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Can Agricultural Insurance Policy Adjustments Promote a 'Grain-Oriented' Planting Structure?: Measurement Based on the Expansion of the High-Level Agricultural Insurance in China

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Abstract: Ensuring national food security is a perennial topic, and securing the grain planting area is an essential solution. Cost savings at scale from agricultural insurance policy adjustments could be a powerful incentive for grain production. In this study, 527 data sets from 31 provinces in China from 2006 to 2022 were used as the sample, and the author applied a multi-stage DID model to measure the effects of agricultural insurance policy adjustments on the grain planting area and planting structure, as well as the influence mechanisms behind them. The results can be summarized as follows: Firstly, agricultural insurance policy adjustments can make a significant contribution to increasing the grain planting area, with some positive impact on the 'grain-oriented' planting structure. Secondly, agricultural insurance policy adjustments can significantly increase the grain planting area by increasing the application of agricultural machinery, but this mechanism does not affect the 'grain orientation' planting structure. Thirdly, agricultural insurance policy adjustments can have a significant positive impact on the grain planting area and 'grain—oriented' planting structure in both high- and low-risk areas, with low-risk areas being more affected than high-risk areas.

Keywords: agricultural insurance; full-cost agricultural insurance; planting income insurance; 'grain-oriented' planting structure

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1. Introduction

Food security is an essential guarantee for world peace and development, and a key factor in building a community of human destiny. When grain production technology reaches its peak, the shortage of cultivated land will become the primary limiting factor for grain production [1]. In the limited cultivated land, the choice of planting structure is an important factor affecting food security. The adjustment direction of planting structure faced by rational farmers includes 'non-grain' and 'grain-oriented'. 'Non-grain' production in China refers to the cultivation of vegetable, cotton, or other multigrain and cash crops. By contrast, 'grain-oriented' production means planting wheat, rice, and corn. 'Grain-oriented' production is vital to ensure food security. However, as shown in Figure 1, there has been a recent trend towards 'non-grain' production in China. The non-grain production of fruits and vegetables will cause the ecological risk of heavy metal pollution [2], and the production of mushrooms will bring the destruction of the quality of the cultivated land [3], which will ultimately have serious negative impacts on ensuring food security. The government has long been concerned about the negative impact of non-grain use of cultivated land. In 2020, The General Office of the State Council issued the *Opinions on Preventing the Non-Grain Use of Cultivated Land and Stabilizing Grain Production*, which clearly stated that strong measures will be taken to prevent the non-grain use of cultivated land and effectively stabilize grain production.

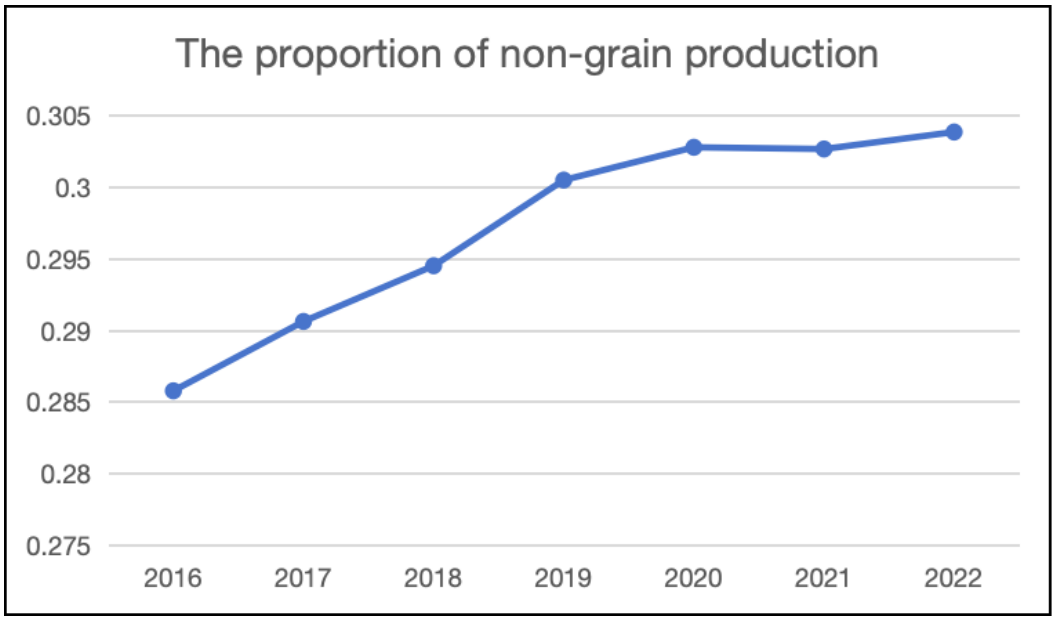


Figure 1. The proportion of non-grain production. Note: Data from China Rural Statistical Yearbook, https://www.stats.gov.cn/(accessed on 1 February 2023).

Policy-based agricultural insurance, with financial support, plays the role of economic compensation and redistribution [4], and agricultural insurance policies are adjusting continuously to the conditions of agricultural production. This study presents the pilot of full-cost agricultural insurance and planting income insurance as agricultural insurance policy adjustments. Full-cost agricultural insurance covers all costs involved in agricultural production, including material and service costs, labor costs, and land costs, and is more in line with the actual production cost for farmers. Then, unlike pure yield and price insurance, planting income insurance covers both natural and market risks. Some scholars have suggested that full-cost agricultural insurance and planting income insurance can meet the needs of large-scale grain growers, promote mechanized input, and promote an increase in the grain planting area and a shift towards a 'grain-oriented' planting structure [5–7]. *The 2024 No. 1 Central Document*, the first policy document for agriculture issued by the Chinese Central government in 2024, highlights the need to stabilize the grain planting area, expand the implementation of full-cost agricultural insurance and planting income insurance policies, achieve nationwide coverage of the three main grains, and ultimately contribute to ensuring food security. At the same time, it can be seen from *the 2024 No. 1 Central Document* that agricultural insurance policy adjustments only cover the three major grain crops (rice, wheat, and corn), but not non-grain crops.

Firstly, this study considers the grain planting area and planting structure as explanatory variables and aims to expand the research on the mechanisms of agricultural insurance policy adjustments to ensure food security. While food production has increased in recent years, this is largely due to advancements in production technology that have increased the yield per unit area. However, it is important to note that this increase in production may be masking the decline in the quality of cultivated land due to non-grain production [8]. Secondly, this study analyzes the effects of full-cost agricultural insurance and plantation income insurance from a macro perspective. Most relevant studies at present focus on a small range of objects, and a lack of research on whether these localised features and problems of full-cost agricultural insurance and planting income insurance affecting food production also have a macro-level impact [9]. Thirdly, this study analyzed the impact of full-cost agricultural insurance and planting income insurance on the heterogeneity of grain area and plantation structure measured by risk level zones to fill in the gaps in existing research.

2. Literature Review

2.1. Planting Structure and Non-Grain Production

'Non-grain' is a rational choice to conform to the market economy, and 'grain-oriented' is a new trend in scale management [10]. Ensuring food security is a top priority, making the promotion of a 'grain-oriented' planting structure a key concern for both the government and academia. Academic attention has been given to the influence of factors such as agricultural mechanization [11], labor transfer [12], land circulation [13], climate change [14,15], and food consumption [16–18] on the planting structure. Among them, many scholars have analyzed the causes of 'non-grain': high grain growing cost, especially labor cost [19,20], low grain yield [21], arable land fragmentation [22,23], urbanization rate [24], and an aging labor force [25]. Adjusting these factors can provide ideas for a 'grain-oriented' planting structure.

2.2. Agricultural Insurance Policy Adjustments for Grain Production

At present, agricultural production is mainly faced with natural risks such as climatic geological disasters, biological pests, and market price fluctuations. Full-cost agricultural insurance can cover the physical, land, and labor costs of agricultural production. Planting income insurance targets the loss of agricultural planting income caused by price and output fluctuations. The typical difference with other agricultural insurance is that the insurance liability of planting income insurance has been expanded [26].

Policy-based agricultural insurance can encourage farmers to increase their grain planting area [27]. Full-cost agricultural insurance and planting income insurance, as important components of policy-based agricultural insurance, have unique advantages in promoting catering for grain. Firstly, planting income insurance is more in line with the actual needs of new agricultural business subjects [6]. Secondly, in relation to agricultural production and operation, farmers or agricultural enterprises can alleviate financing problems by using full-cost agricultural insurance and planting income insurance [28]. Additionally, the use of these insurances can reduce the input of pesticides and fertilizers [29,30], suggest promoting large-scale management of grain production [7,31,32], and then improve the grain planting structure to optimize grain [33,34].

Finally, with regards to agricultural income and the distribution of agricultural benefits, planting income insurance can replace the old interest linkage mechanism and establish a mechanism of 'benefit sharing and risk sharing' [35]. However, studies have shown that as the agricultural production level improves, the effect of agricultural insurance development on agricultural production promotion gradually decreases [36]. What is more, agricultural insurance may cause "moral hazard", leading to a decline in the production management level, which can have a significant negative effect on farmers' operational income [37,38]. As a crucial component of agricultural insurance, full-cost agricultural insurance and planting income insurance may also have unintended consequences resulting from favorable outcomes.

2.3. Commonality, Local Innovation, and the Realistic Constraints

In the actual pilot projects of full-cost agricultural insurance and planting income insurance nationwide, there exists a phenomenon of coexistence of local innovation and realistic difficulties. This feature is constantly shaped by the comprehensive effect of multiple spatial–temporal factors, such as economic and social conditions in the regional space and time of investment and implementation in the actual application of full-cost insurance and planting income insurance. First of all, in terms of product design, the development of China's agricultural futures market is not perfect, and the 'planting income insurance + futures' designed in this way is not effective enough [28] and even has the characteristics of compliance risks [39]. Secondly, in terms of meteorological income insurance: internationally, some scholars believe that high temperature and drought insurance in adverse climates has the characteristics of insufficient protection [40]. In China, although the domestic meteorological index insurance has the advantages of wide coverage and strong government

support compared with the international meteorological index insurance, it is still difficult to obtain data and lacks high-quality output data [41]. And then, in terms of farmers' willingness to pay: the differences in farmers' willingness to purchase agricultural insurance in different countries are comprehensively affected by multiple factors such as agricultural risk exposure, farmers' risk tolerance, agricultural insurance systems and policies, finance and economy of different countries, insurance rates, and farmers' income [42–45]. What's more, insurance pricing and loss assessment are also important considerations. Compared with the United States, where the pricing mechanism is relatively perfect, China's planting income insurance products cover relatively single targets, and the pricing methods of insurance are relatively extensive. Focusing on the regional market prices rather than the local realities [46], a lack of pricing mechanism for some agricultural products, and the inconsistency of futures data due to spatio-temporal differences in agricultural production and trading has led to the inconsistent pricing of insurance products [47] and other problems. Besides, in the assessment of full-cost agricultural insurance and planting income insurance, there are difficulties in the assessment of exploration loss [48], the adoption of provincial or average loss assessment, and the serious lack of dynamic monitoring of agricultural production and the output release mechanism [49]. Finally, in terms of the level of guarantees for planting income insurance, regional variability affects the level of planting income insurance coverage, with coverage levels leading to different results in different risk areas through the probability of being awarded a claim [50].

3. Theoretical Hypothesis

Agricultural insurance can influence farmers' production and management decisions by providing risk guarantees. However, traditional yield and single-cost insurance for natural risks and price insurance for market risks may not be suitable for the changing agricultural production and market environment. This is mainly due to incomplete cost coverage and the insurance liability gap between price and output when guaranteeing farmers' expected income. Therefore, from the perspective of product design and policy subsidies, to enhance the protection of farmers' expected income and promote grain production, it is recommended to use full-cost insurance that covers all the costs from grain production, as well as planting income insurance that covers both the natural and market risks. Based on the existing literature, this study presents a theoretical analysis framework for the impact of full-cost agricultural insurance and planting income insurance on grain planting area and planting structure. The framework is divided into four dimensions based on differences in influencing mechanisms: stable income expectations, increase in the application of agricultural machinery, 'implicit endorsement' coexisting with 'rational economic man', and driven by external factors. The effects of full-cost agricultural insurance and planting income insurance on the grain planting area and planting structure were discussed.

Stable income expectations. Although self-reliance remains a characteristic of China's smallholder peasant economy, it has never been the sole feature of agricultural production. One of the most important attributes is the market exchange of agricultural products. Agricultural products are sold in the market after the cycle of production, except for some that are used for self-consumption. The sale of agricultural products is the main source of income for farmers, and the income of farmers not only meets the needs of life, but also determines the capital input of agricultural production. The sales of agricultural products are mainly determined by factors such as agricultural production and market prices, which often have adverse fluctuations. In situations where natural disasters or adverse changes in the market occur, production may decrease or prices may fall, resulting in a decrease in the overall economic value of grain. From the comparison of traditional agricultural insurance, full-cost agricultural insurance, and planting income insurance, it is evident that the latter two provide a higher income security for farmers. This, in turn, helps to stabilize farmers' income expectations, improve their production enthusiasm, and stabilize the source of funds for the next production cycle, ultimately leading to a stabilized grain planting area. Stable income expectations can also restrain the concerns of grain households about the

input of production resources, moderately expand the input of factors, and ultimately promote the increase in the grain planting area.

Increase the application of agricultural machinery. Full-cost agricultural insurance and planting income insurance can effectively reduce the risk exposure of agricultural production and restrain the damage of agricultural production uncertainty to farmers. The total premium subsidy of full-cost agricultural insurance and planting income insurance exceeds 70%. These factors can reduce insurance costs while spreading risks, and enlarge the profit margin of grain production, which will encourage farmers to carry out grain production and optimize grain production methods. Mechanization is an effective way to optimize grain production. It improves efficiency, reduces pressure on food harvesting, and then minimizes unnecessary losses. Additionally, it reduces the unit area cost of labor and fertilizer, thereby improving the profit margin of grain growing. Ultimately, it promotes an increase in the grain planting area and expands the scale of grain production. Numerous studies have demonstrated that mechanization can enhance the scale of grain production and promote a 'grain-oriented' planting structure [51–54].

'Implicit endorsement' coexists with 'rational economic man'. To ensure food security, the state has implemented various policies for all aspects of grain production. In addition to the full-cost agricultural insurance and planting income insurance in this study, the policies also include subsidies for arable land protection, minimum purchase price policies for rice and wheat, etc. These policies release a positive signal of the country's emphasis on agriculture to grasp grain. Essentially, it is an endorsement to support grain production. This will encourage farmers to view grain production as more beneficial, not just as a means of breaking even or making a profit, so farmers will be more enthusiastic about planting grain, leading to an increase in the area dedicated to grain production and promoting a shift towards grain in the planting structure. However, in terms of grain production, individual decision-making is based on a cost–benefit analysis, assuming a 'rational economic man' [55]. Some scholars have explained that farmers are rational economic people. Farmers compare the production costs and benefits of different crops when choosing what to grow on limited arable land. China's small farmers are the primary producers of grain, and they face challenges due to limited land resources and weak economic strength. As a result, it is difficult for them to obtain full-cost agricultural insurance and planting income insurance to save costs and increase efficiency on a larger scale. In such situations, planting cash crops can be more profitable than planting grain crops when the unit cost is the same. Therefore, small farmers who are economically rational and driven by expected profits will take the initiative to adjust their planting structure and increase the planting area of cash crops. This is not conducive to a 'grain-oriented' planting structure. As a result of this rational economic decision, the positive impact of various food support policies, including full-cost agricultural insurance and planting income insurance, on farmers' increase in grain planting area will be weakened.

Based on the above theoretical analysis, this study proposes research hypotheses (H1 and H2):

H1. *Full-cost agricultural insurance and planting income insurance may have a positive impact on the increase in grain planting area.*

H2. *Full-cost agricultural insurance and planting income insurance may have a positive impact on the 'grain-oriented' of plantation structure.*

Based on the literature review and analysis above, a graphical framework on agricultural insurance policy adjustments and a 'grain-oriented' planting structure can be presented (Figure 2).

Driven by external factors. Food production has historically been closely linked to natural and human conditions. Natural conditions, such as climate, hydrology, terrain, and soil, and human conditions, such as market demand, policies, and regulations, trans-

portation, and production technology, will affect the resource input, production, harvest, circulation, and transaction of food production. Both natural and human conditions vary regionally, affecting the characteristics of grain production.

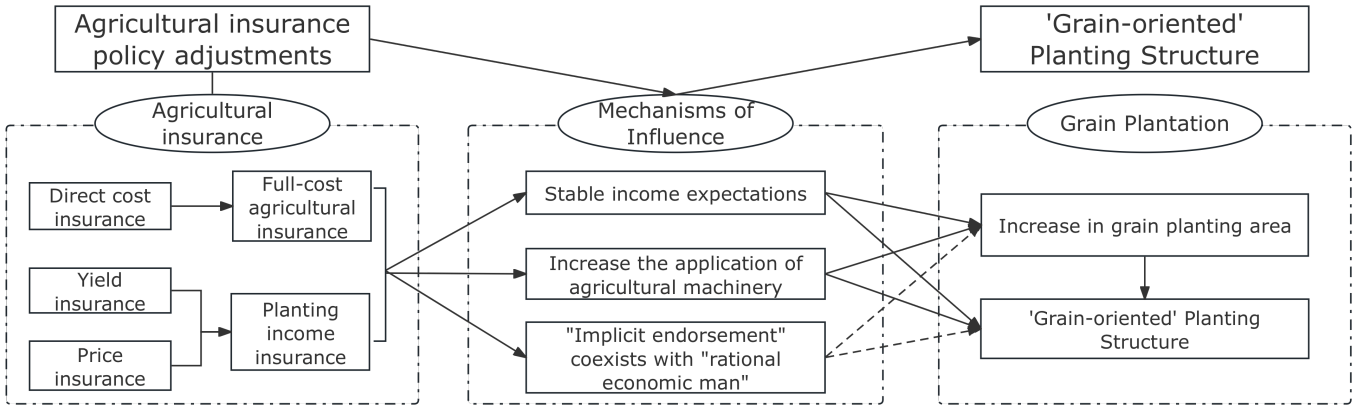


Figure 2. Graphical framework on agricultural insurance policy adjustments and a 'grain-oriented' planting structure.

The implementation of agricultural insurance is also influenced by these conditions. Farmers' willingness to purchase planting income insurance is a key indicator of the effectiveness of agricultural insurance. Farmers' purchasing intentions can be categorized as direct motivation and indirect motivation. Direct motivation refers to the economic compensation function of farmers' desire for full-cost insurance and planting income insurance. Compared with price fluctuations, the occurrence of natural disasters often causes extreme losses to the grain output, so the purchase of planting income insurance will reduce their economic losses. Farmers are more likely to choose full-cost agricultural insurance and planting income insurance with a higher product guarantee level, which includes both income insurance pricing premium and loss detection standard. This is because the higher level of guarantee provides an indirect motive. This study analyses the direct motivation for the demand for agricultural insurance in the high-risk areas of agricultural production. In such areas, the probability of damage is high, and farmers have a strong risk awareness. Therefore, the demand for agricultural insurance is strong, and the guarantee function of agricultural insurance is better reflected. Conversely, in the low-risk areas of agricultural production, farmers' risk awareness is relatively weak due to the low probability of damage, and the protective role of agricultural insurance is not easily reflected.

Based on the above background and theoretical analysis, this study proposes research hypotheses (H3):

H3. *Regional agricultural risk degree may affect the effect of full-cost agricultural insurance and planting income insurance on grain planting area and planting structure.*

4. Empirical Design and Descriptive Statistics

4.1. Sample and Source of Data

This study selects 527 data from 31 provinces from 2006 to 2022. The data in this paper are panel data. Total agricultural planting area, grain planting area, agricultural disaster area, producer price of planting industry, and total power of agricultural machinery were obtained from the *China Agricultural Statistical Yearbook*. The employment rate of primary industry and fiscal expenditure on agriculture, forestry, and water conservancy were obtained from the *China Statistical Yearbook*. The income and payout of agricultural insurance are from the *Statistical Yearbook of China Insurance*. Some indexes have missing

values, and the moving average method is used for interpolation. The descriptive statistics of variables are shown in Table 1.

Table 1. Definition of variables and descriptive statistical analysis results.

Variable	Symbol	Definition	Mean	S.D.
Explained variables				
Total agricultural area	Total	Total agricultural area	5263.19	3821.15
Grain planting area	Grain	Grain planting area	3641.56	3018.55
Planting structure	GT	Grain planting area/Total agricultural area	0.66	0.14
Explanatory variable				
Agricultural insurance policy adjustments Mechanism variables	Adjustment	0 = No, 1 = Yes	0.06	0.24
Total power of agricultural machinery	Machinery	Total power of agricultural machinery	3147.45	2854.94
Control variables				
Labour input	Labour	Employment in the primary industry/Employment in the region	33.88	15.28
Financial expenditure on agriculture, forestry and water	Finance	Financial expenditure on agriculture, forestry and water	443.59	309.63
Gross output value of agriculture, forestry, animal husbandry and fishery	GOV	Gross output value of agriculture, forestry, animal husbandry and fishery	3035.23	2463.87
Agricultural industry structure	Structure	Gross output value of agriculture/GOV	0.52	0.09
Agricultural Insurance Income	Income	Agricultural Insurance Income	1293.37	1508.03
Agricultural Insurance Payout	Payout	Agricultural Insurance Payout	877.41	1111.52
Agricultural Risk Level	Risk	Agricultural disaster area	908.37	944.81
Cultivation Production Price	Price	Plantation Price Index (last year's price was 100)	104.60	6.01

4.2. Variable Selection

The selection and statistical description of the variables are shown in Table 1.

Explained variables: In order to evaluate the incentive effect of pilot policies of full-cost agricultural insurance and planting income insurance on the grain production area and 'grain-oriented' planting structure, based on the theoretical analysis above and combined with the research, there are three main explained variables: ① The total agricultural planting area. ② The absolute index of the grain planting area. ③ The relative index of the proportion of the grain planting area to the total agricultural planting area. In addition, in order to reduce the influence of outliers and other factors on the regression results, this study conducted a logarithmic treatment of the crop planting area, like "*Grain*'".

Core Explanatory Variable: The pilot and promotion of full-cost agricultural insurance and planting income insurance have inter-provincial temporal and spatial differences, based on the central documents, the pilot in Inner Mongolia and Liaoning in 2018, and the promotion to Heilongjiang, Hubei, Hunan, Jilin, Jiangxi, Anhui, Hebei, Henan, Jiangsu, Shandong, Sichuan, and other provinces in 2021. The core explanatory variable of this study is 'Agricultural insurance policy adjustments', and it is investigated whether the province is the pilot province of full-cost agricultural insurance and planting income insurance in the current year. If it is, the variable value is 1, otherwise it is 0.

Control Variables: Combined with the existing literature, this study selects the following four types of control variables. ① Agricultural production variable: Labor input. The agricultural production condition of each province is the primary factor affecting the grain planting area and planting structure. Labor input is selected and measured by the employment rate of the primary industry. ② The level of agricultural development and

structural variables: total output value of agriculture, forestry, animal husbandry, and fishery, and the agricultural industrial structure. The level and structure of agricultural development may affect the status and capacity of food production. Among these variables, the agricultural industrial structure is measured by the proportion of the regional agricultural output value to the total output value of agriculture, forestry, animal husbandry, and fishery. ③ The development variable of agricultural insurance: the amount of agricultural insurance income and agricultural insurance compensation. Agricultural insurance income can reflect farmers' demand for agricultural insurance, and the greater the value, the greater the demand for agricultural insurance. The amount of agricultural insurance payments can reflect the level of agricultural security to a certain extent. Higher levels of security can incentivize farmers to increase the planting areas, adjust their planting structure, and promote a 'grain-oriented' approach. This can lead to an increase in grain production. ④ Other variables: the level of agricultural risk, the level of agricultural financial support, the price of planting and production. Among them: the agricultural risk level is measured by the agricultural disaster area; the level of agricultural financial support is measured by the fiscal expenditure on agriculture, forestry, and water resources. The planting production price is measured by the planting production price index, which takes the price of the previous year as 100, and reflects the price fluctuation in the form of the index, thus affecting the production behavior of farmers.

4.3. Econometric Models and Estimation

4.3.1. Benchmark Model

In order to verify the theoretical hypothesis, this study takes the pilot of full-cost agricultural insurance and planting income insurance as the natural experiment, and uses the multi-stage DID model to evaluate the incentive effect of full-cost agricultural insurance and planting income insurance on the grain planting area and planting structure. Therefore, the Equation (1) is as follows:

$$y_{it} = \alpha_0 + \alpha_1 DID_{it} + \alpha_{control} Controls_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

where the subscript i represents the province (i = 1, 2, 3, . . ., 31), t denotes the year (t = 2006, 2007, . . ., 2022); y_{it} represents the planting area of grain or the proportion of the planting area of grain. DID_{it} indicates whether the pilot of full-cost agricultural insurance and planting income insurance was implemented in the province i and in the year t. If otherwise, it is 0; $Controls_{it}$ represents a set of control variables; μ_i represents the province dummy variable, controlling the individual factors that affect the planting area and planting structure of food crops but do not change with time; ν_t represents the time dummy variable, which controls the time factors affecting all provinces; ε_{it} represents a random disturbance term.

4.3.2. Mechanism Testing Model

According to the results of the baseline analysis, the pilot programs of full-cost agricultural insurance and planting income insurance significantly promoted the increase in the grain planting area and the 'grain-oriented' planting structure. Based on a theoretical analysis, the influence mechanism of full-cost agricultural insurance and planting income insurance on the grain planting area and planting structure is mainly about stable income expectations, increase the application of agricultural machinery, 'implicit endorsement' coexists with 'rational economic man', and driven by external factors. It can be seen from the above that 'implicit endorsement' coexists with 'rational economic man' making full-cost agricultural insurance and planting income insurance have uncertain influence directions on grain production. External factors to promote the analysis of human and natural conditions, covering a wide range of aspects, is not suitable for specific analysis. Stable income expectations reflect the guarantee of agricultural insurance for the income risk of agricultural products. Due to the compensatory nature of agricultural insurance itself, the role of agricultural insurance is mainly to compensate for losses rather than increase additional income, and the increase in agricultural operation income mainly comes from

the cost saving and efficiency increase brought about by the improvement of production mode, including mechanized production. Therefore, this study analyzes the mechanism of agricultural insurance—increasing the application of agricultural machinery—grain planting area and planting structure. The Equations are as follows:

$$M_{it} = \alpha_0 + \alpha_1 DID_{it} + \alpha_{control} Controls_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (2)$$

$$y_{it} = \alpha_0 + \alpha_1 DID_{it} + M_{it} + \alpha_{control} Controls_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (3)$$

where M_{it} is the intermediate variable of the application of agricultural machinery. The analysis idea of intermediary effect is as follows: Firstly, the benchmark regression is performed on Equation (1), then the regression on Equation (2) is used to test the influence of the agricultural insurance pilot on the intermediary variables, and finally, the intermediary effect analysis framework is obtained by substituting Equation (2) into Equation (3). At the same time, the Sobel test and Bootstrap test were carried out in order to prevent the defects of three-step method to test the mediation effect.

5. Results

5.1. Benchmark Results

The results shown in Table 2 were calculated by Stata 16SE. First, the effects of full-cost agricultural insurance and planting income insurance on the total grain planting area and planting structure were estimated. As can be seen from the table, Regressions 1 and 2 report the baseline regression results of full-cost agricultural insurance and planting income insurance on the total agricultural planting area. Participation in the pilot policies of full-cost agricultural insurance and planting income insurance has increased the total agricultural planting area by 411.6 thousand hectares (12.6%) at the level of 1%; Regressions 3 and 4 report the baseline regression results of full-cost agricultural insurance and planting income insurance for the grain planting area, and participation in the pilot policies of full-cost agricultural insurance and planting income insurance increases the grain planting area by 586.4 thousand hectares (an increase of 19.9%) at the level of 1%; Regressions 5 reports the baseline regression results of full-cost agricultural insurance and planting income insurance on planting structure, and participation in the pilot policies of full-cost agricultural insurance and planting income insurance increased the proportion of the grain planting area by 4.47% over 1%. It can be shown that participating in the pilot policies of full-cost agricultural insurance and planting income insurance can promote an increase in agricultural planting area and grain area, and, at the same time, show the 'grain-oriented' planting structure to a certain extent. The validity of the hypothesis must be assessed through testing.

In terms of control variables, the increase in labor input (Labour) significantly lead to an increase in the area of land used for grain planting. This highlights the importance of human capital as a resource allocation decision for grain planting. The crop production price index is treated as a lag period based on research practice [56], as farmers are affected by economic factors in the previous period. The results indicate that the gross output value of agriculture, forestry, animal husbandry, and fishery (GOV) has a significant positive impact on the agricultural and grain planting areas. The gross output value of agriculture, forestry, animal husbandry, and fishery reflects the overall scale and results of production in a given period. The coefficient is positively significant and supports the growth of the agricultural planting output value, which is partly due to the increase in the agricultural planting area and partly due to the increase in the grain planting area. The economic output value of non-grain industries has a significant negative impact on the structure of grain planting in agriculture, forestry, animal husbandry, and fishery (GOV). This may induce some farmers to choose non-grain production, increasing the area of grain planting but causing a decrease in the grain planting structure to a certain extent. According to the existing literature [34,57], fiscal expenditure on agriculture, forestry, and water resources (Finance) has a positive impact on agricultural planting areas. The conclusion about agricultural planting areas

is reflected to some extent in this study. However, this conclusion about grain planting areas and planting structure differs from the findings of this study. It is clear that fiscal expenditure on agriculture, forestry, and water resources (Finance) reflects government financial support for agriculture. For instance, cultivated land protection is an agricultural support policy. However, the subsidy recipient for cultivated land protection is adjusted to the actual cultivation subject, which may result in the classification of the land as 'non-grain' and even 'non-agricultural' [58]. Meanwhile, fiscal measures to support agriculture may have negative externalities that eventually affect grain planting, as well as its structure, through a series of transmission mechanisms. For instance, the reform of producer subsidy policies may have limited the improvement of scale management [59]. To some extent, fiscal agricultural support policies can restrain 'non-grain', but the effect of such policies is limited [60], which is easily covered up by other factors leading to 'non-grain'. What is more, fiscal subsidies may also create a 'moral hazard' for local governments and insurance institutions, which weakens the intensity of financial support for agricultural insurance and the positive effect of budget support for grain farming [4]. Agricultural risk level (Risk), agricultural insurance income (Income), and payout amount (Payout) have some effect on the agricultural planting area and grain planting area to some extent. This confirms that agricultural insurance can have a positive effect on controlling agricultural adverse risks. At the same time, improving the level of agricultural insurance will promote farmers' enthusiasm for production and expand the scale of grain production. The remaining variables were not significant.

Table 2. Results of the benchmark regression model.

	Total	**Total′**	**Grain**	**Grain′**	**GT**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Adjustment	411.6 ***	0.126 ***	586.4 ***	0.199 ***	0.0447 ***
	(81.36)	(0.0219)	(83.93)	(0.0303)	(0.00937)
Labour	2400.1 ***	0.201	2251.3 ***	0.506 *	0.174 **
	(549.3)	(0.148)	(566.6)	(0.205)	(0.0633)
Finance	376.7 **	−0.0418	145.8	−0.109 *	−0.0417 **
	(124.4)	(0.0335)	(128.3)	(0.0464)	(0.0143)
GOV	987.8 ***	0.458 ***	381.5 **	0.435 ***	−0.0194
	(113.6)	(0.0307)	(117.2)	(0.0424)	(0.0131)
Structure	1298.7 *	0.148	135.9	−0.198	−0.183 **
	(539.4)	(0.145)	(556.4)	(0.201)	(0.0621)
Income	−96.56 **	0.0139	−102.8 **	0.00993	−0.00266
	(36.22)	(0.00977)	(37.36)	(0.0135)	(0.00417)
Payout	−36.36	−0.00623	37.04	0.00110	0.00671
	(31.01)	(0.00836)	(31.99)	(0.0116)	(0.00357)
Risk	74.43 **	0.0278 ***	64.04 *	0.0354 ***	0.00343
	(24.24)	(0.00654)	(25.01)	(0.00904)	(0.00279)
Price	74.67	−0.0615	60.02	−0.0443	0.0149
	(384.8)	(0.104)	(397.0)	(0.144)	(0.0443)
Constant	−5597.3 **	5.039 ***	−1394.8	4.939 ***	0.882 ***
	(2099.7)	(0.566)	(2166.0)	(0.783)	(0.242)
Time-fixed effects	Yes	Yes	Yes	Yes	Yes
Province-fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	0.309	0.364	0.208	0.206	0.087
N	527	527	527	527	527

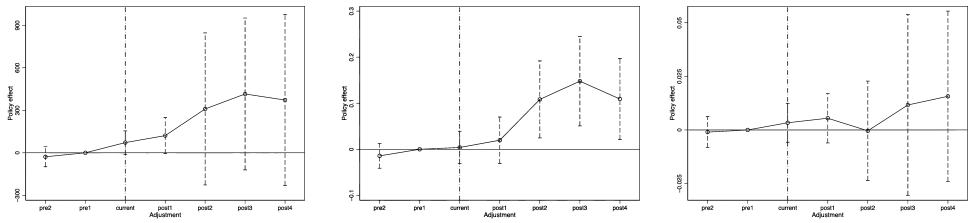
Note: Values in parentheses are standard errors, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Control variables that take logarithms include: Finance; GOV; Income; Payout; Risk; Price. The empirical notes in the later section are consistent with this table, so other regressions are not repeated in the later section.

5.2. Robust Test

5.2.1. Parallel Trend Test

The parallel trend test is the premise of the causal effect of the multi-stage DID model. In this study, the event study method was used to test the parallel trend, and the grain planting area and proportion of grain were selected as explained variables to carry out regression, respectively, in order to fully reflect the dynamic effect of participation in the progressive reform of agricultural insurance policy on the planting structure. Use the previous year of the full-cost agricultural insurance and planting income insurance pilot as the base group to avoid multicollinearity. The estimated results are shown in Figure 3.

As shown in Figure 3a: the estimated results were not significant before or after the implementation of the policy, but graphically, there is a steeper change in the grain planting area to the total agriculture planting area compared to the pre-policy period. The reason may be that the outliers and variables were too large to interfere with the regression results, so this study smooths the results by taking the logarithm of the grain planting area. As can be seen from Figure 3b, there is no significant difference between the full-cost agricultural and planting income insurance in the two years before the implementation. The estimated results in the year of the policy implementation and the first year after the policy implementation are not significant, while the estimated results in the third and fourth years after the policy implementation are significant, which meets the parallel trend test of differential differences, but reflects that the policy effect has a certain time lag. This is in line with the theoretical analysis above, which suggests that farmers' lack of enthusiasm for insurance may be due to the fact that it takes some time for farmers to understand and publicize new types of insurance, which has a direct impact on the promotional effect of full-cost and crop income insurance on the grain planting area.



(**a**) Grain (**b**) Grain' (**c**) GT

Figure 3. Results of the parallel trend test: (**a**) The explanation variable is the grain planting area. (**b**) The explanation variable is the grain planting area (logarithmic form). (**c**) The explanation variable is the grain planting area to total agricultural planting area.

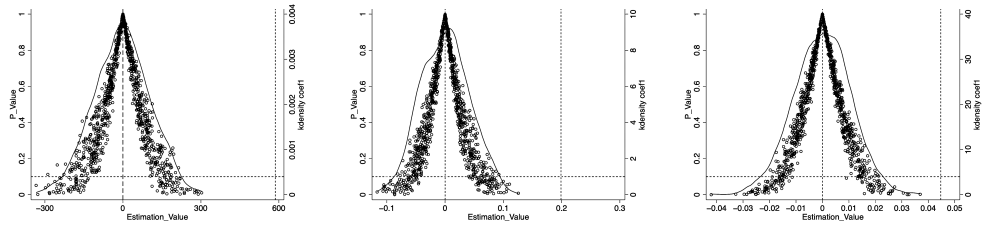
According to Figure 3c, the estimated results were not significant before or after the implementation of the policy, but graphically, there is a steeper change in the grain planting area to the total agriculture planting area compared to the pre-policy period. What is more, after the implementation of the policy, the estimated results were positive (except 2020). Possible reasons include: (1) The policy lag. Different from the simple increase in the grain planting area, the 'grain-oriented' planting structure is reflected in the increase in the proportion of the grain planting area, and only when the benefit of grain farming is greater than the benefit of non-grain farming, will farmers increase the proportion of the grain planting area. The improvement of the benefits of full-cost agricultural insurance and planting income insurance is partly reflected in the cost savings and efficiency increase on the scale. However, a single ordinary small farmer occupies a small amount of arable land resources, and the role of full-cost agricultural insurance and planting income insurance in this influence mechanism is limited. At the same time, combined with the previous literature analysis, the guarantee level of agricultural insurance adjustment at this stage may not be able to meet the effective guarantee of a grain planting risk, so the expected return of grain planting per unit area may still be lower than that of non-grain planting, which ultimately affects the estimated result. However, because the estimated result is

positive, it reflects that full-cost agricultural insurance and planting income insurance still have a positive effect on the 'grain-oriented' plantation structure. In the future, with the optimization of relevant factors, the estimated result may be significant. (2) Interference of data. Like in Figure 3a, there is an interference of the outliers and too large variables. (3) COVID-19 pandemic. COVID-19 pandemic is a terrible influencing factor to grain production, especially for individual farmers. It forced farmers into non-food production by reducing income expectations. So the parallel trend test plot of GT shows a large negative swing in 2020 (post 2). In summary, although the coefficient is not significant, the policy effect of agricultural insurance policy adjustments on planted acreage exists, as it is clear that the estimated results were not significant before the implementation of the policy, and there is a steeper uplift after the policy occurs. Hypotheses 1 and 2 are verified.

5.2.2. Placebo Test

In order to exclude the possibility that the effects of full-cost agricultural insurance and planting income insurance on the grain planting area and planting structure may be affected by some missing variables, this study randomly selects the treatment group in the pilot provinces of full-cost agricultural insurance and crop income insurance, which are determined annually according to the practice of existing studies [34]. Equation (1) is re-estimated and the parameter results of the core explanatory variables are obtained. The specific approach is to repeat the above process 1000 times with the grain planting area and the proportion of grain as the explanatory variables.

The total results are shown in Figure 4. Figure 4a–c show the concrete results of the placebo test. It can be seen that: the mean value of the estimated coefficient of the policy dummy variables is very close to 0 and much smaller than the benchmark regression coefficient of the grain planting area and the proportion of the grain planting area. At the same time, the distribution of the estimated coefficients is relatively close to the normal distribution, indicating that the effects of full-cost agricultural insurance and planting income insurance on the grain planting area and planting structure are not caused by other random factors, which proves that the above estimation results are robust.



(**a**) Grain (**b**) Grain′ (**c**) GT

Figure 4. Results of the placebo test test: (**a**) The explanation variable is the grain planting area. (**b**) The explanation variable is the grain planting area (logarithmic form). (**c**) The explanation variable is the grain planting area to the total agricultural planting area.

5.2.3. Shorten the Sample Cycle

This sample is selected from the provincial panel data from 2006 to 2022. Since the pilot of full-cost agricultural insurance and planting income insurance began in 2018 at the earliest, the period before the policy impact is relatively long. In order to avoid interference from other relevant policies and ensure the robustness of regression results, the sample period was shortened to 2011–2022 for the robustness test. The regression results are shown in Table 3, which are basically consistent with the above reference regression.

Table 3. Results of shortening the sample cycle.

	Grain	Grain′	GT
	(1)	(2)	(3)
Adjustment	409.2 ***	0.162 ***	0.0421 ***
	(82.32)	(0.0280)	(0.00939)
Control Variables	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes
Province-fixed effects	Yes	Yes	Yes
R^2	0.088	0.210	0.089
N	372	372	372

Note: Values in parentheses are standard errors, *** $p < 0.01$.

5.3. Mechanism Inspection

The results are shown in Table 4. First, the results in Regressions 4 show that the pilot programs of full-cost agricultural insurance and planting income insurance have a positive effect on the improvement in the mechanization level, and the results are significant at the 1% statistical level. Secondly, the effects of mediating variables on the grain area and its proportion are analyzed. Combined with the results of Regressions 5 and 6, the mechanization level significantly expanded the grain area at the statistical level of 1%, and the indirect effect of the pilot of full-cost agricultural insurance and planting income insurance—mechanization level—the increase in the grain planting area was established, reflecting the positive role of agricultural insurance on the mechanization level and grain planting area. At the same time, the coefficient of the core explanatory variable is also significantly positive, and the direct effect is also valid.

Table 4. Results of mechanism inspection.

	Grain	Grain′	GT	Machinery	Grain	Grain′	GT
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Adjustment	586.4 ***	0.199 ***	0.0447 ***	0.161 ***	491.0 ***	0.157 ***	0.0434 ***
	(83.93)	(0.0303)	(0.00937)	(0.0366)	(82.82)	(0.0294)	(0.00957)
Machinery					591.7 ***	0.261 ***	0.00775
					(102.2)	(0.0363)	(0.0118)
Sobel:z					3.505	3.753	0.650
Sobel:p					0.000 ***	0.000 ***	0.516
Bootstrap indirect effect					95.365 ***	0.042 ***	0.001
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
T-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
I-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.208	0.206	0.087	0.489	0.259	0.283	0.085
N	527	527	527	527	527	527	527

Note: Values in parentheses are standard errors, *** $p < 0.01$.

The results in Regressions 7 show that mechanization level has a positive effect on the increase in the proportion of the grain planted area, but it is not significant. Meanwhile, according to the regression results of the Sobel test and Bootstrap test, the indirect effect is not valid, which is different from known empirical studies [5,61]. The reasons may include the following: first, there is a high possibility of regression bias; second, the selection of control variables in this study is mainly based on the influencing factors of the grain area, while the application of mechanization may also affect the planting structure through other variables; third, from the theoretical level, the application of mechanization can promote the expansion of grain-scale by virtue of its unique advantages. Especially in order to reduce marginal labor costs, new grain production and management subjects will prefer the application of mechanization to promote the increase in the grain production area.

However, most of the agricultural production subjects in China are still small farmers with fewer cultivated land resources. As long as the planting area reaches a certain scale, the production cost can be well amortized. In addition, before reaching this scale, other non-food planting has a higher income, which will inhibit the adoption of mechanized production or the application of mechanization to other non-food industries to a certain extent, thus limiting the impact of mechanization level on the grain planting structure. That is, there is a threshold effect on business scale [62,63]. At the same time, the direct effect combined with Regressions 5 and 6 is significantly positive, so there are likely to be other influencing mechanisms of full-cost agricultural insurance and planting income insurance on planting structure. In conclusion, the application of mechanization induced by the pilot schemes of full-cost agricultural insurance and planting income insurance has a positive effect on the grain planting area, while the effect on the structure of the planting needs to be further discussed, in line with the parallel trends analysis.

6. Heterogeneity Analysis

Full-cost agricultural insurance and grain planting insurance deal with adverse risks in agriculture, so the degree of production risk is the key factor influencing whether agricultural insurance is taken out. Farmers in areas with a high production risk have a higher probability of compensation and will prefer to demand and purchase agricultural insurance, while farmers in areas with a low risk will be less willing to purchase. Therefore, in order to study the effects of the full-cost insurance and planting income insurance pilot programs on the grain planting area and planting structure in different risk areas, this study takes the ratio of the agricultural disaster area to the total agricultural planting area of each province as the regional agricultural production risk level index, and then calculates the inter-annual average risk level of each province. The high-risk areas are those higher than the overall average risk level (Risk level > 0.11). The low-risk areas are those lower than the overall average risk level (Risk level < 0.11). Grouped results are as shown in Table 5. A regression analysis is then carried out.

Table 5. Adjusting in high- and low-risk areas

Risk Level	Adjustment = 0	Adjustment = 1
High Risk	Gansu, Hainan, Ningxia, Qinghai, Shanxi, Shaanxi, Xinjiang, Yunnan, Zhejiang	Heilongjiang, Hubei, Hunan, Jilin, Jiangxi, Liaoning, Inner Mongolia
Low Risk	Beijing, Fujian, Guangdong, Guangxi, Guizhou, Shanghai, Tianjin, Tibet, Chongqing	Anhui, Hebei, Henan, Jiangsu, Shandong, Sichuan

The regression results are shown in Table 6: in both high-risk and low-risk areas, full-cost agricultural insurance and planting income insurance have significant positive effects on the 'grain-oriented' planting area and planting structure. It can be seen from Regressions 3 and 6 that the degree of 'grain-oriented' planting structure in low-risk areas is greater, and hypothesis 3 is verified. The reason for this may be that full-cost agricultural insurance and planting income insurance are harsh in terms of food incentive conditions for high-risk areas, requiring the risk guarantee level of agricultural insurance to be within an appropriate range. When the risk guarantee level is lower than the lower limit of the appropriate range, agricultural insurance cannot play an incentive effect [61]. In high-risk areas, the risk level is high and the loss is frequent, and the guarantee level of agricultural insurance is insufficient or even lower than the lower limit of the guarantee level, which will weaken the guarantee function of full-cost agricultural insurance and planting income insurance to a certain extent. At the same time, different from the previous theoretical analysis, the pilot of full-cost agricultural insurance and planting income insurance is also relatively good in low-risk areas, indicating that farmers' risk awareness has been continuously improved, the purpose of agricultural insurance has been better realized, and food security can be constantly guaranteed.

Table 6. Results of heterogeneity analysis.

	High Risk			Low Risk		
	(1)	(2)	(3)	(4)	(5)	(6)
	Grain	Grain′	GT	Grain	Grain′	GT
Adjustment	599.5 ***	0.137 ***	0.0288 **	506.9 ***	0.221 ***	0.0693 ***
	(124.0)	(0.0244)	(0.0102)	(97.34)	(0.0599)	(0.0179)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Province-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.383	0.422	0.196	0.166	0.292	0.074
N	272	272	272	255	255	255

Note: Values in parentheses are standard errors, ** $p < 0.05$, *** $p < 0.01$.

7. Conclusions and Policy Implications

7.1. Conclusions

Based on the provincial panel model and multi-period differential model, this study mainly studies the effects of full-cost agricultural insurance and planting income insurance on the grain planting area and planting structure. The conclusions are as follows:

(1) Agricultural insurance policy adjustments can make a significant contribution to increasing the grain planting area, with some positive impact on the 'grain-oriented' planting structure;
(2) Agricultural insurance policy adjustments lead to an increase in the grain planting area as a result of an increased application of agricultural machinery, but this mechanism of influence does not contribute to the 'grain-orientation' planting structure;
(3) There are significant positive effects of agricultural insurance policy adjustments on the grain planting area and 'grain-oriented' planting structure both in high- and low-risk areas, and the impact of full-cost agricultural insurance and planting income insurance on grain structure 'grain-oriented' in low-risk areas is higher than that in high-risk areas.

7.2. Policy Implications

(1) Continue to promote the publicity of full-cost agricultural insurance and planting income insurance and continue to improve the coverage of agricultural insurance. Full-cost agricultural insurance and planting income insurance can promote the grain planting area and planting structure 'toward grain', so the government should promote the promotion of full-cost agricultural insurance and planting income insurance, improve the ability to prevent agricultural production risks, further protect the interests of farmers, and ultimately promote the increase in the grain planting area and planting structure 'toward grain';
(2) Effective linkage of policies to enhance the level of agricultural support. Correctly analyze the implementation environment of policies, straighten out the relationship between policies, implement the effective implementation mechanism of policies, and finally effectively interact with each other to promote the improvement of the level of agricultural support. At the same time, it is also necessary to take into account the production characteristics of local farmers themselves, such as the production resources occupied by farmers, and adopt different policy inclinations [64];
(3) Continue to analyze the size and characteristics of agricultural risks and implement different insurance subsidies and insurance amounts. According to the risk zone, farmers in high-risk areas face greater agricultural risks and greater losses. Therefore, policies should be promoted, premium subsidies should be increased, reasonable insurance amounts should be determined according to the risk level, the insurance amount and insurance liability should be equal as far as possible, and the risk protec-

tion level of full-cost agricultural insurance and planting income insurance should be improved.

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Conflicts of Interest: All authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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