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Can Agricultural Insurance Improve the Nutritional Status of Rural Residents?—Evidence from China's Policy-Based Agricultural Insurance

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Abstract: Based on the provincial panel data from 2008 to 2019, this paper constructs a mediating effect model to analyze the impact of China's agricultural insurance development on the nutritional status of rural residents theoretically and empirically. This study found that agricultural insurance significantly affects the nutritional status of rural residents through two mediators: increased income level and the regional crop diversity. Meanwhile, regional heterogeneity exists in the impact of agricultural insurance on the nutritional status of rural residents. Overall, this paper argues that agricultural insurance should be one of the tools to improve the nutritional status of rural residents in China. Specifically, the design and implementation process of policy-based agricultural insurance should put the nutritional health of rural residents and their complex impact into consideration. Therefore, this paper suggests that even though agricultural insurance can facilitate rural residents' income stability and generation, relevant stakeholders also need to draw awareness, popularize the importance of nutrition and health, and optimize the supply structure of agricultural products.

Keywords: agricultural insurance; calorie intake; HFDI; animal-based food; mediating effect

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1. Introduction

In recent years, the nutritional status of urban and rural residents in China has improved significantly. However, influenced by factors such as insufficient and unbalanced levels of economic and social development, urbanization, and an aging population, China still faces problems such as malnutrition, overnutrition, and the prevalence of nutrition-related diseases [1]. These problems not only challenge the health of human beings but also reduce the quality of an individual's life as well as labor productivity [2]. It exacerbates the risk of economic fluctuations and even threatens social stability.

It is noteworthy that the imbalance between urban and rural development in China is reflected in aspects such as food consumption and nutritional status. According to the China Bureau of Statistics, in 2020, the per capita consumption of meat, eggs, milk, and fruits and vegetables of rural residents was only 72.1% and 79.5% of that of urban residents. This did not meet the standard of the Dietary Guidelines for Chinese Residents (2016). The income level and food consumption level of rural residents are generally lower than those of urban residents. Solving the issues of unequal food consumption and unbalanced nutritional intake between urban and rural residents, and preventing the risk of poverty caused by diseases, are important for the poverty eradication and rural revitalization of China. It is also an important task to achieve the goal of "significantly narrowing the gap between urban and rural regional development and the gap between residents' living standards" in the report of the 19th National Congress of the Communist Party of China.

The existing literature has explored the pathways that influence the nutritional status of the population. In general, an increase in income is the most direct way to increase the level of nutritional intake [3]. Further, economic growth, agricultural production,

urbanization, household consumption habits, infrastructure conditions, and educational attainment are also important factors influencing nutritional status [4–8].

Agricultural insurance is an important tool to prevent agricultural risk and improve farmers' welfare. The existing literature focuses on the impact of agricultural insurance on farmers' income generation [9–11], consumption smoothing [12], and production decisions [13–15]. There is a strong link between agriculture, nutrition, and health. By influencing farmers' production decisions, agricultural insurance not only improves the income levels of farm households but may also influence the nutritional status of rural residents through complex cause-and-effect relationships.

There is little empirical evidence from China on whether agricultural insurance can improve the nutritional status of rural residents. The relevant literature on this issue mainly comes from studies of other countries [16]. To date, China's policy-based agricultural insurance has been carried out for more than 10 years and has experienced a major shift from pilot to full coverage. Has policy-based agricultural insurance in China improved the nutritional status of rural residents? In addition to stabilizing food production and guaranteeing farmers' income, if agricultural insurance can play a certain role in promoting the nutrition improvement of rural residents, then this "value-added effect" should be taken into account when formulating policies.

Given the background of the contradiction between the people's growing need for a better life and unbalanced and inadequate development in the new era of China's social development, this paper aims to examine whether China's agricultural insurance system is conducive to improving the nutritional status of rural residents. Moreover, this paper provides references for future agricultural insurance policy making and product design.

2. Theoretical Analysis and Research Hypotheses

In this section, we discuss the two factors: income level and crop diversity, which mediate the effects of agricultural insurance on the nutritional status of rural residents.

2.1. Income Level

Agricultural income from agricultural operations is an important part of rural people's income. A negative shock to agricultural production can lead to large fluctuations in rural households' income and consumption levels. To reduce the impact of these risk shocks, rural households tend to adopt risk-averse strategies, such as avoiding high-risk and high-return agricultural activities, holding precautionary savings, and reducing productive investments [17].

Agricultural insurance can effectively mitigate risk shocks to agricultural production and stabilize farmers' income levels. In terms of production, smallholder farmers are less able to resist risks. Without agricultural insurance, their rational choice is often not to engage in risky activities. Agricultural insurance enhances the stability of agricultural production and operation, helps to reduce the financing difficulty of agricultural business entities, and facilitates the expansion of production scale. Further, it improves production efficiency and yield and achieves the effect of stabilizing and increasing income levels. In terms of loss compensation, insured farmers receive insurance payouts to cover their economic losses after a disaster and can also use the payouts to purchase production materials to enable rapid recovery of production, which plays an important role in stabilizing farmers' income [18].

Generally, the insured should not receive additional benefits from loss indemnity insurance. However, under the premise of actuarial balance, policy-based agricultural insurance has a transfer payment function because it receives financial support from the government, which achieves the effect of increasing the income of farmers based on stabilizing their income [19]. The per capita income level in this article comes from the national statistical data of China. Agricultural insurance claims will be directly included in the actual income of rural residents, which undoubtedly increases the income level of statistical data.

Increasing income levels is the most direct way to increase food consumption and improve the food consumption structure of rural residents. The rural population's food sources are partly self-produced and partly purchased from the market. The market offers an important way to obtain high-quality food. Agricultural insurance helps to raise the income level of farm households and ease the income constraint on food consumption. It helps households to purchase more and better-quality food from the market; that is the main determinant of the quality of their diet and the nutritional status of the population.

Consumption expenditure is characterized by smoothing relative to income growth, and the marginal propensity to consume varies across income groups. Food consumption is an important component of consumer spending. The income elasticity of food consumption is low because it is constrained by the physiological conditions of human beings, and the income elasticity of food is again lower for high-income earners than for low-income earners. Agricultural insurance mitigates agricultural risk shocks and serves to regulate the distribution of income among different groups. It further improves the income of the relatively poor population and increases the marginal propensity to consume in society. The additional increase in income leads to the availability of low-income earners to purchase high-quality and diversified food, which ultimately has a positive impact on the quantity and structure of nutritional intake.

2.2. Crop Diversity

Farmers' behavior in the agricultural insurance program includes insurance participation and agricultural production. The impact of agricultural insurance on production is mainly reflected in the adjustment of farmers' production structure triggered by the agricultural insurance programs.

Generally, relatively underdeveloped rural areas have weak connections to distant markets. As a result, local markets are the main source of food for non-subsistence farmers. The quantity, quality, and variety of food available on the market are crucial. Local markets are a major source of quality food, as foods such as fruits and vegetables are perishable and cannot be transported for long periods of time [20]. Consequently, regional crop diversity affects the diversity of food supplied to local markets, and market-level food diversity affects the food consumption of nearby non-subsistence farm households and subsequently influences the nutritional status of rural residents.

Since 2007, China's policy-based agricultural insurance has continuously "expanded coverage, increased varieties, and improved the level of protection", covering 16 major agricultural products such as the three major grains (rice, wheat, and corn), natural rubber, and oil crops, and more than 60 local specialty agricultural products [21]. With the increase of crop varieties covered by policy-based agricultural insurance, the agricultural insurance will lead to the transfer of non-insured crops to insured crops, triggering the transformation of the planting structure [14,15]. That is, farmers replace low-income grain crops with higher-income cash crops or fruits and vegetables. This approach increases regional crop diversity, which in turn enriches the food supply in local markets and improves the nutritional status of rural residents.

The above theoretical analysis shows that agricultural insurance can promote the improvement of rural residents' nutritional status by increasing farmers' income levels and crop diversity. Based on this, we propose the following three research hypotheses and establish an empirical model for hypothesis testing:

Hypothesis 1 (H1). *Improving the development level of agricultural insurance can improve the nutritional status of rural residents.*

Hypothesis 2 (H2). *Agricultural insurance improves the nutritional status of rural residents by raising the income level of farmers.*

Hypothesis 3 (H3). *Agricultural insurance improves the nutritional status of rural residents by increasing the level of crop diversity.*

3. Data and Methods

3.1. Variables Selection

3.1.1. Dependent Variable

The nutritional status of rural residents is the dependent variable in this study. Taking the quantity and quality of nutritional intake into consideration, three indicators were selected to measure the nutritional status of rural residents, including daily per capita caloric intake (Energy), healthy food diversity index (HFDI), and animal-based food supply ratio (Animal-based Food). The description and measurement of each indicator are as follows:

Daily per capita calorie intake (Energy): Calorie intake is widely used as a basic indicator to measure nutritional status. Referring to existing research, the per capita consumption of different types of food by rural residents is converted into calories and summed according to the calorie conversion coefficient [22].

Figure 1 shows the daily per capita caloric intake for the main countries. It can be found that China has surpassed the world average since 2010. Compared with India, which is also a developing country, China's daily per capita caloric intake is much higher than India's. Even compared with developed countries like the United States and France, China's daily per capita caloric intake is not far behind. Therefore, increasing the daily per capita calorie intake is not the key to improving the nutritional health status of Chinese residents. However, as a basic indicator to measure nutritional status, we still included it as a dependent variable in the model. It is used as a reference to measure the impact of the development of agricultural insurance on nutritional status.

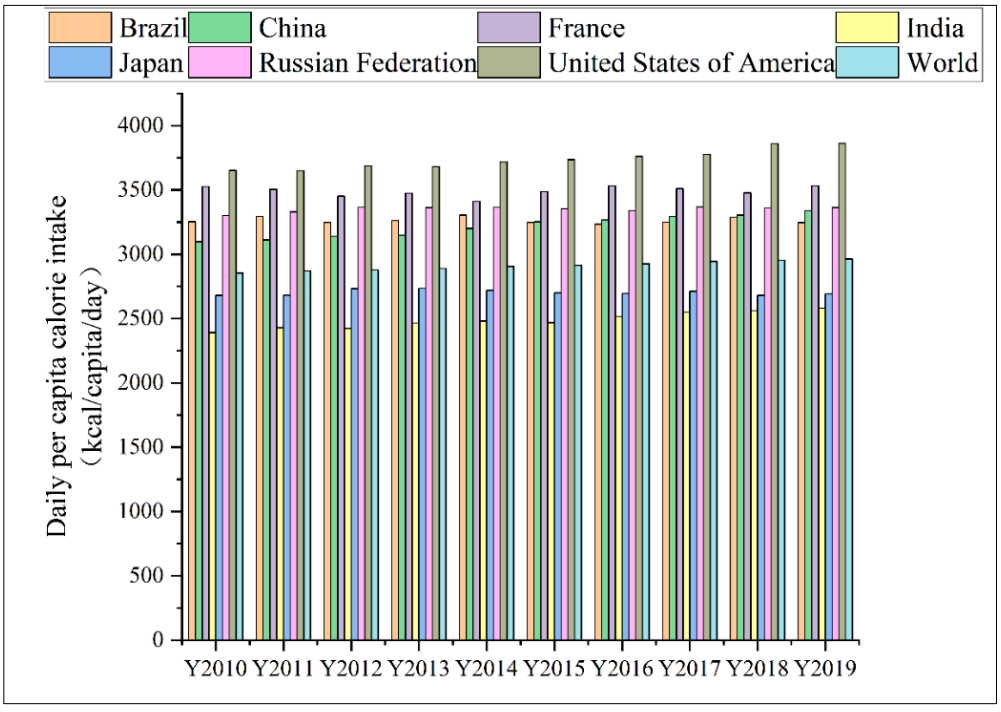


Figure 1. Caloric intake in major countries, 2010–2019. Source: FAO @ Spectator Index. https://www.fao.org/home/en (accessed on 14 February 2022).

Healthy Food Diversity Index (HFDI): A reduction in total caloric intake does not imply a worsening nutritional status. Even a reduction in total calories may improve the nutritional profile and quality if foods are of better quality but fewer calories are added. Likewise, nutritional deficiencies are not only a consequence of insufficient caloric intake

but are the result of poor diet quality and variety. Scholars often use dietary diversity indicators to measure dietary quality [23]. It is believed that diets with a greater variety of foods or food groups are associated with greater energy and nutrient intakes [24–26]. However, the dietary diversity indicator assigns equal weight to each food or food group and does not consider the nutritional contribution of different foods. This practice does not reflect the polarization of food consumption, such as excessive consumption of fat and oil is not good for health.

In this paper, the health food diversity index (HFDI) is used to assign a health coefficient to each group of food to reflect the impact of different food consumption on nutrition and health [27]. It is calculated as follows:

$$HFDI = (1 - \sum s_i^2)hv \quad (1)$$

where $(1 - \sum s_i^2)$ is called Berry-Index (BI), and s_i is the proportion of the i-th food consumption in the total food consumption. The index is bounded between 0 and $1 - 1/n$, whose limit value approximates 1 if the number of n increases. If BI = 0, it means only 1 food product is consumed; if BI = $1 - 1/n$, it means equal consumption of each food product. The index does not distinguish the contribution of healthy and unhealthy foods to nutritional health.

Based on BI, *HFDI* considers the health value of different foods. $hv = \sum hf_i si$ represents the health value of the food group. $hf_i = GB_j \times GW_i$ are the health factors of food group i, which was calculated based on the Dietary Guidelines for Chinese Residents (2016). GB_j is the health value of food category j, and GW_i is the proportion of the consumption of a certain food group in the total consumption of this category. The *HFDI* is bounded between 0 and $1 - 1/n$. When *HFDI* is equal to 0, it means that only one food is consumed or the health value of food consumption is very low. The more varieties consumed, the more uniform the quantity consumed, and the higher the nutritional value, the higher the *HFDI*.

Although the *HFDI* considers differences in the nutritional contributions of different foods, this indicator also has certain limitations. For example, if households only prefer foods with the highest health value and do not consume other foods, the *HFDI* will decline due to reduced food consumption diversity. Therefore, it is necessary to comprehensively analyze the nutritional status in combination with other indicators.

Nutritional structure (Animal-based Food): Animal foods are an important source of high-quality protein. Animal protein has a high absorption rate and nutritional value in the human body. In order to combine the food consumption structure with the nutrient intake structure, this paper classifies the types of residents' food consumption according to plant-based food (grains, vegetable oils, vegetables, and fruits) and animal-based food (meat, eggs, dairy, and aquatic products). At the same time, the proportion of energy provided by each is calculated. The energy supply ratio of animal-based food (Animal-based Food) is used as an indicator to measure the nutritional structure of rural residents. Meat used to be a luxury in the developing world. In rural China, the energy supply ratio of animal-based food for rural residents increased from 2% in 1980 [28] to 16.93% in 2020, indicating an improvement in the structure of nutrition. However, the overall diet structure is still dominated by plant-based food, and further improving the energy supply ratio of animal-based food is the direction to optimize the nutritional structure of rural residents in China. Therefore, the energy supply ratio of animal-based food is regarded as the key index to measure the nutritional structure.

3.1.2. Core Independent Variable

Agricultural insurance development level (X) is the core independent variable in this study. The density of agricultural insurance is a basic index to measure the development degree of regional agricultural insurance and the level of insurance consciousness of rural residents (Agricultural Insurance Density = Agricultural Insurance Premium Income/Agricultural Population). Since 2012, China's statistical departments no longer have statistics on agricultural employment data. Therefore, this paper uses the number

of rural populations instead of the number of agricultural employments to reflect on the development level of agricultural insurance among different regions.

3.1.3. Control Variables

Control variables include non-agricultural employment (W), the total power of agricultural machinery (AM), and market accessibility (M). (1) With the socio-economic development, non-agriculture employment has become a normal method of production and life for rural residents in China. [29]. There is a statistical difference based on China's National Bureau of Statistics between the population of actual food consumption of rural households and the total rural population caused by the increase in non-agricultural employment. Non-agricultural employment has led to an increase in eating out (that is, dining out is not part of the household food consumption data), which results in statistical omissions in household food consumption [30]. In this paper, we select the proportion of wage income as a proxy variable to measure the level of non-agricultural employment. The development of mechanization can replace labor for agricultural production [31]. This physical saving also enables rural residents to reduce their food intake. This paper uses the total power of agricultural machinery in each province to represent the level of agricultural mechanization. The level of market accessibility determines the convenience for rural residents to buy food from the market. In general, the greater the market accessibility, the more likely it is to increase the frequency, variety, and quantity of food consumed. This paper uses the ratio of highway mileage to administrative area as an indicator to measure the market accessibility of each province.

In addition, this paper used income level (MI) and crop diversity (*MD*) to study the policy mechanism. The per capita net income of rural residents is selected as an indicator of income level; crop diversity measures the combination of different proportions of crops planted in various regions and is calculated as follows [32,33]:

$$MD = 1 - \frac{\sum_{i=1}^{n} a_i^2}{\left(\sum_{i=1}^{n} a_i\right)^2} \quad (2)$$

where a_i represents the sown area of the i-th crop in the area, and n represents the total number of crop types sown in the area. *MD* ranges from 0 to 1. When it is 0, it means that only one crop is sown in the area, and the degree of crop diversity in the area is low. When it is 1, it means that the degree of crop diversity in the area is extremely high.

3.2. Model

According to the theoretical analysis, the specific model is as follows:

$$NI_{it} = \alpha_1 + \beta_{11} lnX_{it} + \beta_{12} C_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (3)$$

where NI_{it} is the explained variable, including Energy, *HFDI*, Animal-based Food. lnX_{it} represents the logarithm of the development level of agricultural insurance. C_{it} represents control variables. The coefficient β_{11} is the core indicator to measure the effect of X. φ_t is the year fixed effect, μ_i is province fixed effect, and ε_{it} is the random error. In addition, the focus is on the impact of agricultural insurance on the nutritional status of rural residents rather than on the structural relationship between income, price, and consumption.

3.3. Data Sources

Since 2007, with the implementation of policy-based agricultural insurance pilots, agricultural insurance has entered a period of rapid development in China. Therefore, this paper selected 26 provinces and municipalities of the macro-panel data to investigate the impact of agricultural insurance development on the nutritional status of rural residents and the mechanism of the path (limited to food consumption data availability issues, this study only includes the following provinces: Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong,

Henan, Hubei, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang).

The food consumption data of rural residents come from *the Statistical Yearbook* of each province, the agricultural insurance data comes from *the China Insurance Yearbook*, and the other data comes from *the China Rural Statistical Yearbook* and *the China Statistical Yearbook*. The variable meaning and descriptive analysis are shown in Table 1.

Table 1. Descriptive statistics of the variables.

Statistic	Variables	Unit	Mean	Std.	Min	Max	Observations
Energy	Daily per capita caloric intake	Kcal	2198.961	291.405	1647.878	2998.108	312
HFDI	Healthy food diversity index	-	0.141	0.009	0.107	0.156	312
Animal-Based Food	Animal-based food supply ratio	%	0.143	0.052	0.044	0.269	312
X	Agricultural insurance development level	CNY per capita	74.751	81.210	2.164	375.249	312
W	Non-agricultural employment	%	40.589	13.378	13.600	75.600	312
AM	Total power of agricultural machinery	10,000 kWh	3161.714	3018.050	99.200	12,419.900	312
M	Market accessibility	km/km^2	0.927	0.514	0.088	2.094	312
MI	Income level	CNY per capita	10,575.400	5475.067	3005.410	28,928.400	312
MD	Crop diversity	-	0.730	0.092	0.475	0.855	312

4. Results and Discussion

4.1. Benchmark Regression Analysis

Table 2 shows the results of the benchmark regression analysis. Columns a, c, and e are the two-way fixed effects (FE) estimation results, and columns b, d, and f are the panel-corrected standard errors (PCSE) estimation results. The results of the two estimation methods are similar, and both are statistically significant, indicating that the results are robust.

Table 2. Benchmark regression.

Variable	lnEnergy		HFDI		Animal-Based Food	
	FE (a)	PCSE (b)	FE (c)	PCSE (d)	FE (e)	PCSE (f)
lnX	−0.057 ***	−0.059 ***	0.003 ***	0.003 ***	0.005 ***	0.006 ***
	(−5.41)	(−5.99)	(4.82)	(4.54)	(2.62)	(4.03)
W	−0.004 ***	−0.005 ***	4.05×10^{-5}	3.99×10^{-5}	0.0003	0.0002
	(−2.96)	(−5.25)	(0.58)	(0.91)	(0.231)	(0.75)
lnAM	−0.031	−0.062 ***	0.0007	0.0006	0.011 ***	0.013 ***
	(−1.03)	(−2.73)	(0.44)	(0.59)	(2.06)	(2.86)
M	0.139 **	0.129 *	−0.011 ***	−0.009 ***	0.028 ***	0.029 ***
	(2.02)	(1.94)	(−2.90)	(−3.44)	(2.20)	(2.76)
Cons	8.145 ***	−8.335	0.129 ***	−1.504 ***	−0.023	−8.172 ***
	(34.78)	(−1.52)	(9.81)	(−4.99)	(−0.53)	(−7.82)
Year-fixed	Yes		Yes		Yes	
Province-fixed	Yes		Yes		Yes	
Observations	312	312	312	312	312	312
R-squared	0.2574		0.5603		0.7354	
Wald		2759.35 ***		2194.97 ***		8947.07 ***

Note: t-value or z-value in parentheses. ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively.

In terms of the quantity of nutrient intake, the coefficient of agricultural insurance development level is negative and statistically significant, as shown in columns a and b. This shows that the development of agricultural insurance has reduced the daily per capita caloric intake, and the agricultural insurance elasticity of calorie intake is negative. After farmers are insured, insurance companies will actively carry out disaster prevention and loss prevention work, including strengthening infrastructure construction and technology investment. These measures are conducive to reducing the frequency of disasters and the extent of losses and further reducing the labor intensity of farmers' field management. Further, with the reduction of labor intensity, the total calorie demand of farmers is relatively reduced. In addition, factors such as moral hazard may induce farmers to reduce their production efforts, which objectively reduces labor intensity and calorie demand.

In terms of the quality of nutritional intake, the coefficient of agricultural insurance development level is positive and statistically significant, as shown in columns c and d. This indicates that the development of agricultural insurance has increased the *HFDI* and improved the quality of nutritional intake of rural residents. With the development of agricultural insurance, the total amount of heat demand by rural residents decreased, but the dietary structure tended to be healthy.

In terms of the structure of nutrient intake, the coefficient of agricultural insurance development level is positive and statistically significant, as shown in columns e and f. The development of agricultural insurance is conducive to increasing the ratio of animal-based food supply to energy and improving the nutritional dietary structure of rural residents.

The above conclusions indicate that although the improvement of the development level of agricultural insurance reduces the quantity of nutrient intake, it improves the quality and structure of nutrient intake. Therefore, this conclusion supports Hypothesis 1.

4.2. Robustness Test

In this paper, the method of replacing the main explanatory variables is used to test the robustness. The development level of agricultural insurance is measured by the scale of agricultural insurance premiums, and Formula (3) is re-estimated. The results of the robustness test are shown in Table 3. There is no substantial difference from the benchmark regression results. This shows that the estimation results of the impact of agricultural insurance development on the nutritional status of rural residents in Table 2 are robust.

Table 3. Robustness test.

Variable	lnEnergy		HFDI		Animal-Based Food	
	FE (a)	**PCSE (b)**	**FE (c)**	**PCSE (d)**	**FE (e)**	**PCSE (f)**
lnX	−0.054 ***	−0.056 ***	0.003 ***	0.003 ***	0.004 *	0.004 ***
	(−4.98)	(−5.12)	(4.38)	(4.57)	(1.77)	(2.98)
W	−0.004 ***	−0.005 ***	3.48×10^{-5}	3.69×10^{-5}	0.0003	0.0002
	(−2.84)	(−5.09)	(0.50)	(0.88)	(1.17)	(0.74)
lnAM	−0.027	−0.062 ***	0.0006	0.0005	0.011 **	0.013 ***
	(−0.92)	(−2.66)	(0.33)	(0.57)	(2.00)	(2.88)
M	0.138 **	0.129 **	−0.011 ***	−0.010 ***	0.028 **	0.030 ***
	(1.99)	(2.02)	(−2.86)	(−3.36)	(2.21)	(2.96)
Cons	8.508 ***	−4.677	0.111 ***	−1.627 ***	−0.043	−9.011 ***
	(33.34)	(−0.86)	(7.76)	(−5.66)	(−0.92)	(−9.27)
Year-fixed	Yes		Yes		Yes	
Province-fixed	Yes		Yes		Yes	
Observations	312	312	312	312	312	312
R-squared	0.246		0.554		0.732	
Wald		4643.31***		3517.07 ***		8664.22 ***

Note: t-value or z-value in parentheses. ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively.

4.3. Mechanism Analysis

According to theoretical analysis, agricultural insurance mainly affects the nutritional status of rural residents through two channels: raising income levels and improving crop diversity. It is assumed that the overall impact of agricultural insurance on nutritional status is divided into two parts: the first part is the direct impact of agricultural insurance development on nutrition indicators; the second part is the indirect impact of agricultural insurance development through raising income levels and changing crop diversity. Refer to the five-step method proposed by Smith and Haddad (2002) to analyze the pathways through which the development of agricultural insurance influences nutritional status [6]. The specific process is as follows:

The first step is to regress nutritional status (*NI*) on the development of agricultural insurance (X) to isolate the total effect of X on *NI*. The specific model is the same as Formula (3).

The second step is to test the influence of income level (*MI*) and crop diversity (*MD*) on the nutrition index (*NI*); the model is as follows:

$$NI_{it} = \alpha_2 + \beta_{21} lnMI_{it} + \beta_{22} MD_{it} + \beta_{23} W_{it} + \beta_{24} lnAM_{it} + \beta_{25} M_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (4)$$

The third step is to test whether *X* significantly affects *MI* and *MD*:

$$lnMI_{it} = \alpha_3 + \beta_{31} lnX_{it} + \beta_{32} W_{it} + \beta_{33} lnAM_{it} + \beta_{34} M_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (5)$$

$$MD_{it} = \alpha_4 + \beta_{41} lnX_{it} + \beta_{42} W_{it} + \beta_{43} lnAM_{it} + \beta_{44} M_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (6)$$

The fourth step is to incorporate *NI*, *X*, *MI*, and *MD* into the model. Test whether there is a significant change in the coefficient of the explanatory variable after the addition of the intermediary variable; the model is as follows:

$$NI_{it} = \alpha_5 + \beta_{51} lnX_{it} + \beta_{52} lnMI_{it} + \beta_{53} MD_{it} + \beta_{54} W_{it} + \beta_{55} lnAM_{it} + \beta_{56} M_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (7)$$

The fifth step is to use the above coefficients to calculate the direct effect of agricultural insurance development level on nutrition indicators and the indirect effect transmitted through intermediary variables. τ is the total effect:

$$\tau = \frac{dNI}{dX} = \frac{\partial NI}{\partial X} + \frac{\partial NI}{\partial MI}\frac{dMI}{dX} + \frac{\partial NI}{\partial MD}\frac{dMD}{dX} = \beta_{51} + \beta_{52}\beta_{31} + \beta_{53}\beta_{41} = \beta_{11} \quad (8)$$

Columns b, d, and f of Table 2 show the results of the first step of the methodology. Continue to test the impact mechanism of agricultural insurance development level on the nutritional status of rural residents as follows:

In step 2, we discuss the effect of intermediary variables (*MI*; *MD*) on nutritional status *(NI)*. As Table 4 shows, income level decreased total caloric intake (column a) but significantly increased *HFDI* and animal-based food supply ratio (columns b–c). The increase in income level decreased the calorie intake per capita and increased the *HFDI* and the energy supply ratio of animal-based food. This shows that the relaxation of income constraints is conducive to improving the dietary quality of rural residents and provides the basic conditions for farmers to obtain high-quality food. At the same time, it also improved the food consumption structure of rural residents.

Table 4. Results of different models.

	Step 2			**Step 3**	
	lnEnergy (a)	**HFDI (b)**	**Animal-Based Food (c)**	**lnMI (d)**	**MD (e)**
lnX				0.059 ***	0.004 *
				(6.64)	(2.10)
lnMI	−0.273 ***	0.014 ***	0.026 *		
	(−3.92)	(3.71)	(1.64)		
MD	−0.040	0.018	0.12 ***		
	(−0.21)	(1.61)	(2.93)		
Cons	−37.225 **	0.148	−5.878 *	−179.071 ***	5.418 ***
	(−2.35)	(0.18)	(−1.70)	(−23.46)	(4.27)
Control variables	Yes	Yes	Yes	Yes	Yes
Observations	312	312	312	312	312
Wald	3714.34 ***	7564.89 ***	13,704.19 ***	12,092.90 ***	79,698.28 ***

Note: t-value or z-value in parentheses. ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively.

The increase in crop diversity only significantly promoted the animal-based food supply ratio but had no significant effect on total caloric intake and HFDI. This result indicates that increasing crop diversity will prompt rural residents to adjust their dietary structure but will not affect the total caloric intake and overall quality.

In step 3, we study the effect of the development level of agricultural insurance (*X*) on the intermediate variable (*MI*; *MD*). As Table 4 shows, the coefficients of agricultural

insurance development level (*X*) are positive and statically significant (columns d–e), indicating that the development of agricultural insurance has improved the income level and crop diversity.

Lastly, step 4 involves regressing nutritional status on the agricultural insurance development level (*X*) and intermediary variables (*MI*; *MD*). As Table 5 shows, the development of agricultural insurance (*X*) still significantly affects daily per capita caloric intake, *HFDI*, and animal-based food supply ratio. The sign of the coefficients is not different from that in Table 2. As expected, the coefficients of agricultural insurance development level (*X*) in Table 5 are lower than those in columns b, d, and f of Table 2. This is because the model contains intermediary variables. The effect of income level on the animal-based food supply ratio is no longer significant, indicating that income level is only the mediating way for agricultural insurance development level to affect daily per capita caloric intake and *HFDI*. The effects of crop diversity on per capita daily caloric intake and *HFDI* were no longer significant. It suggests that crop diversity is only a medium way for the development level of agricultural insurance (*X*) to affect the nutritional structure (that is, to affect the ratio of animal-based food supply). After adding intermediary variables, the influence of the agricultural insurance development level (*X*) is still significant. This shows that the development level of agricultural insurance (*X*) can not only play a role through intermediary variables but also directly affect the nutritional status of rural residents.

Table 5. Decomposition estimates of total effects.

		Step 4	
lnX	−0.052 ***	0.002 ***	0.004 ***
	(−4.70)	(3.72)	(2.65)
lnMI	−0.135 *	0.009 **	0.014
	(−1.95)	(2.29)	(0.81)
MD	0.039	0.015	0.113 ***
	(0.22)	(1.36)	(2.85)
Cons	−32.644 **	−0.040	−6.173 *
	(−2.32)	(−0.05)	(−1.82)
Control variable	Yes	Yes	Yes
Observations	312	312	312
Wald	4024.71 ***	1399.19 ***	17,870.90 ***

Note: t-value or z-value in parentheses. ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively.

To sum up, there are not only direct effects but also indirect ways of income level and crop diversity in the influence mechanism of agricultural insurance development level on the nutritional status of rural residents. Among them, income level is the mediating way that agricultural insurance development level affects daily per capita caloric intake and HFDI, and crop diversity is the mediating way that agricultural insurance development level affects the animal-based food supply ratio. This conclusion supports Hypothesis 2 and Hypothesis 3.

Step 5 involves calculating the empirical total derivative of the nutritional index with respect to the development level of agricultural insurance as the sum of the partial impact of the development level of agricultural insurance on the nutritional index (step 4) and the partial impact of the development level of agricultural insurance on nutritional index through the intermediate variables (steps 2 and 3), according to Formula (8). The result is shown in Table 6.

Table 6. Calculation results of coefficients.

		Formula	Coefficients		
			lnEnergy (1)	HFDI (2)	Animal-Based Food (3)
Direct effect (1)		β_{51}	−0.052	0.002	0.004
Indirect effect	Income level (2)	$\beta_{52}\beta_{31}$	−0.008	0.0005	
	Crop diversity (3)	$\beta_{53}\beta_{41}$			0.0005
Direct effect + Indirect effect (4)		$\beta_{51} + \beta_{52}\beta_{31} + \beta_{53}\beta_{41}$	−0.06	0.0025	0.0045
Total effect (5)		β_{11}	−0.059	0.003	0.006

As Table 6 shows, the total effect of agricultural insurance development level on each nutritional index was basically consistent with the "direct effect + indirect effect", and the way of agricultural insurance development level's impact on nutritional status was explained.

4.4. Heterogeneity Analysis

China is a geographically very large country. The different natural conditions, lifestyles, and customs have formed differences in dietary patterns among different regions. The impact of agricultural insurance on the nutritional status of rural residents is influenced by the dietary structure or pattern inherent in different regions. Referring to the division basis of existing research [34], all samples were divided into northwestern (Sichuan, Guizhou, Chongqing, Shanghai, Jiangsu, Zhejiang, Fujian, Jiangxi, Hubei, Anhui, Guangxi, Hainan, Fujian), northern (Jilin, Liaoning, Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Shandong), and southern (Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang) regions according to the characteristics of the dietary structure, in order to explore the regional heterogeneity of the impact that agricultural insurance development had upon nutritional status.

As Table 7 shows, for the southern and northern regions, the sign of the coefficient of agricultural insurance is consistent with the full-sample regression and is statistically significant, which also shows the robustness of regression. The coefficient comparison shows that the effect of agricultural insurance on the nutritional status of rural residents in the northern region is more obvious.

Table 7. Heterogeneity test.

	South			North			Northwest		
	lnEnergy (a)	HFDI (b)	Animal-Based Food (c)	lnEnergy (d)	HFDI (e)	Animal-Based Food (f)	lnEnergy (g)	HFDI (h)	Animal-Based Food (i)
lnX	−0.034 ***	0.001 ***	0.004 *	−0.037 ***	0.002 ***	0.028 ***	0.005	0.007 ***	−0.011 ***
	(−2.72)	(2.86)	(1.76)	(−3.64)	(3.95)	(6.11)	(0.44)	(5.86)	(−3.31)
Cons	−5.436	−0.974 ***	−15.510 ***	−12.429 **	−0.518	2.752	50.006 ***	−1.175	−17.417 ***
	(−0.63)	(−6.25)	(−10.05)	(−2.07)	(−1.62)	(1.23)	(6.35)	(0.183)	(−7.79)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	156	156	156	96	96	96	60	60	60
Wald	9.440 *	558.220 ***	824.890 ***	137.420 ***	613.530 ***	930.180 ***	391.500 ***	153.520 ***	357.330 ***

Note: t-value or z-value in parentheses. ***, **, and * are significant at the level of 1%, 5%, and 10%, respectively.

However, results show that the northwest differs greatly from those of the other two regions. The development of agricultural insurance has no significant impact on the total calorie intake, and it also reduces the energy supply ratio of animal-based food. Influenced by local product types, climate, and social customs, the northwest region has formed a unique eating style, with wheat-based pasta/noodles as the main food, and the meat supply is already relatively abundant. The development of agricultural insurance has reduced the energy supply ratio of animal-based food, which in turn promotes a balanced nutritious diet and improves the index of healthy food diversification for the dietary patterns in the northwest.

In summary, improving the development level of agricultural insurance has a much higher promotional effect on the *HFDI* of rural residents in the northwest than in the south and north. Considering the reality of unbalanced regional development in China, the marginal propensity to consume in the northwest is higher, and food consumption is also more sensitive to changes in income. The development of agricultural insurance has driven the growth of per capita income in the northwest, and this income effect is more obvious in promoting nutritional status.

5. Conclusions

The main contribution of this paper is to propose that agricultural insurance can improve the nutritional status of rural residents through the intermediary of income level and crop diversity. It enhances our understanding of the functional role of agricultural insurance from the perspective of nutrition improvement.

In terms of empirical evidence, using the provincial panel data from 2008 to 2019, three indicators are selected to measure the nutritional status of rural residents, and the impact of agricultural insurance development level on the nutritional status of rural residents and the mediating path are estimated. As a result, we reached three main conclusions:

(1) The development of agricultural insurance significantly reduced the total calorie intake per capita of rural residents and increased the index of food health diversity and animal-based food supply ratio of rural residents. Overall, the development of agricultural insurance is beneficial for improving the nutritional status of the rural population.
(2) Income levels and crop diversity are two mediators through which agricultural insurance affects the nutritional status of rural residents.
(3) The effect of agricultural insurance development on the nutritional status of the rural residents was more significant in the northern regions. In addition, the development of agricultural insurance played almost the opposite role on the nutritional status of the rural population in the northwestern region than in the southern and northern regions of China, which may be due to the differences in dietary patterns and structure among the regions.

This paper proposes the following policy recommendations to facilitate the design and promotion of agricultural insurance for the purpose of improving the nutritional status of rural residents.

First, innovating agricultural insurance varieties and emphasizing the provision of insurance coverage for nutrient-rich non-food crops is of high benefit. By providing insurance coverage for nutrient-rich agricultural products such as vegetables, fruits, and aquatic products, farmers are guided to grow high-value-added, high-nutritional produce. This way, the availability of quality food for rural residents is increased, and the goal of improving the nutritional status of rural residents can be achieved. However, considering the higher production cost and risk of cash crops compared to food crops, it also puts higher demands on the management level of insurance companies. Second, in terms of raising awareness of dietary nutrition among rural residents, making full use of the agricultural insurance grassroots service networks to promote the knowledge of nutrition science will benefit the population in the long run.

This study has the following shortcomings, which are left for future work to consider: First, we focused on China. However, nutritional health is a global issue. Thus, a certain insufficiency is due to the lack of a broader discussion and comparison of different models of agricultural insurance in different countries. For example, in some countries, the model of insurance offered by commercial insurance companies dominates the new mutual insurance model in others offered by producer cooperatives. Therefore, future research should consider more countries and examine the impact of agricultural insurance on nutritional status. Additionally, limited by data availability, this study uses panel data for empirical analysis. In the future, under the condition that the micro database related to

agricultural insurance in China is perfect, in-depth research in this aspect can be carried out to improve the explanatory ability of the model.

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