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Influence of Agricultural Technology Extension and Social Networks on Chinese Farmers' Adoption of Conservation Tillage Technology

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Abstract: Agricultural technology extension and social networks are the essential components of formal and informal institutions, respectively, and their influence on agricultural production has been the focus of academics. This article takes conservation tillage technology as an example, based on simple random unduplicated sampling, and uses survey data of 781 farmers in Heilongjiang, Henan, Shandong, and Shanxi provinces of China. This article empirically tests the interaction effects and heterogeneity of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology and analyzes their substitution effect or complementary effect. The results showed the following: (1) From a single dimension, 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. The average probability of farmers who accept agricultural technology extension and social networks adopting conservation tillage technology increases by 36.49% and 7.09%, respectively. (2) There is a complementary effect between agricultural technology extension and social networks in promoting farmers' adoption of conservation tillage technology. The two functions complement and support each other, and this complementary effect is more evident in social networks' reciprocity. (3) Further analysis reveals that the interaction effect between agricultural technology extension and social networks has significant group differences, technology type differences, and regional differences in farmers' adoption of conservation tillage technology. Therefore, to facilitate the extension and application of conservation tillage technology, efforts need to be made in both agricultural technology extension and social networks, fully leveraging the complementary effects of the two. In addition, differentiated policies and measures should be adopted according to local conditions, and precise policies should be implemented for different groups and technologies.

Keywords: conservation tillage technology; agricultural technology extension; social networks; substitution effect; complementary effect

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1. Introduction

Conservation tillage originated in the United States in the 1940s, and by 1988, it had grown to be applied in more than 700 countries [1]. In 2003, the total global conservation tillage area reached 72 million hectares [2], and now the proportion of agricultural production that incorporates conservation tillage in the United States, Canada, Brazil, and other countries has reached 70% [3]. Experimental research on conservation tillage in China began in the 1960s and has developed rapidly, but there is still a large gap compared to developed agricultural countries [4]. In particular, China has a complex and diverse range of cropland types, ecological regions, and cropping systems, and there are significant regional differences in the choice of conservation tillage practices [5]. The practice

has proved that conservation tillage is an effective way to protect and utilize farmland and is an important tool to implement the strategy of "hiding food in the land and food in technology", which is an inevitable choice and strategic idea to ensure national food security in the new development stage [6].

Currently, China has achieved significant results in the comprehensive protection and utilization of farmland [7], but the degradation of farmland quality and the intensification of ecological and environmental risks in farmland use are more prominent [8,9], posing a threat to national food security and sustainable agricultural development [10]. Conservation tillage technology can effectively improve soil properties [11,12], enhance soil fertility [13,14], reduce wind erosion and water erosion [15,16], increase grain yield [17,18], reduce greenhouse gas emissions [19,20], and increase farmers' income [21]. It has significant ecological and economic benefits.

Farmers are the main implementers and direct beneficiaries of conservation tillage technology [22]. The key reasons are as follows: on the one hand, farmers have a "second-best" path dependence on traditional farming technology [23]; on the other hand, technological and institutional changes face a series of constraints, including policy factors [24], technological factors, economic factors [25], and individual farmer factors [26]. Therefore, it is of great theoretical significance and practical value to investigate the important factors that motivate farmers' adoption of conservation tillage technology and to scientifically formulate relevant measures to promote the dissemination and application of conservation tillage technology.

Changes in agricultural structures, government decentralization, and the development of emerging information and communication technologies have led to diversified and low-cost agricultural technology extension and advisory services [27]. Public agricultural extension is a key force in supporting the development of modern agriculture and an important policy tool for the government to support agriculture. As an important part of the formal institution, agricultural technology extension refers to the activities of transforming and applying advanced agricultural technologies and scientific and technological achievements to the agricultural production process through experiments, demonstrations, training, guidance and consulting services, etc. It has the advantages of wide coverage, diversified methods, and high accuracy of information, and it mainly relies on government power to facilitate its role. In 2021, the Rural Revitalization and Promotion Law of the People's Republic of China was promulgated and implemented. This law emphasizes "strengthening the construction of agricultural technology extension system, promoting the establishment of incentive mechanisms and benefit-sharing mechanisms conducive to the transformation and extension of agricultural scientific and technological achievements, and provide services for agricultural technology extension". At present, Chinese agricultural extension has achieved remarkable results, with the grassroots agricultural technology team steadily growing, technology supply efficiency steadily improving, and agricultural technology associations with extension channels gradually becoming more prominent, which has become an effective way to promote agricultural science and technology progress and agricultural and rural modernization, while also providing an important driving force to motivate farmers to adopt conservation tillage technology.

At the same time, individual farmers' behavior is not completely isolated; social relationships play an important role in shaping behavior [28]. In the traditional relational society of rural China, farmers, as members of rural society, are not only bound by formal rules in their behavior but are often influenced by rural social networks as well [29]. In the traditional relationship society of rural China, farmers, as members of rural society, are not only bound by formal rules but are often influenced by rural social networks [30]. Social networks are a form of social organization based on "networks" (interconnections between nodes) rather than "groups" (clear boundaries and order) [31]. As an important element of informal institutions, social networks influence the economic behavior of farmers through individual interactions, social relationships, and unwritten norms [32]. It has been shown that social networks are an important factor influencing the agricultural production

behavior of farmers [33]. Therefore, when analyzing farmers' adoption of conservation tillage technology, it is necessary to focus not only on the important role of agricultural technology extension but also on the influence of farmers' social networks.

Agricultural technology extension and social networks, as essential components of formal and informal institutions, have received widespread attention in agricultural production. So, what is the impact of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology? What is the relationship between the two in the process of influencing farmers' adoption of conservation tillage technology? Additionally, does this relationship significantly vary in different situations? These are key issues that urgently need to be explored and resolved. Therefore, this article focuses on three core issues: Firstly, what are the separate effects of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology? Secondly, what is the relationship between agricultural technology extension and social networks? Thirdly, does the relationship between agricultural technology extension and social networks vary in different situations?

Compared with previous studies, the innovation of this paper lies in the following: Firstly, an indicator system of social networks is built using the three dimensions of strength, reputation, and reciprocity, incorporating agricultural technology extension and social networks into the same empirical model to study farmers' adoption of conservation tillage technology, accurately measuring the marginal effect of the two, and testing the substitution effect or complementary effect between the two. Compared to existing research, it is more holistic and systematic. Secondly, it is to analyze the relationship between agricultural technology extension and different dimensions of social networks in influencing farmers' adoption of conservation tillage technology. Based on different groups, technologies, and regions, the differences in the interaction effects between agricultural technology extension and social networks were examined, enriching the research on farmers' adoption of conservation tillage technology.

2. Literature Review

2.1. The Relationship between Agricultural Technology Extension and Farmers' Adoption of Agricultural Technology

Regarding the relationship between agricultural technology extension and farmers' adoption, the mainstream view is that agricultural technology extension will promote farmers' adoption of agricultural technology. Feyisa found through a meta-analysis that agricultural technology extension services would significantly increase the adoption rate of agricultural technologies by small farmers in Ethiopia [34]. Li et al. found that a digital extension service based on smartphones significantly increased the probability of farmers adopting soil testing and formulated fertilization technology [35]. Zhao et al. found that an increasing number of agricultural technology extension service organizations promoted biological pesticides through online technical guidance and released technical science videos on new media platforms, which improved the probability of farmers' access to and adoption of bio-pesticide technology [36].

At the same time, some studies also found that the extension of agricultural technology has a partial spillover effect while improving the technology adoption level of farmers, which can promote the technology adoption probability of elderly farmers and small-scale farmers [37]. Different from the studies mentioned above, some studies showed that public agricultural technology extension plays a significant role in the initial stage of new technology dissemination. However, as time goes by, more and more farmers realize the importance of new agricultural technology and begin to adopt it, which leads to the gradual weakening of the marginal effect of agricultural technology extension [38]. Lambrech et al. found that there was significant gender heterogeneity in the effect of agricultural technology extension, female participation in agricultural technology extension was not necessarily conducive to the realization of the agricultural technology extension goal [39]. In addition, other studies showed that government agricultural technology extension services are

mainly obtained by farmers with wealth and power, while vulnerable farmers can hardly access agricultural technology extension services [40,41]. To some extent, it hinders the popularization and dissemination of new agricultural technologies.

2.2. The Relationship between Social Networks and Farmers' Adoption of Agricultural Technology

Regarding the relationship between social networks and farmers' adoption of agricultural technology, the mainstream view is that social networks will promote farmers' adoption of agricultural technology. In some developing countries, farmers usually receive agricultural information from local social networks rather than directly from governments and non-governmental organizations [42]. Communication and interaction between farmers are important channels for them to obtain agricultural technologies [43]. Within a single village area, people will face almost the same environmental conditions and factor constraints. Farmers have similar production and management cognition and working habits, as well as high homogeneity of technical interaction [44]. Therefore, in the implementation of multi-party agricultural protection projects, farmers are more inclined to interact with participating farmers in local social networks [45]. Oriana and Imran found that farmers' neighbors and friends have a significant impact on their decisions for new technology adoption [46].

Social learning exists in the diffusion processes of new agricultural technologies; that is, farmers may follow the agricultural production behaviors of farmers who have been successful in their social networks [47]. In addition, social networks can effectively promote farmers to adopt agricultural technology by reducing the uncertainty of technology adoption [48] and functioning as an information channel [49]. In contrast to the above views, some scholars believe that although the training of demonstration farmers can encourage other farmers to imitate the agricultural technology adopted by demonstration farmers, the difference in socioeconomic status among farmers cannot ensure effective communication between ordinary farmers and demonstration farmers in a village [50]. It makes it impossible for ordinary farmers to imitate and learn the adoption of agricultural technology by demonstration farmers. Munshi discussed the learning problem of a heterogeneous population in the spreading process of the "green technology revolution" in India and found that the heterogeneity of social networks will rapidly weaken the information flow [51], which is not conducive to farmers' learning of new agricultural technology. In addition, the decision delay caused by the externality of social network information will also defer farmers' adoption of new agricultural technologies [52].

2.3. Literature Review and Research Directions

After reviewing the literature, it can be seen that although there have been many studies exploring the impact of agricultural technology extension and social networks on farmers' adoption of agricultural technology, there is still room for further expansion and improvement. Firstly, the conclusions on the impact of agricultural technology extension and social networks on farmers' adoption of agricultural technology are not consistent. Therefore, this article takes conservation tillage technology as the research object and conducts further empirical tests. Secondly, existing research generally overlooks the inherent relationship between agricultural technology extension and social networks in influencing farmers' adoption of agricultural technology and has not included them in the same framework for overall systematic research, making it difficult to present the interactive logic between the two. Thirdly, existing research has not yet examined the differential impact of the relationship between agricultural technology extension and social networks on farmers' adoption of agricultural technology in different situations.

Therefore, this article uses survey data of 781 farmers in Heilongjiang, Henan, Shandong, and Shanxi provinces of China, empirically explores the effect of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology, and examines their interaction effect. At the same time, the heterogeneities of the interaction effect between agricultural technology extension and social networks in different situations

were further investigated. These works provide useful references for the government to formulate relevant policies to promote conservation tillage.

3. Theoretical Analysis

3.1. The Separate Effects of Agricultural Technology Extension and Social Networks on Farmers' Adoption of Conservation Tillage Technology

As one of the "green box policies" encouraged by the World Trade Organization for investment, agricultural technology extension is considered by most scholars as an important political measure to improve agricultural productivity [53–55]. After more than 70 years of development, China has formed an agricultural technology extension system with national, provincial, municipal, county, and township departments, which has made great contributions to agricultural development. The agricultural technology extension has the advantages of wide coverage, diversified methods, and high accuracy of information, which are conducive to the extension and application of agricultural technology. The theoretical logic is proposed in the following three aspects:

First, the direct promotion effect of agricultural technology extension. The replacement of old technologies with new technologies and the extension of new technologies both depend on the promotion strategy of government departments, which combines compulsion and inducement. The compulsory promotion strategy is reflected in the fact that agricultural technology extension is a top-down process. The government can effectively gather dispersed farmers and ensure the timely and orderly development of technology promotion by relying on the institutional advantages of administrative power. The inductive promotion strategy is manifested in that the government actively supports demonstration farmers through interest publicity and policy support and promotes them to play a leading role in demonstration, to reform the agricultural technology [56], and to promote farmers to adopt advanced agricultural technology.

Second, the indirect promotion effect of agricultural technology extension. According to Schulz's human capital theory, the effective way to transform traditional agriculture is to educate and train farmers. The process of agricultural technology extension is also the process of improving farmers' cognition and learning ability. When farmers accept and learn new technology, they often face the problem of a lack of cognition and ability. Dissemination of knowledge and technology through the agricultural technology extension not only improves the cognition of farmers but also expands and enriches the knowledge reserve of farmers, enhances the ability of farmers to learn and apply technology, and contributes to the improvement of the efficiency and level of technology extension.

Third, the diffusion effect of agricultural technology extension. According to the theory of agricultural technology diffusion, technology diffusion can be divided into four stages: the breakthrough stage, the critical stage, the following stage, and the following general trend stage. With the passage of the diffusion stage, more and more farmers adopt the new technology, and the new technology begins to be popularized [57]. Accordingly, this article proposes the first hypothesis:

Hypothesis 1: *Agricultural technology extension has a positive effect on farmers' adoption of conservation tillage technology.*

The social networks of farmers are a relatively stable relationship system formed by connecting them through certain relationships with high-density and short transmission paths [29]. It plays an important role in farmers' technology adoption decisions [58]. Rural China is a typical acquaintance society, where the relationship network between farmers and acquaintances, such as relatives, friends, and neighbors, is built upon factors such as blood, kinship, and geography. By extending, expanding, and maintaining social network relationships, farmers' advantages in accessing resources and opportunities are significantly improved [47]. In terms of the adoption of agricultural technology, the following can be said:

On the one hand, farmers who adopt new agricultural technologies will face high information search and learning costs [59]. Expanding information channels through social networks can reduce information asymmetry in technology adoption, promote information dissemination and sharing, improve farmers' understanding of technology, and ultimately promote their decision-making on technology adoption. At the same time, through communication and learning with farmers who have already adopted new technologies, more knowledge about new technologies can be obtained, the learning cost of technology adoption can be reduced, and the time for technology application can be greatly shortened.

On the other hand, social networks have a risk-sharing mechanism, which is a powerful supplement to resist risks [60]. There will be certain risks and uncertainties in the implementation process of new technologies, and farmers' extensive communication and cooperation through social networks can help resolve technical risks, reduce uncertainty, and, to a certain extent, ensure the effectiveness and quality of technology implementation. In addition, the mutual benefit and assistance formed by farmers in long-term interaction can enhance trust among farmers and help achieve resource sharing and optimized allocation, which not only promotes the diffusion and dissemination of new technologies but also reduces the transaction costs of technologies. Accordingly, this article proposes the second hypothesis:

Hypothesis 2: *Social networks have a positive effect on farmers' adoption of conservation tillage technology.*

3.2. The Influence of the Interaction Effect between Agricultural Technology Extension and Social Networks on Farmers' Adoption of Conservation Tillage Technology

There is a substitution effect between agricultural technology extension and social networks, which means that social networks form a certain substitution for agricultural technology extension.

On the one hand, although agricultural technology can be transferred "top-down" by relying on the extension system of agricultural technology, it cannot obtain positive responses from farmers "bottom-up". That reduces the contribution rate of agricultural technology to agricultural production [61]. The close social networks among farmers can effectively break the asymmetry of technical information transmission. Relying on strong networks, farmers can form interest groups, which can more quickly express their appeals and opinions to the grassroots government to promote farmers' extensive participation in agricultural technology extension, access to technical training, guidance, and relevant services, and receive effective feedback. At the same time, the production characteristics of small-scale decentralized management increase the difficulty of agricultural technology extension. Social networks such as villagers, relatives, and friends can promote the spread of agricultural technology, promote the spread and extension of technology to rural areas in remote areas, and form a substitution effect for agricultural technology extension.

On the other hand, because farmers' knowledge and cognition levels are generally low, the technology dissemination formed through agricultural technology extension can ensure the accuracy of information [37]. However, compared with this one-sided form of technology dissemination, farmers can learn and apply agricultural technology through social networks, and the interactions will be more frequent and in-depth. The inherent trust and understanding among farmers are the most likely to trigger their real emotions, which is conducive to the formation of a stable community of interests. They can also significantly reduce the risk of farmers adopting new technologies, thus improving the efficiency and sustainability of technology adoption. Accordingly, this article proposes the third hypothesis:

Hypothesis 3: *Agricultural technology extension and social networks have a substitution effect on farmers' adoption of conservation tillage technology.*

There is a complementary effect between agricultural technology extension and social networks, and their functions are also complementary. Agricultural technology extension and social networks, as two different communication modes of agricultural technology extension and application, can complement each other in their influences on farmers' adoption of conservation tillage technology.

On the one hand, as technology dissemination is led and implemented by the government, agricultural technology extension has the advantages of high information accuracy and diversified methods [62]. As the leader and implementer, the government can effectively guarantee agricultural technology extension and carry out the extension of agricultural knowledge and agricultural technology through training, publicity, and guidance, which helps to improve the knowledge level and cognition of farmers. In this way, farmers can easily adopt and apply conservation tillage technology.

On the other hand, social networks form a beneficial supplement to agricultural technology extension [63]. Through the extension of social networks, farmers have expanded their social relationships, deepened their understanding of technology through continuous communication and exploration, and presented a clear "herd effect". At the same time, the stable and close social network relationships between farmers provide intellectual, financial, and material support for technology application, question answering, and process assurance, which helps to improve the technology adoption rate of social networks' members and form functional complementarity with the government-led agricultural technology extension. Accordingly, this paper proposes the fourth hypothesis:

Hypothesis 4: *Agricultural technology extension and social networks have a complementary effect on farmers' adoption of conservation tillage technology*.

4. Materials and Methods

4.1. Data

The data are based on a survey of farmers in Heilongjiang, Henan, Shandong, and Shanxi provinces in China from January to February 2022. According to the "Code for the Implementation of Conservation Tillage Projects" and "Key Technical Points of Conservation Tillage", there are six suitable areas to research the implementation of conservation tillage technology within the Northeast Plain monopoly area: the Great Wall along the agricultural and pastoral areas, the northwest loess plateau area, the northwest oasis agricultural area, the Huang-Huai-Hai plain cropping area, and the southern water and dry continuous crop area. Heilongjiang belongs to the Northeast Plain monopoly crop area and the western arid and wind-blown sand area, Henan and Shandong belong to the Huang-Huai-Hai plain cropping area, and Shanxi belongs to the Northwest loess plateau area and the North China Great Wall along the area. At the same time, Heilongjiang, Henan, and Shandong are typical representatives of the main grain-producing areas, and Shanxi is a representative of the grain production and marketing balance area, so the selection of the above four provinces as the research area is both typical and representative.

The research follows the principle of simple random unduplicated sampling, obtaining the list of farmers in advance and selecting the sample of farmers in the surveyed area by machine selection. The respondents include small farmers, large-scale professional farmers, family farms, and other new types of agricultural businesses. The food crops planted mainly include corn, rice, wheat, soybeans, etc. A total of 819 questionnaires were collected, and 781 effective questionnaires were obtained by sorting out the collected questionnaires, with an effective rate of 95.36%. Among the questionnaires, 230 were from Heilongjiang, together with 197 from Henan, 187 from Shandong, and 167 from Shanxi. The survey was mainly conducted in the form of one-to-one interviews with farmers, and questionnaires were filled out by trained researchers to fully ensure the authenticity of each questionnaire. The subjects of this survey are all heads of farmers, and the questionnaire covers individual characteristics of farmers, family characteristics,

production and management characteristics, technology adoption and farmers' social networks, etc.

As shown in Table 1, male heads of farmers accounted for 85.28% of the survey samples. Those aged 50 to 59 years old accounted for 46.22%. The education level of the farmers is generally low, and 79.77% had an education level of junior high school or below. More than half of the farmers are in good health, accounting for 50.06%. Most of the farmers had an income that was less than 100,000 RMB, accounting for 78.87%. The number of agricultural laborers concentrated on 2 or 3 people, accounting for 76.18%. Farmers' scale of the land operation was generally small, accounting for 66.58% of the total of 1 hectare or less. In addition, only 17.29% of farmers joined cooperatives.

Table 1. Basic sample characteristics.

Basic Features	Options	Frequency (%)	Basic Features	Options	Frequency (%)
Gender	Male	666 (85.28)	Education level	Primary school and below	238 (30.47)
	Female	115 (14.72)		Junior high school	385 (49.30)
Age	(0, 29]	10 (1.28)		Senior high school or secondary school	129 (16.52)
	[30, 39]	30 (3.84)		Associate college and above	29 (3.71)
	[40, 49]	185 (23.69)	Number of agricultural laborers	1	165 (21.13)
	[50, 59]	361 (46.22)		2 or 3	595 (76.18)
	[60, +∞)	195 (24.97)		[4, +∞)	21 (2.69)
Health status	Very poor	2 (0.26)	Farmers' income	(0, 50,000 RMB]	309 (39.56)
	Comparatively poor	44 (5.63)		(50,000, 100,000 RMB]	307 (39.31)
	General	226 (28.94)		(100,000 RMB, +∞)	165 (21.13)
	Comparatively well	391 (50.06)	Scale of land operation	(0, 1 hm^2]	520 (66.58)
	Very well	118 (15.11)		(1–2 hm^2]	100 (12.80)
Cooperatives	Yes	135 (17.29)		(2–3 hm^2]	48 (6.15)
	No	646 (82.71)		(3 hm^2, +∞)	113 (14.47)

4.2. Models

To test the effect of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology, the following econometric model was established:

$$Tech_{ij} = \alpha_0 + \beta_1 Exten_{ij} + \gamma X_{ij} + \lambda_j + \varepsilon_{ij} \quad (1)$$

$$Tech_{ij} = \alpha_1 + \beta_2 Net_{ij} + \gamma X_{ij} + \lambda_j + \varepsilon_{ij} \quad (2)$$

$$Tech_{ij} = \alpha_2 + \beta_3 Exten_{ij} + \beta_4 Net_{ij} + \gamma X_{ij} + \lambda_j + \varepsilon_{ij} \quad (3)$$

In Equations (1)–(3), i and j denote the farmer and the province where the farmer is located, respectively. $Tech_{ij}$ is the explanatory variable, indicating whether the farmer adopts conservation tillage technology or not. $Exten_{ij}$ and Net_{ij} are the core explanatory variables, denoting agricultural technology extension and social networks, respectively. X_{ij} denotes a set of control variables. The intercept terms are represented by $\alpha_0, \alpha_1, \alpha_2$, ε_{ij} is the random error, and $\beta_1, \beta_2, \beta_3, \beta_4, \gamma$ are a series of coefficients to be estimated. In addition, a range of unobservable variables at the provincial level may simultaneously affect farmers' adoption of conservation tillage technology, agricultural technology extension, and social networks, leading to biased estimation results. In this regard, the model controls for area effect at the provincial level λ_j.

To further explore the substitution or complementary effect of agricultural technology extension and social networks in influencing farmers' adoption of conservation tillage technology, the interaction terms of agricultural technology extension and social networks were constructed, and the following econometric model was established:

$$Tech_{ij} = \alpha_3 + \beta_5 Exten_{ij} + \beta_6 Net_{ij} + \beta_7 Exten_{ij} \times Net_{ij} + \gamma X_{ij} + \lambda_j + \varepsilon_{ij} \quad (4)$$

In Equation (4), the meaning of the variables is the same as in Equations (1)–(3), where $Exten_{ij} \times Net_{ij}$ denotes the interaction term between agricultural technology extension and social networks. In the empirical analysis, observing β_7 helps to determine the substitution effect or complementary effect between agricultural technology extension and social networks. If β_7 is positive, it means that there is a complementary effect between the agricultural technology extension and social networks; if β_7 is negative, it means that there is a substitution effect between the agricultural technology extension and social networks. As the explanatory variables in the above models are binary categorical variables, the baseline regressions are analyzed using a binary Probit model.

4.3. Variables

4.3.1. Explained Variables

The explained variable represents whether the farmer adopts conservation tillage technology. Referring to existing studies [64–68], this article defines conservation tillage as follows: conservation tillage is a system engineering and comprehensive technology system combining agricultural machinery and agriculture. It is the integration of multiple technologies. The core technologies of conservation tillage not only cover tillage technologies, such as straw returning to the field, sowing with less and no-tillage, and subsoiling, but also cultivation and planting technologies, such as intercropping, strip planting, and crop rotation, as well as green production technologies such as integrated prevention and control of diseases, pests and grasses, soil testing and fertilizer formula, and increased application of organic fertilizers. Therefore, farmers who adopted any one or more of these conservation tillage technologies were assigned a value of 1, and those who did not were assigned a value of 0. In the survey sample, 60.18% of farmers adopted conservation tillage technology.

4.3.2. Explanatory Variables

This article selects agricultural technology extension as the proxy variable of the formal institution. The survey asked farmers, "does the local government promotes conservation tillage technology to you, and assigned the value Yes = 1 and No = 0". At the same time, this article constructs the variable of agricultural technology extension degree to carry out the robustness test. Through the survey, farmers were asked "how much do you think the government promotes conservation tillage technology, and assigned values of none = 0, less = 1, average = 2, and more = 3" for measurement. Social networks were chosen as a proxy variable of the informal institution, mainly from the "interaction with friends and relatives", "interaction with local villagers", "whether you are the village cadre", and "communication experience of conservation tillage technology implementation with others", along with four aspects and descriptions, and the four equally weighted averages were calculated as observed values of indicators of social networks.

Social networks are variables that are difficult to observe directly. Based on different research data and analysis perspectives, scholars also have some differences in the measurement dimensions of social networks. Based on relevant studies [69], this article constructs measurement indicators of social networks from three dimensions: strength, reputation, and reciprocity. The content of social networks' strength mainly includes the situation of interacting with their relatives and friends and the situation of interacting with their local villagers. In rural areas of China, farmers with a higher reputation are more likely to become the "forerunner" and "guide" in the application of agricultural technology, thus helping to drive other farmers to follow and emulate. Therefore, the village cadre status of farmers is selected as the proxy variable of social networks' reputation. Social networks' reciprocity is also considered to be an important dimension of social networks. Reciprocity among farmers will promote the rapid diffusion and dissemination of new agricultural technologies. This study measured social network reciprocity among farmers by asking them, "How often have you communicated experience of conservation tillage technology implementation with others?"

4.3.3. Control Variables

This article constructs control variables from four aspects: individual characteristics of farmers (gender, age, education level, and health status), family characteristics (farmers' income and the number of agricultural laborers), production and management characteristics (scale of land operation and cooperatives), and policy cognition. In addition, to control the influence of differences in resource endowment and economic development level among regions on farmers' adoption of conservation tillage technology, this article fixed the provincial control variables. Variable definitions and descriptive statistics are detailed in Table 2.

Table 2. Variable definitions and descriptive statistics.

Variables	Definition	Mean	S.D.
Technology adoption	Whether to adopt conservation tillage technology. Yes = 1; No = 0	0.6018	0.4898
Agricultural technology extension	Does the local government promote conservation tillage technology to you? Yes = 1; No = 0	0.4699	0.4994
Degree in agricultural technology extension	How much do you think the government promotes conservation tillage technology? None = 0; Less = 1; Average = 2; More = 3	0.8169	0.9397
Social networks	Interaction with friends and relatives. Never = 1; Infrequently = 2; Usually = 3; More often = 4; Very often = 5	3.9283	0.7268
	Interaction with local villagers. Never = 1; Infrequently = 2; Usually = 3; More often = 4; Very often = 5	3.7785	0.7801
	Whether you are the village cadre. Yes = 1; No = 0	0.0602	0.2380
	Communicating experience of conservation tillage technology implementation with others. Never = 1; Infrequently = 2; Usually = 3; More often = 4; Very often = 5	3.3457	0.9020
Gender	Male = 1; Female = 0	0.8528	0.3546
Age	The actual age of the farmer (years)	54.3892	9.6255
Education level	Primary school and below = 1; Junior high school = 2; Senior high school or secondary school = 3; Associate college and above = 4	1.9347	0.7842
Health status	Very poor = 1; Comparatively poor = 2; General = 3; Comparatively well = 4; Very well = 5	3.7414	0.7892
Farmers' income	Annual farmers' income (RMB) expressed as natural logarithms	10.9491	0.8646
Number of agricultural laborers	Number of family farming laborers (pcs)	1.9078	0.6174
Scale of land operation	Area of family-run farmland (hm^2)	2.1398	5.7855
Cooperatives	Whether to join a cooperative. Yes = 1; No = 0	0.1729	0.3784
Policy cognition	Cognitive situation of conservation tillage policies: not familiar = 1, not very familiar = 2, average = 3, relatively familiar = 4, very familiar = 5	2.4277	0.7789
Provinces	Is it Heilongjiang? Yes = 1; No = 0	0.2945	0.4561
	Is it Henan? Yes = 1; No = 0	0.2522	0.4346
	Is it Shandong? Yes = 1; No = 0	0.2394	0.4270
	Is it Shanxi? Yes = 1; No = 0	0.2138	0.4103

5. Analysis and Discussions

5.1. Analysis of the Separate Effects of Agricultural Technology Extension and Social Networks

5.1.1. Analysis of Benchmark Regression Results

The binary Probit model is used to test the separate effect of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology. To overcome the potential heteroscedasticity, the robust standard error is adopted for empirical analysis. The results are shown in Table 3. Model 1 to Model 4 included a single core explanatory variable (agricultural technology extension or social networks), while Model 1 and Model 3 merely considered the individual characteristics of farmers. Model 2 and Model 4 added the family characteristics, management characteristics, and policy cognition of farmers. Model 5 included agricultural technology extension, social network variables, and all control variables. At the same time, the province fixed effect is introduced into the model, which can better solve the endogenous problem of the model. The results show that both agricultural technology extension and social networks can significantly promote farmers' adoption of conservation tillage technology, and Hypothesis 1 and Hypothesis 2 are verified.

Table 3. Baseline regression results for agricultural technology extension and social networks.

Variables	Model 1 (Individual Characteristics)	Model 2 (All Characteristics)	Model 3 (Individual Characteristics)	Model 4 (All Characteristics)	Model 5 (All Characteristics)
Agricultural technology extension	1.2679 ***	1.2788 ***			1.2907 ***
	(0.1161)	(0.1280)			(0.1281)
Social networks			0.2015 *	0.1909 *	0.2510 **
			(0.1041)	(0.1105)	(0.1139)
Gender	0.1547	0.0894	0.1815	0.0498	0.1131
	(0.1499)	(0.1573)	(0.1332)	(0.1406)	(0.1573)
Age	0.0046	0.0040	−0.0137 **	−0.0012	0.0043
	(0.0062)	(0.0066)	(0.0057)	(0.0061)	(0.0066)
Education level	−0.1845 **	−0.1045	0.0123	0.0371	−0.0957
	(0.0744)	(0.0813)	(0.0665)	(0.0757)	(0.0814)
Health status	−0.0436	−0.0097	−0.1234 *	−0.1076	−0.0307
	(0.0745)	(0.0764)	(0.0702)	(0.0710)	(0.0756)
Farmers' income		0.1794 **		0.3381 ***	0.1967 ***
		(0.0714)		(0.0719)	(0.0716)
Number of agricultural laborers		0.2619 ***		0.1967 **	0.2510 **
		(0.0981)		(0.0882)	(0.1000)
Scale of land operation		−0.0014 *		−0.0019 **	−0.0016 *
		(0.0008)		(0.0009)	(0.0008)
Cooperatives		−0.5138 ***		−0.4439 ***	−0.4888 ***
		(0.1446)		(0.1502)	(0.1488)
Policy cognition		−0.1322 *		0.0405	−0.1583 **
		(0.0768)		(0.0682)	(0.0782)
Provincial control	Yes	Yes	Yes	Yes	Yes
Constant term		−2.5632 **		−4.3332 ***	−3.3549 ***
		(1.0082)		(1.0324)	(1.0631)
Observations	781	781	781	781	781
Pseudo R^2	0.2091	0.2471	0.0871	0.1417	0.2514

Note: *, **, and *** indicate significance at the levels of 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses.

According to the results of Model 5, agricultural technology extension and social networks can significantly improve the probability of farmers' adoption of conservation tillage technology at the level of 1% and 5%, respectively, and the calculated average marginal effect is 0.3649 and 0.0709. The probability of farmers' adoption of conservation tillage technology increased by 36.49% and 7.09% on average for farmers who accepted agricultural technology extension and had strong social networks. On the one hand, grassroots agricultural extension organizations have promoted the dissemination and diffusion of conservation tillage technology through various forms of technology publicity and extension work, reducing the search cost and access cost of farmers, thus increasing the probability

of farmers obtaining the technology. On the other hand, the social networks formed by farmers relying on the inherent blood and geopolitical ties in rural areas realize the sharing and diffusion of conservation tillage technologies and exert a significant spillover effect. At the same time, the exchange and cooperation among farmers and reciprocal mutual assistance effectively reduce the risk of technology implementation, ensure the effectiveness of technology implementation, and promote the sustainable and stable adoption of technology. The research showed that formal and informal institutions play an important role in the promotion and application of conservation tillage technology, but whether there is a substitution effect or complementary effect between agricultural technology extension and social networks needs to be tested empirically.

Among the control variables, farmers' income had a significant positive effect on farmers' adoption of conservation tillage technology, indicating that the higher the farmers' income, the more willing farmers were to adopt conservation tillage technology. This is consistent with the research conclusions of Gideon et al. [70] and Cai et al. [71]. The possible reason is that higher incomes of farmers help ease the financial constraints of technology adoption and lower the threshold of technology use, thus promoting farmers' adoption of conservation tillage technology. The number of agricultural laborers has a significant positive effect on farmers' adoption of conservation tillage technology, indicating that the more agricultural laborers, the more willing farmers are to adopt conservation tillage technology. Conservation tillage technology requires a certain amount of labor. A household with a larger agricultural labor force indicates a more productive household.

The scale of land operation has a significant negative effect on the adoption of conservation tillage technology. Guo et al. [65] and De Souza Filho et al. [72] also reached the same conclusion. On the one hand, the larger the scale of land operation, the higher the labor and material cost required by farmers to adopt conservation tillage technology. To reduce agricultural production costs, farmers will reduce or give up the adoption of technology. On the other hand, farmers with a larger scale of land operation will face higher income uncertainty and risk in agricultural production, which inhibits the enthusiasm of farmers to adopt conservation tillage technology. Participation in cooperatives has a significant negative impact on farmers' adoption of conservation tillage technology, which may be due to the lack of service capacity of cooperatives in the sample areas, leading to the lack of technical guidance and services for farmers to participate in cooperatives and the decrease of their enthusiasm in adopting conservation tillage technology.

In addition, policy cognition has a significant negative impact on farmers' adoption of conservation tillage technology. Although some farmers have a clear understanding of conservation tillage policies, conservation tillage technology, as an important means under the new model of green agriculture, is uncertain and risky. To avoid risks, farmers will reduce their willingness to adopt it to a certain extent.

5.1.2. Robustness Test

To test the reliability of the above empirical analysis results, this article mainly uses the methods of replacing models, winsorize treatment, replacing core explanatory variables, and sub-sample regression to test the robustness of the benchmark regression conclusions. The results are shown in Table 4. Among them, Model 6 is the result of using OLS regression. Model 7 is the result of using 1% and 99% percentile narrowing for continuous variables in the sample. Model 8 is the result of using the degree of agricultural technology extension to replace the core explanatory variable for regression. Model 9 is the result of excluding samples aged 65 and above for regression. It should be noted that considering the older age of farmers, their physical strength and management ability may decline, which will have a negative impact on agricultural production and operation. Therefore, this article excluded samples aged 65 and above for re-regression. The results show that after the above robustness test, agricultural technology extension and social networks still have a significant positive impact on farmers' adoption of conservation tillage technology, which

is consistent with the above benchmark regression results. Therefore, it can be considered that the promotion effect of agricultural technology extension and social networks is stable.

Table 4. Robustness test results.

Variables	Model 6 (Logit Model)	Model 7 (Winsorize Treatment)	Model 8 (Replacing Core Explanatory Variable)	Model 9 (Sub-Sample Regression)
Agricultural technology extension	0.3940 ***	1.2819 ***	0.6527 ***	1.2655 ***
	(0.0352)	(0.1282)	(0.0693)	(0.1361)
Social networks	0.0621 *	0.2615 **	0.2235 **	0.2393 *
	(0.0341)	(0.1131)	(0.1100)	(0.1224)
Control variables	Yes	Yes	Yes	Yes
Provincial control	Yes	Yes	Yes	Yes
Constant term	−0.4707	−3.7571 ***	−3.3188 ***	−3.6672 ***
	(0.3142)	(1.0681)	(1.0448)	(1.2223)
Observations	781	781	781	677
R^2/Pseudo R^2	0.2915	0.2534	0.2389	0.2520

Note: *, **, and *** indicate significance at the levels of 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses.

5.2. Analysis of Interaction Effect between Agricultural Technology Extension and Social Networks

The baseline regression results confirm that both agricultural technology extension and social networks significantly promote farmers' adoption of conservation tillage technology. However, whether there is a substitution effect or a complementary effect between agricultural technology extension and social networks still needs an empirical test. This article constructs the interaction terms of agricultural technology extension and social networks for regression. In the empirical analysis, the interaction variables were centralized to overcome the multicollinearity problem and ensure that the interaction effect has strong explanatory power. The empirical results are shown in Table 5. Model 10 is the baseline regression result of the interaction effect between agricultural technology extension and social networks. Models 11 to 14 are the robustness test results of OLS regression, 1% and 99% quantiles of continuous variables, agricultural technology extension degree instead of core explanatory variables, and results excluding samples over 65 years old. The research results show that the interaction coefficients between agricultural technology extension and social networks in Models 10 to 14 are significantly positive and are significant at the levels of 10%, 10%, 10%, 10%, and 5%, respectively. This indicates that there is a complementary effect between agricultural technology extension and social networks, where formal institutions with agricultural technology extension as the proxy variable and informal institutions with social networks as the proxy variable jointly play a role in promoting farmers' adoption of conservation tillage technology, achieving mutual complementarity and support. Hypothesis 4 has been verified.

Grassroots agricultural technology extension organizations fulfill the public welfare responsibilities of agricultural technology extension, relying on professional service teams, demonstration bases, and other entities and platforms to actively implement the task of fine technology promotion. They fully leverage the advantages of high accuracy, diversified methods, and wide coverage of agricultural technology extension information, providing practical guarantees for promoting the implementation and application of conservation tillage technology. At the same time, the social networks of farmers provide useful supplements for agricultural technology extension organizations to carry out technology promotion work. Social networks have obvious advantages in information acquisition, social learning, and risk-taking. In rural acquaintance societies, the probability of farmers accessing and learning conservation tillage technology through social networks increases, and their cognitive and knowledge levels also improve, thereby increasing their enthusiasm for technology adoption. In addition, the stronger the social networks of farmers, the stronger their ability to resist risks, which can reduce the risks and uncertainties of adopting

conservation tillage technology and ensure the effectiveness of technology implementation. Moreover, social networks can effectively exert spillover effects and help promote the learning and adoption of conservation tillage technology by surrounding farmers.

Table 5. Regression results of the interaction effect between agricultural technology extension and social networks.

Variables	Model 10 (Probit Model)	Model 11 (Logit Model)	Model 12 (Winsorize Treatment)	Model 13 (Replacing Core Explanatory Variable)	Model 14 (Sub-Sample Regression)
Agricultural technology extension	1.2941 ***	0.3955 ***	1.2848 ***	0.6485 ***	1.2710 ***
	(0.1276)	(0.0351)	(0.1277)	(0.0699)	(0.1353)
Social networks	0.2679 **	0.0637 *	0.2765 **	0.2480 **	0.2550 **
	(0.1165)	(0.0335)	(0.1153)	(0.1146)	(0.1248)
Agricultural technology extension × social networks	0.4005 *	0.1200 *	0.3874 *	0.2252 *	0.6162 **
	(0.2345)	(0.0643)	(0.2338)	(0.1320)	(0.2513)
Control variables	Yes	Yes	Yes	Yes	Yes
Provincial control	Yes	Yes	Yes	Yes	Yes
Constant term	−1.8901 *	−0.0631	−2.2810 **	−2.1015 **	−2.2134 *
	(1.0179)	(0.3084)	(1.0194)	(1.0131)	(1.2090)
Observations	781	781	781	781	677
R^2/Pseudo R^2	0.2540	0.2944	0.2559	0.2417	0.2583

Note: *, **, and *** indicate significance at the levels of 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses.

Furthermore, social networks include three dimensions: strength, reputation, and reciprocity. What is the relationship between agricultural technology extension and various dimensions of social networks? Based on this, this article constructs interactive terms for agricultural technology extension and social networks in three dimensions for empirical analysis. Among them, the weighted average values of "mobility with relatives and friends" and "mobility with local villagers" are taken as the observed values of the social network strength index. The regression results are shown in Table 6. From the table, it can be seen that the interaction coefficient between agricultural technology extension and social networks' reciprocity is significantly positive, indicating that agricultural technology extension and social networks' reciprocity have complementary effects on farmers' adoption of conservation tillage technology. However, the interaction terms between agricultural technology extension, social networks strength, and social networks reputation did not pass the significance test. Research has shown that social networks' reciprocity promotes the dissemination and diffusion of conservation tillage technology through the exchange of experience among farmers, exerting significant spillover effects and thus forming a synergistic and complementary effect with agricultural technology extension. The strength of social networks reflects the mobility of farmers with local villagers, relatives, and friends. Studies have shown that communication and interaction with relatives, friends, and neighbors have a significant promoting effect on farmers' choice of non-agricultural-dominated livelihoods and are important inducing factors for farmers to go out and engage in non-agricultural work. Therefore, the role of social network strength in agricultural production is not significant, and its impact on farmers' adoption of conservation tillage technology is not significant, making it difficult to generate complementary effects with agricultural technology extension. The reputation of social networks reflects the role of farmers' political identity in the rural economy and society. Farmers who serve as village cadres bear more responsibilities in rural governance, resource coordination at the village level, and the implementation of higher-level policies. However, they have achieved little in promoting conservation tillage technology and still need to be strengthened.

Table 6. Regression results of interaction effects between agricultural technology extension and social networks in different dimensions.

Variables	Model 15	Model 16	Model 17	Model 18
Agricultural technology extension	1.2880 ***	1.2867 ***	1.3026 ***	1.3025 ***
	(0.1294)	(0.1296)	(0.1293)	(0.1295)
Social networks strength	0.0677	0.0615	0.0702	0.0688
	(0.0862)	(0.0857)	(0.0861)	(0.0867)
Social networks reputation	−0.3213	−0.3968 *	−0.2831	−0.3708
	(0.2100)	(0.2331)	(0.2088)	(0.2316)
Social networks reciprocity	0.1621 **	0.1622 **	0.1652 **	0.1668 **
	(0.0679)	(0.0676)	(0.0679)	(0.0678)
Agricultural technology extension × Social networks strength	0.1163			−0.0226
	(0.1661)			(0.1773)
Agricultural technology extension × Social networks reputation		0.4534		0.4615
		(0.4446)		(0.4384)
Agricultural technology extension × Social networks reciprocity			0.3022 **	0.3067 **
			(0.1197)	(0.1268)
Control variables	Yes	Yes	Yes	Yes
Provincial control	Yes	Yes	Yes	Yes
Constant term	−1.9870 *	−2.0879 **	−1.8090 *	−1.8603 *
	(1.0129)	(1.0099)	(1.0149)	(1.0155)
Observations	781	781	781	781
Pseudo R^2	0.2570	0.2574	0.2623	0.2632

Note: *, **, and *** indicate significance at the levels of 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses.

5.3. Heterogeneity Analysis

5.3.1. Heterogeneity Analysis of Different Groups

The above research indicated that agricultural technology extension and social networks have a complementary effect in promoting farmers' adoption of conservation tillage technology. Then, does this complementary effect present a differentiation effect in different groups? This article examines the differences in the interaction effect of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology from three aspects: the scale of land operation, household income, and intergenerational differences. Referring to the practice of Chen et al. [73] taking the scale of land operation and median farmers' income as a dividing basis (the median scale of land operation and the median farmers' income is 0.51 hectares and 64,000 CNY, respectively), farmers who are below the median level are defined as small farmers and low-income farmers, and farmers who are equal to or above the median level of farmers are defined as scale farmers and high-income farmers. Referring to the research of Liu et al. [74], farmers born in 1975 and later are defined as the new generation, and those born before 1975 are defined as the old generation.

The regression results are shown in Table 7, Models 19 to 24. The interaction coefficient between agricultural technology extension and social networks was negative and significant at the level of 10% for small-scale farmers, indicating that there was a significant substitution effect between agricultural technology extension and social networks. In scale farmers, the interaction coefficient between agricultural technology extension and social networks was positive and significant at the 1% level, indicating a significant complementary effect between agricultural technology extension and social networks. Large-scale households have a large scale of operation, and their technology promotion can play a good role in demonstration and leadership. At the same time, large-scale households often have certain resource advantages and a strong social network. Therefore, large-scale households are more likely to adopt conservation tillage technology. Due to the small scale of farming, it is difficult for small farmers to become demonstrators and leaders of agricultural technology extension. In this case, social networks can effectively play a substitution role.

Table 7. Group heterogeneity regression results of the interaction effect between agricultural technology extension and social networks.

Variables	Model 19 (Small Farmers)	Model 20 (Scale Farmers)	Model 21 (Low-Income Farmers)	Model 22 (High-Income Farmers)	Model 23 (Old-Generation Farmers)	Model 24 (New-Generation Farmers)
Agricultural technology extension	1.4490 ***	1.0584 ***	1.2597 ***	1.2550 ***	1.5479 ***	0.4120
	(0.2008)	(0.1870)	(0.1863)	(0.1934)	(0.1538)	(0.2722)
Social networks	0.2926	−0.1502	0.4429 **	−0.0068	0.3931 ***	−0.0576
	(0.2269)	(0.1741)	(0.1751)	(0.1789)	(0.1377)	(0.2449)
Agricultural technology extension × Social networks	−0.8183 *	1.4485 ***	0.2920	0.8770 ***	0.3818	1.1555 **
	(0.4369)	(0.3440)	(0.3520)	(0.3345)	(0.2706)	(0.4715)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Provincial control	Yes	Yes	Yes	Yes	Yes	Yes
Constant term	−1.7909	−0.7612	−0.2261	0.1697	−1.7440 *	−0.1717
	(1.5244)	(1.5329)	(0.8500)	(1.0289)	(0.8956)	(2.2172)
Observations	390	391	389	392	632	149
Pseudo R^2	0.3319	0.2922	0.2370	0.2683	0.3041	0.2038

Note: *, **, and *** indicate significance at the levels of 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses.

Among low-income farmers, the complementary effect of agricultural technology extension and social networks was not significant but was significant at the level of 1% among high-income farmers, indicating that the complementary effect of agricultural technology extension and social networks would significantly promote the adoption of conservation tillage technology by high-income farmers. High-income farmers have relatively strong capital, so they face lower financial constraints. At the same time, high-income farmers have strong social networks and can easily become the arbiter of technology extension and application.

From the perspective of intergenerational differences, the complementary effect of agricultural technology extension and social networks exists significantly in the new generation of farmers but not in the old generation of farmers. On the one hand, the new generation of farmers has a higher level of education and technical learning ability, so they have a higher degree of acceptance of agricultural technology extension. On the other hand, the new generation of farmers pays more attention to the accumulation and expansion of social networks in interpersonal communication.

In the survey, it was found that the new generation of farmers showed higher enthusiasm for strengthening social networks through modern information technology such as the Internet. In conclusion, the complementary effect of agricultural technology extension and social networks exists for large-scale farmers, high-income farmers, and the new generation of farmers but is not obvious for low-income farmers and the old generation of farmers, and it has a substitution effect in small farmers.

5.3.2. Heterogeneity Analysis of Different Technology Types

Conservation tillage is a comprehensive technical system that includes four major technical systems [67,68], namely, protective crop planting technology (intercropping, strip planting, etc.), protective soil tillage technology (less or no tillage, deep loosening, etc.), protective surface covering technology (straw coverage, plastic film coverage, etc.), and protective farmland comprehensive management technology (disease, pest, and grass control, fertilization technology, irrigation technology, etc.). Based on field research, this article divides conservation tillage technologies into the four categories mentioned above and examines the heterogeneity of the interaction effect between agricultural technology extension and social networks in farmers' adoption of different technologies. Table 8 shows that compared to surface cover technologies, the interaction between agricultural technology extension and social networks is significantly positive in crop planting, soil cultivation, and comprehensive farmland management technologies, with complementary

effects. Further comparison of coefficient values reveals that the complementary effect of agricultural technology extension and social networks has the greatest promoting effect on farmers' adoption of farmland comprehensive management technologies, followed by crop planting technologies and, finally, soil tillage technologies. Overall, due to the different nature and characteristics of different types of conservation tillage technologies, there are certain technological differences in the interaction effect between agricultural technology extension and social networks on farmers' adoption of conservation tillage technology.

Table 8. Regression results of technological heterogeneity in the interaction effect between agricultural technology extension and social networks.

Variables	Model 25 (Crop Planting)	Model 26 (Soil Tillage)	Model 27 (Surface Covering)	Model 28 (Farmland Comprehensive Management)
Agricultural technology extension	1.3103 ***	1.2863 ***	1.2879 ***	1.2996 ***
	(0.1281)	(0.1282)	(0.1284)	(0.1277)
Social networks	0.2483 **	0.1991	0.2843 **	0.2063
	(0.1201)	(0.1382)	(0.1201)	(0.1263)
Agricultural technology extension × Social networks	0.1043	0.1190	0.6527 **	0.2116
	(0.2934)	(0.3218)	(0.3267)	(0.2658)
Agricultural technology extension × Social networks × Crop planting	1.2186 ***			
	(0.4236)			
Agricultural technology extension × Social networks × Soil tillage		0.9799 *		
		(0.5794)		
Agricultural technology extension × Social networks × Surface covering			−0.6775	
			(0.4599)	
Agricultural technology extension × Social networks × Farmland comprehensive management				1.3018 **
				(0.6140)
Control variables	Yes	Yes	Yes	Yes
Provincial control	Yes	Yes	Yes	Yes
Constant term	−1.9822 *	−1.9787 *	−1.8180 *	−1.9946 *
	(1.0180)	(1.0170)	(1.0220)	(1.0218)
Observations	781	781	781	781
Pseudo R^2	0.2584	0.2569	0.2559	0.2572

Note: *, **, and *** indicate significance at the levels of 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses.

5.3.3. Heterogeneity Analysis in Different Regions

The results in Table 9 show that for farmers in Heilongjiang and Henan, the interaction coefficient between agricultural technology extension and social networks is positive, and both are significant at the level of 1%, indicating a complementary effect between agricultural technology extension and social networks in promoting farmers' adoption of conservation tillage technology. Therefore, by extending and expanding the social networks of farmers, a synergistic and complementary effect can be formed with agricultural technology extension, maximizing the enthusiasm of farmers to adopt conservation tillage technology. For Shandong farmers, there is no significant interaction effect between agricultural technology extension and social networks, while in Shanxi farmers, social networks can play a good substitution role. The above research indicates that there are significant regional differences that impact the interaction between agricultural technology extension and social networks and farmers' adoption of conservation tillage technology. Therefore, when formulating relevant policies and measures, the government needs to tailor them to local conditions, provide technical services based on actual local conditions, and continuously optimize and improve them based on local economic development level, social culture, local customs, and other factors, to improve the adoption rate of conservation tillage technology among farmers.

Table 9. Regional heterogeneity regression results of the interaction effect between agricultural technology extension and social networks.

Variables	Model 28 (Heilongjiang)	Model 28 (Henan)	Model 28 (Shandong)	Model 28 (Shanxi)
Agricultural technology extension	0.8670 ***	3.5326 ***	1.6258 ***	0.8118 *
	(0.2174)	(0.7356)	(0.3183)	(0.4135)
Social networks	−0.3166	2.2350 ***	0.7192 **	−0.0261
	(0.1955)	(0.4417)	(0.3253)	(0.4040)
Agricultural technology extension × Social networks	1.7662 ***	3.1825 ***	−0.1705	−1.7755 **
	(0.4172)	(0.8161)	(0.5668)	(0.7443)
Control variables	Yes	Yes	Yes	Yes
Constant term	1.0421	−2.3614	3.9981	−4.2157
	(1.8164)	(2.1746)	(2.6805)	(3.3611)
Observations	230	197	187	167
Pseudo R^2	0.1579	0.4281	0.6388	0.4231

Note: *, **, and *** indicate significance at the levels of 10%, 5%, and 1%, respectively. Robust standard errors are in parentheses.

6. Discussion

6.1. New Findings Compared to Previous Studies

Given the important role of the dissemination and application of conservation tillage technology in ensuring national food security in the new development stage, this paper continues to explore the key factors influencing farmers' adoption of conservation tillage technology based on existing studies. Unlike previous studies, this paper has several new findings, which are as follows:

First, unlike the previous studies that focused on conservation tillage technology [75,76], this paper looks at the implementation of conservation tillage technology and farmers' adoption, with farmers being the direct beneficiaries, to find specific initiatives that can improve farmers' adoption and make the dissemination and application of conservation tillage technology more direct and effective, thus achieving the purpose of protecting farmland, raising farmers' incomes, ensuring national food security, and comprehensively promoting sustainable agricultural development.

Second, the impact of agricultural technology extension and social networks on agricultural production has received wide attention as important elements of formal and informal institutions, respectively. However, few studies have examined its impact on farmers' adoption of conservation tillage technology. Through theoretical analysis and empirical tests, this paper finds that agricultural technology extension and social networks are important factors influencing farmers' adoption of conservation tillage technology. Additionally, this paper tries to find a new path for the dissemination of conservation tillage technology.

Third, based on the empirical test that both agricultural technology extension and social networks have a positive influence on farmers' adoption of conservation tillage technology, this paper also compared which channel of agricultural extension and social networks have a greater promotion effect and how the two are related. Complementary effects exist, but they do not always exist and vary across groups, regions, and technology types.

6.2. Research Deficiencies and Prospects

Although we have concluded through theoretical analysis and empirical tests that agricultural technology extension and social networks have important effects on farmers' adoption of conservation tillage technology, there are certain shortcomings in this study, which also provide important research directions for our next study, in two aspects:

On the one hand, as mentioned above, conservation tillage technology contains many types, not only cover tillage technologies, such as straw returning to the field, sowing with less and no-tillage, and subsoiling, but also cultivation and planting technologies, such as intercropping, strip planting, and crop rotation, as well as integrated farm management

techniques such as integrated prevention and control of diseases, pests and grasses, soil testing and fertilizer formula, and increased application of organic fertilizers. Practice shows that there are great differences in the effects of different technologies. However, in this paper, when examining farmers' adoption of conservation tillage technology, farmers are considered to have adoption behavior as long as they adopt one technology, Ignoring the differences between different technologies. Therefore, in future research, the relationship between agriculture technology extension and social networks and farmers' adoption of specific technologies can be examined comprehensively to pinpoint extension initiatives for different types of conservation tillage technologies.

On the other hand, the data used in the current empirical study are from a survey of 781 farmers in four Chinese provinces, which are typical and representative but have not yet covered the six suitable regions for conservation tillage technology in China, namely, northeast plain monopoly area, the agricultural and pastoral areas along the Great Wall, the northwest loess plateau area, the northwest oasis agricultural area, the Huang-Huai-Hai plain cropping area, the southern water and dry continuous crop area. At the same time, there is a lack of a large sample of practice surveys to obtain more survey information and make the empirical research conclusions more precise. Therefore, in future studies, we will conduct continuous follow-up surveys in areas that have been investigated and supplemental surveys in areas that have not been investigated and researched to provide Chinese experience for the comprehensive promotion of conservation tillage technology.

7. Conclusions and Suggestions

Agricultural technology extension and social networks are important components of formal and informal institutions, respectively, and their influence on farmers' adoption of agricultural technology has received widespread attention. However, the analysis of the relationship between the two has not received sufficient attention. This article is based on 781 survey data from farmers in Heilongjiang, Henan, Shandong, and Shanxi provinces. It not only empirically tests the individual effects of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology but also examines the interaction effects of the two. Research has found the following:

Firstly, both agricultural technology extension and social networks significantly promote farmers' adoption of conservation tillage technology, and the promotion effect of agricultural technology extension is greater. The average probability of farmers who accept agricultural technology extension and social networks adopting conservation tillage technology increases by 36.49% and 7.09%, respectively.

Secondly, the impact of agricultural technology extension and social networks on farmers' adoption of conservation tillage technology presents a complementary effect. That is, the two functions complement and support each other, jointly playing a promoting role, and this complementary effect is more evident in the reciprocity of social networks.

Thirdly, the interaction effect between agricultural technology extension and social networks has heterogeneity in farmers' adoption of protective farming techniques by farmers, with significant differences among different groups, technology types, and regions. Specifically, there is a complementary effect between the two for large-scale farmers, high-income farmers, and new-generation farmers and a substitution effect for small farmers. The complementary effect of the two has the greatest promoting effect on the adoption of comprehensive farmland management technologies by farmers, followed by crop planting technologies and, finally, soil tillage technologies. There is a complementary effect between the two for farmers in Heilongjiang and Henan provinces. Additionally, there is a substitution effect for farmers in Shanxi.

Based on the above research conclusions, the following policy recommendations are proposed:

Firstly, agricultural technology extension has promoted the dissemination and diffusion of conservation tillage technology, increased the enthusiasm of farmers for technology adoption, and become an important measure to promote sustainable agricultural develop-

ment and assist rural revitalization. In the future, it is still necessary to further improve and optimize the construction of the grassroots agricultural technology extension system. It is also necessary to implement diversified agricultural technology extension and dissemination strategies, continuously expand the scope, function, and content of agricultural technology extension services, and innovate agricultural technology extension service methods. Additionally, this will thereby improve the quality and efficiency of agricultural technology extension. At the same time, we will accelerate the reform of grassroots agricultural technology extension institutions and the construction of extension teams, adopt targeted training, graded training, and other measures to improve the professional level and workability of agricultural technology extension personnel, and fully play the leading role of agricultural technology extension.

Secondly, there is a complementary effect between social networks and agricultural technology extension in the adoption of conservation tillage technology by farmers. Therefore, it is necessary to accelerate the construction of an effective mechanism for mutual support between agricultural technology extension and social networks. Whilst strengthening agricultural technology extension, we are constantly strengthening the construction of rural social networks. By building various communication and mutual assistance platforms, organizing rural collective activities, and other means, we are gradually forming a long-term mechanism of cooperation, mutual benefit, and benefit sharing among farmers, thereby enhancing their enthusiasm for adopting conservation tillage technology. In addition, we need to accelerate the promotion and application of modern information technology and promote widespread communication and information sharing among farmers by actively creating a harmonious and orderly rural social networks environment, continuously expanding the social networks relationships of farmers, and promoting the dissemination and diffusion of conservation tillage technology.

Thirdly, it is necessary to implement differentiated conservation tillage technology extension strategies. We should pay attention to the differences among different regions and types of farmers. Additionally, we should implement policies tailored to local conditions, people, and precision, and develop and implement targeted promotion plans based on local conditions and farmers' actual needs, especially strengthening assistance to vulnerable groups such as small farmers, low-income farmers, and elderly farmers, providing more professional technical guidance and services and reducing the risks and costs of adopting conservation tillage technology. At the same time, it is necessary to combine the nature and characteristics of different types of conservation tillage technology and adopt differentiated promotion methods to improve the applicability of farmers' technology adoption and ensure the effectiveness and quality of technology extension.

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References

1. Gould, B.W.; Saupe, W.E.; Klemme, R.M. Conservation tillage: The role of farm and operator characteristics and the perception of soil erosion. *Land Econ.* **1989**, *65*, 167–182. [CrossRef]
2. Benites, J.R.; Ashburner, J.E. FAO's role in promoting conservation agriculture. In *Conservation Agriculture: Environment, Farmers Experiences, Innovations, Socio-Economy, Policy*; Springer: Dordrecht, The Netherlands, 2003; pp. 139–153.

3. Blevins, R.; Frye, W.; Smith, M. The effects of conservation tillage on soil properties. In *A Systems Approach to Conservation Tillage*; CRC Press: Boca Raton, FL, USA, 2018; pp. 99–110.
4. Du, Y.; Yao, H.; Zhang, Y. Application status and countermeasure analysis of conservation tillage. *J. Chin. Agric. Mech.* **2020**, *41*, 198–203.
5. Jia, L.; Zhao, W.; Zhai, R.; Liu, Y.; Kang, M.; Zhang, X. Regional differences in the soil and water conservation efficiency of conservation tillage in China. *Catena* **2019**, *175*, 18–26. [CrossRef]
6. Kuhn, N.J.; Hu, Y.; Bloemertz, L.; He, J.; Li, H.; Greenwood, P. Conservation tillage and sustainable intensification of agriculture: Regional vs. global benefit analysis. *Agric. Ecosyst. Environ.* **2016**, *216*, 155–165. [CrossRef]
7. Han, Y. The policy evolution, vision goal and realization path of China's cultivated land protection and utilization. *J. Manag. World* **2022**, *38*, 121–131.
8. Zhang, K.; Li, X.; Zhou, W.; Zhang, D.; Yu, Z. Land resource degradation in China: Analysis of status, trends and strategy. *Int. J. Sustain. Dev. World Ecol.* **2006**, *13*, 397–408. [CrossRef]
9. Xie, H.; Li, J.; Zhu, P.; Peng, C.; Wang, J.; He, H.; Zhang, X. Long-term manure amendments enhance neutral sugar accumulation in bulk soil and particulate organic matter in a Mollisol. *Soil Biol. Biochem.* **2014**, *78*, 45–53. [CrossRef]
10. Liu, H.; Wu, M.; Liu, X.; Gao, J.; Luo, X.; Wu, Y. Simulation of policy tools' effects on farmers' adoption of conservation tillage technology: An empirical analysis in China. *Land* **2021**, *10*, 1075. [CrossRef]
11. Zhang, Z.; Qiang, H.; McHugh, A.D.; He, J.; Li, H.; Wang, Q.; Lu, Z. Effect of conservation farming practices on soil organic matter and stratification in a mono-cropping system of Northern China. *Soil Tillage Res.* **2016**, *156*, 173–181. [CrossRef]
12. Zhang, Q.; Wang, S.; Sun, Y.; Zhang, Y.; Li, H.; Liu, P.; Wang, X.; Wang, R.; Li, J. Conservation tillage improves soil water storage, spring maize (*Zea mays* L.) yield and WUE in two types of seasonal rainfall distributions. *Soil Tillage Res.* **2022**, *215*, 105237. [CrossRef]
13. Ashworth, A.; DeBruyn, J.; Allen, F.; Radosevich, M.; Owens, P. Microbial community structure is affected by cropping sequences and poultry litter under long-term no-tillage. *Soil Biol. Biochem.* **2017**, *114*, 210–219. [CrossRef]
14. Panettieri, M.; de Sosa, L.L.; Domínguez, M.T.; Madejón, E. Long-term impacts of conservation tillage on Mediterranean agricultural soils: Shifts in microbial communities despite limited effects on chemical properties. *Agric. Ecosyst. Environ.* **2020**, *304*, 107144. [CrossRef]
15. Pi, H.; Sharratt, B.; Schillinger, W.F.; Bary, A.I.; Cogger, C.G. Wind erosion potential of a winter wheat–summer fallow rotation after land application of biosolids. *Aeolian Res.* **2018**, *32*, 53–59. [CrossRef]
16. Zhang, J.; Yang, M.; Deng, X.; Liu, Z.; Zhang, F. The effects of tillage on sheet erosion on sloping fields in the wind-water erosion crisscross region of the Chinese Loess Plateau. *Soil Tillage Res.* **2019**, *187*, 235–245. [CrossRef]
17. Wang, Z.; Sun, J.; Du, Y.; Niu, W. Conservation tillage improves the yield of summer maize by regulating soil water, photosynthesis and inferior kernel grain filling on the semiarid Loess Plateau, China. *J. Sci. Food Agric.* **2022**, *102*, 2330–2341. [CrossRef]
18. Bhaskar, K.A.; Al-Hashimi, A.; Meena, M.; Meena, V.S.; Langyan, S.; Shrivastava, M.; Sayyed, R.Z.; El-Enshasy, H.A.; Almunqedhi, B.M.A.; Singh, R. Conservation agricultural practices for minimizing ammonia volatilization and maximizing wheat productivity. *Environ. Sci. Pollut. Res.* **2022**, *29*, 9792–9804. [CrossRef]
19. Jin, V.L.; Schmer, M.R.; Stewart, C.E.; Sindelar, A.J.; Varvel, G.E.; Wienhold, B.J. Long-term no-till and stover retention each decrease the global warming potential of irrigated continuous corn. *Glob. Chang. Biol.* **2017**, *23*, 2848–2862. [CrossRef]
20. Valkama, E.; Kunypiyaeva, G.; Zhapayev, R.; Karabayev, M.; Zhusupbekov, E.; Perego, A.; Schillaci, C.; Sacco, D.; Moretti, B.; Grignani, C. Can conservation agriculture increase soil carbon sequestration? A modelling approach. *Geoderma* **2020**, *369*, 114298. [CrossRef]
21. Lu, X.; Lu, X. Tillage and crop residue effects on the energy consumption, input–output costs and greenhouse gas emissions of maize crops. *Nutr. Cycl. Agroecosyst.* **2017**, *108*, 323–337. [CrossRef]
22. Gao, Q.; Zhang, Z.-C. Analysis on the Efficiency and Beneficiary of Conservation Tillage. *J. Shanxi Agric. Univ. (Soc. Sci. Ed.)* **2015**, *14*, 441–445. [CrossRef]
23. Tang, L.; Luo, X.; Yan, A.; Du, S. Intergenerational Differences in Farmers' Planting Willingness and Fertilizer Reduction: Based on the Field Survey of "Ten Counties and Thousand Households" in Hubei. *J. Agrotech. Econ.* **2022**, *10*, 83–97. [CrossRef]
24. Wei, Y.; Zhang, L.; Sang, P. Exploring the restrictive factors for the development of the construction waste recycling industry in a second-tier Chinese city: A case study from Jinan. *Environ. Sci. Pollut. Res.* **2023**, *30*, 46394–46413. [CrossRef] [PubMed]
25. da Silva, A.C.; Méxas, M.P.; Quelhas, O.L.G. Restrictive factors in implementation of clean technologies in red ceramic industries. *J. Clean. Prod.* **2017**, *168*, 441–451. [CrossRef]
26. Ramsey, S.M.; Bergtold, J.S.; Canales, E.; Williams, J.R. Effects of Farmers' Yield-Risk Perceptions on Conservation Practice Adoption in Kansas. *J. Agric. Resour. Econ.* **2019**, *44*, 380–403.
27. Norton, G.W.; Alwang, J. Changes in agricultural extension and implications for farmer adoption of new practices. *Appl. Econ. Perspect. Policy* **2020**, *42*, 8–20. [CrossRef]
28. Granovetter, M. Economic action and social structure: The problem of embeddedness. *Am. J. Sociol.* **1985**, *91*, 481–510. [CrossRef]
29. Ruan, H.; Chen, J.; Wang, C.; Xu, W.; Tang, J. Social network, sense of responsibility, and resident participation in China's rural environmental governance. *Int. J. Environ. Res. Public Health* **2022**, *19*, 6371. [CrossRef]
30. Guo, Y.; Yao, Y.; Foltz, J. The lineage networks and the income distribution in villages. *Manag. World* **2014**, *244*, 73–89.
31. Rainie, L.; Wellman, B. *Networked: The New Social Operating System*; The MIT Press: Cambridge, UK, 2012.

32. Li, F.; Zhang, J.; He, K. Alternative and complementary: Informal institutions and formal institutions in farmers' green production. *J. Huazhong Univ. Sci. Technol. (Soc. Sci. Ed.)* **2019**, *33*, 51–60.
33. Lv, J.; Liu, H.; Xue, Y.; Han, X. Study on risk aversion, social network and farmers' overuse of chemical fertilizer—Based on survey data from maize farmers in three provinces of Northeast China. *J. Agrotech. Econ.* **2021**, *7*, 4–17.
34. Feyisa, B.W. Determinants of agricultural technology adoption in Ethiopia: A meta-analysis. *Cogent Food Agric.* **2020**, *6*, 1855817. [CrossRef]
35. Li, B.; Zhuo, N.; Ji, C.; Zhu, Q. Influence of Smartphone-Based Digital Extension Service on Farmers' Sustainable Agricultural Technology Adoption in China. *Int. J. Environ. Res. Public Health* **2022**, *19*, 9639. [CrossRef] [PubMed]
36. Zhao, Q.; Pan, Y.; Xia, X. Internet can do help in the reduction of pesticide use by farmers: Evidence from rural China. *Environ. Sci. Pollut. Res.* **2021**, *28*, 2063–2073. [CrossRef] [PubMed]
37. Gao, Y.; Zhao, D.; Yu, L.; Yang, H. Influence of a new agricultural technology extension mode on farmers' technology adoption behavior in China. *J. Rural Stud.* **2020**, *76*, 173–183. [CrossRef]
38. Takahashi, K.; Muraoka, R.; Otsuka, K. Technology adoption, impact, and extension in developing countries' agriculture: A review of the recent literature. *Agric. Econ.* **2020**, *51*, 31–45. [CrossRef]
39. Lambrecht, I.; Vanlauwe, B.; Maertens, M. Agricultural extension in Eastern Democratic Republic of Congo: Does gender matter? *Eur. Rev. Agric. Econ.* **2016**, *43*, 841–874. [CrossRef]
40. Moore, M. Institutional development, the World Bank, and India's new agricultural extension programme. *J. Dev. Stud.* **1984**, *20*, 303–317. [CrossRef]
41. Feder, R.; Slade, R. Contact Farmer Selection und Extension Visits: The Training and Visit Extension System in Haryana, India. *Q. J. Int. Agric.* **1984**, *23*, 6–21.
42. Liao, C.N.; Chen, Y.J. Farmers' Information Management in Developing Countries—A Highly Asymmetric Information Structure. *Prod. Oper. Manag.* **2017**, *26*, 1207–1220. [CrossRef]
43. Tripp, R.; Wijeratne, M.; Piyadasa, V.H. What should we expect from farmer field schools? A Sri Lanka case study. *World Dev.* **2005**, *33*, 1705–1720. [CrossRef]
44. Ward, P.S.; Pede, V.O. Capturing social network effects in technology adoption: The spatial diffusion of hybrid rice in Bangladesh. *Aust. J. Agric. Resour. Econ.* **2015**, *59*, 225–241. [CrossRef]
45. Ataei, P.; Sadighi, H.; Chizari, M.; Abbasi, E. Analysis of Farmers' Social Interactions to Apply Principles of Conservation Agriculture in Iran: Application of Social Network Analysis. *J. Agric. Sci. Technol.* **2019**, *21*, 1657–1671.
46. Bandiera, O.; Rasul, I. Social networks and the adoption of new technology in Northern Mozambique. In Proceedings of the NEUDC Conference, Boston University, Boston, MA, USA, 26–27 September 2003.
47. Conley, T.G.; Udry, C.R. Learning about a new technology: Pineapple in Ghana. *Am. Econ. Rev.* **2010**, *100*, 35–69. [CrossRef]
48. Watts, D.J.; Strogatz, S.H. Collective dynamics of 'small-world'networks. *Nature* **1998**, *393*, 440–442. [CrossRef]
49. 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]
50. Hoang, L.A.; Castella, J.-C.; Novosad, P. Social networks and information access: Implications for agricultural extension in a rice farming community in northern Vietnam. *Agric. Hum. Values* **2006**, *23*, 513–527. [CrossRef]
51. Munshi, K. Social learning in a heterogeneous population: Technology diffusion in the Indian Green Revolution. *J. Dev. Econ.* **2004**, *73*, 185–213. [CrossRef]
52. Hausmann, R.; Rodrik, D. Economic development as self-discovery. *J. Dev. Econ.* **2003**, *72*, 603–633. [CrossRef]
53. Khan, N.; Ray, R.L.; Kassem, H.S.; Khan, F.U.; Ihtisham, M.; Zhang, S. Does the Adoption of Mobile Internet Technology Promote Wheat Productivity? Evidence from Rural Farmers. *Sustainability* **2022**, *14*, 7614. [CrossRef]
54. Rajkhowa, P.; Qaim, M. Personalized digital extension services and agricultural performance: Evidence from smallholder farmers in India. *PLoS ONE* **2021**, *16*, e0259319. [CrossRef]
55. Cai, J.; Hu, R.; Hong, Y. Impact of farmer field schools on agricultural technology extension—Evidence from greenhouse vegetable farms in China. *Appl. Econ.* **2022**, *54*, 2727–2736. [CrossRef]
56. LIU, K.; QI ZH, Y.C. Analysis on the influence of neighbourhood effect and agricultural technology diffusion on farmer's adoption of co-farming technology of rice and crayfish: Complementary effects and substitution effects. *Resour. Environ. Yangtze Basin* **2020**, *29*, 401–411.
57. Han, G.M.; An, Y.F. An analysis of farmer specialized cooperatives in poor areas participating in agricultural technology extension: Based on the perspective of agricultural technology diffusion theory. *Res. Dev.* **2010**, *2*, 37–40.
58. Haythornthwaite, C. Social network analysis: An approach and technique for the study of information exchange. *Libr. Inf. Sci. Res.* **1996**, *18*, 323–342. [CrossRef]
59. Maertens, A.; Barrett, C.B. Measuring social networks' effects on agricultural technology adoption. *Am. J. Agric. Econ.* **2013**, *95*, 353–359. [CrossRef]
60. Grootaert, C. *Social Capital, Household Welfare and Poverty in Indonesia*; World Bank Policy Research Working Paper; World Bank Publications: Washington, DC, USA, 1999.
61. Chen, H.; Zhao, X.F.; Zhang, Z.X. On embeddedness of agricultural extension model. *J. Northwest A&F Univ. (Soc. Sci. Ed.)* **2016**, *16*, 76–80, 88.

62. Altalb, A.A.T.; Filipek, T.; Skowron, P. The role of agricultural extension in the transfer and adoption of agricultural technologies. *Asian J. Agric. Food Sci.* **2015**, *3*, 500–507.
63. Anderson, J.R.; Feder, G. Agricultural extension. *Handb. Agric. Econ.* **2007**, *3*, 2343–2378.
64. Blevins, R.; Frye, W.; Baldwin, P.; Robertson, S. *Tillage Effects on Sediment and Soluble Nutrient Losses from a Maury Silt Loam Soil*; 0047-2425; Wiley Online Library: Hoboken, NJ, USA, 1990.
65. Guo, H.; Zhao, W.; Pan, C.; Qiu, G.; Xu, S.; Liu, S. Study on the influencing factors of farmers' adoption of conservation tillage technology in black soil region in China: A logistic-ISM model approach. *Int. J. Environ. Res. Public Health* **2022**, *19*, 7762. [CrossRef]
66. Gao, H.W.; He, M.; Shang, S.Q.; Fang, X.Q. High yield and high efficiency system of conservation tillage. *Trans. Chin. Soc. Agric. Mach.* **2013**, *44*, 35–38, 49.
67. Liu, E.; Teclemariam, S.G.; Yan, C.; Yu, J.; Gu, R.; Liu, S.; He, W.; Liu, Q. Long-term effects of no-tillage management practice on soil organic carbon and its fractions in the northern China. *Geoderma* **2014**, *213*, 379–384. [CrossRef]
68. Chen, H.; Dai, Z.; Veach, A.M.; Zheng, J.; Xu, J.; Schadt, C.W. Global meta-analyses show that conservation tillage practices promote soil fungal and bacterial biomass. *Agric. Ecosyst. Environ.* **2020**, *293*, 106841. [CrossRef]
69. BarNir, A.; Smith, K.A. Interfirm alliances in the small business: The role of social networks. *J. Small Bus. Manag.* **2002**, *40*, 219–232. [CrossRef]
70. Danso-Abbeam, G.; Dagunga, G.; Ehiakpor, D.S. Rural non-farm income diversification: Implications on smallholder farmers' welfare and agricultural technology adoption in Ghana. *Heliyon* **2020**, *6*, e05393. [CrossRef]
71. Cai, Y.; Qi, W.; Yi, F. Mobile Internet adoption and technology adoption extensity: Evidence from litchi growers in southern China. *China Agric. Econ. Rev.* **2022**, *14*, 106–121. [CrossRef]
72. De Souza Filho, H.; Young, T.; Burton, M.P. Factors influencing the adoption of sustainable agricultural technologies: Evidence from the State of Espírito Santo, Brazil. *Technol. Forecast. Soc. Chang.* **1999**, *60*, 97–112. [CrossRef]
73. Chen, Z.; Li, X.J.; Xia, X.L. Research on the impact of multi-dimensional education on farmers' adoption of IPM technology in the internet development environment. *J. Huazhong Agric. Univ. (Soc. Sci. Ed.)* **2022**, *3*, 83–95.
74. Liu, Y.Z.; Wang, F.; Guo, Y.; Song, D.L. Farmer differentiation, intergenerational differences and acceptance of rural housing mortgage loans. *Chin. Rural Econ.* **2016**, *9*, 16–29.
75. Chimsah, F.A.; Cai, L.; Wu, J.; Zhang, R. Outcomes of long-term conservation tillage research in Northern China. *Sustainability* **2020**, *12*, 1062. [CrossRef]
76. Van den Putte, A.; Govers, G.; Diels, J.; Langhans, C.; Clymans, W.; Vanuytrecht, E.; Merckx, R.; Raes, D. Soil functioning and conservation tillage in the Belgian Loam Belt. *Soil Tillage Res.* **2012**, *122*, 1–11. [CrossRef]

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