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The Impact of Rural Industrial Integration on Agricultural Green Productivity Based on the Contract Choice Perspective of Farmers

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Abstract: Promoting farmers' participation in rural industrial integration and driving farmers' agricultural production with cooperatives and agribusinesses are conducive to realizing cost saving, efficiency, and green production and guaranteeing food security and sustainable agricultural development. Based on the microsurvey data of 1039 grain farmers in Henan Province, China in 2022, this paper examined the impact of contractual choices of farmers' participation in rural industrial integration on agricultural green productivity while analyzing the mechanism of action by using OLS regression, a causal mediation analysis of instrumental variables, propensity score matching, and two-stage least squares (2SLS). The study found that: (1) farmers' participation in a contract, driven by cooperatives or agribusinesses to carry out agricultural production, is conducive to improving their agricultural green productivity, but the effect of each main body to drive farmers varies; (2) farmers' participation in a contract, through cooperatives or agribusinesses to obtain all kinds of agricultural production services—such as agricultural machinery services, agricultural supply services, and technical guidance services—improves the use of agricultural machinery, the standardization of chemical fertilizers, pesticides, and other agricultural materials' use, increases technical guidance, and improves agricultural green productivity. The findings of this paper suggest policy and practical implications for safeguarding food security and promoting sustainable agriculture, as well as enriching research on agricultural productivity.

Keywords: farm households; agricultural green productivity; contract choice; rural industrial integration

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1. Introduction

Improving agricultural green productivity is a key path to guaranteeing food security and sustainable agricultural development. Agricultural operations in China are dominated by farmers' family operations, and at the same time, they are constrained by the resource endowment of many people and little land [1,2]. Under family operation, farm households are constrained by factors such as land and technology, capital, etc., which make it difficult to carry out large-scale, mechanized, and specialized agricultural production, which is not conducive to the achievement of food security goals [3]. At the same time, along with the depletion of natural resources such as land and the destruction of the ecological environment, traditional agricultural production methods have caused a sudden rise in environmental pressure. A key issue in China's agricultural development is the contradiction between the development requirements of agricultural modernization and traditional family management. It is difficult to adapt traditional family farming to the requirements of increased agricultural green productivity. Resource factor constraints and agricultural environmental pollution jeopardize food security and sustainable agricultural development. In the context of the long-term existence of farm family management [4], how to improve agricultural green productivity is still an important topic.

Rural industrial integration is an important initiative to realize sustainable agricultural development and ensure food security. Agricultural operations in China are dominated by smallholder production while being constrained by the resource endowment of many people and little land. Under smallholder family operations, farmers are constrained by technology and factors such as land and capital, making it difficult to carry out large-scale, mechanized, and specialized agricultural production. Document No. 1 of the Central Committee in 2020 mentioned that "small farmers will be integrated into the agricultural industry chain by means of order farming, share and dividend sharing, and custodial services" [5] through various forms of production organization. Driving the production and operation of farm households has received widespread attention. As a development model, rural industrial integration takes agricultural production as the center, connects the secondary and tertiary sectors, extends the industrial chain forward and backward, connects the processing of agricultural products and the supply of agricultural production materials with the primary industry, and relies on agricultural enterprises and cooperatives to drive farmers to carry out agricultural production and operation. Meanwhile, it promotes environmental protection and proenvironmental behavior, thus realizing the multifunctionality of agriculture. To guarantee food security, realize sustainable agricultural development, and improve agricultural green productivity, it is indispensable to be driven by the integration of rural industries [6]. Therefore, it is of great practical significance to promote the participation of farmers in the integration of rural industries through various forms of production organizations and to drive farmers to carry out agricultural production through agricultural enterprises, cooperatives, and other production and management organizations [7,8]. It is also becoming a growing trend for farmers to participate in rural industrial integration by establishing contractual relationships with cooperatives and agribusinesses for the purpose of agricultural production and management.

Agricultural green productivity can be affected by the contractual choices of farmers. Considering all kinds of production organization forms as different contractual choices, farmers' participation in rural industrial integration, cooperation with cooperatives and agribusinesses, and the formation of different contractual choices will change farmers' factor inputs and production technology [9,10], affecting agricultural green productivity. And the rural industrial integration of various types of contractual options to drive farmers to produce and to manage the effect is, in fact, how it can enhance the agricultural green productivity of farmers. Driving farmers to produce and realize the cost savings and efficiency of agricultural production has become a hot topic of research in the field of agricultural economics. Rural industrial integration is an important carrier to drive farmers to carry out agricultural production and management [11], while agribusiness is the dominant force in the development of rural industrial integration, and cooperatives are the link in the development of rural industrial integration [12]. Farmers' participation in rural industrial integration, driven by cooperatives, agribusinesses, and other organizations, will affect their agricultural production and operation [13]. Cooperatives, agribusinesses, and other production and management organizations can provide all kinds of agricultural production and management services for farmers, such as agricultural machinery production services, technical guidance services, agricultural supply services, and so on. The provision of these agricultural production and management services will change the allocation of factors, technical conditions, and the use of agricultural materials in agricultural production, which in turn will affect the efficiency of agricultural production. Farmers cooperate with cooperatives or agricultural enterprises and other organizations to obtain agricultural production services such as agricultural machinery, which is conducive to improving the use of agricultural machinery in agricultural production, through factor substitution, increasing agricultural machinery input, reducing labor input, and changing the factor configuration of farmers, which in turn affects agricultural green productivity [14]. At the same time, cooperatives or agribusinesses have advantages in production technology and can give farmers technical guidance on production [15], which will affect agricultural green productivity by promoting the technical progress of farmers. In addition, cooperatives or agribusinesses provide agricultural supply services and guidance to farmers on how to use them, standardize inputs such as fertilizers and pesticides, and at the same time offer preferential treatment to cooperative farmers in their purchases, changing the level of agricultural green productivity.

The innovations of this paper are as follows: (1) China's grain production is influenced by smallholder farming and yield-oriented agricultural policies, and related research has focused more on grain yield and income. Under the background of "three quantities increasing" and "three costs rising", and facing the threat of agricultural environmental pollution, improving agricultural green productivity is the key to realizing food security and sustainable development of agriculture. This paper centers on agricultural green productivity, supplementing the existing research. At the same time, the existing literature on agricultural green productivity for farmers mostly uses macro data, while this study uses research data to provide evidence at the micro level. (2) The existing literature on farm household agricultural production is mostly based on the perspective of farm household factor inputs, and less consideration is given to the driving role of cooperatives, agribusinesses, and other subjects on farm household agricultural production. Based on the perspective of contractual choice, this paper analyzes the driving role of cooperatives and agribusinesses in farmers' agricultural production. Driven by cooperatives and agribusinesses, it is also conducive to improving agricultural green productivity and realizing food security and sustainable agricultural development. (3) This paper elucidates the mechanism of the impact of contractual choice on the agricultural green productivity of farmers, analyzes the influence path of factor substitution, technological progress, and the use of normative factors of production, and discovers a new mechanism for farmers to influence agricultural production through different contractual choices, which enriches the research on agricultural production of farmers. (4) The existing literature has mostly used stepwise method tests when studying the issue of influence mechanism or action channel, but there may be an endogeneity problem in it, which affects the reliability of the conclusion. This paper applies the causal mediation analysis of instrumental variables to the process of econometric analysis to try to alleviate the endogeneity problem that may exist in the analysis of impact mechanisms.

2. Research Hypotheses

Different agricultural contracting options will have different impacts on the agricultural green productivity of farm households. It is generally accepted in the academic community that farm households participate in rural industrial integration by joining cooperatives or signing contracts with agricultural enterprises [16,17]. Referring to Liang et al. [18], this study classifies contract choices as market sale (farmers produce and operate independently, do not cooperate with other production and management organizations, and do not participate in rural industrial integration), vertical product contract (farmers sign purchase orders with agricultural enterprises, forming order agriculture), horizontal production contracts (agricultural production services provided by cooperatives, unified production, and operation), and vertical production contracts (production contracts signed between farmers and agricultural enterprises regarding production standards, agricultural supply, and acquisition conditions). When farmers join cooperatives or sign contracts with agricultural enterprises, firstly, cooperatives or agricultural enterprises can provide farmers with technology and information [19]. Farmers obtain adequate information and more scientific planting technology, which is conducive to improving the efficiency of the use of factors in their planting [20,21], scientific agricultural production, and reducing the use of chemical fertilizers and pesticides [22], which improves agricultural green productivity. Secondly, farmers join cooperatives or sign contracts with agricultural enterprises, and the cooperatives or agricultural enterprises unify their operations and provide specialized, large-scale, and mechanized agricultural productive services, which improve farmers' production and management capabilities while combining similar production, resulting in scale effects [23], and thus increasing agricultural green productivity. Finally, most cooperatives or agricultural enterprises provide services to procure agricultural supplies, and farmers who are contracted to such entities can obtain lower prices when purchasing agricultural supplies and contribute to agricultural green productivity [19].

The different types of contract choices are specifically analyzed. (1) Market sale: Farmers are independent in agricultural production through the family business and enter the market to sell their agricultural products. (2) Vertical product contract: The contract choice of contract farming is formed when farmers sign a purchase contract with an agricultural enterprise that includes provisions on the quantity, quality, and purchase price of agricultural products. Under this contractual option, due to the setting of the purchase standards, farmers, in order to make the produced agricultural products meet the prescribed quality and standards, will take the initiative to improve their agricultural production methods, conduct agricultural production more scientifically, improve their production and management capabilities, subjectively regulate their production behavior, and reduce the inputs of agricultural chemicals such as pesticides and fertilizers [24], thus improving the efficiency of factor use and increasing agricultural green productivity. At the same time, some agribusinesses are also engaged in the sale of agricultural products, and when signing contracts with farmers for the purchase of agricultural products, they will also provide farmers with agricultural supply services and guide them in the use of fertilizers, pesticides, and other agricultural products, and farmers can also buy relatively inexpensive agricultural products, which is more convenient and helps to improve agricultural green productivity. (3) Horizontal production contracts: Farmers join the cooperative to become members of the cooperative society, and the cooperative society provides farmers with services related to agricultural production and management. Under this contractual option, the cooperative will provide various kinds of agricultural production and management services for member farmers at a relatively low price [10], provide member farmers with seedlings, fertilizer, pesticides, and other agricultural supplies and procurement services before production, provide member farmers with production management services such as cultivation, technical advice, agricultural machinery, etc., and provide member farmers with the acquisition, marketing and other services after production. In addition, after production, the cooperative will also provide member farmers with services such as purchase and marketing. The agricultural supply, technical guidance, production management and other services provided by cooperatives to member farmers are all conducive to improving the production and management capacity of farmers, standardizing their planting and production, and improving agricultural green productivity [25,26]. (4) Vertical production contracts: Farmers and agribusinesses sign production contracts involving the use of agricultural factors, production standards, and product standards. Under this contractual option, in order to ensure the quality of agricultural products delivered by farmers, agribusinesses will provide farmers with guidance on production technologies such as planting and cultivation, fertilizer application, pest control, etc., and farmers can improve the efficiency of factor use, increase yields, and reduce costs by accepting and mastering these scientific production technologies. At the same time, in order to ensure the consistency and quality of agricultural products, agribusinesses will provide seedlings, fertilizers, pesticides, and other factors on credit, and regulate the use of agrochemicals by farmers, and the contracted farmers can also purchase various factors of production at relatively low prices, which can reduce the factor input costs [17] and improve agricultural green productivity. There are also differences in the risks borne by farmers under different contract choices, which will also affect their agricultural production. According to the analysis of contract theory, under different contract choices, the risk to farmers is different. This difference in risk also affects the production decisions of farmers, such as the adoption and use of technology, which in turn affects the productivity of farmers. Most of the related studies believe that farmers have a tendency to risk aversion [27], and therefore, farmers are reluctant to accept new technologies [28], and at the same time use fertilizers and pesticides excessively [29]. However, the above production decision-making behavior of farmers is not conducive to an improvement in green productivity in agriculture. In the context of rural industrial integration, by promoting the establishment of contractual relationships between farmers and cooperatives or agribusinesses, with cooperatives or agribusinesses driving farmers to carry out agricultural production, it is possible to transfer some of the risks originally borne by farmers to cooperatives or agribusinesses. Sharing risks through cooperatives or agribusinesses is conducive to incentivizing farmers to accept new technologies, standardizing the use of agrochemicals such as fertilizers and pesticides, and increasing green productivity in agriculture. Summarize the mechanisms of the above impacts. Cooperatives and agricultural enterprises drive farmers' production and improve farmers' agricultural green productivity mainly by providing farmers with three services: first, providing agricultural supply services, regulating the use of fertilizers, pesticides, and other agricultural products, while reducing farmers' expenditure on purchasing agricultural products, thus improving agricultural green productivity. Secondly, the provision of agricultural production services, such as agricultural machinery services, reduces the labor input of farmers, changes the traditional combination of factors, and realizes an improvement in agricultural green productivity [30,31]. Third, cooperatives or agricultural enterprises provide technical support for farmers to improve their agricultural production technology, the richer the agricultural technology mastery of farmers, the more conducive to the implementation of a more scientific approach to agricultural production, and the more efficiently carry out agricultural production [32], control agrochemical inputs, and improve agricultural green productivity through technological progress. The mechanism of the impact of farmers' contractual choices on agriculture green productivity is shown in Figure 1. Farmers choose to form a contractual relationship with cooperatives or agribusinesses, carry out agricultural production under the leadership of cooperatives or agribusinesses, and obtain various types of agricultural production services, which can improve agricultural green productivity. Therefore, we propose Hypotheses 1 and 2.

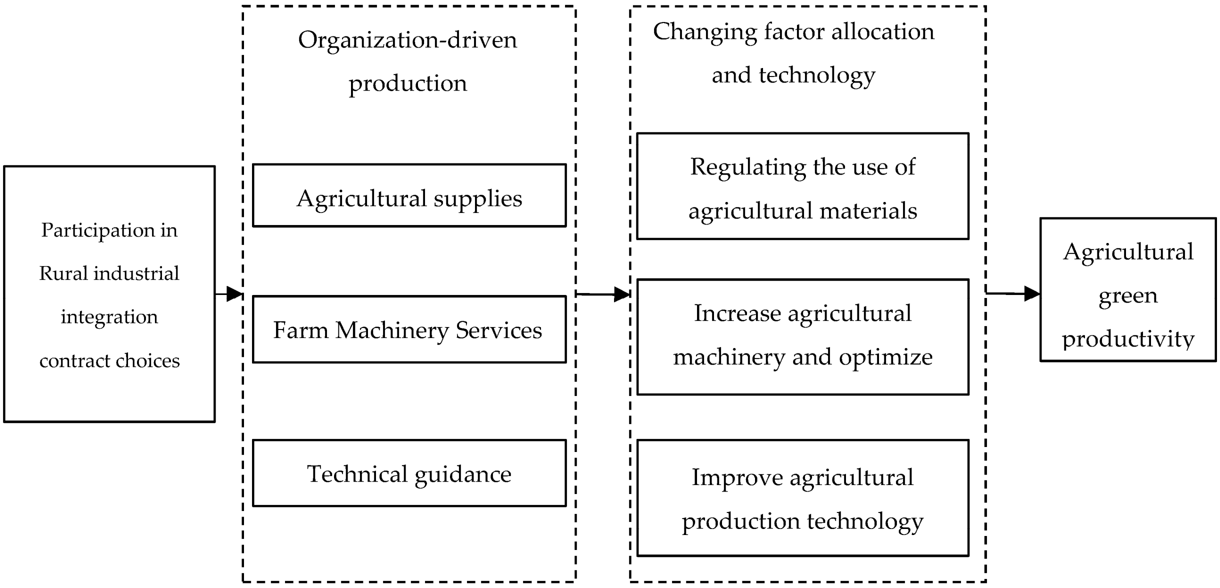

Figure 1. Mechanism map of the impact of farmers' contractual choices on agricultural green productivity.

Hypothesis 1 (H1). *Compared to market sales, farmers can improve agricultural green productivity through vertical product contracts, horizontal production contracts, and vertical production contracts for agricultural production.*

Hypothesis 2 (H2). *Farmers' participation in vertical product contracts, horizontal production contracts, and vertical production contracts for agricultural production will improve agricultural green productivity by influencing the supply of agricultural materials, the use of agricultural machinery, and technical guidance.*

3. Materials and Methods

3.1. Data Sources

The data samples of this study were obtained from the research on the production and operation of grain farmers in Henan Province of China conducted by the rural industrial integration group of Shenyang Agricultural University and the group from the School of Economics and Management of Nanyang Normal College from January to February 2022. The area surveyed in this study is Henan Province, China, which has a temperate continental monsoon climate with a predominantly plain land topography that is suitable for a wide range of crops, including wheat. The research used a combination of stratified and random sampling according to indicators such as geographical location and per capita net income of farmers. In Henan Province, seven cities were selected from south to north: Xinyang, Nanyang, Zhumadian, Zhoukou, Shangqiu, Anyang, and Puyang. In each city, 2 to 3 counties were randomly selected, 1 to 3 townships were randomly selected in each county, 1 to 3 villages were randomly selected in each township, and 10–20 grain farmers were randomly selected in each village. At the same time, combining the type of contract selection that this study is concerned with to avoid the problem of sample selection bias, sample areas that could not meet the existence of cooperatives available for membership in the surrounding area, or where grain processing plants or agricultural enterprises did not sign purchase orders or production orders with farmers in the area were excluded. In the field research, a one-to-one questionnaire was used, and each researcher in the research team filled in the questionnaire for one respondent, i.e., the research team organized undergraduate and graduate students to interview the sample farmers in the form of a one-to-one questionnaire. A total of 1039 questionnaires were collected from grain farmers (wheat and rice), excluding those with logical inconsistencies, missing answers, and missing values of critical variables, and finally, 1017 valid questionnaires were obtained from 57 administrative villages.

3.2. Selection of Indicators

(1) Dependent variable. The dependent variable is the agricultural green productivity of farm households, which is measured using the slack based model (SBM) of non-expected output [33]. The inputs in the process of agricultural production of farm households mainly consist of land, the cost of machine plowing and irrigation, labor, seeds, fertilizers, and pesticides [34]. The outputs are mainly desired outputs and non-desired outputs, with the desired outputs being food outputs and the non-desired outputs being agricultural surface pollution caused by fertilizers, pesticides, and other agrochemicals. Drawing on related research [35], this paper defines input variables and output variables. (1) Input variables: land input is measured by the actual area of land planted by farmers (hectares); seed, fertilizer, and pesticide inputs are measured by the actual cost of seed, fertilizer, and pesticide inputs by farmers; mechanized plowing and irrigation costs are measured by the sum of the costs of using farm machinery, irrigation costs, and various types of service costs paid by farmers in agricultural production; and labor inputs are measured by the total labor time (days) invested in each stage of agricultural production by farmers. (2) Output variables: Desired output is measured by the actual grain income of farmers; undesired output is measured by the nitrogen and phosphorus emissions (kilograms) from grain production of farmers [36]. Drawing on the material balance method [37], nitrogen emissions and phosphorus emissions from grain production are equal to the purity amount of the corresponding element in the fertilizer minus the content of the corresponding element in the grain. Fertilizers used by farmers are mainly compound fertilizers and urea, and it can be seen through the Reference Calculation Table of Fertilizer Purity Amount that the nitrogen and phosphorus contents in compound fertilizers are 15.18% and 27.43%, respectively, and the nitrogen content in urea is 46% [38]. Referring to the *Agricultural Technology and Economics Manual*, the nitrogen content per 100 kg of wheat is 2.75 kg and the phosphorus content is 0.88 kg; the nitrogen content per 100 kg of rice is 2.05 kg and the phosphorus content is 0.95 kg [39].

(2) Independent variable. The independent variables are the behavior of farmers' participation in contracts and contract choice. Among them, the behavior of participation in contracts measures whether farmers participate in vertical product contracts or horizontal production contracts or vertical production contracts. A value of 1 is assigned to farmers participating in the above contract. A value of 0 is assigned to "retail" farmers who do not participate in the above contracts and trade independently in the market. For the measurement of farmers' contract choices, farmers' contract choices are classified into four categories: market sale and purchase, vertical product contract, horizontal production contract, and vertical production contract. Among them, when farmers choose the contract choice of market buying and selling, they mainly produce independently and dock to the market without excessive cooperation with other production and management organizations, i.e., they do not participate in the contract. In contrast, the three types of farmers involved in vertical product contracts, horizontal production contracts, and vertical production contracts, on the other hand, cooperate with other production and management organizations to carry out agricultural production. Therefore, this paper assigns a value of 0 to those farmers who chose market sales as a control group; the remaining three categories for farmers involved in the contract will be those who chose a vertical product contract, those who chose a horizontal production contract, and those who chose vertical production contract will be assigned a value of 1 in their respective subsamples as a treatment group. In this sample, the number of farmers who chose the contract type of market sale was 334, accounting for 32.84% of the total number of farmers in the sample. The number of farmers who chose the contract type of vertical product contract was 114, accounting for 11.21% of the total number of farmers in the sample. The number of farmers who chose horizontal production contracts as the type of contract was 434, accounting for 42.67% of the total number of sample farmers. Vertical production contracts were chosen by 135 households, accounting for 13.27% of the total number of households in the sample.

(3) Mediating variable. This paper explains how farmers' contract choice affects agricultural green productivity through three indicators: technical guidance, agricultural supplies, and agricultural machinery use. Farmers' contract choice affects agricultural green productivity by influencing farmers' access to agricultural supply services, agricultural machinery services, and technical guidance services. First, farmers cooperate with cooperatives or agricultural enterprises to obtain technical guidance services, such as agricultural technology training, etc. Drawing on the relevant literature [34], this paper uses "the number of times farmers participated in agricultural production technology training in the past five years" as a proxy variable to indicate farmers' access to technical guidance services. Second, by cooperating with cooperatives or agribusinesses, farmers may be able to obtain agricultural supply services, standardize the use of agricultural products, and reduce the expenditure on purchasing agricultural products, thus affecting agricultural green productivity, and this paper uses the question of "Whether the fertilizer you purchased was a general quality product or a high-quality product" as a proxy for the access of farmers to agricultural supply. Thirdly, when farmers cooperate with cooperatives or agricultural enterprises, they may obtain agricultural production services such as agricultural machinery and increase the proportion of agricultural machinery use, and "the proportion of agricultural machinery use in the total production process" is used as a proxy variable to indicate the use of agricultural machinery by farmers.

(4) Instrumental variable. This section uses farmers' knowledge of rural industrial integration as an instrumental variable. The questionnaire measures the question "Have you heard of rural industrial integration?" Suitable instrumental variables require correlation with endogenous independent variables and no correlation with random disturbance terms. In this study, farmers' contract choice is based on the organizational form of farmers' participation in rural industrial integration, so whether farmers have heard of rural industrial integration is correlated with farmers' contract choice; whether farmers have heard of rural industrial integration is not directly related to their agricultural green productivity and is not correlated with the random disturbance term.

(5) Control variables. In this section, drawing on relevant studies [35], the following control variables were selected: individual farmer household characteristics, including the age of the household head, education level of the household head, gender of the household head, and health of the household head. Farmer household characteristics include labor force share and the number of frequently contacted relatives and friends. Land characteristics include characteristics of cultivated land and crops grown. Considering the differences in the varieties of grain grown by farmers and the differences in grain production factors and production outputs, this paper adds the variable of farmers' grain varieties for control, specifically through the question, "Are the seedlings you buy general products easily available on the market (or high-quality products with specific requirements and characteristics)? This question was measured. Among other things, the average land area of the surveyed farmers was 1.7 ha. In the total sample, there were 700 farm households with a land area of less than 2 ha, accounting for 67.37% of the total sample. The sample farmers were mainly engaged in small-scale land management. The description and descriptive statistics of each variable are shown in Table 1.

Table 1. Description of variables and descriptive statistics.

Variables	Variable Description	Average Value	Standard Deviation
Dependent variable			
Agricultural green productivity	Measured using the SBM model of non-expected output	0.5533	0.1721
Independent variable			
Participation contract	Whether to participate in vertical product contract or horizontal production contract or vertical production contract: Yes = 1; No = 0	0.6715	0.4698
Vertical product contracts	Yes = 1; No = 0	0.1120	0.3156
Horizontal production contract	Yes = 1; No = 0	0.4267	0.4948
Vertical production contract	Yes = 1; No = 0	0.1327	0.3394
Mediating variable			
Technical guidance	Number of agricultural production technology training sessions attended in the last five years (actual value)	6.4562	2.0298
Agricultural machinery use	The proportion of the use of agricultural machinery in the total production chain	0.6871	0.0327
Agricultural supply	Fertilizer quality: high quality = 1; average quality = 0	0.4281	0.1448
Instrumental variable			
Level of understanding of rural industrial integration	Have you heard of rural industrial integration: Yes = 1; No = 0	0.5231	0.4997
Control variables			
Age of household head	Actual age (years)	54.5132	5.6233
Education level of household head	Elementary school and below = 1; middle school = 2; high school/junior high school = 3; college/bachelor's degree and above = 4	2.0324	0.2547
Gender of household head	Male = 0; Female = 1	0.117	0.3215
Health level of household head	Poor = 1; fair = 2; good = 3	2.2311	0.5256
Labor force share	Number of labor force as a share of household size	0.6747	0.2315
Number of friends and relatives in regular contact	Actual number (persons)	14.7001	4.8693
Land characteristics	Arable land area (hectares)	1.7540	2.1545
Planting varieties	Seedling quality: high quality = 1; average quality = 0	0.3530	0.1848
Growing crops	Wheat = 0; Rice = 1	0.1986	0.3991

Note: Based on stata software results.

3.3. Model Construction

(1) Benchmark regression. In order to analyze the impact of farmers' contractual choices on agricultural green productivity, this paper drew on Xu Qing et al. [34] and Zhang Mengling et al. [35] and constructed a model as shown below:

$$y_i = \alpha_{0i} + \alpha_{1i} con + \alpha_{2i} H + \varepsilon_i \quad (1)$$

In Equation (1), y_i is the agricultural green productivity of the i farm household, *con* denotes the contract choice of the farm household, H denotes the control variables such as land characteristics and age of the farm household, and ε is the disturbance term.

(2) Influence mechanism. Farmers participating in the contract have access to various types of agricultural production services, which in turn affect agricultural green productivity by influencing the supply of farm materials, the use of farm machinery, and technical guidance. To test the above influence mechanisms, this paper draws on the approach in Dippel's [40] study to identify the mechanisms by which farmers' contract choices affect agricultural green productivity through three channels of action: agricultural supply, agricultural machinery services, and technical guidance, with the help of causal mediation analysis of instrumental variables. The econometric model was constructed as follows.

$$\text{Phase I } M = \varphi_M^Z \times Z + \varphi_M^X \times X + \partial_X \tag{2}$$

$$\text{Phase II } Y = \beta_Y^M \times \hat{M} + \beta_Y^X \times X + \partial_Y \tag{3}$$

In Equations (2) and (3), Z denotes farmers' knowledge of rural industrial integration as an instrumental variable; X denotes farmers' contract choice; M denotes the three channels of action of the agricultural supply, agricultural machinery use, and technical guidance; and Y denotes farmers' agricultural green productivity. $\hat{M}$ is the first-stage M estimated quantity. The specific path of analysis is shown in Figure 2.

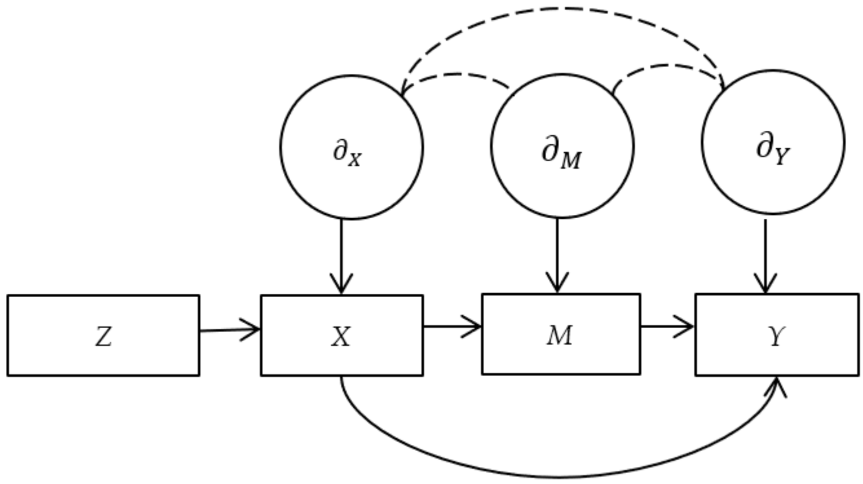

Figure 2. IV-based causal mediation analysis.

(3) Robustness test. In order to consider the influence of sample self-selection behavior and avoid bias in the regression results caused by endogeneity problems, this paper used the propensity score matching method to robustly test the empirical results based on the basic regression to detect the validity of the basic regression results. The specific steps were as follows: first, the propensity scores of the treatment groups were estimated by the logit model; second, the matched average treatment effects were further calculated based on the calculated propensity scores.

For the treatment and control groups, when farmers' participation in contracts was used as an independent variable, the control group was farmers who did not participate in contracts, and the treatment group was farmers who participated in contracts. Regarding farmers' contract choice as an independent variable, the control group was farmers who chose to buy and sell in the market, and the treatment group was farmers who chose vertical product contracts, horizontal production contracts, and vertical production contracts, respectively.

The core independent variable of farmers' participation contract and contract choice were set as 0–1 variables, respectively, and a logit model was used to construct a model to estimate the fitted values of conditional probabilities (propensity scores) of sample farmers' participation in contracts and through which contract choice to participate. The specific probability models were as follows:

$$PS = Logit(S_i = 1 \mid D_i) = \frac{e^{\alpha x_i}}{1 + e^{\alpha x_i}} \tag{4}$$

In Equation (4), i denotes the sample farmers; $S_i = 1$ denotes the treatment group of the core independent variable; D_i denotes the control variable, i.e., the covariate or matching variable; and $\frac{e^{\alpha x_i}}{1+e^{\alpha x_i}}$ is the cumulative distribution function. After estimating the propensity score, the sample farmers were matched, and the average treatment effect (ATT) was finally calculated. The formula is as follows:

$$ATT = E(Y_{1i} - Y_{0i} \mid S_i = 1) = E(Y_{1i} \mid S_i = 1) - E(Y_{0i} \mid S_0 = 1) \tag{5}$$

In Equation (5), Y_{1i} is the agricultural green productivity of farmers in the treatment group, and Y_{0i} is the agricultural green productivity of farmers in the control group.

4. Results and Discussion

4.1. The Basic Regression Results

This paper empirically tested the effect of farmers' contract choice on agricultural green productivity using OLS regression based on a study of grain-growing farmers in China. The R^2 value of the regression was 0.4247, indicating that the model fit well, and the independent variable explained the dependent variable to a high degree. The specific regression results are shown in Table 2.

Table 2. Model estimation results of contract choice on farmers' agricultural green productivity.

Variable Name	Model 1		Model 2	
	Coef.	*S.E.*	*Coef.*	*S.E.*
Participation contract	0.0258 ***	0.0097		
Vertical product contracts			0.0086	0.0132
Horizontal production contract			0.0340 ***	0.0105
Vertical production contract			0.0272 **	0.0145
Age of household head	−0.0032	0.0008	−0.0031	0.0009
Education level of household head	0.0197	0.0166	0.0242	0.0169
Gender of household head	−0.0282	0.0141	−0.0268	0.0141
Health level of household head	0.0286 ***	0.0103	0.0268 ***	0.0109
Labor force share	0.0533	0.0209	0.0489	0.0206
Number of friends and relatives in regular contact	0.0009	0.0010	0.0010	0.0011
Land characteristics	0.0003 *	0.0002	0.0004 **	0.0002
Planting varieties	Control		Control	
Growing crops	Control		Control	
N	1017		1017	
Prob > chi2	0.0000		0.0000	
Pseudo R^2	0.2348		0.2703	

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

Table 2 gives the regression results of farmers' contract choices on agricultural green productivity. From the regression results in Table 2, the impact of the core independent variable, farmers' contract choice, on farmers' agricultural green productivity was basically consistent with our expected results. Farmers' participation in horizontal production contracts and vertical production contracts were favorable to increasing agricultural green productivity. Therefore, the horizontal production contract and vertical production contract parts of Hypothesis 1 proposed in this paper were verified. Based on the estimation results in Table 2, we can draw the following main conclusions:

The effect of farmers' participation in contracts and contract choice on agricultural green productivity is shown in Table 2. As can be seen from model 1, the variable of farmers' participation in the contract has a positive effect on agricultural green productivity and passes the test at the 1% significance level. It indicates that the participation of farmers in the contract is favorable to increasing agricultural green productivity. The explanation is that farmers participate in the integration of rural industries, and establish contractual relationships with cooperatives or agricultural enterprises, which can more conveniently obtain planting, market, and other types of information through cooperatives or agricultural enterprises, so that farmers can more fully understand the planting technology, market information, which is conducive to the development of agricultural production, and at the same time, the cooperatives or agricultural enterprises can also provide farmers with technical guidance, the use of agricultural machinery, the supply of agricultural materials and other agricultural production services which can drive farmers to carry out agricultural production in a more scientific way, improve the efficiency of the use of agricultural factors [41], realize economies of scale [34], and improve agricultural green productivity. As can be seen from Model 2, the estimated coefficients of the different types of contractual choice indicators are all positive, indicating that the formation of contractual links between farmers and cooperatives or agribusinesses is conducive to an improvement in agricultural green productivity. Specifically, first, the coefficient of the indicator of participation in vertical product contracting was positive but failed the test at the 10% significance level. A possible reason for this is that under the vertical product contract, the transactions between farmers and agribusinesses are more centered around the purchase and sale of food. Under this contractual option, agribusinesses are less involved in food production, provide limited production support to farmers, and do not change the situation where farmers are constrained by resources, technology, and other constraints, resulting in the regression results of this part being insignificant. Second, the coefficient of the indicator of participation in horizontal production contracts was positive and passed the test at the 1% significance level. It suggests that farmers joining cooperatives and having cooperatives drive farmers in agricultural production and management is conducive to increasing agricultural green productivity. The explanation for this is that cooperatives, as a new type of agricultural management main body, have technical advantages and can provide farmers with technical advice and guidance to improve the agricultural production and management capacity of farmers and efficiently utilize agricultural factors, and at the same time, cooperatives provide farmers with agricultural supply services and agricultural machinery services, which reduces the cost of production and optimizes the allocation of factors in large-scale production, and ultimately achieves an improvement in agricultural green productivity. Third, the coefficient of the indicator of participation in vertical production contracts was positive and passed the test of a 5% significance level. It indicates that the formation of vertical production contracts between farmers and agribusinesses, driven by agribusinesses to carry out agricultural production, is conducive to improving agricultural green productivity. The explanation is that agribusiness has significant advantages in planting technology research and development, market information collection, etc., while agribusiness masters a more perfect planting system and more scientific planting methods, agribusiness into the production chain and farmers for production collaboration, can give farmers planting guidance, and provide farmers with better quality agricultural supplies and agricultural production services [42,43], thus realizing an improvement in production efficiency [44,45].

Combining Models 1 and 2 of Table 2 to examine the effects of control variables, the health level of household head, and the land characteristics also have an effect on agricultural green productivity in farm households. First, the coefficients of the variable of the health degree of the head of household in Models 1 and 2 were both positive and both passed the test at the 1% significance level. It indicates that the healthier the household head is, the more efficiently he or she engages in agricultural green production. A possible reason for this is that the better the health condition of the household head is, the more efficient he or she is in carrying out agricultural production operations. Second, the coefficients of the variables of cultivated land characteristics in Models 1 and 2 were positive and both passed the 10% significance level test. It indicates that the large scale of land cultivated by farmers is conducive to improving production efficiency, which is the same as the conclusion obtained by Xu Qing et al. [34]. The explanation for this is that a large area of land cultivated by farmers is conducive to the scale effect of agricultural production and the realization of economies of scale so that farmers cultivate large areas of land and their agricultural production is more efficient. The increase in agricultural yield, more crops will absorb more nitrogen and phosphorus, and the more the crops absorb the relevant elements, the less nitrogen, phosphorus and other elements are emitted, which is conducive to an improvement in agricultural green productivity [26].

4.2. Influence Mechanism

Based on a study of grain-growing farmers in Henan Province of China, this paper used a causal mediation analysis of instrumental variables to identify the channels through which farmer participation contracts affect agricultural green productivity. This paper used a subsample regression approach. First, the participation contract, i.e., whether farmers participate in the contract, was taken as the core independent variable and regressed on the total sample to obtain models 3–5; second, farmers who chose vertical product contracts, horizontal production contracts, and vertical production contracts were divided into three subsamples, while farmers with market sale patterns were added to each subsample as a control group and grouped for regression to obtain models 6–14. In the estimation results, the one-stage F-statistic of models 3–5 was 34.8090, the one-stage F-statistic of models 6–8 was 33.2648, the one-stage F-statistic of models 9–11 was 49.6778, and the one-stage F-statistic of models 12–14 was 49.3344, all of which were larger than the one-stage F-statistic in the causal mediation analysis of instrumental variables that should be more than 30 as suggested by Dippel [40]. At the same time, all passed the 1% significance level test, indicating that the instrumental variables selected in this paper are more appropriate and there is no weak instrumental variable problem. The estimation results of the specific impact mechanism analysis are shown in Table 3.

Table 3. Results of impact mechanism estimation.

	Contract Selection	Action Path	Effect	Effect Value	Standard Error	One-Stage F-Statistic
Model 3	Participation contract	Agricultural supply	Indirect effects	0.0542 *	0.0338	34.8090
Model 4	Participation contract	Agricultural machinery use	Indirect effects	0.0945 ***	0.0511	34.8090
Model 5	Participation contract	Technical guidance	Indirect effects	0.0893 *	0.0284	34.8090
Model 6	Vertical product contracts	Agricultural supply	Indirect effects	0.0563	0.0507	33.2648
Model 7	Vertical product contracts	Agricultural machinery use	Indirect effects	0.0930	0.0632	33.2648
Model 8	Vertical product contracts	Technical guidance	Indirect effects	0.1695	0.0440	33.2648
Model 9	Horizontal production contracts	Agricultural supply	Indirect effects	0.1240 *	0.0183	49.6778
Model 10	Horizontal production contracts	Agricultural machinery use	Indirect effects	0.1305 *	0.0772	49.6778
Model 11	Horizontal production contracts	Technical guidance	Indirect effects	0.1276 ***	0.0357	49.6778

Table 3. *Cont.*

	Contract Selection	Action Path	Effect	Effect Value	Standard Error	One-Stage F-Statistic
Model 12	Vertical production contracts	Agricultural supply	Indirect effects	0.0137 *	0.0100	49.3344
Model 13	Vertical production contracts	Agricultural machinery use	Indirect effects	0.1012	0.0909	49.3344
Model 14	Vertical production contracts	Technical guidance	Indirect effects	0.1034 **	0.0239	49.3344

Note: *, **, *** indicate significant at the 10%, 5%, and 1% levels.

As shown in the estimation results in Table 3, in terms of indirect effects, first, the coefficients of the indirect effects of the three paths of action of agricultural machinery use, agricultural supply, and technical guidance in Models 3–5 were all positive. They all passed the test at the 10% significance level. It shows that farmers can obtain farm machinery services, farm supply services, and technical guidance services by participating in contracts with cooperatives or agribusinesses, which in turn influences the use of farm machinery, farm supplies, and technologies by farmers to improve agricultural green productivity. The interpretation is that farmers participate in the contract, form cooperation with cooperatives or agricultural enterprises, improve their own agricultural production technology by obtaining agricultural production services provided by other subjects, change the allocation of factors in agricultural production, standardize the use of agricultural resources and other factors, and realize an improvement in agricultural green productivity. The specific role of the channel is as follows: (1) farmers participate in the contract, access agricultural machinery services provided by cooperatives or agricultural enterprises, increase the use of agricultural machinery, and through factor substitution, optimize the allocation of factors and achieve an improvement in agricultural green productivity. (2) Farmers participate in the contract to obtain agricultural supply services provided by cooperatives or agribusinesses, which regulates the use of fertilizers and pesticides, and at the same time purchase seeds, fertilizers, pesticides, and other agricultural supplies at a cheaper price, which increases agricultural green productivity. (3) By participating in the contract, farmers receive technical guidance services from cooperatives or agribusinesses to apply better and more scientific technologies to agricultural production, and through technological advances, they can realize an increase in agricultural green productivity.

Second, the coefficients of the indirect effects of the three paths of action of agricultural machinery use, agricultural supply, and technical guidance in Models 6–8 were all positive. Still, they did not pass the test at the 10% significance level. It indicates that the effect of farmers signing vertical product contracts with agribusinesses to increase agricultural green productivity through access to related agricultural production services was not significant in this sample. The possible reason is that the indirect effect through the three paths of action of agricultural machinery use, agricultural supply, and technical guidance was not significant because in a vertical product contract between farmers and agricultural enterprises, which mainly involves only the sale and purchase of farm products, agricultural enterprises are less likely to enter into the production process and provide limited agricultural production services to farmers. Under a vertical product contract, agricultural enterprises rarely enter the production link, cannot provide farmers with more perfect and efficient production services and support, and it is difficult to influence farmers' production decisions, so the estimation result is not significant.

Third, in Models 9–11, the coefficients of the indirect effects of the three paths of agricultural machinery use, agricultural supply, and technical guidance were all positive, and they all passed the 10% significance level test. It indicates that cooperatives, as professional agricultural production organizations, have advantages in scale and technology, and at the same time, cooperatives emphasize "cooperation" to help farmers carry out agricultural production. Farmers join cooperatives, and under the unified production management of the cooperatives, they can obtain various types of agricultural production services, including pre-production, production, mid-production, and post-production services, such as agricultural machinery services, agricultural supply services, and technical guidance services. The post-production of various types of agricultural production services changed the allocation of factors of agricultural production of farmers, improved production efficiency, by influencing the use of agricultural machinery, agricultural capital, and technology of farmers, and improved agricultural green productivity. Specific channels of action are as follows: (1) Farmers join cooperatives; agricultural production is unified by cooperatives; cooperatives provide farmers with agricultural machinery services and large-scale, mechanized production; cooperatives improve the use of agricultural machinery; and cooperatives optimize the allocation of factors, which in turn improves agricultural green productivity. (2) Farmers join cooperatives, and cooperatives provide seeds, fertilizers, pesticides, and other agricultural supplies and purchasing services. Through unified agricultural procurement by cooperatives, farmers can attain a lower purchase price; agricultural supplies will generally be sold at a lower price to the farmers than the market price; and the farmers buy the agricultural supplies, which, at the same time, is conducive to standardizing the use of fertilizer and pesticides and to improving agricultural green productivity. (3) Cooperatives, as agricultural production organizations, have more scientific agricultural planting techniques, and farmers who join cooperatives can receive technical support to improve planting techniques and increase agricultural green productivity.

Fourth, in Models 12–14, the coefficients of the indirect effects of the three action paths of agricultural machinery use, agricultural supply, and technical guidance were all positive, and agricultural supply and technical guidance passed the 10% significance level test. This indicates that the vertical production contract between farmers and agribusinesses, where agribusinesses drive agricultural production and provide agricultural production services such as agricultural supply, technical guidance, etc., can realize an improvement in agricultural green productivity by influencing the use of agricultural materials and technical guidance of farmers. The explanation is that agricultural enterprises have the advantages of capital, technology, and other aspects, farmers and agricultural enterprises form a collaborative production relationship, agricultural enterprises can be standardized, and a perfect production system to guide the development of agricultural production through the supply of agricultural factors and standardized production standards can be achieved. This provides farmers with more efficient production services to achieve an improvement in agricultural green productivity. The specific role of the channel is as follows: (1) Agribusinesses provide agricultural resourcesfor farmers, affecting the use of agricultural supply for farmers. Farmers and agricultural enterprises sign a vertical production contract to ensure the quality of agricultural products, and agricultural enterprises will generally supply agricultural supplies or provide them on credit [22]. The agricultural supply service of agricultural enterprises is also conducive to standardizing the use of fertilizers, pesticides, and other agricultural chemicals. At the same time, agribusinesses provide cheaper agricultural supplies, which helps farmers to reduce their costs. (2) Agribusinesses will provide technical guidance to farmers, and by standardizing production standards and providing technical support, farmers can increase agricultural green productivity. (3) The indirect effect of the channel of action of the use of agricultural machinery by farmers is not significant when farmers sign vertical production contracts with agribusinesses; the possible reason for this is that under a vertical production contract, farmers themselves use agricultural machinery to a higher degree, and therefore have a smaller impact on agricultural green productivity. Alternatively, the cost-saving effect of agribusinesses' provision of agricultural machinery services is not significant, and agribusinesses charge farmers for such agricultural services for profitability reasons, which has less impact on reducing farmers' production costs.

4.3. Robustness Test

This paper tested the robustness of the baseline regression results by replacing the measures. For the consideration that the possible self-selection bias of the sample farmers may bring bias to the regression results, this paper used the propensity score matching method for robustness testing [46]. Specifically, the nearest neighbor matching method (k = 4) was used to analyze the impact of farmers' participation in the contract and contract choice on agricultural green productivity, while the proximity distance selected for the analysis was 4. The final obtained estimation results are shown in Table 4. The estimation results show that, first, the average treatment effect (ATT) of the impact of participation in the contract on agricultural green productivity was 0.0590, passing the test at the 1% significance level. This indicates that the agricultural green productivity of participating contract farmers is greater than that of non-participating contract farmers, and participating in the contract and having other agricultural business organizations that drive farmers to agricultural production help increase agricultural green productivity. Second, the average treatment effect (ATT) of the impact of participation in vertical product contracts on agricultural green productivity was 0.0087. Still, it did not pass the test at the 10% significance level. Third, the average treatment effect (ATT) of the impact of participation in horizontal production contracts on agricultural green productivity was 0.0845, passing the test at the 1% significance level. This indicates that the agricultural green productivity of farmers participating in horizontal production contracts is greater than that of non-participating farmers and that farmers joining the cooperative and being driven by the cooperative to carry out agricultural production are beneficial to increasing agricultural green productivity. Fourth, the average treatment effect (ATT) of the impact of participation in vertical production contracts on agricultural green productivity was 0.0706, which also passed the 5% significance level. This indicates that the agricultural green productivity of farmers participating in vertical production contracts is greater than that of non-participating farmers, and the formation of production collaboration between farmers and agricultural enterprises is conducive to driving the agricultural production of farmers and increasing agricultural green productivity. The above robustness test results are consistent with the baseline regression results, and the conclusions obtained are still robust after replacing the measurement method.

Table 4. Average treatment effects of farmer contractual choices affecting agricultural green productivity.

	Treatment Group	Control Group	ATT	Standard Error	*t*-Value
Treatment effects of participation contracts on the impact of agricultural green productivity	0.5634	0.5044	0.0590 ***	0.0190	3.0900
Treatment effects of participation in vertical product contracts on the impact of agricultural green productivity	0.5337	0.5250	0.0087	0.0157	0.5500
Treatment effects of participation in horizontal production contracts on the impact of agricultural green productivity	0.5559	0.4714	0.0845 ***	0.0178	4.7400
Treatment effects of participation in vertical production contracts on the impact of agricultural green productivity	0.5606	0.4900	0.0706 **	0.0294	2.3900

Note: **, *** indicate significant at the 5%, and 1% levels.

4.4. Endogeneity Test

This paper dissected the effect of farmers' participation contracts on their agricultural green productivity and tested the robustness of the findings. However, it is also necessary to consider this endogeneity, i.e., the possible interaction between farmers' participation in the contract and their agricultural green productivity. Farmers can increase agricultural green productivity by participating in the contract and forming a cooperative relationship with cooperatives or agricultural enterprises to produce grain with the help of other agents. On the other hand, however, farmers may seek to join cooperatives, cooperate with agribusinesses, and participate in contracts in grain production for the sake of increasing agricultural green productivity. Therefore, instrumental variables were selected in this section, and endogeneity was treated using two-stage least squares (2SLS) [47]. This paper chose the degree of farmers' knowledge about rural industrial integration as an instrumental variable for farmers' participation in the contract [48]. The structure of the chosen instrumental variables using the two-stage least squares (2SLS) test is shown in Table 5.

Table 5. Endogeneity test results.

	Agricultural Green Productivity (IV-2SLS)		
	Phase 1		**Phase 2**
Participation contract			0.1367 *
			(0.0615)
Instrumental variable → participation contract	0.1649 ***		
	(0.0384)		
Control variables	Control		Control
Phase 1 R-squared		0.2206	
Phase 1 F-statistic		34.8090 ***	
N	1017		1017

Note: *, *** indicate significant at the 10% and 1% levels. Robust standard errors are given in parentheses.

As can be seen in Table 5, the first stage F-statistic was 34.8090, which is greater than the commonly considered critical value of 10 and passed the test at the 1% level of significance, indicating that there was no weak instrumental variable problem and the selected instrumental variables were more appropriate. From the estimation results of the second stage, the estimated coefficient of the participation contract variable was positive and passed the test at 10% significance level. It indicates that after trying to solve the endogeneity problem, the impact of farmers' participation contract on agricultural green productivity was precisely in the same direction as in the benchmark regression, except that the results differed from the benchmark regression in terms of the degree of significance and the impact effect. Overall, the estimation results obtained from this paper after selecting instrumental variables using two-stage least squares to deal with the endogeneity problem were consistent with the results of the benchmark regression, further supporting the robustness of the findings of this paper.

According to the results of the analysis in the empirical part of the paper, the thesis of horizontal versus vertical production contracts in Hypotheses 1 and 2 presented in the previous section is verified. Through horizontal production contracts or vertical production contracts, farmers choose to form a contractual relationship with cooperatives or agribusinesses, carry out agricultural production under the leadership of cooperatives or agribusinesses, and obtain various types of agricultural production services, which can improve agricultural green productivity. The specific impact mechanism relies on cooperatives or agribusinesses to enter the production process; provide agricultural supply services, agricultural machinery services, and technical guidance to farmers; improve their agricultural production and management capacity; regulate their use of agrochemicals; and achieve increased agriculture green productivity. However, this effect is not significant under a vertical product contract. The possible reason for this is that under a vertical product contract, farmers and agribusinesses mainly trade around the sale of agricultural products. In a vertical product contract, agribusinesses are less likely to enter the agricultural production chain, cannot provide farmers with perfect and efficient agricultural production services, and cannot directly influence farmers' production decisions. Therefore, the impact of vertical product contracts on agricultural green productivity is not significant.

5. Conclusions and Policy Implications

Under the double impact of resource endowment constraints and agricultural surface pollution, improving agricultural green productivity has become the key to guaranteeing food security and promoting sustainable agricultural development. In the context of the integrated development of rural industries, the inclusion of farmers in the agricultural industry chain [49], the strengthening of the link between agricultural producers and the main body of the other links in the value chain, and the driving of farmers by cooperatives and agribusinesses to carry out agricultural production are the embodiment of the trend in the development of the scale, intensification, and mechanization of agriculture [50], and a realistic path to improving agricultural green productivity. Based on the contractual choice perspective in the context of China's rural industrial integration, this study explored farmers' agricultural green productivity. It aimed to analyze how to improve agricultural green productivity, guarantee food security, and promote the sustainable development of agricultural production. Based on the questionnaire survey data of grain farmers in China, this paper empirically tested the effect of farmers' contract choice on agricultural green productivity through the OLS regression model. Furthermore, using the method of causal mediation analysis of instrumental variables, the channels of the effect of farmers' contract choice on agricultural green productivity were identified through instrumental variables. It was found that farmers' participation in the contract, driven by cooperatives or agribusinesses for agricultural production and operation, was beneficial to improving their agricultural green productivity. Still, the effect of driving farmers by each subject also varied. Secondly, the participation of farmers in the contract and their access to various types of agricultural production services through cooperatives or agribusinesses, such as agricultural machinery services, agricultural supply services, and technical guidance services, improved the use of agricultural machinery, standardized the use of elements, and increased technical guidance, which can increase agricultural green productivity. This study can provide theoretical support for improving farmers' agricultural green productivity, which is of policy and practical significance for guaranteeing food security and promoting the sustainability of agricultural production.

In order to guarantee food security and promote sustainable agricultural development, the above findings have the following policy implications:

Firstly, the use of farmers' resource input to promote the participation of farmers in various contract choices of rural industrial integration. To carry out agricultural production more efficiently and encourage farmers' involvement across multiple contract choices of rural industrial integration, we should ensure that farmers' existing resource rights, such as land, are fully guaranteed on the one hand, and improve farmers' agricultural production and operation ability and expand the quantity and improve the quality of resources owned by farmers on the other hand. In turn, this can optimize the allocation of agricultural production resources, promote the efficient use and flow of factors, bring into play the internal living power of agricultural production of farmers, promote farmers to actively establish contractual relationships with cooperatives or agricultural enterprises, and form cooperation and linkages with other agricultural production and management organizations.

Second, strengthen the linkage between farmers and cooperatives and agricultural enterprises, and give full play to the pivotal role of cooperatives and agricultural enterprises. Constrained by resource factors, it is difficult for farmers to realize modern agrarian production methods of intensification, scale, and mechanization only by their inputs. Cooperatives and agricultural enterprises have the advantage of capital and the ability to carry out large-scale and mechanized agrarian operations, as well as mastering more scientific agricultural production technology. Therefore, the government should guide cooperatives and agricultural enterprises to form a linkage with farmers and then let them drive farmers to agricultural production, which is conducive to improving agricultural production efficiency and increasing agricultural green productivity. Through the government's construction of a farming production organization system that serves farmers, the government can improve the interest linkage mechanism between farmers and other agricultural business organizations and break the factors that prevent farmers from participating in contracts [50].

Third, optimize the allocation of resources and factors for farmers, and consider the synergistic effect of cooperatives and agricultural enterprises. The individual production of farmers and other agricultural subjects to organize production both aim to improve production efficiency, and cooperatives and agricultural enterprises can play a synergistic effect by driving farmers to agricultural production. Therefore, we should actively cultivate new agricultural management subjects, diversify the main bodies of rural industrial integration, and play the role of organizing, coordinating, driving, and servicing cooperatives and agricultural enterprises. Through cooperatives and agricultural enterprises to drive farmers to carry out specialized, large-scale, and mechanized agricultural production, the synergistic effect can be brought into play to improve the efficiency of the agricultural output and realize the improving agricultural green productivity.

This study also had some potential limitations. First, in terms of the data and sample, this study used cross-sectional data, which only gave an idea of the agricultural operations of the farmers for one year. Further research would be more detailed and informative if panel data and longer time periods were chosen. Second, according to the contract theory, the production subject carries out production operations under different contractual choices and bears different risks. Differences in risk under different contractual choices will also affect farmers' agricultural production operations. However, this paper did not discuss this issue to a great degree. An interesting question, and also the next step in the research, is this: What will be the impact if the risk variable is introduced? Third, this study only analyzed and researched the survey data of farmers in Henan Province, China. The findings need further verification for other countries and regions.

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