

Article

The Impact of Social Capital on Farmers' Green Production Behavior: Moderation Effects Based on Agricultural Support and Protection Subsidies

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Abstract

Farmers' green production behavior is key to addressing resource and environmental constraints and advancing agricultural green transformation, with social capital critically influencing their production decisions. However, rural population mobility amid urbanization and market economy penetration have reshaped farmers' social interactions, reconstructing and differentiating social capital into distinct types. Few studies now focus on the complex link between this transformed social capital and farmers' green production behavior. Moreover, though the government has long used agricultural subsidies to encourage green production, how these subsidies function when different social capital types affect green production remains unclear. To address the aforementioned issues, using 2022 CLES data and a binary logit model, this study examines how embedded and disembedded social capital influence farmers' green production behavior and the moderating role of subsidies. Results show that (1) disembedded social capital has a significantly positive impact on farmers' green production behavior, stronger than embedded social capital; (2) subsidies only positively moderate embedded social capital's impact. The results have rich theoretical and practical implications, which can promote farmers' adoption of green production behavior and accelerate the green transformation of agriculture.

Keywords: farmers' green production behavior; embedded social capital; disembedded social capital; agricultural support and protection subsidies



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1. Introduction

Promoting green production among farmers is a key strategy for promoting the green transformation of agriculture, and it has resonated widely with the proposals of the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, and others regarding sustainable development [1,2]. According to statistics, the total amount of greenhouse gases contributed by the global food system has already exceeded one third of the total anthropogenic emissions [3,4]. "Global Agricultural Outlook 2022–2031", jointly released by the OECD and the FAO, reveals that global agricultural direct greenhouse gas emissions are expected to increase by 6% over the next decade [5]. This has led to a series of resource and environmental issues, such as extreme climates and severe pest and disease disasters. Therefore, countries around the world are promoting the green transformation of agriculture through multilateral mechanisms, and calling for the adoption of more environmentally friendly and energy-saving agricultural production strategies [6]. For instance, the Common Agricultural Policy (CAP) of the European Union,

which has been implemented since 2023, places greater emphasis on green development. It encourages farmers to adopt green measures such as organic farming to reduce their carbon footprint [7]. China is the largest developing country with a large proportion of agricultural population. It also faces key issues such as agricultural non-point source pollution and national food security [8]. Over the years, the Chinese government has always regarded agricultural issues as an important part of the national strategy in the form of the Central Document No. 1 [9,10], and attaches great importance to the green development of agriculture. Farmers are the direct entities in agricultural production and operation. Whether they adopt green production practices directly determines the degree to which the goal of agricultural green development can be achieved [11]. The adoption of green production behavior can bring about numerous benefits, such as enhancing food security, reducing carbon emissions, and promoting the green transformation of agriculture [12,13]. Although agricultural green production has multiple benefits, farmers may still have low adoption rates of green production practices due to factors such as high investment costs and high risks [14]. They still rely on the traditional high-consumption, high-emission production [15,16]. Therefore, scientifically guiding and motivating farmers to implement green production is the key to promoting the green transformation of agriculture [8].

The influencing factors of farmers' green production behavior in the existing literature can be mainly classified into two categories: One category focuses on the agricultural production entities. The existing literature has concentrated on the impact of individual characteristics and family characteristics on farmers' green production behavior. Among them, individual characteristics include factors such as gender, age, educational level, and time preference [17–19], while family characteristics include factors such as family annual income and the number of laborers [16]. The other category is from the perspective of agricultural production conditions. The existing literature mainly focuses on the influence of factors such as land tenure stability and agricultural subsidies on farmers' green production behavior [10,20]. For instance, previous studies have shown that factors such as the degree of land fragmentation and the scale of land management can influence farmers' choices of livelihood strategies, which in turn affects their choices of green production behavior [21]. And job subsidies, social services, and technical training can lower the threshold for farmers to adopt green technologies, thereby encouraging them to adopt green production practices [15,22,23].

Among all the influencing factors, we pay particular attention to the impact of social capital on farmers' decisions regarding green production behavior. After decades of development, the international community has reached a consensus on the fundamental role of social capital in local development, especially its extensive connection to key issues such as rural poverty and hunger alleviation and sustainable community development [24]. In the specific context of agricultural production, a large-scale survey covering seven African countries including Nigeria, Rwanda, and Uganda found that a higher level of social capital significantly promoted local farmers' adoption of green agricultural production technologies, such as intercropping, crop rotation, and the use of organic pesticides [25]. This holds true in developed countries as well: for instance, a survey of farmers in Germany and Greece by some scholars showed that farmers with high social capital were more likely to adopt green agricultural technologies like biomass technology [26]. Additionally, studies have found that social capital is crucial to agricultural sustainability in the United States and Denmark [27]. As an important non-institutional resource for rural social governance [28], social capital can make up for the deficiencies of relying solely on the market or the government in the promotion of green agricultural production technologies [29]. Numerous studies have shown that in the process of farmers' green production, social capital influences and alters farmers' behavioral decisions through means such as information dissemination,

cost savings, and resource support [30,31]. However, as the market economy expands into rural areas and the population mobility caused by urbanization occurs, the social structure in rural areas undergoes drastic changes, and social capital is also restructured accordingly [32]. The social interaction patterns of farmers have broken free from the constraints of the original geographical space and have changed along with the passage of time and the alteration of space and location [28]. The traditional embedded social capital, which was constructed based on blood ties and geographical connections, is gradually undergoing differentiation: a new type of social capital corresponding to the embedded social capital has emerged—disembedded social capital [33].

Unlike resource endowments such as social capital that individuals possess directly, agricultural subsidies are “context-dependent”. Using agricultural subsidies as a policy incentive to encourage farmers to practice green production concepts has also resonated widely globally and is recognized as an effective policy tool. Although agricultural subsidies, as a reflection of national will, are not related to farmers’ micro-level behavioral decisions, they still influence the role of social capital in farmers’ green production decision-making through pathways like reducing adoption costs and adapting to contexts [34]. In practice, agricultural support policies are often funded by the government (e.g., in the form of direct financial subsidies and technology extension to rural areas), with farmers participating passively and having no autonomous choice. Thus, the role of agricultural subsidies is more reflected in intervening in the relationship between social capital and green production [35].

The existing research has laid the foundation for clarifying the relationship between social capital, agricultural subsidies and farmers’ green production behavior. However, the current research still has some room for improvement: Firstly, the heterogeneity of social capital has been overlooked. Most existing studies have focused on the overall perspective of social capital to investigate its impact on green production behavior. With the flow of urban-rural factors and the in-depth penetration of the market economy, the geographical constraints on farmers’ social networks have gradually disappeared [36]. This has led to changes in the ways and scopes of their social interactions, giving rise to a phenomenon of “disembedding”. Disembedded social capital has gradually become the main form of rural social capital [33]. However, existing studies have not made a more detailed differentiation regarding the changes in social capital and have not opened the black box of how social capital influences farmers’ green production behavior. Secondly, most studies have analyzed the impact of farmers’ psychological cognition on their decision-making behavior at the micro level, while neglecting the role of policy interventions in shaping the decision-making pathways of farmers’ behavior. In addition, previous studies have mostly simply incorporated agricultural subsidies as external factors into the models, ignoring the moderating role of agricultural subsidies in the social capital’s influence on farmers’ green production behavior. This is not conducive to the government formulating more precise and effective agricultural subsidy policies.

This paper aims to investigate the influence of embedded social capital and disembedded social capital on farmers’ green production behavior, and to examine the role of agricultural support and protection subsidies in this process. It seeks to contribute to filling the research gaps in this field. Based on this, this paper uses China’s land economic survey data to attempt to answer two key questions. First, from the perspective of the differentiation of social capital, we attempt to construct a theoretical analysis framework for social capital and farmers’ green production behavior. Based on existing research and practical situations, we explore the influence of both embedded social capital and disembedded social capital on farmers’ green production behavior, and open up the black box of the mechanism of action. Secondly, by incorporating agricultural subsidies as a

moderating variable into the theoretical analysis framework, we can further explain the role that subsidies play in social capital and farmers' green production behavior.

The rest of this article is organized as follows: In Section 2, based on real-world issues and research questions, a theoretical analysis was conducted on the relationship between social capital and farmers' green production behavior, as well as the moderating role of agricultural support and protection subsidies in this context. At the same time, the theoretical framework of this article was established. Section 3 mainly introduces the research design, describing the data, variables and methods used in this article. In Section 4, we report the main empirical results and provide corresponding interpretations. Based on the content of the previous sections, in Section 5, we further discuss the results of this article. Section 6 concludes the research findings and proposes targeted policy implications.

2. Theoretical Framework

2.1. *The Impact of Social Capital on Farmers' Green Production Behavior*

As Chinese society undergoes the transformation from a traditional rural society to a modern urban-rural integration model, the connotation of social capital has undergone profound changes [32]. It has gradually evolved from the "embedded social capital" based on specific geographical spaces to the "disembedded social capital" that breaks through geographical limitations [20,37]. The action field, social relationship networks, and resource acquisition methods have also undergone systematic changes.

From the perspective of the functional field, The traditional rural society was a familiar society where people were born and died in the same place [38]. The field of action of social capital has a strong regional attachment. Its scope is usually limited to a certain area centered around its own village and extending to nearby villages, and is restricted by factors such as land and transportation conditions. With the penetration of urbanization and the market economy, social capital has broken regional isolation. The action field has expanded from the surrounding areas of villages to cities across counties and provinces. For instance, the flow of capital to rural areas has led to the influx of urban capital into the countryside, enabling them to participate in agricultural industry development and other projects. This has broken down the geographical barriers within the dual economic structure of urban and rural areas [39]. This change is directly manifested in that the social capital of farmers is no longer confined within the village but instead connects with market resources in broader urban or county-level fields, significantly expanding its scope of action. Giddens' concept of "disembedding" provides a compelling explanation for why the establishment, maintenance, and functioning of social capital are no longer confined by the physical boundaries of the village [40]. The expansion of this sphere of influence serves as the foundation for the "delocalization" of social capital, and provides a spatial prerequisite for farmers to connect with the outside world.

From the perspective of social relationship networks, embedded social capital is centered around blood relatives, geographical neighbors, and traditional clan communities. It has the characteristics of "strong relationships, high familiarity, and low mobility", and the information exchanged among them is highly homogeneous. The relationship network of disembedded social capital shifts towards occupational-based associational relationships, characterized by "weak ties, low familiarity, and high mobility" [37]. Granovetter's theory of weak ties suggests that compared to the repetitive and homogeneous information released by "strong ties", "weak ties" play a more significant role as "information bridges" in social interactions [41]. That is to say, kinship ties, as "weak ties", can more effectively enable farmers to break through the closed boundaries of traditional villages and obtain richer external information and resources [20,37].

Apart from the specific position of an individual within a given social structure (social relationship network), the way resources are obtained through this social structure is also an important aspect of social capital [42]. From the perspective of resource acquisition, in embedded social capital, resource exchange follows the norm of moral rationality and is based on mutual reciprocity of human relationships, relying on localized information advantages. This conforms to the logic of “moral economy” [43]. Take the acquisition of funds as an example. Traditionally, it was mainly based on private lending, relying on the mechanisms of personal relationships and reputation. The loan scale was small and the interest rate was highly flexible. With the modernization of rural areas, the traditional rule-based order has gradually disintegrated. As a social exchange behavior, rural mutual assistance no longer relies on traditional ethical obligations as the main basis for interpersonal mutual cooperation. Instead, it has shifted towards considering interests. Rural people are now constructing a new mutual assistance order through the universal rule of prioritizing interests [44]. Furthermore, the objects of resource acquisition have become more extensive compared to “acquaintances”, such as commercial banks and industrial and commercial enterprises that accompany capital investment in rural areas [45]. The ownership of these resources is clearly defined, usually through laws and regulations. At the same time, all parties will also stipulate the relevant rights and obligations through the signing of formal contracts.

In conclusion, the changes in the rural social structure have led to the differentiation of social capital, resulting in the emergence of disembedded social capital, which coexists with embedded social capital. Among them, embedded social capital is deeply rooted in the familiar social network and can provide farmers with production suggestions and information resources through kinship and geographical relationship networks. This mainly relies on local experiential information, such as the exchange of production experiences among villagers. However, it lacks external advanced technologies and market information. Additionally, the resource acquisition method based on reciprocity and human relations helps farmers meet their short-term and small-scale demands in green production. For instance, it assists farmers in addressing issues like labor and capital shortages in agricultural green production. The disembedded social capital can break through geographical limitations through professional ties and build a broader social relationship network. This weak relationship network acts as an “information bridge” to convey heterogeneous information that is beyond the reach of embedded social capital, such as technical information and market information. It can help farmers understand new green production technologies and the market demand for organic agricultural products, thereby breaking the traditional farming inertia. Meanwhile, the external entities connected by disembedded social capital can provide larger-scale and long-term resource support compared to embedded social capital. For instance, in terms of funds, commercial banks can offer long-term funds of several hundred thousand yuan to help farmers purchase green production equipment. Such large-scale resources help farmers solve the problem of high investment in green production. Furthermore, farmers enter into contracts through the legal system to connect with external entities such as commercial banks, replacing reliance on personal connections with standardized ownership agreements and a credit system. This provides a guarantee for farmers to obtain large amounts of stable funds and technical services. Therefore, compared to embedded social capital, disembedded social capital has greater advantages in terms of the diversity and stability of resource supply, and can more effectively increase the likelihood of farmers adopting green production behavior. Based on this, we propose the following hypothesis:

Hypothesis 1 (H1). *Disembedded social capital has a significantly positive impact on farmers' green production behavior, and its influence effect is greater than that of embedded social capital.*

2.2. The Moderating Effect of Agricultural Support and Protection Subsidies on the Influence of Social Capital on Farmers' Green Production Behavior

Green agricultural production technologies such as soil-test based formulated fertilization, straw returning to the field, and pesticide packaging waste recycling not only bring economic benefits to farmers but also generate extensive ecological and environmental benefits, such as promoting the sustainable development of agriculture. However, adopting green agricultural production technologies means farmers have to make additional investments, which directly increases their production costs. For example, using low-toxicity and low-harm pesticides and chemical fertilizers usually comes with higher unit prices. The externality of this behavior means that its costs cannot be borne by farmers alone, and other entities such as the government need to participate in cost-sharing and benefit-sharing [8]. As a contextual factor, governments of various countries participate in agricultural production through policies, subsidies, and other forms, and exert a moderating effect on farmers' behaviors. The so-called moderating effect refers to a variable changing the intensity or direction of the relationship between two other variables, mainly reflecting the condition under which one variable affects another.

The moderating effect of agricultural subsidies on farmers' green production behaviors is mainly achieved through the following paths: (1) Subsidies strengthen the impact of social capital on green production behaviors by reducing economic costs. The role of social capital in green production needs to be realized through an "information-action" bridge, but this transformation process is often restricted by "economic costs". If green production (such as technology adoption and chemical fertilizer reduction) requires additional investment and the benefits are uncertain, farmers may abandon the action due to cost concerns even if they have abundant social capital (e.g., access to relevant information). Subsidies, however, can provide conditions for the "information-action" transformation of social capital by offsetting costs, thereby strengthening its impact on green production. (2) Subsidies accurately adjust the green production behaviors of different groups by adapting to the "heterogeneity of social capital scenarios". Existing studies show that different farmers have different responses to subsidies. For instance, grain-growing households prefer economic subsidies more—when their income losses are reduced, the driving effect of social capital on green production is enhanced. In contrast, high-income farmers who grow cash crops tend to prefer technical training over economic subsidies [46]. Agricultural production practices in various countries have proven that the moderating function of subsidies has advantages such as immediacy, durability, flexibility, and operability, enabling policymakers to directly influence individuals' internal psychological processes and modify and optimize them according to specific circumstances [35]. Based on the above analysis, we propose the following hypothesis:

Hypothesis 2 (H2). *Agricultural support and protection subsidies are positively regulating the influence of farmers' social capital on their green production behavior.*

Based on the above analysis, the analytical framework for the impact of building social capital on farmers' green production behavior is presented in Figure 1.

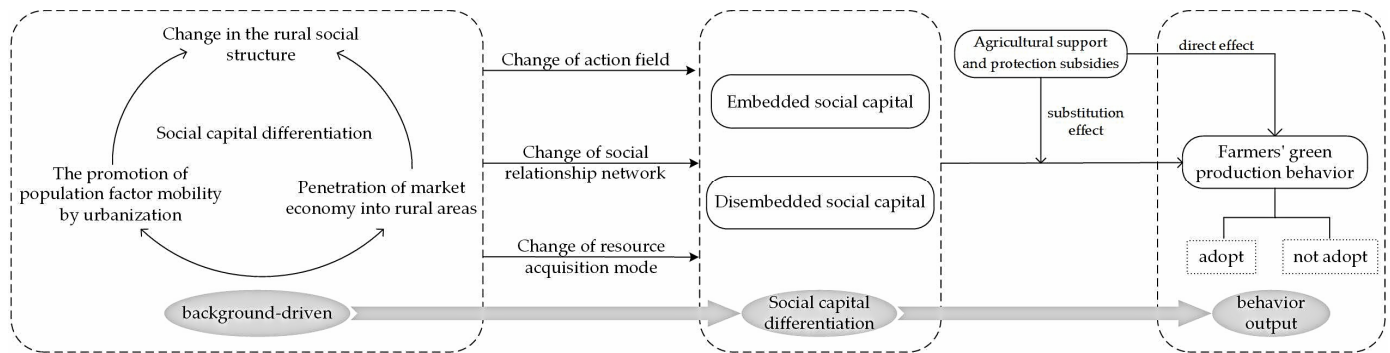


Figure 1. Theoretical analysis framework.

3. Materials and Methods

3.1. Data Source

The data used in this study was sourced from the “China Land Economy Survey” (CLES) conducted by Nanjing Agricultural University in 2022. The survey employed the Probability Proportional to Size (PPS) sampling methodology, effectively mitigating sampling bias that might arise from neglecting differences in scale. Due to the impact of the epidemic, the survey subjects in 2022 were set as 6 prefecture-level cities and 24 administrative villages in Jiangsu Province. The China Land Economy Survey conducted a baseline investigation in Jiangsu Province in 2020. The survey covered various aspects including rural industries, agricultural production, living environment, and rural governance. In the field-level investigation, it collected basic information such as the personal situation of farmers, the family population situation, and the farming operation situation. It also included information related to whether pest control and pesticide packaging recycling were carried out during the agricultural production process, which can well meet the needs of this research. Based on the statistical indicators required for this study, we processed the 2022 CLES data. The sample exclusion criteria are as follows: first, excluding samples with missing key variables; second, excluding abnormal samples that lack key information in the survey questionnaire. Finally, a total of 1054 research samples were confirmed (see Figure 2).

3.2. Variable Selection

3.2.1. Dependent Variable

The dependent variable is farmers’ green production behavior, which refers to the comprehensive behavior of farmers in agricultural production that adopts green production technologies for energy conservation, reduction in consumption, and pollution reduction [16,47], including soil testing and fertilization technology, straw returning to the field, and collection of pesticide packaging waste, etc. Drawing on the studies of Xu et al. [21] and Zhu et al. [48], and combining with the existing data, this paper measures whether farmers adopt green production behavior. We select four behaviors: farmland pollution control and remediation, deep plowing and deep tillage of soil, pest and disease prevention and control, and pesticide packaging recycling. These behaviors encompass the full agricultural production process. Calculate the average number of each sample for the adoption of the above four behaviors. If the number of green production behavior adopted by the farmers is greater than the average value, assign a value of 1; if it is less than or equal to the average value, assign a value of 0.

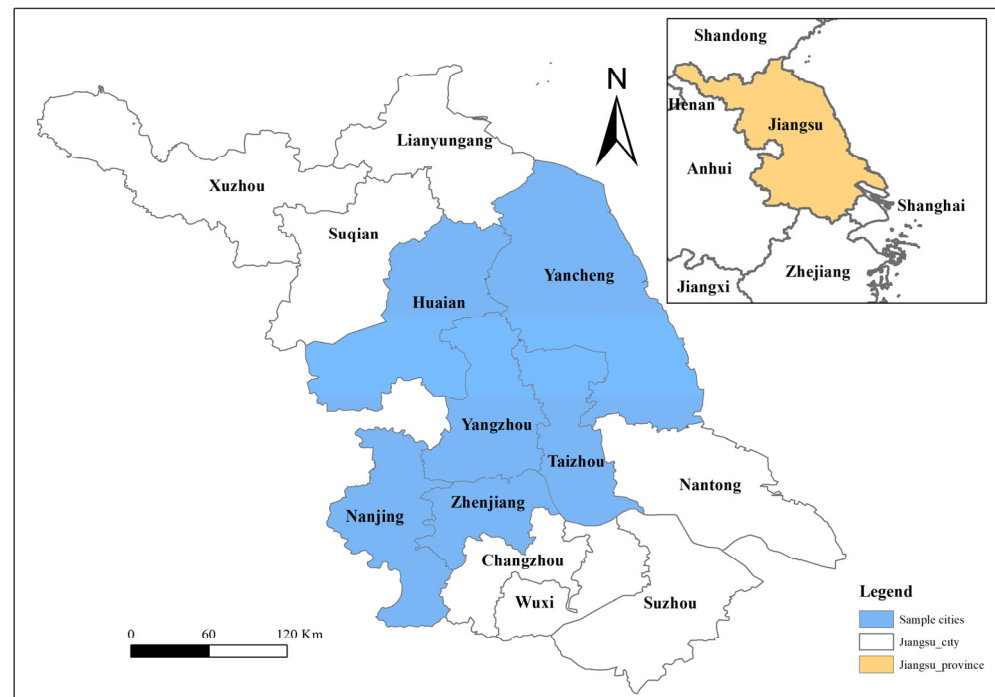


Figure 2. Study area. The map was made based on the standard map of China in 2024, with the map review number GS(2024)0650, and the base map has not been modified.

3.2.2. Core Independent Variable

The core independent variables are the embedded social capital and the disembedded social capital of the farmers. Embedded social capital, as defined in the text, refers to the homogeneous social resources formed by kinship and geographical ties [20,49]. According to the analytical framework presented earlier, we distinguished traditional social capital from the perspectives of action field, relationship network, and resource acquisition. Specifically, first of all, village ethos, as the direct manifestation of the ethical relationships and the operational rules of the acquaintance society within the village [50], reflects the community order characteristics that embedded social capital relies on. Good village ethos is an important manifestation of the functioning of embedded social capital within the village field, and it can effectively promote collective actions among villagers. Therefore, the action field for measuring the satisfaction of farmers with the village's moral civilization is selected. Secondly, in the process of agricultural production, farmers are initially influenced by their closest social relationships, such as the influence of family members, which can better reflect the relationship network that farmers are involved in. The daily interactions with these close groups are an important channel for obtaining and disseminating information on agricultural green production. Their viewpoints and behaviors may have a direct impact on the green production behavior of farmers [51]. Therefore, we measure the relationship network by counting the number of people in the farmers' households who have engaged in agricultural labor. Furthermore, the process by which farmers participate in village affairs is one of accumulating personal connections and practicing moral reciprocity within the network of acquaintances. This aligns with the acquisition logic of embedded social capital, which "depends on personal connections to obtain resources". The higher the degree of participation, the stronger the foundation for obtaining such resources [20,50]. Therefore, we use the degree of farmers' participation in village affairs as a measure of the way resources were obtained.

Disembedded social capital mainly examines the heterogeneous social resources that are accumulated through indirect communication based on new social ties and employment

spaces [20,49]. Firstly, the career transformation of farmers needs to go beyond the limited space within their village and connect with regional markets and resources. This will cause the field of operation to break through the physical boundaries of the village. At the same time, this career transformation can help farmers develop a standardized awareness of commercial credit [52]. Therefore, we measure the action field by whether the farmers are entrepreneurial households. Secondly, members of the family who have worked in non-agricultural sectors can assist farmers in expanding their network scope and obtaining more heterogeneous information about green production. Therefore, the relationship network is measured by the number of people in the household who have worked in non-agricultural sectors. Furthermore, the providers of technical training resources are mostly external government departments, enterprises and other professional institutions [15,53]. This has led to a change in the way farmers obtain resources, shifting from relying on the traditional logic of “human relations reciprocity” within their own village to obtaining resources through external channels and in a non-moralistic manner. Therefore, we chose the specific situation of farmers’ participation in agricultural technology training as an indicator to measure the way of resource acquisition. Finally, this paper draws on existing research [47] and assigns 1/3 of the weight to each variable of embedded social capital and disembedded social capital, respectively, for weighted averaging. The corresponding comprehensive indicators are then calculated.

3.2.3. Moderator Variable

The moderating variable in this study is the agricultural support protection subsidy. In 2016, the direct subsidies for grain production, subsidies for improved seeds, and subsidies for agricultural machinery were all merged into the agricultural support and protection subsidy. This subsidy is used to encourage farmers to take some protective measures, such as returning crop residues to the soil and applying organic fertilizers. The aim of this subsidy policy is to enhance the protection of agricultural ecological resources and ensure food security [54]. Based on the meaning of the agricultural support and protection subsidies mentioned above, and in combination with the data in this article, the agricultural subsidies in the data include subsidies for improved seeds, direct subsidies for grain farmers, and comprehensive subsidies for agricultural production materials, etc. Therefore, we use the total amount of agricultural subsidies received by farmers to measure the agricultural support and protection subsidies.

3.2.4. Control Variable

To avoid estimation bias caused by the omission of variables, this paper draws on previous studies [16,18,55] and selects farmer characteristics, farmer household characteristics, and external environmental characteristics as control variables. Table 1 displays the descriptive statistics for the variables.

Table 1. Variable assignment and descriptive statistics.

Variables	Descriptions	Mean	S.D.
Farmers’ green production behavior (GPB)	farmland pollution control and remediation, deep plowing and deep tillage of soil, pest and disease prevention and control, and pesticide packaging recycling; The number of adoptions exceeds the average of the four actions, No = 0; Yes = 1	0.473	0.496

Table 1. Cont.

Variables	Descriptions	Mean	S.D.
Embedded social capital (ESC)	Do you volunteer to vote in the village committee election or are you mobilized to participate: 1 = passive participation; 2 = Take the initiative, because there is a gift; 3 = Active participation, even without gifts	2.554	0.774
	How many members of your family have worked in agriculture(people)	1.506	1.005
	Your satisfaction with the village-style civilization: 1 = very dissatisfied; 2 = less satisfied; 3 = general; 4 = more satisfied; 5 = Very satisfied	4.124	0.732
Disembedded social capital (DSC)	Education or training in agricultural technology: No = 0; Yes = 1	0.431	0.495
	How many members of your family have worked outside the farm(people)	1.352	1.112
	Whether you are a business owner: No = 0; Yes = 1	0.076	0.266
Agricultural support and protection subsidies (AS)	Planting subsidies (10,000 CNY)	0.210	1.105
Household head's educational attainment (HHEA)	The number of years of education for the head of household	7.435	3.780
The health condition of the household head (HHHC)	Self-perceived health status of the head of household: 1 = incapacity to work; 2 = difference; 3 = medium; 4 = good; 5 = Excellent	3.626	1.438
Permanent resident population of the household (HHPRP)	How many people live in your family (6 months or more a year)	3.033	1.565
Age of family members (FMA)	Average age of family members	53.331	13.927
Educational attainment of family members (FMEA)	Family members average years of education	7.196	2.893
Annual household income (AHI)	Take logarithm of total annual household income	1.841	4.433
Farmland scale (FS)	Total farmland land operation area (mu)	15.988	75.113
Agricultural socialized services (ASSs)	agricultural socialized machinery operation service fee (yuan)	87.289	327.380
Ecologically livable environment (ELE)	Your satisfaction with the ecological livability of the village: 1 = very dissatisfied; 2 = less satisfied; 3 = general; 4 = more satisfied; 5 = Very satisfied	3.294	1.419
Rural living environment (RLE)	Do you know about the improvement of the rural living environment?: 1 = Never heard of it; 2 = Have heard of it but don't know much; 3 = Know a little about it; 4 = Know it relatively well; 5 = Know it very well	2.774	1.364

3.3. Methods

Based on the above theoretical analysis and the availability of data, whether farmers adopt green production practices is a binary decision-making problem. Therefore, this study empirically analyzes the impact of social capital on farmers' green production behavior by constructing a binary Logit model.

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum \beta_i X_i \quad (1)$$

In Equation (1), P_i represents the probability of farmers adopting green production behavior. β_i is the estimated coefficient of relevant influencing factors. X_i is a group of variables that affect farmers' green production behavior, including embedded social capital,

disembedded social capital, farmers' personal characteristics, family characteristics, and external environmental characteristics.

In order to further investigate the direct impact of social capital on farmers' green production behavior, as well as the differences in farmers' green production behavior when other factors change, this paper uses the moderation effect model for corresponding verification.

$$Y = \alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 M + \beta_4 X_1 M + \beta_5 X_2 M + \delta_1 \quad (2)$$

In Equation (2), Y represents the dependent variable, indicating the green production behavior of farmers. X_1 and X_2 are independent variables, representing embedded social capital and disembedded social capital, respectively. M is the moderating variable, representing agricultural support and protection subsidies. $X_1 M$ is the interaction term between embedded social capital and agricultural support and protection subsidies. $X_2 M$ is the interaction term between disembedded social capital and agricultural support and protection subsidies. β is the corresponding regression coefficient, and δ_1 represents the error estimation term.

3.4. Multicollinearity Test

Prior to model estimation, considering the potential collinearity among variables, this study adopted the Variance Inflation Factor (VIF) method to conduct a multicollinearity test on all independent variables. The results are presented in Table 2. As shown in the test results, the maximum value of the obtained variance inflation factors is 4.62, and the average variance inflation factor is 2.02, both of which are far less than 10. This indicates that there is no severe multicollinearity among the variables selected in this study.

Table 2. Multicollinearity test results.

Variables	VIF	1/VIF
RLE	4.62	0.2166
HHHC	4.24	0.2357
ELE	4.01	0.2493
AS	1.71	0.5846
FS	1.68	0.5953
HHEA	1.39	0.7183
FMEA	1.38	0.7258
HHPRP	1.32	0.7589
DSC	1.29	0.7772
FMA	1.28	0.7789
AHI	1.14	0.8799
ESC	1.13	0.8814
ASSs	1.04	0.9629
Mean VIF	2.02	

4. Results

4.1. Benchmark Regression Analysis

To examine the mechanism through which social capital influences farmers' green production behavior, Model 2 presents the regression results of farmers' green production behavior after including control variables. The estimation results are shown in Table 3. It can be seen from the results that, regardless of whether the control variables are included or not, the influence of disembedded social capital on farmers' green production behavior is significant at the 1% level. According to Model 2, the marginal effect results show that a one unit increase in embedded social capital increases the probability of adoption by 9.6%, and one unit increase in disembedded social capital increases the probability of adoption

by 13.2%. That is to say, compared with embedded social capital, the promoting effect of disembedded social capital on farmers' green production behavior is more significant. Thus, hypothesis H1 is verified. Furthermore, to more clearly present the differences in the marginal effects between embedded social capital and disembedded social capital, we have plotted marginal effect graphs for the two types of social capital (see Figure 3).

Table 3. The regression results of the baseline analysis of the impact of social capital on farmers' green production behavior.

Variables	Model 1		Model 2	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect
ESC	0.527 *** (0.108)	0.121 *** (0.024)	0.461 *** (0.115)	0.096 *** (0.023)
DSC	0.633 *** (0.104)	0.145 *** (0.022)	0.637 *** (0.126)	0.132 *** (0.025)
HHEA			0.056 (0.080)	0.012 (0.017)
HHHC			0.023 (0.047)	0.005 (0.010)
HHPRP			−0.130 * (0.075)	−0.027 * (0.016)
FMA			−0.020 (0.074)	−0.004 (0.015)
FMEA			−0.111 (0.081)	−0.023 (0.017)
AHI			0.027 (0.059)	0.006 (0.012)
FS			0.004 (0.003)	0.001 (0.001)
ASSs			1.551 *** (0.267)	0.322 *** (0.049)
ELE			0.045 (0.050)	0.009 (0.010)
RLE			0.034 (0.052)	0.007 (0.011)
Constant	−0.249 *** (0.064)		−0.538 * (0.315)	
N	1054		1054	
Pseudo R ²	0.0493		0.1232	
Prob > chi2	0.0000		0.0000	

Note: * and *** denote significance at the 10%, 5%, and 1% levels.

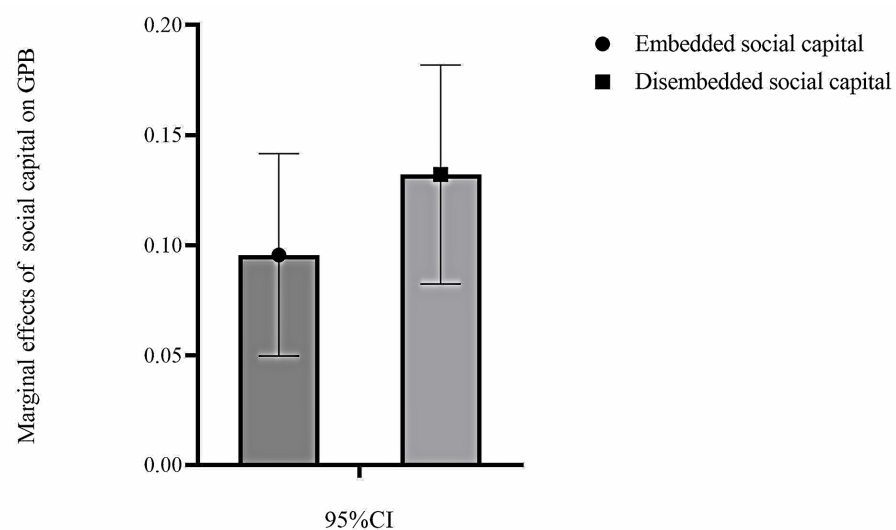


Figure 3. Marginal effects of social capital on GPB.

4.2. Robustness Test

To ensure the reliability of the estimation results, this study conducted a robustness test by restricting the sample and changing the model [16]. The test results are shown in Table 4. Firstly, considering that green production practices rely on the physical capabilities and learning abilities of farmers as a prerequisite, we excluded the sample groups whose age was over 70 years old. As demonstrated in Model 3, the direction and significance of embedded social capital and disembedded social capital are largely consistent with the baseline regression. This indicates that the estimation results are robust. Secondly, considering that the dependent variable of this study is a binary variable and the sample size of this research is relatively large, a binary probit model is adopted for robustness testing. As shown in Model 4 of Table 4, both embedded social capital and disembedded social capital have a significantly positive impact on farmers' green production behavior at the 1% significance level. This indicates that the regression results are consistent with the previous findings, confirming the validity and robustness of our conclusions. Furthermore, to address the potential heteroscedasticity issue in the model, we employed robust standard errors (achieved through the `vce(robust)` option in Stata 18) when estimating the model. The robust standard errors do not require the specific form of heteroscedasticity to be assumed, and can provide consistent standard error estimates even in the presence of heteroscedasticity, ensuring more reliable statistical test results for model coefficients and marginal effects [56]. The standard errors, z-statistics and *p*-values in all reports are all calculated based on robust standard errors.

Table 4. Robustness test.

Variables	Limiting Samples	Replacing Models
	Model 3	Model 4
ESC	0.381 *** (0.138)	0.289 *** (0.070)
DSC	0.627 *** (0.148)	0.402 *** (0.076)
Control variable	controlled	controlled
Constant	−0.504 (0.357)	−0.336 * (0.190)
N	775	1054
Pseudo R ²	0.1148	0.1181
Prob > chi2	0.0000	0.0000

Note: * and *** denote significance at the 10%, 5%, and 1% levels.

4.3. Moderation Effect Test of Agricultural Support and Protection Subsidies

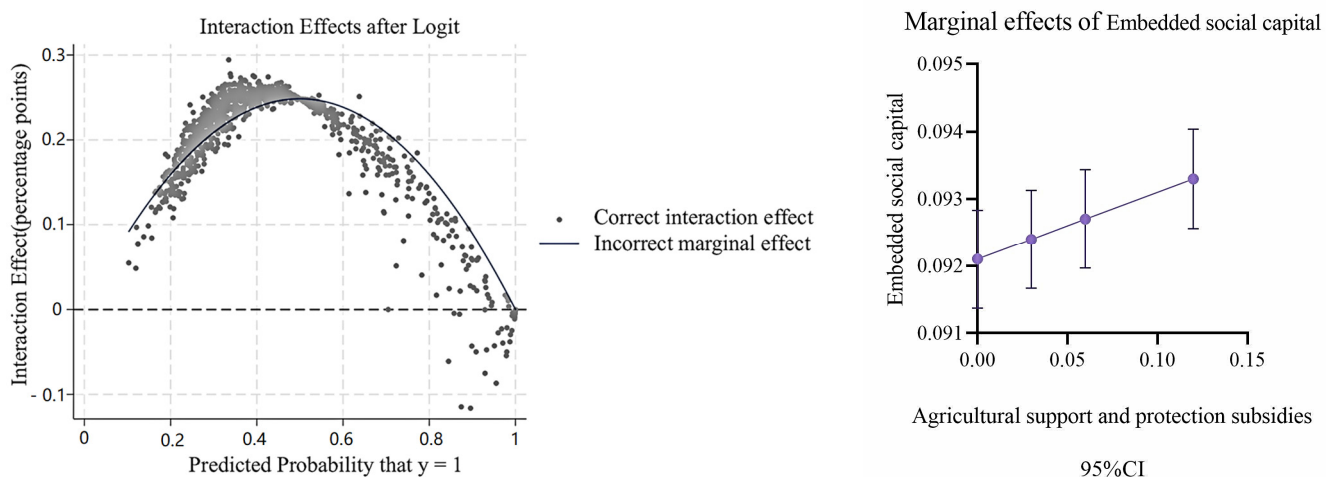
This study explored the moderating effect of agricultural support and protection subsidies on the influence of social capital on farmers' green production behavior by constructing an interaction term between social capital and agricultural support and protection subsidies. The results are shown in Table 5. From Model 6, we found that the results were in line with our expectations. The interaction coefficient between embedded social capital and agricultural support and protection subsidies is 0.994, and it passes the significance test at the 10% statistical level. This indicates that the agricultural support and protection subsidies have a significant positive moderating effect on the influence of embedded social capital on farmers' green production behavior. In Model 7, the interaction coefficient between disembedded social capital and agricultural support and protection subsidies is −0.402, and it fails to pass the significance test. This indicates that subsidies do not positively moderate the effect of disembedded social capital on farmers' green practices. Thus, hypothesis H2 is partially verified.

Table 5. Moderation effect test.

Variables	Model 5		Model 6		Model 7	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
ESC	0.440 *** (0.115)	0.091 *** (0.023)	0.353 *** (0.120)	0.073 *** (0.024)	0.438 *** (0.115)	0.090 *** (0.023)
DSC	0.601 *** (0.126)	0.124 *** (0.025)	0.598 *** (0.127)	0.123 *** (0.026)	0.655 *** (0.134)	0.135 *** (0.027)
AS	0.688 ** (0.315)	0.142 ** (0.064)	0.615 ** (0.295)	0.126 ** (0.060)	0.911 *** (0.348)	0.187 *** (0.071)
ESC×AS			0.994 ** (0.484)	0.204 ** (0.098)		
DSC×AS					−0.402 (0.336)	−0.083 (0.069)
Control variable	controlled		controlled		controlled	
Constant	−0.583 * (0.318)		−0.584 * (0.319)		−0.585 * (0.318)	
N	1054		1054		1054	
Pseudo R ²	0.1289		0.1316		0.1299	
Prob > chi2	0.0000		0.0000		0.0000	

Note: *, **, and *** denote significance at the 10%, 5%, and 1% levels.

As shown in Figure 4, we further analyzed the moderating effect of agricultural support and protection subsidies. In the left panel, the regression results indicate that the majority of interaction term coefficients in the sample are positive (above the 0-axis) and statistically significant ($z = 2.05$). This means that farmers with higher embedded social capital and more agricultural support and protection subsidies are more likely to adopt green production behavior. Specifically, when the predicted probability of farmers adopting green production behavior ranges from 0.2 to 0.5, the moderating effect is positive and shows an increasing trend—this suggests that the “combined effect” of embedded social capital and agricultural support and protection subsidies has the strongest promotional impact on farmers with moderate willingness to practice green production behavior.

**Figure 4.** Interaction effect.

Furthermore, more precisely, the right panel presents a detailed analysis of embedded social capital under different subsidy levels, from which we can conclude that as the amount of agricultural support and protection subsidies increases, the marginal effect of embedded social capital on farmers’ adoption of green production behavior continues to strengthen. Specifically, when the subsidies received by farmers range from 0 to 1500 yuan,

the contribution rate of embedded social capital to farmers' willingness to adopt green production behavior increases with the increase in subsidy amount ($p = 0.000$). However, when agricultural support and protection subsidies exceed this range, this effect is no longer statistically significant. In summary, agricultural support and protection subsidies significantly positively moderate the relationship between embedded social capital and farmers' green production behavior.

5. Discussion

Firstly, the research results indicate that both embedded and disembedded social capital positively influence farmers' green practices, with disembedded capital (0.132) exerting a stronger effect. Consistent with the research results of Gao et al. [20] and Guo et al. [49], from the perspective of social capital differentiation, we linked the regional social capital and the disembedded social capital with the green production practices of farmers. We confirmed the positive effects of both regional social capital and disembedded social capital, and the influence effect of disembedded social capital was greater than that of regional social capital.

From the perspective of global agricultural production practice cases, mass media as well as agricultural extension and consulting services play an important role in introducing new technologies and green agriculture concepts. However, there is no doubt that the attention paid to local traditional farmers, i.e., embedded farmers, is very low. A key manifestation of this is insufficient investment in farmers' education, which leaves their agricultural planting experience limited to outdated production practices and prevents them from adapting to new technologies and concepts. In this regard, developed economies such as the Netherlands, the United States, and the United Kingdom have made considerable efforts, such as establishing "farmer study groups" [57], "4-H Clubs", and "breed improvement societies" [58], to help small-scale farmers access more advanced agricultural production technologies. Nevertheless, based on the current production practices of Chinese farmers, resources like these new technologies and concepts have not been well disseminated to local farmers. For example, since 2012, the Chinese government has issued the No. 1 Central Document for four consecutive years, emphasizing the promotion of the New Professional Farmers' Training (NPFT) program. However, judging from the actual effect of the policy implementation, many farmers have given negative evaluations of the NPFT, considering it useless due to inappropriate training content and insufficient funding support [59].

A large number of field surveys also show that, due to limited human and financial resources, Chinese agricultural technology extension staff usually select a small number of farmers as the target of technology dissemination in a targeted manner. These target farmers are usually agricultural elites with higher education levels and larger farms in the village. As a result, most local farmers know very little about new agricultural technologies, and only a tiny number of local farmers adopt new agricultural technologies in the early stage of promotion [60]. In contrast, most large-scale farmers are more likely to readily accept the technology training promoted by the government. For instance, Li Xingjun, a farmer entrepreneur from Henan Province in China, was able to accurately identify the green consumption trend of people around him, who were concerned about food health. He adopted green and environmentally friendly biological agents and established a farming and breeding cycle model to promote green production. At the same time, he promptly adjusted his production strategies to meet the market demand for safe agricultural products, ultimately achieving a 30–40% increase in crop value and reaping higher economic benefits [61].

Secondly, we found that agricultural support and protection subsidies played a positive moderating role in the farmers' green production behavior through embedded social capital. Government agricultural subsidies usually carry a certain degree of national will and political implications. Farmers with abundant regional social capital exhibit more traditional characteristics. They have a "loyalty to the state" mentality and a "compliance" consciousness [62], which makes them more compliant with agricultural subsidy policies that embody state will. Subsidies, as signals for the government to guide green production [63], will spread rapidly within the interpersonal networks of villages. For instance, through the exemplary effects of village officials and model farmers, other farmers can directly observe that green production not only earns government subsidies but also receives more recognition and support in the context of embedded social capital. Under this influence, farmers will be more willing to follow this practice, thereby increasing the adoption rate of green production behavior.

This result is also consistent with existing literature. As farmers are rational actors who comprehensively consider risks and benefits, they have a stronger willingness to promote agricultural green production when government subsidies can cover the additional costs of adopting green agricultural technologies. In Chen's study [64], he found that agricultural subsidies have the most significant effect on improving the planting willingness of low- and middle-income farmers—who are usually embedded traditional farmers mainly engaged in grain crop cultivation. This also indicates that the adoption of green technologies is directly related to farmers' planting structures and the agricultural risks they face. Since the input costs for these farmers mainly come from production factors with relatively low economic value (such as chemical fertilizers and pesticides) rather than large investments like agricultural machinery, government subsidies can effectively cover their cost inputs. Our study provides additional empirical insights into these findings. In our regression model, it can be seen that when agricultural subsidies range from 0 to 1500 yuan, they have the strongest boosting effect on the green production willingness of farmers with high levels of embedded social capital; however, when subsidies exceed this amount, the effect becomes statistically insignificant.

According to our research results, the moderating effect of agricultural subsidies on disembedded social capital is not statistically significant. This may stem from contradictions in the following two aspects. First, disembedded farmers who receive large subsidies do use the subsidies to purchase agricultural machinery and adopt advanced technologies such as soil-test based formulated fertilization, which improves production efficiency and promotes green production. For example, some scholars have proposed establishing a new type of agricultural subsidy model, in which small-scale farmers no longer receive direct subsidies from the government. This new model aims to support large-scale producers and operators—modern agricultural entities with high levels of disembedded social capital, including large-scale farmers, professional farmers' cooperatives, and agricultural social service organizations—which is conducive to the adoption of green agricultural production technologies and the promotion of sustainable agriculture [65]. Second, this group of farmers is highly market-oriented, and their behavioral decision-making logic prioritizes economic interests [66]. Specifically, many farmers in this group tend to use subsidies to purchase traditional chemical fertilizers such as urea and phosphate fertilizer. Compared with organic fertilizers, traditional chemical fertilizers have a more direct effect on increasing yields and can largely reduce farmers' agricultural production costs [67]. A more serious issue is that farmers with high levels of disembedded social capital may view subsidies as a supplement to short-term income rather than a long-term incentive to promote green production; some even engage in speculative behaviors such as "embezzling subsidy funds". For instance, the Finance Department of Anhui Province and the

Department of Agriculture and Rural Affairs of Anhui Province jointly issued the 2022 Implementation Plan for One-Time Subsidy Funds for Actual Grain-Growing Farmers, which clearly stipulates that provincial finance departments must distribute planting subsidies to actual grain-growing farmers based on factors such as the amount of funds allocated to counties and sown area [68]. However, a certain Mr. Wu falsely reported over 1000 mu of planted area (without actually completing the project) by fabricating projects such as “Promotion and Service of Green Production Technologies for Wheat Professional Brands” and forging materials including land transfer contracts, defrauding a total of more than 20,000 yuan in special subsidy funds. This case clearly shows that some entities with disembedded social capital, when faced with agricultural support and protection subsidies, regard subsidies as a tool to simply obtain economic benefits rather than a driving force for green production—this seriously deviates from the original intention of the subsidy policy [69]. Therefore, in our research, agricultural subsidies have no direct intervention effect on whether individuals with high disembedded social capital adopt green behaviors.

Finally, this paper also has limitations: Firstly, the research area of this article is Jiangsu Province, which only reflects the situation of some developed areas in southern China. Since 1953, the economic development of China has gradually formed a clear “strong south and weak north” pattern. Especially after 2013, China entered an unprecedented period of significant divergence in economic development between the north and the south [70]. Due to the economic development gap, the social capital in southern and northern China will exhibit different characteristics. The social capital in the south may show a more pronounced disembedded feature, while the social capital in the north may have a more traditional nature. Therefore, future research can build upon this study and, in combination with social surveys, conduct sampling in different cities in the north and south to further refine the theoretical understanding of social capital within the academic community. Secondly, regarding the research scope. China’s agricultural subsidies have been implemented nationwide since 2016. Since this paper is based on cross-sectional data, it cannot capture the varying characteristics of agricultural subsidies across different phases of policy implementation. Thirdly, the farmers’ green production discussed in this paper is under normal agricultural production conditions. Due to the vulnerability of agricultural production, farmers’ psychological and behavioral logic may change when extreme weather events or pests and diseases occur [71]. Future research should explore the roles of farmers’ social capital and agricultural subsidies under abnormal agricultural production conditions. This will lead to a more comprehensive understanding of farmers’ green production behaviors and enable the proposal of more scientific policy recommendations for agricultural green transformation.

6. Conclusions and Policy Implications

Promoting green agricultural production is an inevitable choice to address global ecological challenges and a strategic path for achieving high-quality agricultural development. This paper examines the influence of embedded social capital and disembedded social capital on farmers’ green production behavior from the perspective of social capital differentiation. At the same time, further incorporate agricultural support and protection subsidies into the analytical framework to analyze their regulatory role in the social capital. Based on the 2022 China Land Economic Survey (CLES) data, this paper systematically analyzed the impact of social capital on farmers’ green production behavior, and examined the differences in the influence of the two types of social capital as well as the moderating role of agricultural support and protection subsidies. The main conclusions are as follows: (1) Both embedded social capital and disembedded social capital have a significant positive impact on farmers’ green production behavior, and the promoting effect of disembed-

ded social capital is greater than that of embedded social capital. After restricting the sample and conducting a robustness test using the binary probit model, the conclusion remained unchanged. (2) The embedded social capital plays a positive regulatory role in farmers' green production behavior only when it is influenced by regional social capital; however, there is no such positive regulatory effect when it is influenced by disembedded social capital.

The above research findings reveal that social capital helps farmers adopt green production behavior. The policy implications of these findings are as follows: (1) Guide social capital through classification, precisely match farmers' needs. The government strengthens rural community construction and promotes the formation of embedded social capital through organizing diverse activities. At the same time, it helps farmers establish extensive external social networks and enhance their disembedded social capital level. Among them, for those entities with a high level of disembedded social capital, the government should formulate more targeted guiding policies. For example, by strengthening the training of green production concepts for major grain producers and specialized cooperatives, and inviting experts to explain the market prospects and long-term economic benefits of green agricultural products, their production concepts can be transformed. (2) Optimize the government subsidy mechanism and enhance the targeting of policies. When fiscal conditions permit, appropriately increase subsidies for traditional farmers. For farmers with a high level of disembedded social capital, the subsidy distribution should be linked to the actual effectiveness of green production. For instance, the government should establish evaluation indicators for the effectiveness of green production, including the status of green certification for agricultural products and the extent of application of green technologies. Finally, subsidies should be distributed based on the assessment results in different tiers. At the same time, relevant departments should strengthen the supervision of subsidy funds. By leveraging big data technology, a monitoring system for the flow of subsidy funds should be established to conduct full-process tracking of the fund usage. The government needs to severely crack down on the acts of embezzling subsidy funds and ensure that the funds are truly used for green production.

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