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Impact of Agricultural Insurance on Agricultural Output: A Case Study of Shandong Province

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Abstract: Agricultural output plays a crucial role in the quality and level of agricultural development, contributing significantly to ensuring food security and promoting the coordinated development process of rural revitalization. Shandong Province, as a major agricultural province with a large agricultural population and vast arable land, is utilized as a case study. This paper employs panel data from 16 prefecture-level cities in Shandong Province from 2012 to 2021 and employs a fixed effects model to empirically examine the impact of agricultural insurance on agricultural output and regional heterogeneity. The study indicates a significant positive effect of agricultural insurance on agricultural output, along with a positive promotion relationship between mechanization level and agricultural output. Agricultural insurance demonstrates a significant positive correlation with agricultural output in eastern and western regions, but its impact on agricultural output in central regions is not significant. The study suggests focusing on coordinated regional development, appropriately favoring central regions to alleviate the development imbalance across regions.

1. Introduction

The development of agriculture is essential for maintaining the basic livelihood of the nation and controlling the economic lifeline of the country. Agricultural production faces dual risks from nature and the market, making agricultural insurance the primary means of risk management in agriculture, providing support and protection to agricultural output to a certain extent. In 2010, the Central Committee issued Document No. 1, proposing to significantly expand the coverage of agricultural insurance premium subsidies in terms of varieties and regions, and to increase central government subsidies for premiums in central and western regions. By 2012, China had basically achieved full coverage of policy-oriented agricultural insurance. Thanks to government guidance and the dual impetus of the financial market, the scale of agricultural insurance has continued to expand, the types of insurance have been continuously improved, and agricultural insurance development has grown rapidly, achieving a qualitative leap. This paper takes prefecture-level cities in Shandong Province as samples and utilizes panel data from 2012 to 2021 as the basis to empirically analyze the impact of agricultural insurance on agricultural output in Shandong Province using a fixed effects model.

2. Literature Review

Regarding whether agricultural insurance promotes agricultural production, the research results of most scholars are affirmative, believing that agricultural insurance has a positive promotion effect on agricultural production. Based on panel data from Hebei Province, Zhou Wenhai [1] and others believe that agricultural insurance significantly promotes agricultural production, and its promotion effect on agricultural production depends on the agricultural risk level in various regions. Dai Ning [2] and others believe that the level of development of agricultural insurance can significantly promote the improvement of agricultural production levels, and the promotion effect of agricultural insurance payout levels on agricultural production levels is relatively small. Li Qinying [3] and others analyzed the positive impact of agricultural insurance on agricultural output from the perspective of the scale of agricultural insurance, explored the optimal scale of agricultural insurance in Henan Province, and analyzed the synergistic effects of agricultural insurance and agricultural total factor productivity on agricultural output. Jin Shaorong [4] and others discussed the positive promotion effect of agricultural insurance on agricultural economic growth and affirmed the intermediary effect of agricultural total factor productivity. Li Jieyu [5] based on panel data from the Beijing-Tianjin-Hebei region, believes that agricultural insurance density plays a positive regulatory role in agricultural total factor productivity and agricultural output and affirmed the positive correlation between agricultural technological progress indicators. Liu Wei [6] and others believe that the breadth and level of protection of agricultural insurance have a positive promotion effect on the net income of farmers, while Wang Siyi [7] and others explored the impact of agricultural insurance on the security of agricultural product supply quantity and analyzed the positive impact of agricultural total factor productivity on the security level of agricultural product supply quantity. However, some scholars believe that agricultural insurance does not promote an increase in agricultural output. Yuan Hui [8] and others believe that due to serious moral hazard issues, the level of protection and compensation of policy-oriented agricultural insurance have a reverse effect on the level of agricultural output in Hubei Province.[9]

3. Research Design

To further reflect regional characteristics, this paper takes the 16 prefecture-level cities of Shandong Province as the research objects. Panel data from 2012 to 2021 are utilized, with per capita added value of agriculture, forestry, animal husbandry, and fishery as the dependent variable. Agricultural insurance density is chosen as the explanatory variable, while rural human capital level, agricultural mechanization level, fertilizer input, per capita sown area of crops, and agricultural insurance payout level are controlled variables. A fixed effects model is employed to conduct regression analysis on the data. The results indicate that agricultural insurance in Shandong Province significantly promotes agricultural output. However, there exist issues such as regional imbalance in agricultural insurance development and fertilizer use inhibiting agricultural output. Relevant government departments should implement appropriate policy inclinations towards regions with weak agricultural insurance development and carry out exploratory projects of green agricultural insurance across the province to better promote the development of agricultural insurance in Shandong Province, enhance agricultural output, and ensure the quality and level of agricultural development.[10]

3.1 Indicator Selection

1) Agricultural output (AGDP). Using the per capita added value of agriculture, forestry, animal husbandry and fishery in 16 prefecture-level cities in Shandong Province, the calculation formula is

as follows: per capita added value of agriculture, forestry, animal husbandry and fishery in a city in a certain year = added value of agriculture, forestry, animal husbandry and fishery in the city in that year/the number of employment in the primary industry in the city in that year. Agricultural output was taken as the explained variable in the regression model.[11]

2) Development level of agricultural insurance (INS). This index is reflected by the agricultural insurance density of 16 prefecture-level cities in Shandong Province. Agricultural insurance density refers to the amount of per capita agricultural insurance premium calculated according to the number of employment in the primary industry of the city in that year, and the calculation formula is: agricultural insurance density of a city in a certain year = the agricultural insurance premium income of the city in that year/the number of employment in the primary industry. As an explanatory variable in the model.[11]

3) Rural human capital level (HUM). The level of human capital is proportional to labor productivity, which is conducive to technological progress and thus to agricultural output. In this paper, the proportion of rural labor force with high school education or above in Shandong Province is reflected by the number of years of rural population receiving education.

4) Level of agricultural mechanization (MECH). In the process of China's development from traditional agriculture to modern agriculture, the improvement of mechanization level can greatly improve labor productivity and save labor costs. The level of mechanization can positively affect agricultural output. The index is expressed by the number of major agricultural machinery per capita at the end of the year in each city of Shandong Province.[12]

5) Fertilizer input (FER). The rational use of chemical fertilizer will increase agricultural output, and thus positively affect agricultural output; excessive use of chemical fertilizer will reduce agricultural output and reduce crop quality, which will have a negative impact on agricultural output, especially environmental pollution. The index is expressed by the amount of fertilizer input in Shandong Province.[13]

6) Crop sown area per capita (PS). Crop sown area directly affects crop yield and thus agricultural output. The calculation formula is: per capita crop sown area = crop sown area/number of employment in the primary industry.

7) The improvement of agricultural insurance indemnity level (LIC) is conducive to farmers' recovery of agricultural production, thereby reducing the risk of agricultural production and positively affecting agricultural output. The formula is: agricultural insurance payout rate = agricultural insurance compensation amount/premium income.

The meanings and calculation methods of each variable are shown in Table 1.

Table 1: Meaning and calculation method of each variable

variable	meaning	computing method
AGDP	Per capita added value of agriculture, forestry, animal husbandry and fisheries (yuan)	Added value of agriculture, forestry, animal husbandry and fishery/Number of employment in primary industry
INS	Agricultural insurance density (Yuan)	Agricultural insurance premium income/employment in primary industry
HUM	Proportion of rural labor force with high school education or above (%)	Number of rural labor force with high school education or above/Number of employment in primary industry
MECH	Per capita ownership of major agricultural machinery at the end of the year (kW)	The number of major agricultural machinery at the end of the year/the number of employment in the primary industry
FER	Fertilizer input (tons)	Total annual fertilizer input
PS	Crop sown area per capita (ha)	Crop acreage/employment in primary industry
LIC	Agricultural Insurance payout rate (%)	Agricultural insurance compensation amount/premium income

3.2 Model Construction

This paper adopts the Cobb-Douglas production function as the model, which mainly measures the impact of inputs such as labor, technology, and capital on output during the production process. The model is set as follows:

$$Y = A \cdot L^{\alpha} \cdot K^{\beta} \quad (1)$$

Where:

- Y represents total output.
- A represents comprehensive technological level.
- L represents labor input.
- K represents capital input.
- α and β represent the elasticity coefficients of labor and capital output, respectively.

In this study, referring to the Cobb-Douglas production function, AGDP represents per capita added value of agriculture, forestry, animal husbandry, and fishery in the prefecture-level cities of Shandong Province; INS represents per capita agricultural insurance premiums in the prefecture-level cities of Shandong Province; HUM represents the proportion of high school-educated or higher rural population in each city of Shandong Province; MECH represents per capita ownership of major agricultural machinery at the end of the year in each city of Shandong Province; FER represents fertilizer input in each city of Shandong Province; PS represents per capita sown area of crops in each city of Shandong Province; LIC represents the level of agricultural insurance payout.The empirical analysis in this paper uses panel data. Based on the selected variables and the characteristics of panel data, a panel data regression model is established. The model used is as follows:

$$\ln yit = \beta_0 + \beta_1 \ln x_{1it} + \beta_2 \ln x_{2it} + \beta_3 \ln x_{3it} + \beta_4 \ln x_{4it} + \beta_5 \ln x_{5it} + \beta_6 \ln x_{6it} + \text{vit} \quad (2)$$

In formula (2), β_0 is the constant term, y represents the explained variable AGDP and explanatory variable INS, $x_2, x_3, x_4, x_{15}, x_6$ represents the control variables HUM, MECH, FER, PS and LIC, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ represents the explained variable and the elastic coefficient between the explanatory variable and each control variable, and vit represents the random interference term. yit Represents the AGDP for t year i of the city, x_{1it} represents the INS for t year i of the city, and so on for other control variables.

4. Empirical analysis

4.1 Descriptive statistics

Table 2: Descriptive statistics of each variable

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	mean	sd	min	max
LNAGDP	160	14.85	0.444	13.86	15.73
LNINS	160	5.050	0.912	1.137	6.913
HUM	160	0.0437	0.0144	0.0192	0.0796
LNMECH	160	2.139	0.376	1.342	3.120
LNFER	160	13.48	0.547	12.32	14.27
PS	160	0.838	0.285	0.387	1.574
LIC	160	0.722	0.427	0.0815	2.334

In order to reflect regional characteristics, this paper selected 16 prefecture-level cities in Shandong Province as the research object, and the data came from Shandong Statistical Yearbook and China Statistical Yearbook. Complete data collection, reasonable values, no missing values and serious differences. The measurement software used is stata17.0. In this paper, based on municipal panel data, in order to reduce the fluctuation of variables, logarithmic processing was taken for the four variables of explanatory variable, explained variable, per capita ownership of main agricultural machinery at the end of the year and fertilizer input. The descriptive statistical analysis of the processed variables was shown in Table 2.

4.2 Basic regression

In this paper, the most effective estimation model is determined by F-test and Hausman test, and the test results are shown in Table 3. It can be seen from Table 3 that the p value of F and test is 0.000, and the p value of Hausmann test is 0.000, which rejects the null hypothesis and therefore believes that the fixed effect model should be used.

Table 3: Summary of test results

Test type	Test value	model selection
F-test	F(15, 138) = 125.58,Prob > F = 0.0000	fixed effect model
Hausman test	chi2(6) =2300.24,Prob > chi2=0.0000	fixed effect model

Table 4: Regression results of the influence of agricultural insurance on agricultural output

	(1)	(2)
	LNAGDP	LNAGDP
LNINS	0.173***	0.105***
	(22.168)	(9.234)
HUM		0.495
		(0.460)
LNMECH		0.105**
		(2.050)
LNFER		-0.599***
		(-7.434)
PS		0.013
		(0.183)
LIC		-0.022*
		(-1.712)
_cons	13.979***	22.157***
	(350.051)	(19.099)
N	160	160
R2	0.775	0.859
F	491.411	139.619
***p<0.01", "**p<0.05", "*p<0.10		

According to the regression results in Table 4, column (1) is the regression result before adding control variables, and column (2) is the regression result after adding control variables. Column (1) is the result of fixed-effect model without adding control variables. The influence of agricultural insurance on agricultural output is significant at 1% level, and the regression coefficient is 0.173. The result shows that agricultural output will increase by 0.173 percentage points for every unit change of agricultural insurance. The goodness of fit R2 increased from 0.775 to 0.859, indicating that the selected control variables were reasonable and the model fitting degree was continuously improved. Column (2) shows that after the addition of control variables, agricultural insurance still has a significant positive correlation with agricultural output, and the regression coefficient of agricultural insurance is 0.105, which indicates that agricultural insurance has a positive promoting effect on agricultural output. According to the regression results of control variables in column (2), the fertilizer input has a significant inhibitory effect on agricultural output at the level of 1%, the per capita ownership of main agricultural machinery at the end of the year has a significant promotion effect on agricultural output at the level of 5%, and the agricultural insurance indemnity rate has a significant inhibitory effect on agricultural output at the level of 10%.[14]

4.3 Robustness test

In order to ensure the robustness of the regression results, this paper uses the replacement of the explained variables for robustness test, replaces the per capita added value of agriculture, forestry, animal husbandry and fishery with the total value of agriculture, forestry, animal husbandry and fishery. Similarly, logarithmic processing is performed on the total value of agriculture, forestry, animal husbandry and fishery, and the fixed effect model is used. The results are shown in Table 5.

Table 5: Test results after replacing explained variables

	(1)	(2)
	lnGDP	lnGDP
LNINS	0.145***	0.108***
	(22.494)	(10.538)
HUM		1.435
		(1.472)
LNMECH		0.125***
		(2.691)
LNFER		-0.336***
		(-4.613)
PS		-0.116*
		(-1.812)
LIC		-0.027**
		(-2.381)
_cons	14.729***	19.236***
	(445.688)	(18.336)
N	160	160
R2	0.780	0.835
F	505.991	116.315
***p<0.01", "**p<0.05", "*p<0.10		

The analysis results in Table 5 show that after being replaced by explanatory variables, when no control variables are added to column (1), the impact of agricultural insurance on agricultural output is significant at the level of 1%, and the regression coefficient is 0.145. After the addition of control variables in column (2), agricultural insurance still has a significant positive correlation with agricultural output, and the regression coefficient of agricultural insurance is 0.108, and other control variables are significant. Among them, the amount of fertilizer applied is significantly negative on agricultural output at 1% level, and the per capita ownership of main agricultural machinery at the end of the year is significantly positive on agricultural output at 1% level. Agricultural insurance loss rate has a significant inhibitory effect on agricultural output at the level of 5%, and crop sown area per capita has a significant promotion effect on agricultural output at the level of 10%, which is basically consistent with the analysis conclusion of the per capita added value of agriculture, forestry, animal husbandry and fishery. Therefore, the robustness of the regression results in this paper can be obtained.

4.4 Heterogeneity analysis

Due to the difference of policy orientation and economic development level, the influence of agricultural insurance on agricultural output in different prefecture-level cities is also different. In order to further analyze the impact of agricultural insurance on agricultural output in different prefecture-level cities, 16 prefecture-level cities were divided into eastern, central and western regions, and the three sub-samples were respectively returned. The regression results are shown in Table 6. Column (1) shows the regression of the impact of agricultural insurance on agricultural output in prefecture-level cities in eastern China, which is significantly positive at 1%; Column (2) shows that agricultural insurance has no significant effect on agricultural output in the central region; Column (3) shows that agricultural insurance also has a significant promoting effect on agricultural output in the western region.

Table 6: Results of heterogeneity analysis

	(1)	(2)	(3)
	lnagdp	lnagdp	lnagdp
lnins	0.117***	0.039	0.122***
	(8.990)	(1.295)	(3.775)
hum	-0.112	2.646	-4.950
	(-0.045)	(1.629)	(-1.410)
lnmech	0.202*	0.141	0.047
	(1.965)	(1.542)	(0.704)
lnfer	-0.560***	-0.970***	-0.430**
	(-4.782)	(-5.328)	(-2.464)
ps	-0.190	-0.088	0.271**
	(-1.035)	(-0.544)	(2.080)
lic	-0.003	-0.027	-0.057***
	(-0.127)	(-1.162)	(-2.986)
_cons	21.536***	27.155***	20.159***
	(12.330)	(10.638)	(7.872)
N	70	60	30
R2	0.894	0.825	0.924
F	79.870	37.762	42.606

***p<0.01", "**p<0.05", "*p<0.10

5. Countermeasures and suggestions

5.1. We will increase subsidies for agricultural insurance in the central region

The development level of agricultural insurance in Shandong Province has regional heterogeneity in the eastern, central and western regions, and the promotion of agricultural insurance in the eastern and western regions is greater than that in the eastern region, while the impact of agricultural insurance in the central region is not significant. Therefore, the relevant government departments should increase the subsidies for agricultural insurance, pay attention to the coordinated development of regions, and implement different agricultural insurance policies for different regions, which can be appropriately tilted to the central region to alleviate the imbalance of development in different regions. First, increase subsidies. We will increase government subsidies for insurance premiums, reduce the premiums paid by agricultural producers and operators, and increase the insurance participation rate of rural households. Second, we will improve the subsidy structure. The government should vigorously develop a variety of subsidy methods, multi-faceted, multi-channel to ensure the sustainable development of agricultural producers and operators.

5.2. We will explore and develop green agricultural insurance projects

The rise of agricultural industrialization has led to the transformation of agriculture from traditional production to process production, and industrial agglomeration has also led to an increase in the demand for agricultural insurance. The development of agricultural industry in Shandong Province cannot be achieved without the innovation of agricultural technology. At present, the main body of agricultural management in Shandong Province is still small farmers, whose low level of education leads to low willingness to accept technology. Therefore, it is suggested that the government provide corresponding guarantees to promote the promotion of new agricultural technologies. Agricultural insurance can play a role in dispersing risks and compensating losses. In the face of technical risks that farmers may face when adopting new technologies, the government should formulate corresponding rules and regulations and increase subsidies. Through policy guidance and financial support, the government should do a good job in publicity and promotion services and promote the establishment of close cooperation between insurance companies and farmers. Support insurance companies to develop new green agricultural insurance products such as agricultural technology quality insurance, small amount of chemical insurance and high efficiency insurance, and land non-point source low pollution insurance.

5.3. Strengthen the publicity of agricultural insurance and enhance the recognition of farmers

At present, the rural population in Shandong Province generally has a low level of education, and farmers' awareness of risk and insurance is weak. Even if they follow the crowd to take out insurance, they have insufficient understanding of agricultural insurance. Especially in economically underdeveloped areas, farmers generally have misunderstandings about agricultural insurance. Therefore, effective measures must be taken. First of all, the government and insurance companies can hold lectures, put up posters, broadcast, newspaper, Internet, wechat public number, television, paper propaganda and other channels to popularize the knowledge of agricultural insurance, so that agricultural insurance will be deeply popular. Secondly, give play to the leading role of rural grassroots, encourage them to take the lead in agricultural insurance training, and play a positive role; In addition, the relevant departments and insurance companies can go into the grassroots, regularly carry out lectures or research, understand the actual needs of farmers, and carry out differentiated agricultural insurance program recommendations and policy guidance according to different situations. In order to enhance farmers' understanding of agricultural insurance, so that farmers truly understand the value and significance of agricultural insurance, and really promote the enthusiasm of farmers to actively participate in insurance.

6. Conclusions

Aiming at the impact of agricultural insurance on agricultural output, based on the data of 16 prefecture-level cities in Shandong Province from 2012 to 2021, this paper empirically analyzed the impact of agricultural insurance on agricultural output, and analyzed the heterogeneity of agricultural insurance on agricultural output in different prefecture-level cities. The study found that, first, from the whole sample data, the development of agricultural insurance can promote agricultural output, and it is of great practical significance to develop agricultural insurance in rural areas of Shandong Province. The improvement of mechanization level will significantly promote agricultural output, and there is a positive correlation. The use of fertilizers can significantly inhibit agricultural output; Farm insurance payouts also depress agricultural output. Second, the analysis and test of different prefecture-level cities show that the development of agricultural insurance can promote agricultural output in the eastern and western regions, but has no significant impact on farmers' income in the central region, indicating that there is still regional uncoordination and imbalance in the agricultural development of Shandong Province.

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