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The Impact of Agricultural Insurance on the Level of Agricultural Green Development

-- Based on Moderated Mediation Effects

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Abstract: Agricultural green development is a key path to realize sustainable agricultural development, while agricultural insurance, as an important risk management tool, has a potential role in promoting the level of agricultural green development. This paper takes agricultural insurance as an entry point to explore its influence mechanism on the level of agricultural green development. It is found that agricultural insurance directly promotes the enhancement of the level of green development of agriculture by reducing the pre-farming risk prevention, mid-risk control and post-risk compensation. Agricultural insurance can enhance the level of green development of agriculture by expanding the scale of agricultural operation, agricultural insurance promotes the scale of agricultural production, which in turn improves the efficiency of agricultural production, reduces the waste of resources and environmental pollution, and promotes the green development of agriculture. At the same time, environmental regulation plays a regulatory role in the relationship between agricultural insurance and large-scale operation. Under the strict environmental regulation policy, the protection function of agricultural insurance can better guide the agricultural production and management main body to expand the scale of operation and adopt green production technology, reduce the negative impact on the environment, to more effectively promote the green development of agriculture.

Keywords: Agricultural insurance; Level of greening of agriculture; Environmental regulation; Large-scale operations.

1. Introduction

Agriculture is the foundation of the national economy and has a bearing on people's well-being and economic and social development. Since the reform and opening up of China, its comprehensive agricultural production capacity has maintained a relatively rapid growth trend, playing a pivotal role in ensuring the security of national food production and national development. However, the over-exploitation of natural resources and the excessive use of agrochemicals have caused serious damage to the ecological environment, which not only hinders the sustainable development of agriculture, but also poses a great threat to people's living environment. Therefore, promoting the green development of agriculture and realizing the harmonious coexistence of agriculture and the ecological environment have become the important issues of agricultural development nowadays. Environmental regulation, as an important policy tool for governments to regulate the environmental externalities of agriculture and promote the green transformation of agriculture, has had a far-reaching impact on agricultural production methods and resource allocation. Agricultural insurance, as an important financial means of agricultural risk management, has the functions of risk protection and economic compensation, which can not only reduce the losses of agricultural producers when they suffer from risks, but also improve the risk protection ability of agricultural production operators, and expand the scale of agricultural operations to a certain extent. It can also guide agricultural producers to change their agricultural production behavior and reduce the use of agrochemicals, thus promoting the green development of agriculture. In view of this, this paper will deeply analyze the impact of agricultural insurance on the level of green development of agriculture and its role in the mechanism and other issues, which will help to better play the role of agricultural insurance protection, comprehensive and in-depth promotion of green development of agriculture.

To sum up, the over-utilization of agricultural resources, greenhouse gas emissions and other problems are seriously constraining the green development of China's agriculture, and agricultural development needs to be comprehensively transformed into greening. So, as a "green box policy" recognized by the WTO, is agricultural insurance an important tool for promoting the green development of China's agriculture? What is the path through which agricultural insurance influences the green development of agriculture? Is there any moderating effect of other factors in the path? Is there a gap between this impact in different regions? Focusing on this series of questions, this paper analyzes the relationship between agricultural insurance and agricultural green development, further explores the mechanism and path of agricultural insurance's influence on agricultural green development, and puts forward optimization suggestions to give full play to the role of the "dual-carbon" goal-oriented role and the supportive role of agricultural insurance, so as to help China's agricultural green development.

2. Theoretical Analysis and Research Hypotheses

2.1. Analysis of the Effects of Agricultural Insurance on The Greening of Agriculture

China is a large agricultural country, and the green development of agriculture is an important path for the construction of China's ecological civilization. However, in

the process of improving the level of green development of agriculture faces many risks. Agricultural insurance, as one of the basic tools of modern agricultural risk management, has the functions of ex ante risk prevention, ex post risk control and ex post loss compensation, and the functions of agricultural insurance are constantly expanding and playing a crucial role in promoting the green development of agriculture.

For ex ante risk prevention. On the one hand, the promotion of agricultural insurance can significantly enhance the risk awareness of farmers (Zhu Guoping and Liu Jifang, 2014), through the insurance publicity and education, farmers have a clearer knowledge of the natural risks and market risks faced in agricultural production, which guides farmers to change from passively responding to risks to actively preventing risks, thus prompting them to take preventive measures, such as optimizing the planting structure and adopting disaster-resistant varieties, strengthening farmland infrastructure construction, etc., in order to reduce the waste of resources and environmental damage caused by disasters. On the other hand, facing many risks in the production process, agriculture is highly susceptible to natural disasters and market risks (Irene Wan and Tien-Huei Chuang, 2024). Agricultural insurance can provide comprehensive risk protection for farmers, which significantly improves their risk resistance. It makes farmers no longer rely on a single production method when facing potential risks, but prefer to adopt environmentally friendly agricultural production techniques. This incentive mechanism not only promotes the popularization of green agricultural production techniques, but also helps to reduce the negative impact of agricultural production on the environment and enhance the level of green agricultural development.

As far as ex post risk control is concerned, after farmers have taken out agricultural insurance, the insurance company will usually monitor and evaluate the production activities of the insured farmers on a regular or irregular basis to ensure that their production behaviors are in line with the requirements of the insurance contract. This whole process supervision mechanism not only helps to regulate the production behavior of farmers, timely detection and correction of production methods that may have a negative impact on the environment, prompting farmers to pay more attention to environmental protection in the production process, but also help farmers avoid potential production risks, to ensure the stability of agricultural production, thus providing strong support for the green development of agriculture. In addition, the insurance company in order to minimize the risk of their own insurance, but also for farmers to carry out green production to provide professional technical guidance and support, to provide farmers with a full range of green production technology training and services. Such technical guidance not only helps farmers to optimize the production process and improve the efficiency of agricultural production, but also reduces the use of chemical inputs, makes rational use of resources, reduces the pressure of agricultural production on the environment, and promotes the development of agriculture in a green direction.

With regard to compensation for losses after the occurrence of a risky accident, insurance companies will fulfill their contractual agreements to compensate farmers for losses caused by the risk in a timely manner, so as to alleviate their economic pressure, thus avoiding the impact of natural and market risks on the instability of the income of agricultural producers, and helping farmers to resume their production as soon as possible, thus greatly guaranteeing the stability of agricultural production. When the expected income of agricultural producers is stabilized, it will enhance their confidence in green agricultural production. In addition, while providing risk protection for agricultural producers, insurance companies are also actively exploring differentiated compensation policies to incentivize the adoption of new green technologies. For farmers adopting green technologies such as organic fertilizers and ecological control, insurance companies may offer higher payout ratios or lower deductibles, thus reducing their potential risks arising from technological transformation. To a certain extent, this policy promotes the transformation of production methods by agricultural producers, thereby reducing the use of chemical fertilizers, pesticides and other chemicals, thus reducing the number of pollutants emitted because of the excessive use of agrochemicals in the agricultural production process, which plays an important positive role in the promotion of the green development of China's agriculture.

Based on this, this paper proposes hypothesis 1:

Agricultural insurance has a significant positive impact on the level of green development of agriculture. The mechanism diagram is shown in Figure 1.

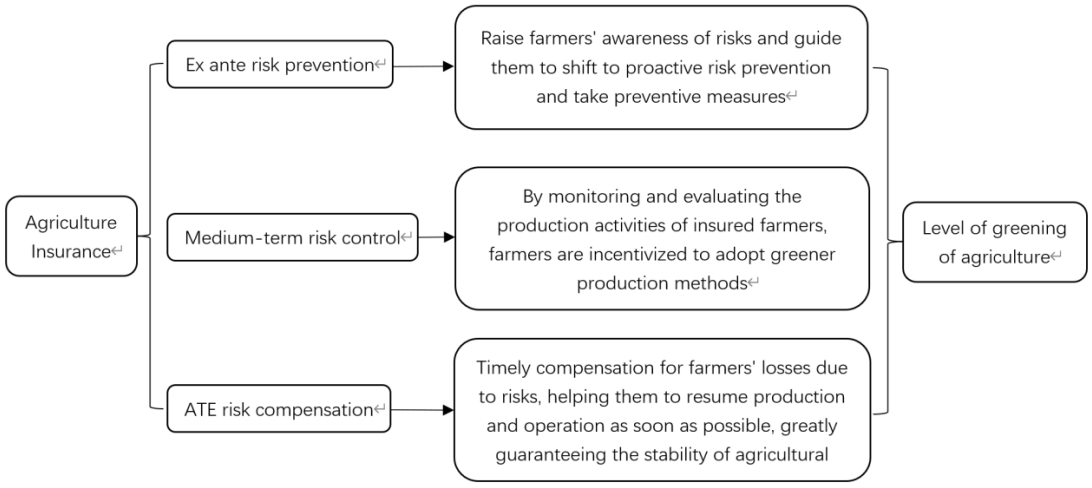

Figure 1. Mechanism of agricultural insurance influencing the level of greening in agriculture

2.2. Analysis of the Impact Mechanism of Agricultural Insurance on The Greening of Agriculture

2.2.1. Mediating effects of large-scale operations

Agricultural insurance, as an important risk management tool, has a significant role in promoting agricultural scale operation. At present, China's traditional agricultural production mode is family-type smallholder production, the average household production scale is small and dispersed, and the ability of small-scale producers to withstand risks is relatively weak (Cai Yingping and Du Zhixiong, 2016), thus affecting the stability of agricultural production. Agricultural insurance can effectively transfer or disperse agricultural risks, providing comprehensive risk protection for farmers, improving household risk tolerance, and contributing to stabilizing farmers' income. This guaranteed mechanism not only reduces the natural and market risks faced by agricultural producers, but also enhances their confidence in expanding production scale. The expansion of large-scale operation can optimize resource allocation, reduce unit production costs, increase agricultural output rate (Guo Sufang and Liu Linlin, 2017), and bring higher returns for farmers. Therefore, as an economically rational agricultural producers, in order to pursue profit maximization, they will continue to expand agricultural reproduction on the basis of the original scale through the transfer of land, transforming the original mode of production behavior, and forming a new type of family farms, cooperatives and other new types of large-scale agricultural business subjects. Therefore, under the protection of agricultural insurance, agricultural producers will expand agricultural scale operation.

To a certain extent, the large-scale operation of agricultural land can contribute to the green development of agriculture. On the one hand, large-scale operation can reduce surface pollution through standardized production. The input intensity of fertilizers and other agrochemicals is closely related to the scale of farmland management, compared with the decentralized family-type small farmers, the larger-scale farmers have a more complete and systematic agricultural knowledge system and agricultural management system. These large-scale business subjects are also relatively more concerned about the efficiency of inputs and outputs, so they are more inclined to adopt specialized and refined production and management methods. In this process, the agricultural scale management main body can not only reduce the use of fertilizers and other agrochemicals, but also improve the efficiency of its use. Thus, to a certain extent, the environmental crisis faced in the green development of agriculture can be solved, thus promoting the green development of agriculture. On the other hand, the expansion of large-scale operation is the basis for farmers to adopt agricultural green technology. The expansion of large-scale operation of agricultural land can adjust the structure of agricultural planting, so that farmers' planting from multi-species decentralized planting to single-species specialized scale planting. In the process of planting, the main body of large-scale operation will continue to learn more professional planting knowledge, master more standardized management skills, and adopt more advanced and environmentally friendly new agricultural green technology, which can significantly improve the efficiency of agricultural production and reduce carbon emissions in the production process. In addition, such technological progress can also drive small farmers to participate in green production through the demonstration effect. Therefore, agricultural scale operation plays an important role in promoting agricultural green development and is a key path to achieving sustainable agricultural development.

Based on this, Hypothesis 2 is formulated in this paper:

Agricultural insurance influences the level of green development of agriculture through scale operations. A diagram of the mechanism is shown in Figure 2.

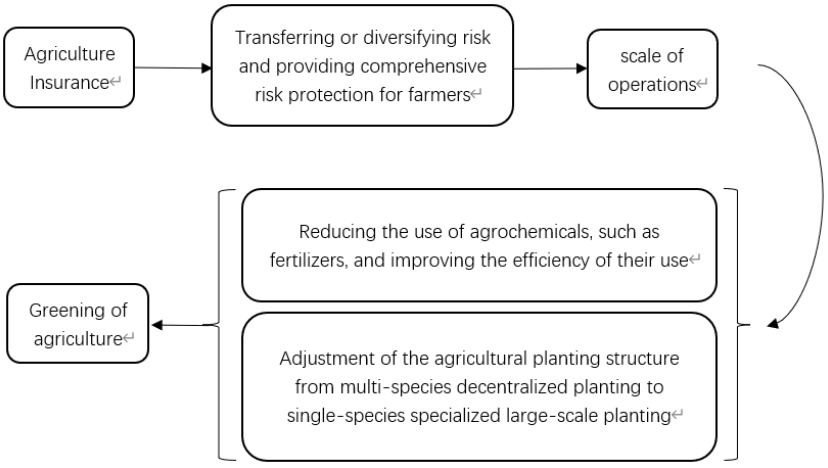

Figure 2. Mediating Effects of Agricultural Business Size

2.2.2. Regulatory effects of environmental regulation

The previous paper discussed the mediating role of scale operation in the process of the impact of agricultural insurance on the level of green development of agriculture in China, and in that path of influence, this paper argues that there is also a moderating role of environmental regulation.

Generally speaking, environmental regulation refers to the Government's direct or indirect influence on agricultural producers to make changes to the production behaviors of agricultural products in order to achieve the goal of environmental protection, thereby promoting the green development of agriculture. At present, the negative externalities of agriculture are mainly reflected in the excessive use of chemical fertilizers and other agrochemicals by agricultural producers, as well as the unregulated encirclement of lakes and fields by agricultural producers in order to expand the area of arable land, which has caused serious agricultural surface pollution and a series of ecological problems. It is difficult to effectively prevent and control them by relying only on market mechanisms, and

government environmental regulation is a necessary means of mitigating market failures, so it is necessary for the government to formulate environmental regulation policies to intervene. To this end, the government has introduced a series of agricultural green development policies to change this status quo. 2024 Central Document No. 1 puts forward the "greening of agriculture" and makes specific deployments to strengthen the construction of rural ecological civilization in terms of fighting the battle of pollution control in agriculture and rural areas, and promoting the reduction of fertilizers and pesticides and increasing efficiency.

These policies have helped to restructure the industrial structure and transform the country's production model from a crude to a green industrial structure. On the one hand, the Government's policy support and the corresponding subsidies provided by the Government to agricultural producers who comply with the requirements for green development in agriculture have boosted the motivation of agricultural producers. At the same time, other agricultural producers will be motivated to move in the direction of green development when they see the additional policy benefits for farmers who comply with the green production requirements, thus increasing the level of green development in agriculture. As the global awareness of environmental protection increases, the environmental awareness of farmers is also enhanced. Environmental regulation not only helps to reduce the negative impact of agricultural production activities on the environment, but also promotes the green transformation of the agricultural industry. Under the impetus of environmental regulations, agricultural producers will take the initiative to gradually shift to greener and more sustainable production methods, adopt more environmentally friendly production technologies and methods, and reduce the use of chemical fertilizers, pesticides and other pollutants, thus effectively reducing the pollution of soil, water and air. In addition, the public is a key force in leading the development of green transformation of production methods, increasing public recognition of green agricultural products, encouraging green consumption, and inversely forcing agricultural producers to apply green technologies and green production modes in the production chain. At the same time, the public will also monitor the green production and operation of farmers to a certain extent due to the government's strengthening of environmental regulation (Li Shanshan and Li Jigang, 2023). On the other hand, environmental regulation can also promote the research and development and application of green technology by enterprises, promote the innovation and development of green technology in agriculture, and provide strong human resources and technical support for the green development of agriculture. For example, the adoption of bio-pesticides to replace chemical pesticides, the promotion of organic fertilizers to replace chemical fertilizers and other green technologies can effectively reduce the pollution emissions in the process of agricultural production and reduce the pressure of agricultural production on the environment. Through reasonable environmental regulation, it is possible to realize the harmonious coexistence of agricultural production and the ecological environment, and lay a solid foundation for the sustainable development of agriculture.

Accordingly, this paper argues that environmental regulation plays a moderating role in the first half of the pathway of "agricultural insurance - large-scale operation - green agricultural development", i.e., as the level of environmental regulation increases, the role of agricultural insurance in promoting large-scale operation in agriculture also increases. The mechanism is shown in figure 3.

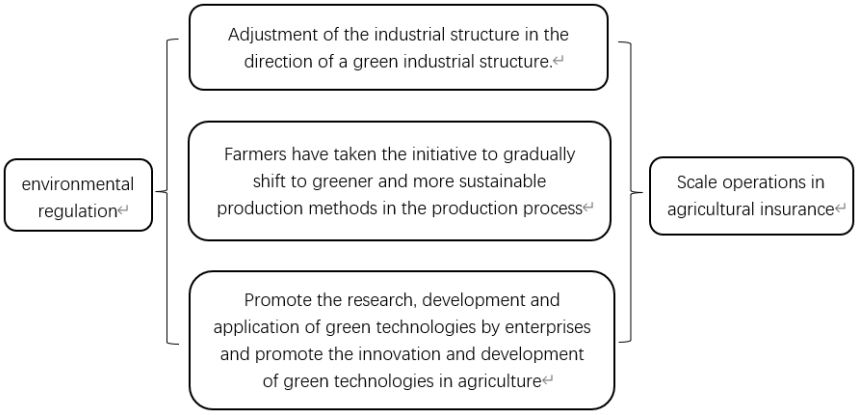

Figure 3. The moderating role of environmental regulation

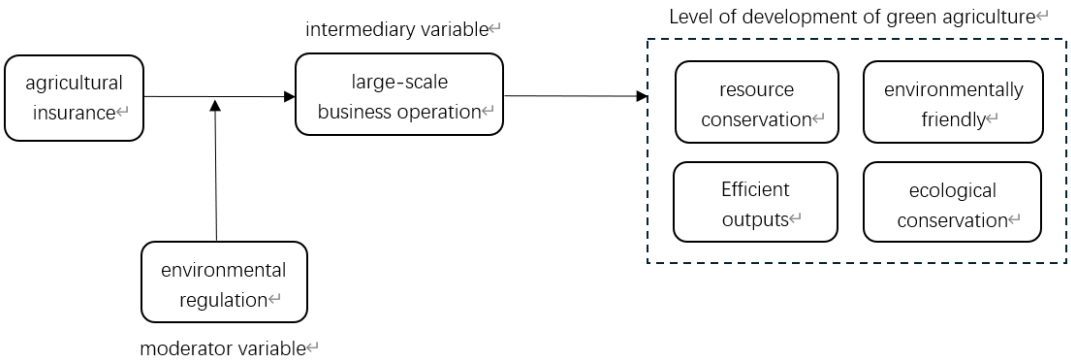

Figure 4. Mechanisms of Agricultural Insurance's Impact on the Level of Green Development in Agriculture

Synthesizing the above theoretical analysis, this paper argues that agricultural insurance can affect the level of

agricultural green development by expanding the scale of agricultural operation under the moderating effect of environmental regulation, so this paper constructs a moderated mediation effect model to clearly show the relationship between environmental regulation, agricultural insurance, scale operation, and agricultural green development, as shown in Figure 4.

2.2.3. Impact effect hypothesis

In this section, a theoretical model is constructed to analyze the impact of agricultural insurance on the level of green development of agriculture with reference to Sheng et al. (2021); Sun Linlin et al. (2022). The production function of farmers is:

$$F(\mathrm{Y},\ \mathrm{X},\ \mathrm{t}) = \mathrm{e}^{\mathrm{c}} \tag{1}$$

Where Y = [y_1, y_2, ..., y_j] denotes the output vector; X = [x_1, x_2, ..., x_i] denotes the input vector; t is a time-trend term, and the inclusion of t in the model F denotes that the production frontier is allowed to move over time; and e^c denotes the factors that change over time (e.g., climate, the effects from technology, etc.).

Further assuming that the market is perfectly competitive and hit is the probability that a farmer avoids a disaster loss, agricultural insurance increases hit and the production function of the farmer becomes:

$$F(\mathrm{Y},\ \mathrm{X},\ \mathrm{t}) = \mathrm{h_{it}e^{c}} \tag{2}$$

Taking the logarithm of both sides of the above equation gives:

$$\ln F(Y,\ X,\ \mathrm{t}) = \ln \mathrm{h_{it}} + c \tag{3}$$

Derivation for t yields:

$$\sum \frac{\partial \ln F}{\partial \ln \mathrm{y_j}} \cdot \frac{\partial \ln \mathrm{y_j}}{\partial \mathrm{t}} + \sum \frac{\partial \ln F}{\partial \ln \mathrm{x_i}} \cdot \frac{\partial \ln \mathrm{x_i}}{\partial \mathrm{t}} + \frac{\partial \ln F}{\partial \mathrm{t}} = \frac{\partial \ln \mathrm{h_{it}}}{\partial \mathrm{t}} + \frac{\partial c}{\partial t} \tag{4}$$

Let $\frac{\partial \ln F}{\partial \mathrm{t}} = \lambda_{\mathrm{t}}$, $\frac{\partial \ln F}{\partial \ln \mathrm{y_j}} = \lambda_{\mathrm{y_j}}$, $\frac{\partial \ln F}{\partial \ln \mathrm{x_i}} = \lambda_{\mathrm{x_i}}$, then there are:

$$\lambda_Y\left(\sum \frac{\lambda_{\mathrm{y_j}}}{\lambda_Y} \cdot \frac{\partial \ln_{\mathrm{y_j}}}{\partial \mathrm{t}} + \sum \frac{\lambda_{\mathrm{x_i}}}{\lambda_Y} \cdot \frac{\partial \ln \mathrm{x_i}}{\partial \mathrm{t}}\right) + \lambda_{\mathrm{t}} = \frac{\partial \ln \mathrm{h_{it}}}{\partial \mathrm{t}} + \frac{\partial \mathrm{c}}{\partial \mathrm{t}} \tag{5}$$

Let $O_{\mathrm{j}} = \frac{\mathrm{p_j y_j}}{\sum \mathrm{p_j y_j}}$, $I_{\mathrm{i}} = \frac{\mathrm{w_i x_i}}{\sum \mathrm{w_i x_i}}$, where p_j denotes the price of the jth agricultural output and w_i denotes the price of the ith agricultural input factor, which can be obtained by combining Solow's residual value method:

$$\dot{GL} = \sum O_{\mathrm{j}} \dot{\mathrm{y}}_{\mathrm{j}} - \sum I_{\mathrm{i}} \dot{\mathrm{x}}_{\mathrm{i}} \tag{6}$$

In the formula, $\dot{GL}$、$\dot{\mathrm{y}}_{\mathrm{j}}$、$\dot{\mathrm{x}}_{\mathrm{i}}$ represents the rate of change of agricultural green development level variable, agricultural output variable and agricultural input variable, respectively. Substituting equation (6) into equation (5) can be obtained:

$$\left[\sum O_j \dot{y}_j - \sum I_i \dot{x}_i\right] + \sum\left[\frac{\lambda_{\mathrm{y_j}}}{\lambda_{\mathrm{Y}}} - O_{\mathrm{j}}\right]\dot{\mathrm{y}}_{\mathrm{j}} + \sum \frac{\lambda_{x_i}}{\lambda_Y}\dot{x}_i + \sum I_i \dot{x}_i + \frac{\lambda_t}{\lambda_Y} = \left(\frac{\partial \ln h_{it}}{\partial t} + \frac{\partial c}{\partial t}\right)\Big/\lambda_Y \Rightarrow$$

$$\dot{GL} + \sum\left[\frac{\lambda_{\mathrm{y_j}}}{\lambda_{\mathrm{Y}}} - O_{\mathrm{j}}\right]\dot{\mathrm{y}}_{\mathrm{j}} + \sum\left[\frac{\lambda_{x_i}}{\lambda_Y} - \frac{\lambda_X}{\lambda_Y} I_i\right]\dot{x}_i + (1-RTS)\sum I_i \dot{x}_i + \frac{\lambda_t}{\lambda_Y} = \left(\frac{\partial \ln h_{it}}{\partial t} + \frac{\partial c}{\partial t}\right)\Big/\lambda_Y \tag{7}$$

In Eq. (7), RTS denotes the returns to scale, such that $B_{\mathrm{j}} = \frac{\lambda_{\mathrm{y_j}}}{\lambda_{\mathrm{Y}}} - O_{\mathrm{j}}$, $D_{\mathrm{i}} = \frac{\lambda_{x_i}}{\lambda_Y} - \frac{\lambda_X}{\lambda_Y} I_i$, then we have:

$$\dot{GL} + \sum B_j \dot{\mathrm{y}}_{\mathrm{j}} + \sum D_i \dot{x}_i + (1-RTS)\sum I_i \dot{x}_i + \frac{\lambda_t}{\lambda_Y} = \left(\frac{\partial \ln h_{it}}{\partial t} + \frac{\partial c}{\partial t}\right)\Big/\lambda_Y \Rightarrow$$

$$\dot{GL} = (RTS-1)\sum I_i \dot{x}_i - \sum B_j \dot{\mathrm{y}}_{\mathrm{j}} - \sum D_i \dot{x}_i - \frac{\lambda_t}{\lambda_Y} + \left(\frac{\partial \ln h_{it}}{\partial t} + \frac{\partial c}{\partial t}\right)\Big/\lambda_Y \tag{8}$$

Under the assumption of a perfectly competitive market, this can be obtained based on the first-order condition that farmers maximize their profits:

$$\begin{cases} p_j + \mu \dfrac{\partial F}{\partial y_j} = 0 \\ -w_i + \mu \dfrac{\partial F}{\partial x_j} = 0 \end{cases} \tag{9}$$

It is known that $\frac{\partial \ln F}{\partial \ln \mathrm{y_j}} = \lambda_{\mathrm{y_j}}$, $\frac{\partial \ln F}{\partial \ln \mathrm{x_i}} = \lambda_{\mathrm{x_i}}$, can be obtained

$$\begin{cases} \dfrac{p_j y_j}{F} = -\mu \lambda_{y_j} \\ \dfrac{w_i x_i}{F} = \mu \lambda_{x_i} \end{cases} \tag{10}$$

From equation (10):

$$O_{\mathrm{j}} = \frac{\mathrm{p_j y_j}}{\sum \mathrm{p_j y_j}} = \frac{\lambda_{y_j}}{\sum \lambda_{y_j}} = \frac{\lambda_{y_j}}{\lambda_Y} \Rightarrow B_j = 0$$

$$I_i = \frac{w_i x_i}{\sum w_i x_i} = \frac{\lambda_{x_i}}{\sum \lambda_{x_i}} = \frac{\lambda_{x_i}}{\lambda_X} \Rightarrow D_i = 0$$

In summary, the level of green development in agriculture under conditions of perfect competition in agricultural markets can be expressed as follows:

$$\dot{GL} = (RTS - 1)\sum I_i \dot{x}_i - \frac{\lambda_t}{\lambda_Y} + \frac{\partial \ln h_{it}}{\partial t} \Big/ \lambda_Y + \frac{\partial c}{\partial t} \Big/ \lambda_Y \quad (11)$$

Through equation (11), the change in the rate of change in the level of greening of agriculture can be divided into the following components: growth in scale operations $(RTS-1)\sum I_i \dot{x}_i$, change in the depth of agricultural insurance $\frac{\partial \ln h_{it}}{\partial t} \Big/ \lambda_Y$, and the effect of a combination of factors that include climate, technology, etc. $\frac{\partial c}{\partial t} \Big/ \lambda_Y$.

The above analysis points out that changes in agricultural insurance and large-scale operations are one of the factors affecting the level of green development in agriculture, and according to formula (11), the depth of agricultural insurance and changes in large-scale operations both positively affect the level of green development in agriculture.

3. Empirical Analysis of the Impact of Agricultural Insurance on the Level of Green Development in Agriculture

3.1. Variable Selection and Modeling

3.1.1. Variable selection

(1) Explained Variables

Based on the above, the explanatory variables in this paper are selected as comprehensive indicators of the level of green development of agriculture. The indicator system is constructed from the four aspects of resource conservation, environmental friendliness, output efficiency and livelihood security, and is measured by the entropy value method. The data used in this paper comes from the calculated comprehensive score of agricultural green development.

(2) Explanatory variables

The explanatory variable of this paper is the level of agricultural insurance development. Agricultural insurance depth is used as an indicator to measure the level of agricultural insurance development. The depth of agricultural insurance is defined as the ratio of agricultural insurance premium income to the gross agricultural product.

(3) Mediating variables

In this paper, agricultural scale operation is selected as the mediating variable. The per capita arable land area of agriculture, forestry, animal husbandry and fishery employees are used to measure the scale of agricultural operation, i.e., the ratio of the sown area of crops to the number of employees in the primary industry is used to express it.

(4) Moderating variables

In this paper, environmental regulation is selected as a moderating variable. The intensity of environmental regulation is measured by the ratio of regional agricultural environmental protection expenditures to GDP, where agricultural environmental protection expenditures are based on the ratio of the total value of the primary industry to GDP multiplied by local environmental protection expenditures.

(5) Control variables

In order to ensure that the impact of agricultural insurance on agricultural green development can be measured more accurately, this paper, for the selection of control variables affecting agricultural green development, comprehensively consider the actual situation of agricultural green development and the availability of data, and finally selected the following five indicators as control variables, in order to minimize the error brought by other factors to the results.

The level of financial support for agriculture (FIN), the level of financial expenditure on agriculture and forestry directly reflects the importance the government attaches to the development of agriculture, and has an important impact on the development of agriculture. Financial support for agriculture is calculated as the ratio of expenditure on agriculture, forestry and water affairs to financial expenditure.

The level of industrial structure (STR), the upgrading of industrial structure can reflect the type of the main economic activities of the country or region, and is also an important indicator for

judging economic development. In this paper, the index of the added value of the secondary industry in each region as a proportion of GDP is selected to measure.

Level of economic development (GDP). The level of economic development is a key indicator for assessing the comprehensive strength of a region, and it largely influences the process of green development. In this paper, the level of economic development is measured by GNP per capita.

Internet penetration (INT). Internet penetration affects rural residents' external communication and external trade of agricultural products. This paper chooses the Internet penetration rate to measure.

Disaster affected rate (DIS). The agricultural disaster rate reflects the extent to which agriculture in each area is affected by natural disasters, and the ratio of the affected area (in thousands of hectares) to the total sown area of crops (in thousands of hectares) has been chosen to replace

Rural human capital (EDU). The increase in the education level of agricultural producers is conducive to the green development of agriculture, and the longer the average education level of agricultural producers, the more skillful they are in the application of agricultural technology and the higher their awareness of green agricultural production. The sum of the product of the proportion of the number of agricultural producers educated in different years and the corresponding year of education is the corresponding average years of education, which is logarithmically processed as a measure of the literacy level of the labor force.

Table 1. Variable Definitions

Variable type	name (of a thing)	notation	Description of variables
explanatory variable	Level of greening of agriculture	GL	Composite indicators measured by the entropy approach
explanatory variable	Depth of agricultural insurance	INS	Agricultural insurance premiums/gross agricultural product
control variable	Level of financial support for agriculture	FIN	Expenditures on agriculture, forestry and water affairs/financial expenditures
	Level of industrial structure	STR	Value added of secondary sector/GDP
	Level of economic development	GDP	Gross national product/total population
	Internet penetration	INT	Number of Internet users/total population
	disaster rate	DIS	Affected area/total sown area of crops
	Rural human capital	EDU	Years of schooling per capita in rural areas
intermediary variable	Large-scale agricultural business	SCA	Area sown under crops/persons employed in the primary sector
moderator variable	environmental regulation	ER	Gross primary sector/GDP*Local environmental protection expenditure

(6) Data sources

Considering the availability of data, the data in this paper are selected from the panel data of 30 provinces in China (excluding Tibet) from 2010 to 2022 as the sample for examination, and the level of green development in agriculture, the depth of agricultural insurance and each control variable are described separately. The data are obtained from documents such as China Rural Yearbook, China Insurance Statistical Yearbook, China Statistical Yearbook, China Rural Management Statistical Yearbook and other platforms such as the National Bureau of Statistics (NBS), and the missing values are filled in by interpolation and the statistical yearbooks of each province and city, and a total of 390 valid samples are obtained after the collation and calculation. The descriptive statistics of each variable are shown in Table 2:

Table 2. Variable Descriptive Statistics

Variable category	variable name	observed value	average value	(statistics) standard deviation	minimum value	maximum values
explanatory variable	Greening of agriculture	390	0.257	0.052	0.140	0.427
explanatory variable	Depth of agricultural insurance	390	0.012	0.017	0.002	0.126
control variable	Level of financial support for agriculture	390	0.113	0.331	0.040	0.204
	Rural human capital	390	2.063	0.761	1.809	2.317
	Level of industrial structure	390	0.409	0.082	0.160	0.620
	Level of economic development	390	1.611	0.488	0.253	2.946
	Internet penetration	390	54.696	15.488	19.8	91.9
	disaster rate	390	0.148	0.119	0	0.696

3.1.2. Model construction

(1) Baseline regression

In this study, panel data from 30 provinces (excluding Tibet) in China during 2010-2022 were used to conduct panel data regression using Stata17. To explore the impact of agricultural insurance on the green development of agriculture, a panel data model is selected for regression analysis. The panel data model considers both time and individual dimensions, and this paper uses a two-way fixed effects model to explore the effect of agricultural insurance on agricultural green development and test hypothesis 1.

$$GL_{it} = a_0 + a_1 INS_{it} + a_i \sum \text{controls}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (12)$$

Where the explanatory variable GL represents the level of green agricultural development, the explanatory variable INS represents agricultural insurance, Controls is each control variable, including the level of economic development, the level of industrial structure, the Internet penetration rate, the level of financial support for agriculture, and the rural human capital. i denotes the provinces (i = 1, 2, 3, ...), t denotes time (t = 1, 2, 3, ...), is the constant term, and denotes the random error term. ...), a_0 is the constant term, and ε denotes the random error term.

(2) Mediating effects model

In order to verify whether scale operation has produced mediating effect in the process of agricultural insurance affecting agricultural green development, this paper refers to the mediating effect model proposed by Wen Zhonglin et al. (2014), and introduces equations (4.2) and (4.3) on the basis of equation (4.1) to construct a mediating effect model to test hypothesis 2. The specific model is constructed as follows:

$$M_{it} = b_0 + b_1 INS_{it} + b_2 \sum \text{controls}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (13)$$

$$GL_{it} = c_0 + c_1 INS_{it} + c_2 M_{it} + c_3 \sum controls_{it} + \mu_i + \lambda_t + \varepsilon_{3it} \quad (14)$$

Where M_{it} is the scale of agricultural operations.

(3) Moderated mediation effects model

On the basis of the mediating effect of scale operation above, in order to further verify the impact of agricultural insurance on scale operation and the effect of scale operation on the level of green development of agriculture is affected

by environmental regulation, this paper introduces the moderating variable ER (environmental regulation), and combines the moderating effect of environmental regulation with the mediating effect to explore the impact path of agricultural insurance and green development of agriculture.

In order to avoid the multicollinearity brought by the interaction, this paper de-centered the explained variables, core explanatory variables, mediating variables and moderating variables, and multiplied the centered core explanatory variables and moderating variables to get the interaction effect term. In this paper, we refer to the mediated effect model with moderation of Wen Zhonglin and Ye Baojuan for analysis, and construct the model as follows:

$$c\_GL_{it} = \alpha_0 + \alpha_1 c\_INS_{it} + \alpha_2 c\_ER_{it} + \alpha_3 (c\_INS_{it} \times c\_ER_{it}) + \alpha_4 \sum Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (15)$$

$$c\_M_{it} = \beta_0 + \beta_1 c\_INS_{it} + \beta_2 c\_ER_{it} + \beta_3 (c\_INS_{it} \times c\_ER_{it}) + \beta_4 \sum Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (16)$$

$$c\_GL_{it} = \gamma_0 + \gamma_1 c\_INS_{it} + \gamma_2 c\_ER_{it} + \gamma_3 (c\_INS_{it} \times c\_ER_{it}) + \gamma_4 c\_M_{it} + \gamma_5 (c\_M_{it} \times c\_ER_{it}) + \gamma_6 \sum controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (17)$$

Where c_GL_{it}, c_INS_{it}, c_ER_{it}, c_M_{it} are centered variables,α 1 denotes the total effect of agricultural insurance on rural green development under the moderating effect of environmental regulation. β_1 denotes the effect of agricultural insurance on the mediator variable under the moderating effect of environmental regulation, and γ_2 denotes the effect of the mediator variable on agricultural green development under the moderating effect of environmental regulation. α 3, β 3, γ_3, and γ_5 represent the magnitude of the moderating effect, and a positive sign means that the environmental regulation promotes the positive effect of the independent variable on the dependent variable, and a negative sign means that the environmental regulation will weaken the positive effect of the independent variable on the dependent variable.

3.2. Test of the Direct Effect of Agricultural Insurance on The Level of Green Development in Agriculture

3.2.1. Benchmark regressions

In order to test the impact of agricultural insurance on agricultural green development, this paper carries out regression based on national level data. In addition, since the green development of agriculture is affected by a variety of factors, a stepwise regression is used, in which the core explanatory variables and control variables are added to the model one by one for regression, and the results are shown in Table 3 The regression results are as follows:

Table 3. Benchmark regressions of agricultural insurance on greening agriculture

	(1) GL	(2) GL	(3) GL	(4) GL	(5) GL	(6) GL	(7) GL
INS	0.0801***	0.0744***	0.0758***	0.0966***	0.0787***	0.0871***	0.0860***
	(2.9046)	(2.6923)	(2.7419)	(3.4218)	(2.7038)	(2.8743)	(2.8337)
FIN		0.1754*	0.1701*	0.1877**	0.2045**	0.1891**	0.1850**
		(1.8838)	(1.8268)	(2.0335)	(2.2225)	(2.0265)	(1.9795)
STR			-0.0570	-0.1245**	-0.1075**	-0.0939*	-0.0911*
			(-1.2461)	(-2.4579)	(-2.1119)	(-1.7834)	(-1.7260)
GDP				0.0576***	0.0466**	0.0405*	0.0434**
				(2.9578)	(2.3390)	(1.9434)	(2.0548)
EDU					0.1228**	0.1337**	0.1341**
					(2.2834)	(2.4369)	(2.4427)
INT						0.0003	0.0003
						(0.9973)	(0.9532)
DIS							0.0105
							(0.8718)
_cons	0.2535***	0.2338***	0.2577***	0.1897***	-0.0541	-0.0853	-0.0923
	(161.5926)	(22.1929)	(11.7947)	(6.0091)	(-0.4863)	(-0.7384)	(-0.7964)
N	390	390	390	390	390	390	390
R^2	0.8673	0.8686	0.8692	0.8724	0.8744	0.8747	0.8750

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively, with standard errors in parentheses.

As can be seen from Table 4, column (1) is the regression result of agricultural insurance density on agricultural green development without adding control variables, indicating that agricultural insurance density can effectively promote agricultural green development. From the point of view of significance, for every 1% increase in agricultural insurance density, the level of agricultural green development will increase by 0.0801; Columns (2)-(7) sequentially add the

level of financial support for agriculture, the level of industrial structure, the level of economic development, the level of rural human capital, Internet penetration and the disaster rate and other control variables, and compare the coefficients of agricultural insurance found to have no significant change, it can be seen that regardless of the whether control variables are added or not, agricultural insurance density has a significant contribution to green agricultural development, which indicates that the results are reliable. The regression results in column (7) show that the impact of agricultural insurance density on agricultural green development is still positive and significant at 1% level, with a coefficient of 0.0860, which is consistent with the results of the theoretical analysis in the previous section, so it can be initially determined that the development of agricultural insurance can promote the development of agricultural green and improve the agro-ecological environment.

3.2.2. Robustness Tests

In order to further determine whether the empirical findings are reliable, a robustness test is required. In this paper, the above regression model is tested for robustness by replacing explanatory variables, eliminating municipalities, shrinking tail treatment and endogeneity test.

(1) Replacement of explanatory variables. This paper adopts agricultural insurance density as a substitute explanatory variable. Agricultural insurance density is a measure of the popularity of the insurance industry in the region, and also reflects the status of economic development in the region and the strength of farmers' awareness and acceptance of agricultural insurance. The regression results are shown in column (1) of Table 4, indicating that with the replacement of the explanatory variables, the depth of agricultural insurance has a positive impact on the green development of agriculture at the 10% significance level, which is basically consistent with the results of the baseline regression, and verifies the research conclusions of this paper.

(2) Excluding municipalities. Considering that municipalities directly under the central government exist as political and economic centers compared to other provinces, agricultural development is not their basic task, and the share of agriculture in the GDP of municipalities directly under the central government has been declining in recent years, the sample may cause interference in the overall results. Therefore, this paper chooses to exclude the samples of Beijing, Tianjin, Shanghai and Chongqing municipalities. The regression results are shown in column (2) of Table 4, indicating that there is a significant positive impact of agricultural insurance on agricultural green development under the exclusion of the four municipalities directly under the central government, and the level of significance is consistent with the benchmark regression, which suggests that the regression results of the benchmark model are robust.

(3) Tailoring. In this paper, all the variables involved in the model are regressed after shrinking at the 1% level, and the regression results are shown in column (3) of Table 4, which shows that agricultural insurance has a positive impact on agricultural green development at the 1% significance level, which indicates that agricultural insurance can help to promote the enhancement of the level of green development in agriculture, thus further verifying that the empirical results of this paper are robust, and that the core conclusions of this paper's research are relatively Reliable.

Table 4. Robustness Tests

	(1)	(2)	(3)
	Substitution of explanatory variables	Excluding municipalities	shrinkage treatment
INS1	0.2468*		
	(1.6884)		
INS		0.3113***	0.1417***
		(3.5909)	(3.5176)
FIN	0.1958**	0.1023	0.1786*
	(2.0694)	(1.0352)	(1.8776)
STR	-0.0824	-0.1124*	-0.0972*
	(-1.5538)	(-1.9561)	(-1.8232)
GDP	0.0380*	0.0546**	0.0467**
	(1.7947)	(2.3840)	(2.1484)
EDU	0.1459***	0.1361**	0.1632***
	(2.6352)	(2.0560)	(3.0040)
INT	0.0002	0.0005*	0.0003
	(0.6285)	(1.6856)	(1.2272)
DIS	0.0109	0.0113	0.0104
	(0.8937)	(0.8853)	(0.8230)
_cons	-0.1076	-0.1092	-0.1613
	(-0.9203)	(-0.7845)	(-1.3905)
N	390	338	390
R^2	0.8731	0.8745	0.8769

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively, with standard errors in parentheses.

3.2.3. Heterogeneity analysis

Table 5. Subregional regression results

	(1)	(2)	(3)
	model1	model2	model3
INS	0.5859***	0.0274	0.1312
	(0.1623)	(0.0354)	(0.1792)
FIN	0.3657**	0.5130*	0.1064
	(0.1725)	(0.2700)	(0.1687)
STR	-0.0492	-0.2764*	-0.1757
	(0.0789)	(0.1612)	(0.1386)
GDP	0.0989***	0.0656	0.0927*
	(0.0341)	(0.0571)	(0.0515)
EDU	0.3877***	0.2010**	-0.0086
	(0.1230)	(0.0849)	(0.1076)
INT	0.0001	0.0009*	-0.0012*
	(0.0005)	(0.0005)	(0.0007)
DIS	-0.0037	0.0050	0.0015
	(0.0275)	(0.0186)	(0.0245)
_cons	-0.7216***	-0.3080	0.2380
	(0.2601)	(0.2140)	(0.2192)
N	169	91	117
adj. R^2	0.8178	0.8732	0.7945

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively, with standard errors in parentheses.

Because in agricultural production, there is a large gap between the resources, environment, industrial structure and other conditions in each region of China, so in food production, the planting structure of each province and city is not the same, which may also lead to differences in the impact on the level of green development of agriculture in the process of agricultural production, so in order to test the existence of regional heterogeneity of agricultural insurance on the green

development of agriculture, this paper will be divided into three major regions, namely 13 main grain producing areas, 7 main grain marketing areas and 10 balanced grain production and marketing areas, respectively, to explore the regional heterogeneity of agricultural insurance in each region. Therefore, in order to test whether there is regional heterogeneity in agricultural green development, this paper divides the total sample into 13 main grain producing areas, 7 main grain marketing areas and 10 grain production and marketing balance areas, respectively, to explore the regional heterogeneity of the impact of agricultural insurance on agricultural green development in each region.

The reason for this difference may lie in the fact that China is a large country with a large population and that food is an important strategic material, the security of which is of particular importance. With the support of the state or local governments, agricultural insurance rates in these provinces are heavily subsidized, which in turn increases the incentives for farmers to take out agricultural insurance and for insurance companies to operate agricultural insurance. As a result, the coverage rate of agricultural insurance in the main grain-producing regions is high compared to that of the other two regions, the level of protection is also higher, and agricultural practitioners receive more comprehensive services related to agricultural production, which correspondingly improves the green development of agriculture. In addition, because agricultural insurance companies have more advanced agricultural technology and management experience, farmers can not only better avoid the risks encountered in green agricultural production after purchasing agricultural insurance, but also help farmers to improve the efficiency of agricultural production, and more easily promote green agricultural technology and eco-agricultural practices, which in turn has an important impact on the green development of agriculture. The main grain marketing areas are the more economically developed eastern coastal provinces, which are more industrialized than other provinces, and agricultural production accounts for a smaller proportion of their total social production, preferring to develop secondary and tertiary industries, so there may be a certain lag in the impact of agricultural insurance to support the green development of agriculture. In addition, due to the high level of economic development and farmers' income in the region, agricultural producers themselves have a high degree of awareness of green agriculture, and have a full understanding of green agricultural technology and practice, so the increase in the density of agricultural insurance in the region does not have a significant impact on the green development of agriculture. On the other hand, the balance of production and marketing areas are mostly located in the western regions, which are constrained by insufficient resources, weak incentives for agricultural technological innovation and insufficient construction of agricultural infrastructures, and the level of development of agricultural insurance in the region is lagging behind the needs of green agricultural development, with insufficient risk protection, which is not able to effectively diversify the risks faced by farmers engaging in agricultural production, thus leading to a weaker effect of green agricultural development.

3.3. Moderated Mediation Effect Tests

3.3.1. A test of the mediating effect of scale operations

The above has tested the existence of a significant positive impact of agricultural insurance on agricultural green development, and this section examines the intermediary mechanism that exists in the process of agricultural insurance for agricultural green development. In the theoretical analysis above, agricultural insurance mainly affects the level of agricultural green development through scale operation. This paper refers to the practice of scholars such as Wen Zhonglin et al. (2014), adopts the panel data of 30 provinces and municipalities in China (excluding Tibet) from 2010 to 2022, constructs the intermediary effect model of "Agricultural insurance → Agricultural scale operation → Agricultural green development", and adopts the method of stepwise regression to the stepwise regression method is used to verify the above mediation mechanism.

Table 6. Scale-up Intermediation Test

	(1) GL	(2) Gui	(3) GL
INS	0.0860***	3.1023*	0.0773**
	(2.8337)	(1.7662)	(2.5659)
SCA			0.0028***
			(3.0309)
FIN	0.1850**	9.5723*	0.1582*
	(1.9795)	(1.7696)	(1.7049)
STR	-0.0911*	3.2952	-0.1004*
	(-1.7260)	(1.0783)	(-1.9203)
GDP	0.0434**	-3.0624**	0.0520**
	(2.0548)	(-2.5047)	(2.4678)
lnjiao	0.1341**	-5.7596*	0.1502***
	(2.4427)	(-1.8128)	(2.7561)
EDU	0.0003	0.0831***	0.0000
	(0.9532)	(5.4728)	(0.0636)
DIS	0.0105	0.3076	0.0097
	(0.8718)	(0.4402)	(0.8097)
_cons	-0.0923	17.3798***	-0.1410
	(-0.7964)	(2.5906)	(-1.2192)
N	390	390	390
R^2	0.8750	0.9355	0.8783

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively, with standard errors in parentheses.

The above table shows the mediating effect of scale operation on the process of agricultural insurance to promote green agricultural development. Column (2) is the scale of operation as an explanatory variable, the regression results show that agricultural insurance has a positive effect on the scale of operation at the 10% significant level, with a regression coefficient of 3.1023. This indicates that for every 1% increase in the density of agricultural insurance, the scale of operation improves by 3.1023%; that is to say, the increase in the density of agricultural insurance can significantly promote the development of the scale of agricultural economy. Column (3) is to take agricultural green development as an explanatory variable, agricultural insurance and agricultural scale operation are included in the regression equation at the same time, to test the effect of agricultural insurance on agricultural green development under the intermediary effect of scale operation, and the results show that the scale of operation positively promotes the development of agricultural green development at a significant level of 1%, which indicates that the scale of operation of agriculture can promote the development of agricultural green development and agricultural insurance also positively promotes the

development of agricultural green development at a significant level of 5%. The results show that the scale of operation positively promotes agricultural green development at the 1% significant level, indicating that agricultural scale operation can promote agricultural green development, and agricultural insurance at the 5% significant level. The results show that the scale of operation positively promotes agricultural green development at the 1% significant level, indicating that agricultural scale operation can promote agricultural green development, and agricultural insurance also positively promotes agricultural green development at the 5% significant level.

3.3.2. Tests of the moderating effect of environmental regulation

Table 7. Moderated Mediation Effects Tests

	(2)	(3)
	gui	y
c_INS	7.6116***	0.1309***
	(2.5470)	(0.0481)
c_ER	-0.0201	0.0022
	(0.0976)	(0.0017)
c_INSc_ER	5.3372**	0.0599
	(2.1512)	(0.0433)
FIN	8.7784	0.1385
	(5.3827)	(0.0933)
STR	1.3313	-0.1048*
	(3.1307)	(0.0538)
GDP	-2.4388**	0.0553**
	(1.2395)	(0.0214)
EDU	-5.9907*	0.1515***
	(3.1680)	(0.0549)
INT	0.0813***	0.0000
	(0.0151)	(0.0003)
DIS	0.2600	0.0114
	(0.6943)	(0.0120)
c_gui		0.0025 ***
		(0.0009)
c_SCAc_ER		-0.0006
		(0.0004)
_cons	18.0221***	-0.1201
	(6.6928)	(0.1157)
N	390	390
adj. R^2	0.9274	0.8612

Note: *, ** and *** indicate significant at the 10%, 5% and 1% levels, respectively, with standard errors in parentheses.

Table 7 shows the regression results of the indirect effects in the mediated mediation model with moderation, and the results demonstrate the results of the moderating effect of environmental regulation on the paths before and after the mediating role in the process of agricultural insurance influencing the green development of agriculture. In column (1), the interaction term between agricultural insurance and environmental regulation is significantly positive at the 5% level of significance, indicating that the development of environmental regulation will make the promotion effect of agricultural insurance on agricultural green development play a strengthening effect. Under the moderating effect of environmental regulation, the coefficient of the effect of agricultural insurance on scale operation is significantly positive at the 1% level of significance, indicating that the development of agricultural insurance will promote the development of agricultural scale operation.

In column (2), the interaction term between environmental regulation and scale operation is not significant, indicating that there is no moderating effect in the influence path of scale operation on agricultural green development. Under the moderating effect of environmental regulation, the regression coefficient of scale operation on agricultural green development is significantly positive at the 1% level, indicating that scale operation has a significant promotion effect on agricultural green development, which verifies hypothesis 3.

Taken together, environmental regulation only plays a certain moderating role in the first half of the path of "agricultural insurance-agricultural scale operation-agricultural green development", i.e., in regions with high environmental regulation, the stronger the promotion effect of agricultural insurance on agricultural scale operation is, and the more conducive to the enhancement of agricultural green development. In the first half of the path, agricultural insurance plays a moderating role in the first half of the path. In the second half of the path, there is no moderating effect, the reason may be that when farmers change the scale of operation, more consideration is given to factors such as arable land resources, their own income, policy support, etc., and the environmental effect is a non-major condition that affects the production decision of farmers.

4. Research Findings and Policy Recommendations

4.1. Conclusions of the Study

Based on relevant literature, this paper analyzes the influence mechanism of agricultural insurance on agricultural green development from the theoretical level. The main research conclusions of this paper are as follows:

First, Agricultural insurance has a significant positive impact on the green development of China's agriculture, a finding that suggests that improving the development of agricultural insurance can effectively promote green agricultural development. The function of agricultural insurance in spreading risks and compensating losses supports the potential value of agricultural insurance in promoting environmental sustainability, indicating that it is necessary for China to advocate the high-quality development of agricultural insurance in order to promote the green development of agriculture in China.

Second, this paper selects scale operation as the mechanism variable and environmental regulation as the moderating variable based on the benchmark regression. Agricultural insurance can influence the green development of agriculture through scale operation. It can be argued that the development of agricultural insurance can help agricultural producers to operate on a large scale, and the scale of operation can significantly reduce the use of pesticides and other chemicals, increase the use of new agricultural green technology, improve the productivity of agricultural products, and then make the green development of agriculture has been improved to a certain extent. From the results of the mediation effect test with regulation, in the scale of operation to play the mediation effect at the same time, environmental regulation only in the "agricultural insurance → scale of operation → agricultural green development" in the first half of the path to play a significant positive regulatory role, that is, in the

agricultural insurance affects the scale of operation of this path to play a regulating role; and does not significantly affect the second half of the path, that is, in the scale of operation affects the scale of operation of this path to play a regulating role.

4.2. Policy Recommendations

4.2.1. Strengthening financial subsidies

Our Government should continue to increase its support for agricultural insurance through financial subsidies and other means, and improve the agricultural insurance guarantee system, with a view to better promoting the green development of agriculture. The basis for the effective functioning of agricultural insurance is the improvement of agricultural insurance protection system. Based on the previous study, agricultural insurance not only assumes the function of risk management in agricultural production and operation, but also has a positive impact on promoting the green development of agriculture. In view of this, it is suggested that the relevant departments should further improve the agricultural insurance system, including the facilitation of insurance, the speedy settlement of claims, and the expansion of the scope of protection, in order to increase the enthusiasm of farmers to purchase agricultural insurance. Insurance companies can strengthen cooperation with the government to promote agricultural insurance on a wider scale by increasing financial subsidies, etc. Providing different levels of insurance subsidies to farmers who comply with relevant national policies and can significantly reduce the use of agrochemicals will not only help to reduce the cost of production, but also better attract farmers to independently choose green production methods in agriculture. In addition, the government's increased financial expenditure can also prompt insurance companies to improve and innovate agricultural green insurance, while ensuring that the basic crops are covered, according to the differences between different regions, develop diversified insurance products in accordance with local conditions, and guide farmers to choose the appropriate insurance products according to their own needs, in order to enhance the coverage and protection of agricultural insurance. While building China's agricultural risk prevention system, it provides more comprehensive protection and helps agriculture realize green and sustainable development.

4.2.2. Strengthening the promotion and publicity of agricultural insurance

At present, although the level of agricultural insurance protection in China has improved, there are still large differences in the level of agricultural insurance development in various regions. Publicity and education on agricultural insurance should be strengthened to raise agricultural producers' awareness and understanding of agricultural insurance. Insurance companies can cooperate with local governments to carry out regular agricultural insurance knowledge publicity activities, and invite agricultural insurance salespeople to explain to agricultural producers based on real insurance claims cases. Not only can they effectively publicize agricultural insurance, let farmers understand the actual role of agricultural insurance, eliminate the adverse effects of agricultural insurance, increase the enthusiasm and initiative of farmers to participate in agricultural insurance, and enhance the popularity and coverage of agricultural insurance. As agricultural insurance companies have more experience, they can also help farmers solve problems encountered in the process of agricultural production, help establish disaster prevention and loss prevention facilities, and better risk prevention. In addition, insurance companies can use short videos, live broadcasts and other media for online marketing, and use big data to analyze the insurance needs and questions of agricultural producers and respond in a timely manner. This can improve the marketing coverage area as well as realize accurate marketing and reduce marketing costs.

4.2.3. Promoting large-scale operations range

Agricultural scale operation is an important path to promote green agricultural development. At present, agricultural scale operation mainly includes two basic modes: one is the land scale operation centered on the transfer and concentration of agricultural land, and the other is the service scale operation mode centered on the professional division of labor and the purchase of services. Agricultural insurance has the guarantee, can boost agricultural production scale operation. And through the development of agricultural moderate scale, on the one hand, can optimize the allocation of agricultural resources such as land, improve the organization of agricultural production, the introduction of a large number of machinery, technology, etc., to improve the efficiency of agricultural output, and promote the income of farmers; on the other hand, the scale of operation can prompt people to carry out green production in agriculture, optimize the industrial structure, through the reduction of fertilizers and pesticides to improve the efficiency of their use, to reduce agricultural pollution, and to improve the green development of agriculture and promote sustainable development of agriculture. Therefore, it is particularly important to promote agricultural scale operation. To make full use of the power of insurance to promote the large-scale operation of agriculture, insurance companies should develop innovative insurance varieties adapted to the diversified needs of the main body of large-scale operation, and accelerate the realization of a comprehensive coverage of agricultural insurance protection for the main grain-producing regions with fertile soil, abundant water, and high levels of machinery, so as to improve the ability to resist risks in the process of large-scale production. In addition, insurance companies should also provide specialized, low-cost services for the whole industry chain for practitioners of large-scale agricultural operations, promote the cooperation of relevant universities, talent centers, industry-academia-research bases, etc., with insurance institutions, increase the research and development and application of high-tech insurance technologies such as digital insurance, intelligent insurance monitoring, data sharing, etc., and guide a large number of insurance teams with knowledge and patents to villages and towns to realize the perfect allocation of factors, such as land, capital, talent, information technology, insurance, etc., to achieve a better understanding of the needs and needs of the industry and the industry, insurance, information technology and other elements to meet the needs of practitioners for agricultural insurance coverage in large-scale operations.

4.2.4. Increasing government environmental regulation

From the above conclusion, it can be seen that environmental regulation plays a positive regulatory role in agricultural insurance to improve agricultural scale operation, so the government should be policy-oriented, increase the strength of environmental regulation, optimize the means of environmental regulation, continuously improve the laws and regulations on agricultural environmental protection,

formulate a reasonable standardized system of environmental regulation, and scientifically apply diversified policy tools. In addition, in addition to mandatory laws and regulations, the government should also advocate farmers to take the initiative to take appropriate measures to help the green development of agriculture. At the same time, environmental regulation policies should be incorporated into the agricultural carbon peak, carbon neutral strategy and the medium- and long-term planning of sustainable agricultural development, forming a coherent and powerful supervision system, and realizing the construction and improvement of an efficient and win-win environmental regulation planning system. Lastly, combining environmental regulation with technological innovation and promoting the application of new technologies in the agricultural sector, such as big data and artificial intelligence, in environmental management can improve the accuracy, finesse and timeliness of environmental management, thereby mitigating the negative impacts brought about by mandatory regulatory means.

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