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Original Research

Reform of Agricultural Land Property Rights System and Green and High-Quality Development of Agriculture: Empirical Evidence Based on China's "Three Rights Separation" Reform

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Abstract

The latest reform of China's agricultural land property rights system has achieved the separation of rural land ownership, contracting rights, and management rights (the "three rights separation" reform), which is an important means for the Chinese government to achieve the rational allocation of agricultural land resources and plays an important role in improving the green and high-quality development of agriculture. Based on the panel data of 30 sample provinces in China from 2001 to 2020, this paper explores the impact of the latest rural land property rights system reform (the "three rights separation" reform) on the high-quality green development of agriculture. Research has found that, firstly, the reform of the agricultural land property rights system that separates the collective ownership of land, the contracting rights of farmers, and the management rights of land can effectively improve the green development of agriculture. Secondly, the "three rights separation" reform can enhance the green development of agriculture through three paths: expanding the scale of agricultural economy, promoting the upgrading of agricultural industrial structure, and innovating agricultural technology. In addition, fiscal investment in supporting agriculture has played a positive regulatory role in the impact of the "three rights separation" reform on the green development of agriculture. Thirdly, the impact of the "three rights separation" reform on agricultural green development is characterized by regional heterogeneity and production structure heterogeneity, with a more significant promoting effect on the eastern and central regions, as well as the main grain producing areas. The research conclusion provides new ideas for promoting sustainable agricultural development.

Keywords: reform of agricultural land property rights system, the "three rights separation" reform, green and high-quality development of agriculture, impact mechanism

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Introduction

Agriculture is the lifeline of the national economy and is related to social stability and national security. The improvement and rationality of the agricultural land property rights system is the foundation of agricultural production and development. The traditional Chinese small-scale agricultural economy has scattered land resources, low production enthusiasm of farmers, and weak ability to resist natural disasters, leading to insufficient agricultural economic benefits and seriously hindering the high-quality development of agriculture. In order to fully tap into the potential of rural land and labor in China, at the beginning of the reform and opening up, the household contract responsibility system was implemented, with land ownership belonging to the collective and contracted management rights belonging to farmers, known as the "two rights separation". The implementation of the household contract responsibility system has granted farmers long-term and secure land contract management rights, mobilized their enthusiasm, released productivity, and promoted the steady growth of China's agricultural output value and farmers' income year by year [1]. However, this traditional fragmented and decentralized agricultural development model reduces the efficiency of agricultural land use, and agricultural development is largely achieved through sacrificing resources and damaging the ecological environment, which is not conducive to human well-being and sustainable development [2]. At present, China's agricultural consumption demand has shifted from a demand for "quantity" to a demand for "quality", requiring agriculture to change its traditional development model, explore intensive and green production methods, and pursue high efficiency in agricultural production while also taking into account the green and high-quality development of the agricultural ecological environment. This has become an important path choice for sustainable development of modern agriculture [3].

With the development of industrialization and urbanization in China, problems such as the sharp decrease in rural vitality, decline in agricultural comparative benefits, and excessive farmland decentralization lead to land fertilizer pollution becoming increasingly prominent. The effect of the household contract responsibility system's dividend has begun to decline, agricultural production is excessively dependent on agricultural subsidy. Decentralized household management makes it difficult to transfer land, which is not conducive to large-scale operation and comprehensive management of agriculture. The endogenous development power and ability of agriculture are insufficient, and sustainable development is greatly inhibited, the household contract responsibility system no longer adapt to the needs of economic development in the new era [4-6]. The 19th National Congress of the Communist Party of China once again stressed the need to improve the system of separating the "three rights" of contracted land. The "three rights separation" refers to the parallel separation of the collective ownership of rural land, the contract right of farmers, and the management right of land. It is another major institutional innovation in rural reform after the household contract responsibility system.

The Chinese government attempts to implement land ownership, stabilize land contracting rights, and revitalize land management rights through the "three rights separation" reform, promote land circulation and rational allocation, improve rural land use efficiency, and achieve moderate scale operation of agriculture and continuous effective investment in advanced production factors, thereby promoting green technology innovation in the agricultural sector and stable and orderly transformation and upgrading of agricultural industrial structure [7, 8]. So, how has the green development effect of China's agricultural sector been since the implementation of the latest reform of agricultural land property rights system? Can the "three rights separation" reform promote the green and efficient development of agriculture? What is the path through which this policy affects the green and high-quality development of agriculture? What are the effects of different paths? Against the strategic background of green development becoming one of the core development goals of Chinese agriculture, timely assessment of the true development situation of Chinese agriculture under resource and environmental constraints, and evaluation of the implementation effectiveness of the three rights split reform, have important theoretical and practical significance for the Chinese government's next step in formulating green and high-quality development strategies for agriculture and improving the land system.

Literature Review

The implementation of a sustainable agricultural development strategy is an effective way to achieve green agricultural development [8]. As the world attaches great importance to the green development of agriculture, a large body of literature has discussed the influencing factors of the green development of agriculture, such as digital inclusive finance [9], carbon trading [10], green finance [11], climate change [12], Consumption [13], and environmental regulation [14], which are important factors affecting the green development of agriculture. However, few studies have analyzed the impact of land property rights system reform in academia, and only part of the literature involves the impact of agricultural land property rights system reform on agricultural green and high-quality development, mainly discussing the following issues: (1) agricultural environmental protection behavior. The "three rights separation" reform promotes the use of organic fertilizers in rural households, thus ensuring

the sustainable development of the rural environment [15]. Land reform has a positive impact on agricultural environmental protection behaviors such as straw returning by improving information channels and extension services [16]. (2) Agricultural productivity. The reform of the farmland property rights system is conducive to agricultural investment and credit access, and thus significantly promotes the improvement of pure technical efficiency of agricultural production. The registration and certification of farm management rights and the three rights have significantly improved agricultural productivity [17]. (3) Investment of farmers. The security of farmland property rights has a significant and positive impact on the possibility and amount of overall farmland investment, and the retained farmland share seriously affects the investment in improving soil quality and changing land use [18]. (4) Household income. The reform of the farmland property rights system is helpful in the significant increase of agricultural output and farmers' net income. For example, the confirmation of agricultural land rights promoted the development of the farmland leasing market, improved the expectation of tenure security, and greatly increased agricultural income [19].

Although the academic circle has carried out some research on the green and high-quality development of land property rights system reform, there are still the following limitations: (1) There are few kinds of literature on the empirical analysis of the impact of the "three rights separation" reform on the green and high-quality development of agriculture, and there is a lack of detailed description of the effect path of the "three rights separation" reform on the green and high-quality development of agriculture. (2) Existing literature generally only studies the effect of the reform of farmland property rights system from the single perspective of environment or production efficiency, but the impact of the "three rights separation" reform on the green and high-quality development of agriculture that takes into account agricultural development, resource conservation, and environmental protection needs to be systematically studied. Compared to existing literature, this article has three possible marginal contributions. (1) On the basis of empirical analysis, the impact mechanism of China's latest agricultural land property rights system reform on the green and high-quality development of agriculture was deeply analyzed. (2) From the dual perspectives of improving agricultural production efficiency and environmental protection, this paper examines the effectiveness of the "three rights separation" reform on the green and high-quality development of agriculture. (3) Explore the impact of the "three rights separation" reform on the green and high-quality development of agriculture in different regions and production structures.

Theoretical Analysis and Research Hypothesis

The Direct Impact of the "Three Rights Separation" Reform on the Green and High-Quality Development of Agriculture

As the material foundation for human survival, land is of great significance for optimizing the allocation and sustainable use of land resources, ensuring food safety, and achieving high-quality economic and social development. The implementation of the "three rights separation" reform separates collective ownership, farmers' contracting rights, and operators' management rights, which helps with the rational utilization and allocation of production resources and thus affects the high-quality development of green agriculture.

For farmers, the implementation of the "three rights separation" reform allows them to retain their land contracting rights while also having the right to transfer land management rights. On the premise that the land contracting rights and land ownership remain unchanged, farmers can transfer their land management rights, accelerate the transfer and concentration of rural land, improve the utilization rate of rural land, and allocate land resources reasonably. This helps to solve the land resource waste caused by the fragmentation of agricultural land and alleviate the problem of large-scale abandonment of rural farmland caused by urbanization, thereby improving agricultural output.

For business entities, on the one hand, the "three rights separation" reform allows the management rights of contracted land to be mortgaged and financed by financial institutions, which helps the land inflow party to expand the scale of land management and achieve efficient development of agricultural land. On the other hand, the "three rights separation" reform helps cultivate new business entities to develop moderate scale operations, implement modern agricultural production, improve agricultural technological progress and efficiency, and thus promote green and high-quality development of agriculture.

For rural collectives, by exercising ownership, they can constrain the non-standard exercise of other rights, while safeguarding and legally safeguarding the rights of farmers and business entities required for agricultural production, fully safeguarding the rights of contracted farmers to use, transfer, mortgage, and withdraw from contracted land, and encouraging the use of various business methods such as land stock cooperation, land trusteeship, and proxy farming, Explore more effective ways to revitalize land management rights, leverage the advantages and role of collective ownership of land, and promote green and high-quality development of agriculture.

In addition, from the perspective of property rights economics, the "three rights separation" reform has

stabilized the contracting rights of farmers and the management rights of business entities. The stability of land property rights can promote farmers' investment, especially long-term investment, which helps farmers and business entities improve soil quality and promote green agricultural development.

In summary, this article proposes the following hypothesis:

Hypothesis 1: The "three rights separation" reform contributes to the green and high-quality development of agriculture.

The Indirect Impact of the "Three Rights Separation" Reform on the Green and High-Quality Development of Agriculture

The "three rights separation" reform can promote green and high-quality development of agriculture through agricultural scale operation, industrial structure upgrading, and agricultural technology innovation.

Agricultural Scale Operation

On the one hand, the "three rights separation" reform solves the problem of insufficient incentives for large-scale land management of new agricultural business entities by subdividing land contract management rights, promoting the optimized allocation of rural land on a larger scale, improving land output rate, labor productivity, and resource utilization rate, and promoting the shift of agricultural production towards a moderately scaled and specialized division of labor economic system. On the other hand, the agricultural scale management can promote the improvement of agricultural green and high-quality development. For example, the scale economy effect of agriculture can save pollution control costs, optimize factor allocation, and improve resource utilization efficiency, thereby promoting the improvement of green agricultural development. Based on this, this article proposes the following hypothesis:

Hypothesis 2: The "three rights separation" reform promotes green and high-quality development of agriculture through the improvement of agricultural scale management.

Upgrading Agricultural Industrial Structure

On the one hand, the "three rights separation" reform can promote the upgrading of agricultural industrial structure. Firstly, the "three rights separation" reform has improved the stability of land rights, increased the scale of agriculture and the use of machinery, achieved specialization of labor, promoted modern agricultural production, and promoted the upgrading of agricultural industrial structure. At the same time, the "three rights separation" reform has released some rural labor and capital, achieving diversified choices for farmers, socialized allocation of land, and two-way and cross-border flow of urban-rural factors, which helps to achieve industrial integration, scale, integration, and ecological development, and promotes the upgrading of agricultural industrial structure. Secondly, the "three rights separation" reform has prompted the government and enterprises to increase investment in agriculture, improve agricultural infrastructure and production conditions, accelerate agricultural scientific and technological progress, and have a significant impact on the development level of the agricultural industry [20].

On the other hand, the upgrading of agricultural industrial structure can promote the improvement of agricultural green and high-quality development by reducing pollution emissions in agricultural production and exchange links and improving the efficiency of agricultural green development. Based on this, this article proposes the following hypothesis:

Hypothesis 3: The "three rights separation" reform will promote the upgrading of agricultural industrial structure and enhance the green and high-quality development of agriculture.

Agricultural Technology Innovation

Firstly, the core meaning of the "three rights separation" reform is to clearly endow the management rights with the legal status and powers they should have. The clear definition and stability of agricultural land property rights help farmers implement advanced agricultural technology, improve agricultural technology efficiency, and thus affect the green and high-quality development of agriculture. Secondly, the "three rights separation" system realizes the way to obtain production funds through mortgage loans of land management rights, alleviates the financing constraints of operators, makes technology introduction and innovation entities more active, promotes agricultural technology progress and innovation [21], and thus affects the green development of agriculture [22]. In addition, the "three rights separation" system creates a good institutional environment for the coupling of agricultural technology innovation and factor endowment, which helps to fully leverage agricultural technology efficiency and promote green and high-quality development of agriculture [23].

Based on this, this article proposes the following hypothesis:

Hypothesis 4: The "three rights separation" reform will promote agricultural technology innovation and improve the green and high-quality development of agriculture.

Regulating Effect of Fiscal Input to Support Agriculture

Firstly, as a means of macro-control, financial support for agricultural input is a kind of incentive measure [24]. It is helpful for producers to reconfigure production resources and input factors, and induce the

transformation of agricultural planting structure in the corresponding direction, to realize the optimization and adjustment of planting structure and realize the green and high-quality development of agriculture. Secondly, the financial input to support agriculture expands the scale of agricultural operations [25]. The increase in the proportion and scale of food crops will promote the deepening of the agricultural division of labor and specialized production, and the increase of agricultural division of labor and specialization will further promote the improvement of agricultural production technology and production efficiency, thus promoting the improvement of green agricultural development. Thirdly, in the process of the "three rights separation" reform, the agricultural sector can use the financial funds to support agriculture to improve agricultural production technology, enhance the level of agricultural innovation and improve agricultural production conditions, to promote the green and high-quality development of agriculture. Accordingly, this paper proposes the following hypothesis:

Hypothesis 5: Fiscal support for agriculture has a positive regulating effect on the impact of the "three rights separation" reform on the green and high-quality development t of agriculture.

Material and Methods

Variable Selection

1. Dependent variable: green and high-quality development of agriculture (AGTFP). The agricultural Total factor productivity calculated by taking agricultural land, labor and machinery as input indicators and agricultural gross output value as output indicators represents high-quality agricultural development. On this basis, the output indicators added with carbon emissions represent green agricultural development [26]. Therefore, this paper uses the green total factor productivity of agriculture in 30 provincial-level administrative regions (excluding Tibet, Hong Kong, Macao, and Taiwan) from 2001 to 2020 as a proxy variable for green agricultural development, mainly because the green total factor productivity of agriculture can be more accurately estimated by including agricultural resource factors and agricultural carbon emissions into the TFP growth measurement framework, and whether the agricultural economic development approach meets the "win-win" requirements of energy conservation and emission reduction and agricultural economic growth. The Directional Distance Function (DDF) allows for independent consideration of the effects of expected and unexpected outputs, and is one of the most widely used models for measuring energy and environmental performance. Assuming that the decision-making units (DMUs) of each province obtain a set of M expected outputs and K unexpected outputs when using N inputs. x, y, and d represent inputs, expected outputs, and unexpected outputs, and the set of production possibilities P (x) is:

$$P(X)=\left\{x,y,d:x\ produce(y,d),x\in R_N^+,y\in R_M^+,d\in R_K^+\right\} \tag{1}$$

Chung et al. revised the production possibility set to address the issue of strongly disposable non-expected outputs [27]:

$$\vec{D}_0(x,y,d;g)=\sup\left\{\beta:[(y,d)+\beta\ g]\in P(x)\right\} \tag{2}$$

Tone proposed the super efficiency SBM model in 2002 [28], which solved the problem of radial models not including relaxation variables in the measurement of inefficiency, and could distinguish the efficiency values of effective DMUs. Combining SBM with DDF can effectively prevent the radial features and directionality of DDF models from being avoided, thereby reducing the overestimation of efficiency in traditional DDF models. Therefore, the non-radial and non-directional SBM-DDF model based on relaxation measures can more accurately measure carbon emission performance. The model is as follows:

$$\begin{aligned}\vec{D}_0^t(x^t,y^t,d^t,g^x,g^y,g^d)=\max_{s^x,s^y,s^d}\ &\frac{\frac{1}{N}\sum_N^{n=1}\frac{s_n^x}{g_n^x}+\frac{1}{M+1}[\sum_N^{m=1}\frac{s_m^x}{g_m^x}+\sum_K^{k=1}\frac{s_k^x}{g_k^x}]}{2}\\ s.t.&\sum_{j=1}^J z_j^t x_{jn}^t+s_n^t=x_{jn}^t,\forall n;\sum_{j=1}^J z_j^t x_{jm}^t+s_m^t=x_{jm}^t,\forall m;\\ &\sum_{j=1}^J z_j^t x_{jk}^t+s_k^t=x_{jk}^t,\forall k;\sum_{j=1}^J z_j^t\geq 0,\forall j;\\ &s_n^x\geq 0,\forall n;s_m^y\geq 0,\forall m;s_k^d\geq 0,\forall k\end{aligned} \tag{3}$$

In addition, the Malmquist index, Malmquist-Luenberger (ML) index, and global Malmquist-Luenberger (GML) productivity index can be used to measure the dynamic changes in productivity. Because the GML index has the advantages of transitivity and cycle accumulation, it can effectively avoid the problems that the traditional ML index does not have the cycle transitivity and linear programming does not solve [19], so this study uses the GML index to measure the dynamic change of carbon emission performance. The GML formula is as follows:

$$\begin{aligned}GML^{t+1}&=\left[\frac{1+\vec{D}_0^t(x^t,y^t,d^t;y^t,-d^t)}{1+\vec{D}_0^t(x^{t+1},y^{t+1},d^{t+1};y^{t+1},-d^{t+1})}\times\frac{1+\vec{D}_0^{t+1}(x^t,y^t,d^t;y^t,-d^t)}{1+\vec{D}_0^{t+1}(x^{t+1},y^{t+1},d^{t+1};y^{t+1},-d^{t+1})}\right]^{\frac{1}{2}}\\ &=AGTC^{t+1}\times AGEC^{t+1}\end{aligned} \tag{4}$$

The GML^{t+1} index characterizes the changes in agricultural green total factor production efficiency of two adjacent periods (t to t+1 periods) during the research period. The decomposition of agricultural green and high-quality development can be divided into two parts: agricultural technology change index (AGTC) and agricultural efficiency change index (AGEC).

AGTC>1 and AGEC>1 respectively mean the progress of agricultural technology and the improvement of efficiency. The input indicators of agricultural green and high-quality development (AGTFP) are as follows: mainly include agricultural labor input, which is represented by the number of employees in the primary industry; In this paper, the actual sown area of crops is used to represent land input. Agricultural machinery input, this paper is represented by the total power of agricultural machinery; fertilizer input is expressed by converting the amount of fertilizer application; Irrigation input is expressed by effectively irrigated area; agricultural film cover area and pesticide use seven indicators. Output indicators of agricultural green and high-quality development (AGTFP) measurement: among them, the expected agricultural output level is represented by the total output value of agriculture, forestry, animal husbandry and fishery and agricultural carbon absorption (mainly including the carbon absorption of rice, wheat, corn, beans, and other crops). In order to eliminate the influence of price factors on the measurement results, taking 2001 as the base period, the price index of the total output value of agriculture, forestry, animal husbandry, and fishery was used to process the desired output level of each sample year. The level of agricultural undesired output was represented by agricultural carbon emission (unit: ten thousand tons), and the agricultural carbon emission was calculated by the input of fertilizers, pesticides, agricultural film, diesel oil, plowing, and irrigation, and their carbon emission coefficient in the process of agricultural production.

2. Independent variable: The independent variable in this paper is the of "three rights separation" reform of agricultural land (REFORM). Taking the specific time of the implementation of the whole province's rural land ownership registration and certification as the signal of the policy beginning, dummy variables were set to represent the reform policy of "three rights separation" of rural contracted land. The value of the year when the reform began to be implemented and the year after that was 1. The year in which the "three rights separation" reform of agricultural land has not begun is 0. Sichuan, Anhui, and Shandong carried out whole-province reforms in 2014; Henan, Jiangsu, Jiangxi, Hubei, Hunan, Gansu, Ningxia, Jilin, and Guizhou carried out reform in 2015. Ten provinces – Shaanxi, Yunnan, Hainan, Guangdong, Zhejiang, Hebei, Shanxi, Inner Mongolia, Liaoning, and Heilongjiang – were reformed in 2016. Guangxi, Qinghai, Fujian, Tianjin, and Beijing started in 2017; In 2018, pilot reforms were launched in Tibet and Xinjiang.

3. Mediating variable: Agricultural scale operation (SCALE) is expressed by the ratio of the sown area of grain crops to the number of agricultural employees [15]; the transformation of agricultural industrial structure is represented by the use of industrial upgrading (AIS-SE), industrial rationalization index (AIS-RA), and industrial efficiency index (AIS-HE). Industrial upgrading (AIS-SE) is represented by the ratio of the gross domestic product of the primary industry to the gross domestic product of the tertiary industry, and industrial rationalization index (AIS-RA) is constructed by constructing the agricultural industrial rationalization index[1]. industrial efficiency index (AIS-HE) is expressed as the ratio of industrial added value to intermediate consumption in agriculture, forestry, animal husbandry, and fishery; The innovation level of agricultural technology in this article is represented by agricultural industry invention patents (INNOVATE) [14], and agricultural mechanization per mu total power (MACHINE)[2], respectively. The agricultural industry invention patents (INNOVATE) are represented by the logarithm of the number of agricultural, forestry, animal husbandry, and fishery invention patents.

4. Regulating variable: the fiscal support for agriculture (FUND). the fiscal support for agriculture (FUND) is expressed by the logarithm of the proportion of fiscal support for agriculture expenditure in the total fiscal expenditure of each province.

5. Control variable: Referring to the relevant literature, the following control variables are added in this paper [8, 10, 12]. The education level of the labor force (EDU) is expressed by the proportion of the agricultural workforce with a high school diploma or higher in each province, and the agricultural natural disaster (DISASTER) is expressed by the ratio of the affected area at the end of the year to the total area of crops sown in that year, the degree of industrialization (INDUSTRY) is expressed by the ratio of industrial added value to the regional gross domestic product, and the urbanization level (URBAN) is expressed by the proportion of the urban population to the total population, The level of economic development (GDP) is expressed as the logarithm of the per capita GDP of each province, and the dependence on foreign trade of agricultural products (TRADE) is expressed as the ratio of the total import and export of agricultural products to the total agricultural production. See Table 1 for descriptive statistics.

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[1] $IR = \sqrt{\sum_{i=1}^{4} g_i - g^2 \times \frac{w_i}{q}}$ Among them, i = 1, 2, 3, and 4 respectively represent the regional agriculture, forestry, animal husbandry, and fishery sectors; g_i represents the growth rate of the total output value of department i; g represents the growth rate of the total output value of agriculture, forestry, animal husbandry, and fishery; w_i represents the proportion of the total output value of department i to the total output value of agriculture, forestry, animal husbandry, and fishery. When IR approaches 0, the internal structure of agriculture becomes more reasonable; When the IR deviates from 0, the internal structure of agriculture becomes more unreasonable.

[2] The average total power per mu (MACHINE) of agricultural mechanization can be directly obtained from the statistical yearbook.

Table 1 Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
AGTFP	600	1.015	0.067	0.702	1.340
AGTC	600	1.000	0.047	0.793	1.306
AGEC	600	1.015	0.028	0.900	1.193
REFORM	600	0.280	0.449	0	1
EDU	600	7.400	0.740	3.695	9.660
DISASTER	600	0.221	0.155	0	0.936
INDUSTRY	600	0.374	0.0853	0.097	0.530
URBAN	600	0.527	0.151	0.245	0.896
GDP	600	10.288	0.837	7.971	12.013
TRADE	600	0.126	0.189	0.005	1.330
SCALE	600	6.463	3.299	2.090	27.714
AIS-SE	600	0.490	0.275	0.009	1.442
AIS-RA	600	0.650	0.375	0.098	2.177
AIS-HE	600	1.445	0.356	0.581	2.355
INNOVATE	600	5.612	0.414	2.147	8.521
MACHINE	600	0.561	0.264	0.139	1.394
FUND	600	2.010	0.727	0.122	10.592

Model Setting

In this study, a difference-difference model with bi-directional fixed effect was adopted to evaluate the impact of the "three rights separation" reform on green and high-quality development of agriculture. Referring to Beck et al [29], the measurement model is built as follows:

$$AGTFP_{it} = \beta_0 + \beta_1 REFORM_{it} + \beta_2 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \quad (5)$$

Among them, $AGTFP_{it}$ represents the level of agricultural green and high-quality development in region i during the t period, $REFORM_{it}$ represents whether region i implemented the "three rights separation" reform during period t, and X_{it} represents a series of related control variables, γ_i represents the individual fixed effect of region i, μ_i represents a fixed time effect, ε_{it} represents a random perturbation term.

In order to explore that the reform of "separation of three powers" has improved the level of agricultural green and high-quality development through three ways: agricultural scale operation (SCALE), agricultural industry transformation (including AIS-SE, AIS-RA, AIS-HE), and agricultural technology innovation level (INNOVATE, MACHINE), this paper uses the mesomeric effect model to test its mechanism, as shown in Formula (6):

$$M_{it} = \beta_0 + \beta_1 REFORM_{it} + \beta_2 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \quad (6)$$

The dependent variable Mit represents the mediating variable of this article. In addition, in order to examine the moderating effect of fiscal support for agriculture (FUND) on the impact of "three rights separation" reform on agricultural green and high-quality development, we further added the interaction term between policy and fiscal support for agriculture in the benchmark model (1), and obtained model (7):

$$AGTFP_{it} = \beta_0 + \beta_1 REFORM_{it} + \beta_2 REFORM_{it} * FUND_{it} + \beta_3 X_{it} + \gamma_i + \mu_t + \varepsilon_{it} \quad (7)$$

β_2 is the key focus coefficient. If the coefficient is significant, it indicates that fiscal support for agriculture plays a moderating role in the policy's impact on agricultural green and high-quality development.

Sources of Data

This study selected 30 provincial-level administrative regions in China except Tibet Autonomous Region, Hong Kong Special Administrative Region, Macao Special Administrative Region and Taiwan Province as samples. Due to the long agricultural production cycle, the process of converting input into output has a certain time lag. Based on the practice of most domestic scholars, the output index lags behind the input index by one year, that is, the input index data from 2001 to 2020 correspond to the output index data from 2002 to 2021. The data are derived from China Rural

Statistical Yearbook, China Statistical Yearbook, China Agricultural Statistical Yearbook, provincial statistical Yearbook and the Department of Trade of the Ministry of Commerce.

Results and Discussion

Temporal and Spatial Evolution Characteristics of Green Agricultural Development

Fig. 1 displays the annual mean changes in the agricultural green and high-quality development level (AGTFP) and its decomposed agricultural green technology progress index (AGTC) and agricultural green technology efficiency index (AGEC). AGTFP shows a fluctuating trend from 2001 to 2020, with a period of worsening from 2001 to 2003, followed by a brief period of improvement from 2004 to 2005, and then a state of "decline, increase, decline" thereafter. The evolution of AGTC follows a highly consistent trend with AGTFP, indicating that the driving force of agricultural green and high-quality development and growth lies in the progress of agricultural green technology. AGEC, however, shows a relatively stable decline of 3% per year.

All three indices experienced a significant decline from 2008 to 2009, which may be attributed to the impact of natural disasters on agriculture. In 2008, massive floods occurred throughout China, which had a direct and fatal impact on agricultural production. After 2015, the growth trend of the three indices became more apparent, reflecting the initial effects of China's agricultural green and high-quality development concept, environmental protection awareness, and policy implementation.

Fig. 2 presents the temporal and spatial trends of China's agricultural green and high-quality development level from 2001 to 2020. Panels (a)-(c) show the mean values of agricultural green and high-quality development level during 2001-2007, 2008-2014, and 2015-2020, respectively. During 2001-2007, the average AGTFP development level was relatively low, with higher levels in eastern and northern China. As the main grain-producing area, Central China had a slower development level of AGTFP with significant growth potential. From 2008 to 2014, the AGTFP in the central region increased significantly, while the AGTFP in the eastern coastal region continued to grow due to higher levels of scientific and technological development and progress in green and smart agriculture. In the period of 2015-2020, AGTFP showed balanced development and high growth levels. This was due, in part, to the Chinese government's promotion of green agricultural development and the adoption of green and low-carbon production modes in China's agriculture. The reform of the land property rights system also released the vitality of the agricultural economy, leading to rapid development of agricultural output value.

Baseline Regression

Table 2 presents the benchmark regression results of the "three rights separation" reform on agricultural green and high-quality development. The coefficient of the policy dummy variable is positive and statistically significant at the 1% level of significance in column (1), which indicates that the reform can effectively promote the green and high-quality development of China's agriculture, thus verifying hypothesis H1. After adding control variables in column (4), the coefficient of the policy dummy variable remains positive and statistically significant at the 5% level of significance. This suggests that the positive effect of the reform on agricultural green and high-quality development is robust to the inclusion of other relevant factors.

Furthermore, we decompose AGTFP into AGTC and AGEC in columns (2)-(3) and (4)-(5), respectively. The coefficients of both AGTC and AGEC are significantly positive, indicating that the "three rights separation" reform is conducive to the progress of agricultural technology and the improvement of agricultural technology efficiency.

We also observe the coefficients of control variables and find that agricultural natural disasters inhibit the green and high-quality development of agriculture. The

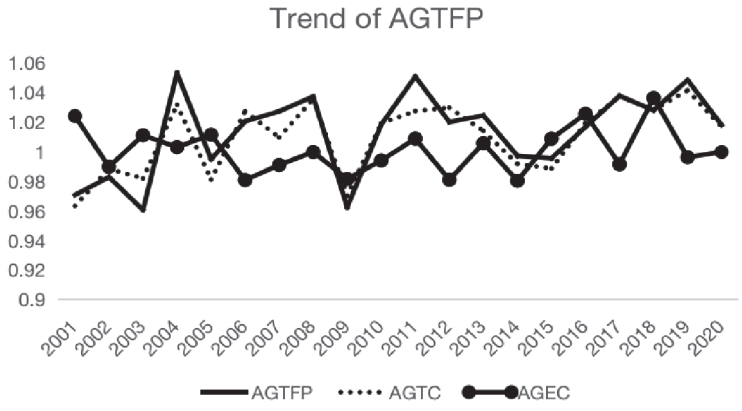

Fig. 1. Dynamic evolution trend of China's agricultural green and high-quality development level and its decomposition factors.

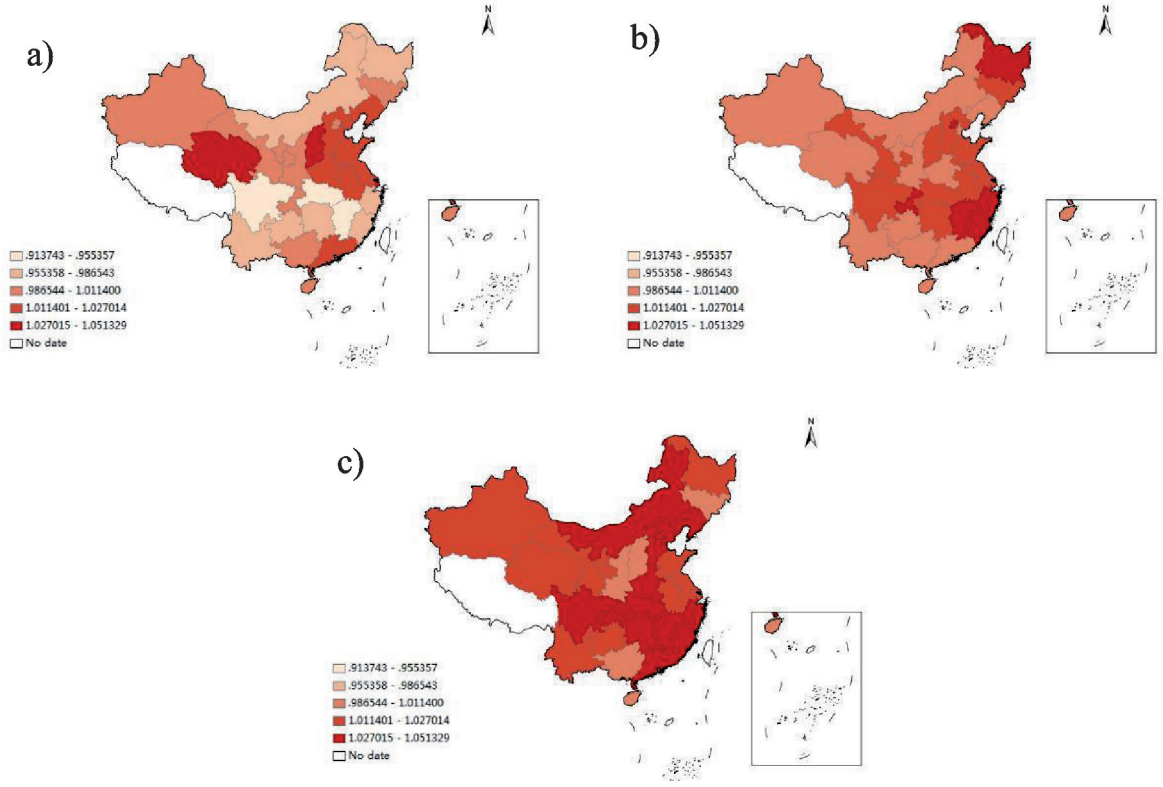

Fig. 2. Temporal and spatial trends of China's agricultural green and high-quality development from 2001 to 2020. a)2001-2007, b) 2008-2014, c)2015-2020.

Table 2. Results of baseline regression.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	AGTFP	AGTC	AGEC	AGTFP	AGTC	AGEC
REFORM	0.022*** (0.006)	0.006*** (0.002)	0.005** (0.003)	0.016** (0.007)	0.004** (0.002)	0.005** (0.003)
EDU				0.002 (0.005)	-0.001 (0.004)	-0.001 (0.002)
DISASTER				-0.080*** (0.020)	-0.039*** (0.014)	-0.031*** (0.011)
INDUSTRY				0.087** (0.034)	0.081** (0.031)	0.053*** (0.016)
URBAN				0.055* (0.033)	0.040** (0.021)	-0.016 (0.019)
GDP				0.006 (0.008)	0.003 (0.006)	0.002 (0.003)
TRADE				0.027** (0.009)	0.021** (0.015)	0.021** (0.015)
Province	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.172	0.218	0.201	0.207	0.253	0.234
N	600	600	600	600	600	600

Note: *, ** and *** indicate passing the test at significance levels of 10%, 5%, and 1%, respectively. The ones in parentheses are robust standard errors (the same below).

degree of industrialization, the level of urbanization, and the dependence on foreign trade of agricultural products all play a significant role in promoting the green and high-quality development of agriculture.

Heterogeneity Analysis

Considering the differences in agricultural development levels between East, middle, and west China, the influence of the "three rights separation" reform policy on agricultural green and high-quality development may have regional heterogeneity. We divided the research samples into three groups based on the different geographical locations and natural attributes of the eastern region, central region, and western region. The regression results in Table 3 showed that the "three rights separation" reform had no significant impact on the green and high-quality development of agriculture in the western region, but had a significant impact in the eastern and central regions, with a more significant impact on the eastern region. The possible reason is that agricultural production in the western region is relatively backward, and the implementation of the reform lacks corresponding supporting measures, making the effect not significant. In contrast, the higher economic development level and more perfect agricultural industrial structure system in the eastern region, coupled with the reform of the agricultural land property rights system, have enabled agricultural production and management to better adopt scale management and technological innovation to achieve green and high-quality development of agriculture, resulting in a more significant effect.

What is more, we conducted subsample regressions based on the 13 major grain-producing areas[3] designated by the Ministry of Finance in 2003 and non-grain main producing areas (17 provinces) to account for production structure heterogeneity. The results showed that the "three rights separation" reform had a more significant impact on the green and high-quality development of agriculture in major grain-producing areas compared to non-major grain-producing areas. The possible reason is that the scale management level and degree of mechanization of agriculture are higher in major grain-producing areas, and the implementation of the reform makes it easier for agricultural production in these areas to adopt green environmental protection technology, facilitating the realization of green and high-quality development of agriculture.

Robustness Test

To strengthen the credibility of our conclusions, we adopted four methods to test the robustness of our research results (Table 4). First, we used the system GMM estimation method to address the endogeneity problems that may arise from missing variables and two-way causality in traditional regression. The P-value of AR (1) in the model is less than 0.1, while the P-value of AR (2) is greater than 0.1. Hansen's test passes, indicating that the Arellano Bond sequence correlation test rejects the original hypothesis that the model does not have first-order sequence correlation, and cannot reject the original hypothesis that the model does not have second-order sequence correlation and instrumental variable validity. The test results indicate that the estimation results using system GMM in this paper are effective.

Second, we conducted regression after tail reduction treatment at the 5% level for the main variables involved in the model. The regression results showed that the reform significantly promoted the green and high-quality development of agriculture, and the test results indicated that the baseline regression results were robust.

Third, we controlled for lag phase variables to avoid endogenous effects and reverse causality. All control variables were delayed by one stage and then returned. The regression results were consistent and significant in the direction of the baseline regression coefficient, indicating that the baseline regression results were robust.

Fourth, the purpose of China's "three rights separation" reform is to guide the orderly transfer of land management rights and develop agricultural scale management. According to data from the National Bureau of Statistics of China, the land transfer area in China has increased from 4 million hectares in 2007 to 31 million hectares in 2016 after the reform. This article believes that the reform of the "separation of three rights" is closely related to the area of land transfer. Therefore, we changed the explanatory variables by replacing the dummy variable of the "three rights separation" reform with the proportion of farmland transfer area. The regression results showed that farmland transfer significantly promoted the green and high-quality development of agriculture, and the test results again confirmed the robustness of the baseline regression results.

Further Discussion – Mechanism Analysis

To explore the "three rights separation" reform, the agricultural green and high-quality development level is improved through three approaches: agricultural SCALE operation (SCALE), agricultural industry transformation includes advanced (AIS-SE), rationalization (AIS-RA), high efficiency (AIS-HE), and agricultural technology innovation (INNOVATE, MACHINE). The mediation effect model was adopted in this paper to test its mechanism of action, and the regression results are shown in Table 5. The study found that the reform had a significant positive impact on SCALE, indicating that the reform promoted agricultural scale operation, and

[3] The 13 main grain producing regions are Heilongjiang, Henan, Shandong, Sichuan, Jiangsu, Hebei, Jilin, Anhui, Hunan, Hubei, Inner Mongolia, Jiangxi, and Liaoning provinces.

Table 3. Heterogeneity analysis.

AGTFP	(1)	(2)	(3)	(4)	(5)
	Eastern region	Central region	Western region	Main grain producing areas	Non-grain main producing areas
REFORM	0.037*** (0.008)	0.034** (0.015)	0.011 (0.010)	0.031*** (0.009)	0.013* (0.008)
Control	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
R^2	0.281`	0.296	0.305	0.303	0.361
N	200	120	220	260	340

Table 4. Robustness test.

AGTFP	(1)	(2)	(3)	(4)
	System GMM	Regression after tail reduction	Lagging control variable of phase 1	Replace the explanatory variable
L.AGTFP	0.029*** (0.008)			
REFORM	0.021*** (0.006)	0.018*** (0.005)	0.012*** (0.004)	0.019*** (0.005)
Control	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
AR(1)	0.003			
AR(2)	0.593			
Hansen	0.739			
R^2	0.171	0.218	0.221	0.209
N	570	600	570	600

the expansion of agricultural production and operation could promote the improvement of agricultural green development [15], that is, the reform promoted the green and high-quality development of agriculture by expanding agricultural scale operation. Secondly, this study explored the impact of the "three rights separation" reform on the upgrading of the agricultural industry from three aspects: industrial upgrading (AIS-SE), industrial rationalization (AIS-SE), and industrial efficiency (AIS-HE). The results showed that the reform significantly promoted the advanced development of the agricultural industry and the efficient development of the agricultural industry. However, the influence on the rationalization of the agricultural industry is not significant, and the structure of the agricultural industry is an important factor affecting the growth of green agricultural development [6], that is, the reform promotes the upgrading of agricultural industrial structure and then promotes the green and high-quality development of agriculture. Thirdly, the influence coefficients of reform on the level of agricultural technological innovation (INNOVATE and MACHINE) were 0.238 and 0.057 respectively, and were significantly positive, and agricultural innovation could improve the green and high-quality development of agriculture [14], that is, the reform can improve the green development of agriculture by improving the level of agricultural technological innovation.

In addition, this paper further uses financial support for agriculture (FUND) as the moderating variable to discuss the important role of financial support for agriculture (FUND) on the influence of the "three rights separation" reform on the green and high-quality development of agriculture. As shown in column (7) of Table 5, the interaction terms between REFORM and FUND are significantly positive, that is, financial input to support agriculture enhances the promoting effect of the reform of the farmland property rights system on the green and high-quality development of agriculture. Thus, hypothesis H5 is verified.

Table 5. Mechanism analysis.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variable	SCALE	AIS-SE	AIS-RA	AIS-HE	INNOVATE	MACHINE	AGTFP
REFORM	2.351*** (0.346)	1.172*** (0.026)	0.0274 (0.021)	0.183*** (0.054)	0.238*** (0.055)	0.057** (0.026)	
REROM *FUND							0.002*** (0.005)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.147	0.755	0.319	0.413	0.264	0.243	0.019
N	600	600	600	600	600	600	600

Conclusions

This study used the SBM-GML index method to measure the level of agricultural green and high-quality development of each province in China from 2001 to 2020 and examined the impact of the "three rights separation" reform on agricultural green and high-quality development using the two-way fixed-effect differential model. Research findings: first, the level of agricultural green and high-quality development in China is generally on the rise, with a high distribution in the east and low in the west. The progress of agricultural green technology is the main driving factor of agricultural green and high-quality development. Second, the "three rights separation" reform has a significant role in promoting agricultural green and high-quality development, contributing to the progress of agricultural green technology and the efficiency of agricultural green technology. Third, the mechanism analysis results showed that the reform mainly promotes agricultural green and high-quality development by promoting agricultural scale management, agricultural industrial structure transformation, and agricultural technology innovation. In addition, financial input to support agriculture plays a positive moderating role in promoting the green and high-quality development of agriculture. Fourth, the "three rights separation" reform has regional heterogeneity and production structure heterogeneity, with a more significant impact on the green and high-quality development of agriculture in the eastern and central regions, especially in the eastern region. The reform also has a more significant impact on green agricultural development in major grain-producing areas compared to non-major grain-producing areas.

Based on the above conclusions, the study suggests the following policy recommendations: First, explore the direction of agricultural land property rights reform that is conducive to the green and efficient development of agriculture. This can be achieved by increasing investment in agricultural science and technology, reducing the cost of agricultural mechanization, promoting the integration of regional industry and scientific research, and establishing a reward system for scientific research results. Second, while expanding the scale of agricultural land operation, strengthen the scientific management of planting structure, fertilization, spraying, irrigation, the use of agricultural machinery and tools, and other production links to realize the scientific and low-carbon use of agricultural land. Third, attach importance to the adjustment of the agricultural industrial structure. This can be achieved by encouraging the combination of market demand and policy guidance, ensuring the rational development and structural optimization of agricultural subdivisions, and increasing the transformation of high-carbon industries such as animal husbandry. Fourth, continue to strengthen the application of advanced technologies, production modes, and management modes in agriculture, promote the flow of capital, personnel, and technology to efficient modern agriculture, and deepen the supply-side structural reform of agriculture.

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Conflict of Interest

The authors declare no conflict of interest.

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