asymmetry. Through technical exchanges, farmers increase their likelihood of technology selection. The geographical region had a positive impact on farmers' selection of fertilizer-reduction and efficiency-increasing technologies at the 1% significance level. This indicates significant regional differences in farmers' selection behavior, possibly attributed to variations in technology extension policies across different regions [72].

4.3. Robustness Test

This study conducted robustness tests using different methodologies, including modifying the dependent variable and excluding specific samples. Firstly, the dependent variable was changed to whether farmers opted for fertilizer-reduction and efficiency-increasing technologies. A binary probit model was employed for regression, assigning a value of 1 to indicate selection behavior if a farmer chose at least one technology and 0 otherwise. Second, considering the limited cognitive and learning abilities of the elderly population in understanding fertilizer-reduction and efficiency-increasing technologies, samples with individuals aged 65 and above were excluded from the robustness test. Both approaches maintained the core variables, control variables, and regional dummy variables constant. The regression results in Table 5 indicate that there are no significant differences in coefficients, significance, and signs between the two approaches. This suggests the robustness of the previously estimated results, confirming the significant and positive impact of capital endowment on farmers' selection behavior related to fertilizer-reduction and efficiency-increasing technologies.

Table 5. Robustness test of capital endowment on farmers' choices in fertilizer-reduction and efficiency-increasing technologies.

Variable	**Modifying the Dependent Variable**		**Excluding Specific Samples**	
	(1)	**(2)**	**(1)**	**(2)**
Capital endowment	1.9141 ** (0.6443)		2.1922 *** (0.3663)	
Natural capital		−2.3881 (1.8254)		−3.005 ** (1.0582)
Material capital		10.8148 ** (3.4066)		7.6025 *** (1.8374)
Human capital		0.9089 (4.0354)		3.4811 (2.5541)
Economic capital		2.2549 * (0.9306)		2.9900 *** (0.5362)
Social capital		1.3304 (1.3457)		1.1900 (0.7953)
Control variables	Controlled		Controlled	
N	1208		1032	
LR chi^2	62.39	74.85	163.77	203.56
Pseudo R^2	0.0826	0.0991	0.0419	0.0521
Prob > chi^2	0.0000	0.0000	0.0000	0.0000

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

4.4. Mechanism Examination

The previous analysis suggests a significant and positive effect of capital endowment on farmers' selection behavior regarding fertilizer-reduction and efficiency-increasing technologies. However, further investigation is needed to understand the mechanism by which capital endowment affects this behavior. Following the steps and principles of testing for a mediation effect, we first assessed the significance of the regression coefficient of capital endowment on the farmers' selection behavior toward fertilizer-reduction and efficiency-increasing technologies, examining it for the presence of a mediation effect. If present, a subsequent analysis determines whether it is a complete or partial mediation effect. As depicted in the regression results in Table 6, the coefficient of capital endowment in column (1) is significantly positive at the 1% confidence level, indicating that capital endowment positively influences farmers' selection behavior toward fertilizer-reduction and efficiency-increasing technologies. In column (2), the estimated coefficient of capital endowment on the information-acquisition capability is 1.8401, and it is statistically significant at the 1% confidence level, suggesting that capital endowment enhances farmers' information-acquisition capabilities. In column (3), when both capital endowment and information-acquisition capability are simultaneously included in the regression equation, their coefficients are both significantly positive at the 1% confidence level, indicating a significant and positive impact on the selection behavior concerning fertilizer-reduction and efficiency-increasing technologies. Comparing the results of Models (1) and (3), with the inclusion of the mediator variable, the coefficient representing the impact of capital endowment on the farmers' selection behavior related to fertilizer-reduction and efficiency-increasing technologies decreased from 2.2236 to 1.8291. This indicates that part of the influence of capital endowment on farmers' selection behavior is realized through their information-acquisition capability, thus supporting hypothesis H3. In terms of variable parameters, the proportion of the mediating effect was 19.62%, signifying that approximately 19.62% of the impact of capital endowment on farmers' selection behavior related to fertilizer-reduction and efficiency-increasing technologies is achieved through the mediating role of the information-acquisition capability.

Table 6. Mediating effect test of the information-acquisition capability.

Variable	Oprobit			Ologit		
	(1)	(2)	(3)	(1)	(2)	(3)
	Technology Selection	Information-Acquisition Capability	Technology Selection	Technology Selection	Information-Acquisition Capability	Technology Selection
Capital endowment	2.2236 *** (0.3420)	1.8401 *** (0.2592)	1.8291 *** (0.3481)	3.7466 *** (0.5873)	1.8401 *** (0.2592)	3.0934 *** (0.5963)
Information-acquisition capability			0.2371 *** (0.0382)			0.4297 *** (0.0663)
Control variables	Controlled			Controlled		
N	1208			1208		
LR chi^2(F)	218.41	17.49	256.96	215.75	17.49	257.93
Pseudo R^2 (Adj R^2)	0.0482	0.0985	0.0567	0.0476	0.0985	0.0569
Prob > chi^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: *** $p < 0.001$.

5. Further Discussion

5.1. Moderating Effect of Agricultural-Technology Extension

Given the mediating role of information-acquisition capability in the influence of capital endowment on the selection of fertilizer-reduction and efficiency-increasing technologies, it is essential to explore whether the effect of the information-acquisition capability on farmers' selection behavior is subject to the influence of other factors. In other words, it is crucial to understand the boundary conditions under which the mediating effect operates. According to the theoretical analysis presented earlier, the impact of the information-acquisition capability on farmers' selection behavior concerning fertilizer-reduction and efficiency-increasing technologies may vary depending on the different modes of agricultural-technology extension. Therefore, drawing on the approach used by Wen Zhonglin et al. [69], this study introduces interaction terms between the information-acquisition capability and three types of agricultural-technology extension. This aims to investigate whether different modes of agricultural-technology extension moderate the impact of information-acquisition capability on farmers' selection behavior related to fertilizer-reduction and efficiency-increasing technologies. To mitigate the correlation between interaction terms and the variables constructed, the original variables were centralized.

The regression results in Table 7 reveal that the coefficient of the interaction term between information-acquisition capability and technical training is significant at the 10% level (0.1524), the coefficient of the interaction term between information-acquisition capability and subsidy is significant at the 5% level (0.1930), and the coefficient of the interaction term between information-acquisition capability and government publicity is significant at the 10% level (0.1767). All three coefficients align with the coefficient of information-acquisition capability. This implies that the three modes of agricultural-technology extension enhance the positive impact of information-acquisition capability on farmers' selection behavior toward fertilizer-reduction and efficiency-increasing technologies. In other words, technical training, subsidies, and government publicity play positive moderating roles, supporting hypothesis H4. One possible explanation is that technical training, subsidies, and publicity act as external factors that activate farmers' technological awareness. By boosting farmers' information-acquisition capability, production skills, and risk tolerance, these methods enhance farmers' objective assessments of fertilizer-reduction effects. Essentially, they alleviate farmers' traditional habits of applying fertilizer, positively encouraging farmers to select fertilizer-reduction and efficiency-increasing technologies.

Table 7. Test of moderating effects.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Information-acquisition capability	0.2614 *** (0.0377)	0.2608 *** (0.0377)	0.2615 *** (0.0377)	0.2525 *** (0.0378)	0.2663 *** (0.0376)	0.2653 *** (0.0376)
Technical training	0.6638 *** (0.0632)	0.6696 *** (0.0633)				
Financial subsidies			−0.3775 *** (0.0627)	−0.3810 *** (0.0627)		
Government publicity					0.5696 *** (0.0638)	0.5762 *** (0.0639)
Information-acquisition capability * Technical training		0.1524 * (0.0753)				
Information-acquisition capability * Financial subsidies				0.1930 ** (0.0733)		
Information-acquisition capability * Government publicity						0.1767 * (0.0767)
Control variables	Controlled		Controlled		Controlled	
N	1208		1208		1208	
LR chi^2	340.15	344.24	265.65	272.59	309.22	314.52
Pseudo R^2	0.0750	0.0759	0.0586	0.0601	0.0682	0.0694
Prob > chi^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

5.2. Heterogeneity of Moderating Effects

While agricultural-technology extension can effectively guide and regulate farmers' selection behavior concerning technologies, the impact of these efforts may vary because of differences in education levels and generational factors. These factors influence farmers' abilities to learn, understand, and adopt new technologies, creating significant heterogeneity in the effectiveness of technology extension. Given the diverse nature of farmers, the effects of technology extension may differ across educational backgrounds and generations. Therefore, this study examined whether the moderating effects of the three modes of agricultural-technology extension on the relationship between information-acquisition capability and farmers' selection behavior toward fertilizer-reduction and efficiency-increasing technologies exhibited variations based on education levels and generational differences.

5.2.1. Heterogeneity Analysis Based on Different Education Levels

This study categorized farmers into two groups according to their education levels: the "high-education" group, composed of individuals with a high-school education or above, and the "low-education" group, consisting of those with education levels at junior high school or below. The outcomes of the heterogeneity analysis for the moderating effects of the three modes of agricultural-technology extension are outlined in Table 8.

Table 8. Heterogeneity of moderating effects based on different education levels.

Variable	**High**	**Low**	**High**	**Low**	**High**	**Low**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Information-acquisition capability	0.1768 (0.1029)	0.2700 *** (0.0408)	0.2253 * (0.1023)	0.2554 *** (0.0411)	0.1882 (0.1028)	0.2733 *** (0.0408)
Technical training	1.002 *** (0.1775)	0.6272 *** (0.0681)				
Financial subsidies			−0.0744 (0.1614)	−0.4439 *** (0.0683)		
Government publicity					0.9553 *** (0.1790)	0.5244 *** (0.0688)
Information-acquisition capability * Technical training	0.6857 ** (0.2064)	0.0709 (0.0815)				
Information-acquisition capability * Financial subsidies			0.3974 * (0.1970)	0.1471 (0.0801)		
Information-acquisition capability * Government publicity					0.6995 ** (0.2093)	0.0942 (0.0830)
Control variables	Controlled		Controlled		Controlled	
N	183	1025	183	1025	183	1025
LR chi^2	91.30	258.52	57.41	218.37	88.17	232.12
Pseudo R^2	0.1272	0.0679	0.0800	0.0574	0.1228	0.0610
Prob > chi^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

The results from Table 8 indicate that in the high-education group, the coefficient of the interaction term between information-acquisition capability and technical training is significantly positive at the 5% level (0.6857). The coefficient of the interaction term between information-acquisition capability and financial subsidies is significantly positive at the 10% level (0.3974), and the coefficient of the interaction term between information-acquisition capability and government publicity is significantly positive at the 5% level (0.6995). However, in the low-education group, none of these coefficients are significant. This suggests that the three modes of agricultural-technology extension can enhance the positive impact of the information-acquisition capability, and this effect is more pronounced for farmers with a higher educational attainment. As farmers' educational attainment increases, their understanding and cognitive abilities strengthen, making it more likely for them to absorb and accept new knowledge and skills through agricultural-technology extension. This enables them to promptly address technical obstacles encountered in practice, thereby increasing their probability of choosing fertilizer-reduction and efficiency-increasing technologies. This observation aligns with the conclusions of existing research [73,74], indicating that for more effective agricultural-technology extension and information services, government departments tend to select farmers with abundant resource endowments as target recipients.

5.2.2. Heterogeneity Analysis Based on Different Generations

In this study, farmers were categorized into two groups based on the birth year of the household head: the "new generation" group, consisting of those born after 1975, and the "old generation" group, composed of those born in 1975 or earlier. This followed the approach of Liu Yanzhou et al. [75]. The results of the heterogeneity analysis for the moderating effects of the three modes of agricultural-technology extension in classifying farmer generations are presented in Table 9.

Table 9. Heterogeneity of moderating effects based on different generations.

Variable	New	Old	New	Old	New	Old
	(1)	(2)	(3)	(4)	(5)	(6)
Information-acquisition capability	0.1650 (0.0958)	0.2855 *** (0.0413)	0.1733 (0.0970)	0.2743 *** (0.0415)	0.1696 (0.0958)	0.2902 *** (0.0413)
Technical training	0.7741 *** (0.1726)	0.6500 *** (0.0683)				
Financial subsidies			−0.6120 *** (0.1708)	−0.3365 *** (0.0678)		
Government publicity					0.7721 *** (0.1735)	0.5404 *** (0.0690)
Information-acquisition capability * Technical training	0.2763 (0.2046)	0.1200 (0.0819)				
Information-acquisition capability * Financial subsidies			0.2385 (0.1941)	0.2020 * (0.0799)		
Information-acquisition capability * Government publicity					0.2802 (0.2044)	0.1464 (0.0835)
Control variables	Controlled		Controlled		Controlled	
N	181	1027	181	1027	181	1027
LR chi^2	48.05	316.77	41.37	254.94	47.78	288.14
Pseudo R^2	0.0699	0.0825	0.0602	0.0664	0.0695	0.0750
Prob > chi^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: *** $p < 0.001$; * $p < 0.05$.

According to the results in Table 9, for both the new- and old-generation groups, the coefficients of the interaction terms between information-acquisition capability and technical training, as well as information-acquisition capability and government publicity, are not statistically significant. This suggests that there is no heterogeneity in the moderating effects of technical training and government publicity across the different generational groups. However, in the old-generation group, the coefficient of the interaction term between information-acquisition capability and financial subsidies is significantly positive at the 10% significance level (0.2020), while in the new-generation group, it is not significant. This indicates that financial subsidies can enhance the positive impact of information-acquisition capability specifically for the old-generation farmers. One possible explanation is that, on the one hand, because of liquidity constraints, financial subsidies can effectively compensate for the shortcomings faced by the old-generation farmers, such as reduced opportunities for off-farm employment and insufficient income sources. This alleviates the adaptability risks and cost-increasing risks associated with new technologies, positively influencing the technology selections of farmers [76]. On the other hand, financial subsidies can be used to improve the communication and network facilities of the older generation of farmers and broaden the channels of access to information so that the older generation of farmers can more easily obtain technical information and improve their enthusiasm for technology decisions.

6. Discussion

6.1. Conclusions

This study is based on data from 1208 valid apple farmers in the provinces of Shaanxi and Gansu. Utilizing the weighted-frequency method to investigate the priority sequence of farmers' preferences for choosing fertilizer-reduction and efficiency-increasing technologies, we employed the ordered-probit model, the mediation-effect model, and the moderation-effect model. These were used to empirically analyze the impact and mechanisms of capital endowment on farmers' decisions regarding the selection of fertilizer-reduction and efficiency-increasing technologies. Additionally, the study explores the moderating role of agricultural-technology extension in this mechanism. The main conclusions are outlined as follows:

(1) Capital endowment significantly and positively influences farmers' selection of fertilizer-reduction and efficiency-increasing technologies. In essence, higher capital endowment levels correlate with an increased likelihood of farmers selecting fertilizer-reduction and efficiency-increasing technologies. More specifically, the selection of fertilizer-reduction and efficiency-increasing technologies is significantly and negatively associated with natural capital, as well as being significantly and positively associated with material capital, economic capital, and social capital.

(2) Information-acquisition capability acts as a mediating factor in the influence of capital endowment on farmers' decisions regarding fertilizer-reduction and efficiency-increasing technologies, with the proportion of the mediating effect being 19.62%

(3) The methods of agricultural-technology extension, such as technical training, financial subsidies, and government publicity, have a significantly positive moderating effect on the influence of information-acquisition capability on farmers' decisions to select fertilizer-reduction and efficiency-increasing technologies. That is to say, a higher intensity of agricultural-technology extension enhances the impact of information-acquisition capability on farmers' decisions regarding the selection of fertilizer-reduction and efficiency-increasing technologies. This indicates that the occurrence of farmers' technology selection is closely associated with the support provided by agricultural-technology extension.

(4) Educational attainment and generational differences resulted in distinct moderating effects for various agricultural-technology extension methods. The effects of technical training, financial subsidies, and government publicity were more prominent in the high-education group compared with the low-education group. Additionally, the impact of financial subsidies was more effective in the old-generation group compared with the new-generation group.

6.2. Policy Implications

On the basis of the findings of this study, the following recommendations can be put forward: (1) Prioritize the accumulation of farmers' capital endowment and fully exploit its role in promoting the adoption of fertilizer-reduction and efficiency-increasing technologies. On the basis of enhancing the constraints posed by farmers' capital endowment, optimize the structure of farmers' capital endowment. In terms of material capital, vigorously develop a socialized service system for agricultural production to compensate for shortcomings in material capital and to improve agricultural production efficiency. In economic capital, focus on developing the apple industry to ensure increased production and income for farmers, providing diverse financing services to alleviate financial constraints in agricultural production and to enhance farmers' economic capital. Regarding social capital, leverage the "acquaintance society" in rural areas as a channel for information dissemination, establish a resource-sharing platform, strengthen interactive communication among farmers, and effectively guide mutual learning among them. (2) Enhance farmers' information-acquisition capabilities. In addition to traditional technical services, broaden farmers' information channels through new media devices such as computers and smartphones. Simultaneously, intensify training efforts to enhance farmers' information-acquisition capabilities using a combination of online and offline methods. (3) Increase the government's efforts at agricultural-technology extension, improve farmers' information-acquisition capabilities, and stimulate their enthusiasm for technology adoption, with particular attention to differences in educational attainment and generational factors. Formulate targeted policy incentives for different types of farmers, such as strengthening subsidies for those with higher educational attainment and the older generation in terms of technology applicability. Actively conduct technology training and promotion for farmers with a higher educational attainment.

6.3. Limitations and Areas for Further Research

The research has important practical significance for improving the popularization and application of fertilizer-reduction and efficiency-increasing technologies for farmers, improving the quality of cultivated land, reducing the pollution of farmland ecological environment, promoting the sustainable development of agriculture, realizing the increase in farmers' income, and revitalizing the industry. Because agricultural production is highly dependent on and sensitive to climate change, the impact of climate change has gradually become an issue of great interest in the field of agricultural production research. This paper ignores the change in the capital endowment of farmers caused by climate change, which has an impact on the selection behavior of farmers related to fertilizer-reduction and efficiency-increasing technologies. At the same time, it is not clear whether the PLS-SEM method will affect the research results. This model does not have stringent requirements related to the data sample size, model identification problems and distribution state, and can effectively deal with collinearity problems among variables. Currently, it is often used in questionnaire survey data and is an effective method to estimate a causality model. In the future, research on the selection behavior of farmers concerning fertilizer-reduction and efficiency-increasing technologies can combine the advantages of different disciplines and use a variety of observational data, experimental data, and different research methods to conduct cross-research, and further panel data can be collected for analysis in the future. By carrying out follow-up research and obtaining continuous panel data, we can better reveal the mechanism by which capital endowments impact farmers' behavior in choosing fertilizer-reduction and efficiency-increasing technologies.

Author Contributions: Y.C.: Conceptualization, Methodology, Software, Formal analysis, Writing—original draft preparation; W.X.: Software and Formal analysis; M.Z.: Methodology, Validation, Data curation, Supervision, and Writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Major Research Projects of the National Social Science Fund of China entitled "Research on innovation and policy of agricultural green development system under the goal of double carbon" (No. 22&ZD083).

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The data used in this study contain sensitive information about the study participants, and they did not provide their consent to share these data publicly. A minimal dataset may be shared upon request from a qualified academic investigator for the sole purpose of replicating the present study.

Acknowledgments: The authors are grateful to the individuals who volunteered to participate.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Lin, J. Rural Reforms and Agricultural Growth in China. *Am. Econ. Rev.* **1992**, *82*, 34–51.
2. Paudel, K.P.; Lohr, L.; Martin, N.R. Effect of risk perspective on fertilizer choice by sharecroppers. *Agric. Syst.* **2000**, *66*, 115–128. [CrossRef]
3. Abdoulaye, T.; Sanders, J.H. Stages and determinants of fertilizer use in semiarid African agriculture: The Niger experience. *Agric. Econ.* **2005**, *32*, 167–179. [CrossRef]
4. Qi, Y.; Chen, X.; Zhang, J.; Li, Y.; Zhu, D. How Do Rising Farmland Costs Affect Fertilizer Use Efficiency? Evidence from Gansu and Jiangsu, China. *Land* **2022**, *11*, 1730. [CrossRef]
5. Zhang, X.; Davidson, E.A.; Mauzerall, D.L.; Searchinger, T.D.; Dumas, P.; Shen, Y. Managing nitrogen for sustainable development. *Nature* **2015**, *528*, 51–59. [CrossRef] [PubMed]
6. Gao, L.; Zhang, W.; Mei, Y.; Sam, A.G.; Song, Y.; Jin, S. Do farmers adopt fewer conservation practices on rented land? Evidence from straw retention in China. *Land Use Policy* **2018**, *79*, 609–621. [CrossRef]
7. Lefroy, R.; Bechstedt, H.; Rais, M. Indicators for sustainable land management based on farmer surveys in Vietnam, Indonesia, and Thailand. *Agric. Ecosyst. Environ.* **2000**, *81*, 137–146. [CrossRef]
8. Xuan, W.S.; Dušan, D.; Junbiao, Z. How channels of knowledge acquisition affect farmers' adoption of green agricultural technologies: Evidence from Hubei province, China. *Int. J. Agric. Sustain.* **2023**, *21*. [CrossRef]
9. Zhang, S.; Sun, Z.; Ma, W.; Valentinov, V. The effect of cooperative membership on agricultural technology adoption in Sichuan, China. *China Econ. Rev.* **2020**, *62*. [CrossRef]
10. Hattam, C. Adopting Organic Agriculture: An Investigation Using the Theory of Planned Behaviour. In Proceedings of the 2006 Annual Meeting, Queensland, Australia, 12–18 August 2006.
11. Zhang, L.; Bai, Y.; Sun, M.; Xu, X.; He, J. Views on Agricultural Green Production from the Perspective of System Science. *Issues Agric. Econ.* **2021**, *42*, 42–50. [CrossRef]
12. Schreinemachers, P.; Chen, H.; Nguyen, T.T.L.; Buntong, B.; Bouapao, L.; Gautam, S.; Le, N.T.; Pinn, T.; Vilaysone, P.; Srinivasan, R. Too much to handle? Pesticide dependence of smallholder vegetable farmers in Southeast Asia. *Sci. Total Environ.* **2017**, *593–594*, 470–477. [CrossRef] [PubMed]
13. Yamamura, E. Experience of technological and natural disasters and their impact on the perceived risk of nuclear accidents after the Fukushima nuclear disaster in Japan 2011: A cross-country analysis. *J. Socio-Econ.* **2012**, *41*, 360–363. [CrossRef]
14. Zhang, Y.; Long, H.; Li, Y.; Ge, D.; Tu, S. How does off-farm work affect chemical fertilizer application? Evidence from China's mountainous and plain areas. *Land Use Policy* **2020**, *99*, 104848. [CrossRef]
15. Xie, D.; Gao, W. Low-carbon transformation of China's smallholder agriculture: Exploring the role of farmland size expansion and green technology adoption. *Environ. Sci. Pollut. Res.* **2023**, *30*, 105522–105537. [CrossRef]
16. Ren, Z.; Zhong, K. Driving mechanism of subjective cognition on farmers' adoption behavior of straw returning technology: Evidence from rice and wheat producing provinces in China. *Front. Psychol.* **2022**, *13*, 922889. [CrossRef]
17. Savari, M.; Eskandari Damaneh, H.; Eskandari Damaneh, H.; Cotton, M. Integrating the norm activation model and theory of planned behaviour to investigate farmer pro-environmental behavioural intention. *Sci. Rep.* **2023**, *13*, 5584. [CrossRef]
18. Ma, G.; Dai, X.; Luo, Y. The Effect of Farmland Transfer on Agricultural Green Total Factor Productivity: Evidence from Rural China. *Int. J. Environ. Res. Public Health* **2023**, *20*, 2130. [CrossRef]
19. He, Z.; Jia, Y.; Ji, Y. Analysis of Influencing Factors and Mechanism of Farmers’ Green Production Behaviors in China. *Int. J. Environ. Res. Public Health* **2023**, *20*, 961.
20. Huang, Y.; Luo, X.; Liu, D.; Yu, W.; Tang, L. Factors affecting farmers' adoption of organic fertilizer instead of chemical fertilizer-explaining the phenomenon of farmers' little behavior with strong willingness. *Resour. Environ. Yangtze Basin* **2019**, *28*, 632–641.
21. Hall, T.J.; Dennis, J.H.; Lopez, R.G.; Marshall, M.I. Factors Affecting Growers' Willingness to Adopt Sustainable Floriculture Practices. *HortScience* **2009**, *44*, 1346–1351. [CrossRef]
22. Kabir, J.; Cramb, R.; Alauddin, M.; Gaydon, D.S.; Roth, C.H. Farmers' perceptions and management of risk in rice/shrimp farming systems in South-West Coastal Bangladesh. *Land Use Policy* **2020**, *95*, 104577. [CrossRef]

23. Du, S.; Luo, X.; Huang, Y.; Tang, L. Does labor migration promote farmers to adopt green control techniques? *China Popul. Resour. Environ.* **2021**, *31*, 167–176.
24. Aldana, U.; Foltz, J.; Barham, B.; Useche, P. Sequential Adoption of Package Technologies: The Dynamics of Stacked Trait Corn Adoption. *Am. J. Agric. Econ.* **2011**, *93*, 130–143. [CrossRef]
25. Negatu, W.; Parikh, A. The impact of perception and other factors on the adoption of agricultural technology in the Moret and Jiru Woreda (district) of Ethiopia. *Agric. Econ.* **1999**, *21*, 205–216. [CrossRef]
26. Griliches, Z. Hybrid Corn: An Exploration in the Economics of Technological Change. *Econometrica* **1957**, *4*, 501–522. [CrossRef]
27. Guo, Z.; Zhang, X. Carbon reduction effect of agricultural green production technology: A new evidence from China. *Sci. Total Environ.* **2023**, *874*, 162483. [CrossRef] [PubMed]
28. Yue, M.; Li, W.-J.; Shan, J.; Jing, C.; Chang, Q.; Glyn, J.; Chao, Y.; Yang, G.-J.; Li, Z.-H.; Lynn, J.F. Farmers' precision pesticide technology adoption and its influencing factors: Evidence from apple production areas in China. *J. Integr. Agric.* **2023**, *22*, 292–305. [CrossRef]
29. Zheng, X.; Wang, F.; Ying, R. Farmers' endowment constraints, technical properties and agricultural technology selection preferences: An analytical framework of farmers' technology adoption under an incomplete factor market. *Chin. Rural. Econ.* **2018**, 105–122. [CrossRef]
30. Ramirez, O.; Shultz, S. Poisson Count Models to Explain the Adoption of Agricultural and Natural Resource Management Technologies by Small Farmers in Central American Countries. *J. Agric. Appl. Econ.* **2000**, *32*, 21–33. [CrossRef]
31. Zhang, T.; Yan, T.; He, K.; Zhang, J. Impact of capital endowment on peasants' willingness to invest in green production: Taking crop straw returning to the field as an example. *China Popul. Resour. Environ.* **2017**, *27*, 78–89.
32. Wang, X.; Zhang, J.; Tong, Q. Can participating in agricultural technology training promote farmers to implement green production behavior? Based on the analysis of family endowment and ESR model. *Resour. Environ. Yangtze Basin* **2021**, *1*, 202–211.
33. Li, H.; Yin, M.; Ma, Y.; Kang, Y.; Jia, Q.; Qi, G.; Wang, J. Effects of planting scale and fragmentation on the behavior of smallholders' farmland quality protection: Taking the application of pesticide and fertilizer in vegetable cultivation as an example. *China Land Sci.* **2022**, *36*, 74–84.
34. Mi, Q.; Li, X.; Li, X.; Yu, G.; Gao, J. Cotton farmers' adaptation to arid climates: Waiting times to adopt water-saving technology. *Agric. Water Manag.* **2021**, *244*, 106596. [CrossRef]
35. Qiao, D.; Xu, S.; Xu, T.; Hao, Q.; Zhong, Z. Gap between Willingness and Behaviors: Understanding the Consistency of Farmers’ Green Production in Hainan, China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 11351. [PubMed]
36. Li, H.; Wang, C.; Chang, W.; Liu, H. Factors affecting Chinese farmers' environment-friendly pesticide application behavior: A meta-analysis. *J. Clean. Prod.* **2023**, *409*, 137277. [CrossRef]
37. Xu, X.; Wang, F.; Xu, T.; Khan, S.U. How Does Capital Endowment Impact Farmers' Green Production Behavior? Perspectives on Ecological Cognition and Environmental Regulation. *Land* **2023**, *12*, 1611. [CrossRef]
38. Wang, H.; Wang, X.; Sarkar, A.; Zhang, F. How Capital Endowment and Ecological Cognition Affect Environment-Friendly Technology Adoption: A Case of Apple Farmers of Shandong Province, China. *Int. J. Environ. Res. Public Health* **2021**, *18*, 7571. [CrossRef] [PubMed]
39. Shikuku, K.; Pieters, J.; Bulte, E.; Laderach, P. Incentives and the Diffusion of Agricultural Knowledge: Experimental Evidence from Northern Uganda. *Am. J. Agric. Econ.* **2019**, *10*, 1164–1180. [CrossRef]
40. Luh, Y.; Jiang, W.; Chien, Y. Adoption of genetically-modified seeds in Taiwan. *China Agric. Econ. Rev.* **2014**, *6*, 669–697. [CrossRef]
41. Chen, Z.; Li, X.; Xia, X.; Zhang, J. The impact of social interaction and information acquisition on the adoption of soil and water conservation technology by farmers: Evidence from the Loess Plateau, China. *J. Clean. Prod.* **2024**, *434*, 139880. [CrossRef]
42. Jiang, W.; Yan, T.; Chen, B. Impact of media channels and social interactions on the adoption of straw return by Chinese farmers. *Sci. Total Environ.* **2021**, *756*, 144078. [CrossRef]
43. Xu, J.; Cui, Z.; Wang, T.; Wang, J.; Yu, Z.; Li, C. Influence of Agricultural Technology Extension and Social Networks on Chinese Farmers' Adoption of Conservation Tillage Technology. *Land* **2023**, *12*, 1215. [CrossRef]
44. Richardson, J.G. *Handbook of Theory and Research for the Sociology of Education*; Greenwood Press: New York, NY, USA, 1986.
45. Khaledi, M.; Weseen, S.; Sawyer, E.; Ferguson, S.; Gray, R. Factors Influencing Partial and Complete Adoption of Organic Farming Practices in Saskatchewan, Canada. *Can. J. Agric. Econ./Rev. Can. D'Agroecon.* **2010**, *58*, 37–56. [CrossRef]
46. Qian, L.; Wang, J.; Wang, X.; Wang, Y. The impact of alternative policies on livestock farmers' willingness to recycle manure: Evidence from central China. *China Agric. Econ. Rev.* **2020**, *12*, 583–594. [CrossRef]
47. Ellis, F. *Rural Livelihood Diversity in Developing Countries: Evidence and Policy Implications*; Natural Resource Perspectives, ODI (NRP): Brighton, UK, 1999.
48. Tan, S.; Heerink, N.; Kuyvenhoven, A.; Qu, F. Impact of land fragmentation on rice producers' technical efficiency in South-East China. *China's Agric. Dev. Chall. Prospect.* **2010**, *57*, 117–123. [CrossRef]
49. Fleisher, B.; Li, H.; Zhao, M.Q. Human capital, economic growth, and regional inequality in China. *J. Dev. Econ.* **2010**, *92*, 215–231. [CrossRef]
50. Paustian, M.; Theuvsen, L. Adoption of precision agriculture technologies by German crop farmers. *Precis. Agric.* **2017**, *18*, 701–716. [CrossRef]
51. Erbaugh, D.; Donnermeyer, J. Assessing the Impact of Farmer Field School Participation on IPM Adoption in Uganda. *J. Int. Agric. Ext. Educ.* **2010**, *17*, 5–17. [CrossRef]

52. Wossen, T.; Berger, T.; Di Falco, S. Social capital, risk preference and adoption of improved farm land management practices in Ethiopia. *Agric. Econ.* **2015**, *46*, 81–97. [CrossRef]
53. Isham, J. The Effect of Social Capital on Fertiliser Adoption: Evidence from Rural Tanzania. *J. Afr. Econ.* **2002**, *11*, 39–60. [CrossRef]
54. Doyle, J. Social trust, cultural trust, and the will to sacrifice for environmental protections. *Soc. Sci. Res.* **2023**, *109*, 102779. [CrossRef]
55. Schmitt Olabisi, L.; Wang, Q.; Ligmann-Zielinska, A. Why Don't More Farmers Go Organic? Using A Stakeholder-Informed Exploratory Agent-Based Model to Represent the Dynamics of Farming Practices in the Philippines. *Land* **2015**, *4*, 979–1002. [CrossRef]
56. Khataza, R.; Doole, G.; Kragt, M.; Hailu, A. Information acquisition, learning and the adoption of conservation agriculture in Malawi: A discrete-time duration analysis. *Technol. Forecast. Soc.* **2018**, *132*, 299–307. [CrossRef]
57. Genius, M.; Pantzios, C.; Tzouvelekas, V. Information Acquisition and Adoption of Organic Farming Practices: Evidence from Farm Operations in Crete, Greece. *J. Agric. Resour. Econ.* **2006**, *31*, 93–113.
58. Wozniak, G.D. Joint Information Acquisition and New Technology Adoption: Late versus Early Adoption. *Rev. Econ. Stat.* **1993**, *75*, 438–445. [CrossRef]
59. Van Campenhout, B.; Spielman, D.J.; Lecoutere, E. Information and Communication Technologies to Provide Agricultural Advice to Smallholder Farmers: Experimental Evidence from Uganda. *Am. J. Agric. Econ.* **2021**, *103*, 317–337. [CrossRef]
60. Barrett, C.; Islam, A.; Malek, M.; Pakrashi, D.; Ruthbah, U. Experimental Evidence on Adoption and Impact of the System of Rice Intensification. *Am. J. Agric. Econ.* **2021**, *104*, 4–32. [CrossRef]
61. Xiang, W.; Gao, J. Do Not Be Anticlimactic: Farmers' Behavior in the Sustainable Application of Green Agricultural Technology—A Perceived Value and Government Support Perspective. *Agriculture* **2023**, *13*, 247. [CrossRef]
62. Wang, X.; Zhang, J. Basic path and system construction of agricultural green and low-carbon development with respect to the strategic target of carbon peak and carbon neutrality. *Chin. J. Eco-Agric.* **2022**, *4*, 516–526.
63. Chesterman, N.S.; Entwistle, J.; Chambers, M.C.; Liu, H.; Agrawal, A.; Brown, D.G. The effects of trainings in soil and water conservation on farming practices, livelihoods, and land-use intensity in the Ethiopian highlands. *Land Use Policy* **2019**, *87*, 104051. [CrossRef]
64. Mao, H.; Quan, Y.; Fu, Y. Risk preferences and the low-carbon agricultural technology adoption: Evidence from rice production in China. *J. Integr. Agric.* **2023**, *22*, 2577–2590. [CrossRef]
65. Geleta, S.; Natcher, D.; Henry, C.J. The effect of information networks on the scaling out of new agricultural technologies: The case of pulse variety adoption in Southern Ethiopia. *J. Rural Stud.* **2023**, *99*, 153–166. [CrossRef]
66. Hu, R.; Cai, Y.; Chen, K.; Cui, Y.; Huang, J. Effects of inclusive public agricultural extension service: Results from a policy reform experiment in Western China. *China Econ. Rev.* **2012**, *23*, 962–974. [CrossRef]
67. Zhou, W.; He, J.; Liu, S.; Xu, D. How Does Trust Influence Farmers’ Low-Carbon Agricultural Technology Adoption? Evidence from Rural Southwest, China. *Land* **2023**, *12*, 466.
68. Li, C.; Li, X.; Jia, W. Non-Farm Employment Experience, Risk Preferences, and Low-Carbon Agricultural Technology Adoption: Evidence from 1843 Grain Farmers in 14 Provinces in China. *Agriculture* **2023**, *13*, 24. [CrossRef]
69. Wen, Z.; Zhang, L.; Hou, J.; Liu, H. Testing and application of the mediating effects. *Acta Psychol. Sin.* **2004**, *36*, 614–620.
70. Willy, D.K.; Holm-Müller, K. Social influence and collective action effects on farm level soil conservation effort in rural Kenya. *Ecol. Econ.* **2013**, *90*, 94–103. [CrossRef]
71. Genius, M.; Koundouri, P.; Nauges, C.; Tzouvelekas, V. Information Transmission in Irrigation Technology Adoption and Diffusion: Social Learning, Extension Services, and Spatial Effects. *Am. J. Agric. Econ.* **2014**, *96*, 328–344. [CrossRef]
72. Foster, A.; Rosenzweig, M. Microeconomics of Technology Adoption. *Annu. Rev. Econ.* **2010**, *2*, 395–424. [CrossRef] [PubMed]
73. Verhaeghen, P.; Salthouse, T. Meta-analyses of age-cognition relations in adulthood: Estimates of linear and nonlinear age effects and structural models. *Psychol. Bull.* **1997**, *122*, 231–249. [CrossRef]
74. Kabir, M.H.; Rainis, R. Adoption and intensity of integrated pest management (IPM) vegetable farming in Bangladesh: An approach to sustainable agricultural development. *Environ. Dev. Sustain.* **2015**, *17*, 1413–1429. [CrossRef]
75. Liu, Y.; Wang, F.; Guo, Y.; Song, D. Farmer differentiation, generational difference and acceptability of rural housing mortgage loan. *Chin. Rural Econ.* **2016**, *9*, 16–29.
76. Chatzimichael, K.; Genius, M.; Tzouvelekas, V. Informational cascades and technology adoption: Evidence from Greek and German organic growers. *Food Policy* **2014**, *49*, 186–195. [CrossRef]