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Research on the Influence of Agricultural Insurance on Grain Production in Hubei, China Based on Cobb- Douglas Production Function Model

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Abstract. This paper uses panel data of 13 cities in Hubei Province, China from 2008 to 2019 to establish a multiple linear regression model with the improved Cobb-Douglas production function, and analyzes the influence of agricultural insurance on grain production in Hubei Province as a whole, in eastern Hubei, and in western Hubei. All of the 3 regression results of the Hubei Province overall model, the eastern model and the western model show that agricultural insurance has a significant positive impact on grain production in Hubei, but the impact is small, and the output elasticity of insurance premiums is only 0.0308. In terms of regional differences, the output elasticity of agricultural insurance in eastern Hubei, which is 0.0314, is smaller than that in western Hubei, i.e., 0.0386. The empirical results indicate that agricultural insurance does have a certain role in guaranteeing grain production in Hubei, but it is very limited. Finally, this paper puts forward some countermeasures in order to cultivate a refined agricultural insurance market, so as to achieve stable agricultural production.

Keywords: agricultural insurance, grain production, Cobb- Douglas production function, influence

1. Introduction

In 2020, the sudden outbreak of COVID-19 made the Chinese people realize the importance of food supply. Observing the relevant data of China in recent years, it can be found that China's food supply is greatly dependent on imports. Although the effective control of the epidemic has temporarily alleviated the problem of tight food supply, the successive outbreaks of natural disasters in China's major grain-producing provinces in the past two years have made the problem of food security increasingly serious. China's food security issues have aroused deep concerns from relevant authorities. As an important tool for risk diversification in agricultural production, agricultural insurance has always been highly valued by government departments. The first document of central government in China in 2020 issued a number of guidelines for the healthy development of agricultural insurance, including detailed guidance advice covering premium subsidies, subsidy structure, regional inclination of financial subsidies and insurance rates.

As a major grain-producing province, Hubei provides a large amount of grain supply to other provinces every year. Hubei's total annual crop output exceeds 25 billion kilograms,and the province has sufficient rice and wheat stocks. The government attaches great importance to the problem of grain production in Hubei Province. In recent years, a large amount of funds and policy support have been provided to the agricultural sector in Hubei Province, with particular emphasis on the support of agricultural insurance, an important transfer tool for agricultural production risks. The total agricultural insurance premium income of the 13 prefecture-level cities in Hubei reached 1,092.38 million yuan in 2018, nearly doubling from 589.69 million yuan in 2015. However, the growth of grain output in Hubei Province is visibly slow, and there is even a slight decline. Therefore, it is urgent to study the relationship between agricultural insurance and grain production in Hubei Province, which will be of great significance to the agricultural development of the entire Hubei Province and to the solution of national food security problems.

2. Methods and Materials

2.1. Model specification and variable selection

This paper uses the panel data of agricultural production and agricultural insurance in 13 prefecture-level cities in Hubei Province from 2008 to 2019 to establish a Cobb-Douglas production function model, hereinafter referred to as C-D production function model. The general form of the C-D production function is as follows.

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

Where $\alpha>0$ and $\beta<1$. $Y(t)$, $A(t)$, $K(t)$ and $L(t)$ in Equation (1) represent the agricultural output, technological progress, agricultural capital input, and agricultural labor input in year t, respectively. In this paper, the agricultural insurance premium income is added to the production function as a capital input and *A* is regarded as a constant. Besides, inputs of agricultural production factors such as seeding input, fertilizer input, and mechanical input are included in the model as well. Therefore, the following empirical model is established.

$$Y_{\mathrm{it}} = f\,(Ins_{it}, Area_{it}, Mch_{it}, Fert_{it}, Lbr_{it}) \tag{2}$$

Where i=1, 2, ⋯, 13, which represents the 13 prefecture-level cities in Hubei Province. t=1, 2, ⋯, t, which is the time trend reflecting technological changes. Y_{it} represents the grain output of the i-th city in year t, reflecting the regional grain production status. Ins_{it} represents the agricultural insurance premium income of the i-th city at time t, indicating the development level of regional agricultural insurance. *Area*, *Mch*, *Fert* and *Lbr* are all control variables, where $Area_{it}$ is the grain sown area of the i-th city at t, reflecting the seeding input. Mch_{it} is the total power of agricultural machinery in the i-th city at t, reflecting the input level of agricultural machinery. $Fert_{it}$ is the fertilizer application amount of the i-th city at t, reflecting the fertilizer input. Lbr_{it} is the number of agricultural employees in the i-th city at t, indicating labor input.

For ease of estimation and to reduce the effect of heteroskedasticity on the model, all original variables were logarithmically processed. The final logarithmic C-D production function model is as follows.

$$\ln Y_{\mathrm{it}} = \varphi + \vartheta_1 \ln Ins_{it} + \vartheta_2 \ln Area_{it} + \vartheta_3 \ln Mch_{it} + \vartheta_4 \ln Fert_{it} + \vartheta_5 \ln Lbr_{it} + \alpha_i + \lambda_t + \xi_{it} \tag{3}$$

Where ϑ_1, ϑ_2, ... ϑ_5 are the parameters to be estimated, representing the output elasticity of each explanatory variable. φ is the intercept term and ξ is the random disturbance term. α_i reflects the time-invariant individual characteristics of grain production in each city of Hubei Province, and λ_t is the time effect that does not change with individuals. The definitions and descriptions of variables in Equation (3) are shown in Table 1 below.

Table 1: Description of variables

Variable Type	**Variable**	**Description**	**Theoretical Expectation**
Dependent Variable	*Y*	Gain yield (10^4 ton)	N/A
Core Explanatory Variable	*Ins*	Net premium income of agricultural insurance (million yuan)	Positive
Control Variables	*Area*	Grain crops sown area (10^4 hectares)	Positive
	Mch	Total power of agricultural machinery (10^4 kilowatts)	Positive
	Fert	The pure application rate of chemical fertilizers (10^4 ton)	Positive
	Lbr	Number of rural employees in agriculture, forestry, animal husbandry and fishery at the end of the year (10^4)	Positive

In addition to establishing the overall model of Hubei Province according to Equation (3), two regional models of the eastern and western parts of Hubei Province were also constructed in order to make a horizontal comparison. In this study, the division of eastern and western Hubei Province takes Jingzhou City as the dividing line. Jingzhou and the east of it are defined as the eastern part of Hubei, and the west of Jingzhou is defined as the western part of Hubei. The eastern part includes 7 cities: Huanggang, Huangshi, Ezhou, Wuhan, Xianning, Xiaogan, Jingzhou, whereas the west includes 5 cities: Jingmen, Suizhou, Xiangyang, Yichang, Enshi, Shiyan. Therefore, we build three models for analysis based on Equation (3), i.e., the overall model of Hubei Province, the eastern model and the western model. The sample intervals of the three models are all from 2008 to 2019, but the cross-sectional information for the 3 models is different.

2.2. Data sources and descriptive statistics

In this paper, the relevant data of 13 prefecture-level cities in Hubei Province from 2008 to 2019 were collected, including grain yields, net premium income of agricultural insurance, pure application of chemical fertilizers, total power of agricultural machinery, number of rural employees and grain sown area. The data come from "China Insurance Yearbook", "Hubei Statistical Yearbook", "China Rural Statistical Yearbook" and local statistical yearbooks. In order to eliminate the impact of price factors, the agricultural insurance premium income was processed and converted to the constant price in 2019. Data interpolation was performed for a small amount of missing data. The descriptive statistics after taking the logarithm of each variable in the three models are shown in Table 2 below.

Table 2: Descriptive statistics of variables

Model	Variable	Sample Size	Mean	Std. Deviation	Min	Max
Overall Model of Hubei Province	ln*Y*	156	5.0150	0.7343	3.2339	6.2252
	ln*Ins*	156	3.7395	0.8675	0.4249	5.347
	ln*Area*	156	3.3184	0.6807	1.4156	4.4190
	ln*Mch*	156	5.4064	0.6454	3.8144	6.5233
	ln*Fert*	156	2.9778	0.6589	1.4725	4.1045
	ln*Lbr*	156	4.0120	0.5633	2.8314	4.9192
Model of Eastern Hubei	ln*Y*	84	4.8462	0.8364	3.2339	6.1599
	ln*Ins*	84	3.7716	1.0497	0.4250	5.3469
	ln*Area*	84	3.1105	0.7828	1.4156	4.3013
	ln*Mch*	84	5.2267	0.7170	3.8144	6.4740
	ln*Fert*	84	2.7439	0.6954	1.4725	3.9323
	ln*Lbr*	84	3.9457	0.7009	2.8314	4.9192
Model of Western Hubei	ln*Y*	72	5.2121	0.5349	4.3966	6.2252
	ln*Ins*	72	3.7020	0.5934	2.2886	4.8805
	ln*Area*	72	3.5611	0.4293	2.9572	4.4190
	ln*Mch*	72	5.6161	0.4750	4.7153	6.5233
	ln*Fert*	72	3.2506	0.4923	2.2220	4.1045
	ln*Lbr*	72	4.0893	0.3276	3.5249	4.5907

3. Analysis and Results

3.1. Model identification and verification

According to the VIF test, all variables in the overall model are retained, yet the control variable *Lbr* in the eastern model and western model is excluded in order to avoid multicollinearity. The results of the heteroskedasticity test showed that there were heteroscedasticity in the three models. Therefore, the heteroscedasticity robust standard errors were generated for each of the three models when they were estimated.

To ensure the validity of the panel model setting, we performed an F-test, which showed that none of the three models was applicable to Pooled OLS. The Hausman test was then performed on the three models respectively to determine whether a fixed-effects model or a random-effects model is effective. The results showed that p-values of the overall model, the eastern model and the western model are 0.0042, 0.0222, and 0.9860 in turn. Thus, the overall and eastern models of Hubei Province should employ the fixed-effects model, while the western model should reject the fixed-effects model and use the random-effects model.

3.2. Analysis of regression results

3.2.1 Estimation results of the overall model

The fixed-effects model estimation results of the impact of overall agricultural insurance on grain output in Hubei Province are shown in Table 3 below.

Table 3: Regression results for the overall model of Hubei

Variable	Coefficient	Standard Error	significance
ln*Ins*	0.0308***a	0.0083	0.003
ln*Area*	0.3971**	0.1392	0.015
ln*Mch*	0.0748	0.0618	0.250
ln*Fert*	0.2278**	0.0907	0.027
ln*Lbr*	-0.2071	0.1445	0.177
Constant	3.3304***	0.9204	0.004
R^2	0.9470		
P-value for F test	0.0000		
P-value for Hausman test	0.0042		
Model selection	Fixed effects model		

a. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

According to the results in Table 3, R^2 of the fixed effect model is 0.9470, which indicates that the goodness of fit of the overall model is great and the regression results are reliable. The core explanatory variable *Ins* has a positive impact on grain output at a significant level of 1%, and the output elasticity of premium income is 0.0308, meaning that when other factors remain unchanged, every 1% increase in premium income, grain production will increase by 0.03%. As to control variables, *Area* and *Fert* both have a positive impact on grain production at a significant level of 5%, which means that given other factors remain unchanged, for every 1% increase in grain sown area, grain yield will increase by 0.397%, and for every 1% increase in fertilizer application, grain output will raise by 0.23%.

3.2.2 Estimation results of the eastern model and the western model

Equation (3) is used to estimate the panel data of the eastern and western regions of Hubei Province, respectively, and the results are shown in Table 4.

Table 4: Regression results for the eastern and western model

Variable	The Eastern Model		The Western Model	
	Coefficient	***Std. Error***	***Coefficient***	***Std. Error***
ln*Ins*	0.0314**b	0.0094	0.0386***	0.0147
ln*Area*	0.3631**	0.1392	0.6429***	0.2284
ln*Mch*	0.2036**	0.0822	0.0069	0.0574
ln*Fert*	0.2490*	0.1147	0.2501***	0.0368
Constant	1.8513**	0.6907	1.9278**	0.8548
R^2	0.9905		0.8326	
P-value for F test	0.0000		0.0000	
P-value for Hausman test	0.0222		0.9860	
Model selection	Fixed effects model		Random effects model	

b. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

According to Table 4, R^2 of the eastern model and the western model are 0.9905 and 0.8326, respectively, indicating that the goodness of fit of the two regional models is high. Agricultural premiums in both eastern and western Hubei Province have significant positive impacts on grain yields. The output elasticities of agricultural premiums in eastern and western Hubei are 0.0314 and 0.0386, respectively. Therefore, given other factors unchanged, for every 1% increase in agricultural premium income in eastern and western Hubei, grain output will increase by 0.031% and 0.039% respectively.

In the eastern model, the control variables *Area*, *Mch* and *Fert* have positive effects on grain production at the 5%, 5% and 10% significant levels, respectively, and the output elasticity of sown area, mechanical power and fertilizers are 0.3631, 0.2036 and 0.2490 in turn. Given other conditions remaining unchanged , for every 1% increase in grain sown area in eastern Hubei, the grain output will increase by 0.363%. For every 1% increase in the total power of agricultural machinery in eastern Hubei, the grain yield will increase by 0.203%. For every 1% increase in fertilizer application, the grain output will increase by 0.249%.

In the western model, the control variables *Area* and *Fert* both have significant positive impacts on grain production, and their output elasticities are 0.6429 and 0.2501, respectively. Therefore, for every 1% increase in grain sown area in western Hubei, there will be a 0.64% increase in grain output and for every 1% increase in fertilizer application in western Hubei, grain output will increase by 0.25%. The total power of agricultural machinery has no significant impact on grain output in western Hubei Province, mainly because the western region of Hubei is mostly mountainous, and the utilization rate of machinery is low.

According to the above results, agricultural insurance in Hubei Province has a significant positive impact on grain output, but the positive impact is relatively weak and need to be improved. Agricultural insurance in the eastern and western parts of Hubei Province also has positive impacts on the local grain output, and the positive impact in the west is greater than that in the east. This mainly due to the fact that the western part of Hubei Province is a mountainous area with relatively poor land resources and farming conditions together with more natural disasters. Therefore, agricultural insurance plays a more significant role in guaranteeing grain production in the west of Hubei than in the east.

4. Conclusions and Implications

4.1. Conclusions

From the empirical results, the current agricultural insurance in Hubei Province as a whole, in western Hubei, and in the eastern Hubei all has significant positive effects on grain production. For the whole province, the output elasticity of agricultural insurance premiums is 0.0308. The output elasticities of agricultural insurance in eastern and western Hubei are 0.0314 and 0.0386, respectively. The output elasticity of agricultural insurance in western Hubei is higher than that in the eastern region. This is mainly due to the fact that the western Hubei is a mountainous region with more natural disasters, thus, agricultural insurance plays a greater role in ensuring grain production in the west than in the east.

However, the output elasticity of agricultural insurance in Hubei Province is relatively small, whether in terms of the whole province or sub-regions, indicating that the role of current agricultural insurance in safeguarding grain production in Hubei Province has not been brought into full play. At present, there are still many problems in the development of agricultural insurance in Hubei Province that need to be solved urgently, such as low insurance coverage, few types of insurance, insufficient level of insurance protection, and lack of innovation in insurance products.

4.2. Implications and suggestions

In view of the positive but limited impact of agricultural insurance on grain production in Hubei Province, government departments should consider cultivating a sound agricultural insurance market from the following aspects, so as to stabilize agricultural production and increase farmers' income.

First and foremost, agricultural insurance subsidies should be strengthened, and at the same time, the publicity of agricultural insurance should be improved. Grassroots government departments should conduct more knowledge lectures on agricultural insurance for farmers to effectively enhance farmers' interests and enthusiasm for participating in insurance.

Second, the structure of agricultural insurance should be adjusted. The regulatory department could make some reasonable adjustments to insurance system, insurance environment, subsidy mechanism and insurance structure. Insurance institutions can also launch some special types of insurance products in line with local conditions according to the characteristics of agricultural products in different regions, so as to create a better development environment for agricultural insurance in Hubei Province.

Third, the investment in science and technology should be increased and the level of agricultural insurance technology need to be optimized. Although the current development level of agricultural science and technology in Hubei Province is not extremely low, there is still plenty of room for improvement, and there are still some gaps compared with other provinces with a higher level of science and technology. Insurance institutions and government departments should consider providing more preferential protection and subsidy services for the use of state-of-the-art agricultural machinery and equipment.

Fourth, insurance service level needs to be improved in order to enhance insured farmers' experience. The staffing situation of agricultural insurance in Hubei Province has been poor, and one of the important reasons is the lack of professional and high-quality talents. In the future development, Hubei Province should attach importance to the training of professional insurance practitioners and carry out more professional training activities.

Last but not least, commercial agricultural insurance requires vigorously support. Hubei Province can adopt the mode of combining policy-based agricultural insurance and commercial agricultural insurance to promote the cultivation of a perfect agricultural insurance market.

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