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What are the Effects of Policy-Based Crop Insurance on Capital Factors Inputs? Evidence from Farmers of Heilongjiang Province in China

Jiajia Tian
College of Economics and Management, Northeast Agricultural University, Harbin, Heilongjiang, China

Abstract:

Agricultural insurance, as one of the most efficient approaches to disperse agricultural external risks, has become a vital part of agricultural support and protection policy system in China. As the agricultural production scale is being expanded, and as the agricultural risk management is increasingly demanded in China, further enhancing the status of agricultural insurance in the agricultural support and protection policy system has become the future development direction of policy-based crop insurance in China. Accordingly, this paper primarily focus on the effects of policy-based crop insurance on capital factors` inputs. This study used the two-way fixed effect model and the instrumental variable method to analyze the influence of policy-based crop effects on the capital factors` input of farmers under different scales and different differentiation types. based on the large sample micro-data from the fixed observation points in Heilongjiang Province from 2009 to 2017, The results show that policy-based crop insurance has a significant negative impact on farmers' per mu chemical fertilizer input. Moreover, the policy-based crop insurance has a significant negative effect on farmers' input of pesticides per mu.

***Keywords**: Policy-based crop insurance, Capital factors, Fertilizers input, Pesticides input*

I. INTRODUCTION

Capital factor input has always been an important factor affecting agricultural total factor productivity. Many scholars' studies have found that modern inputs represented by intermediate factor inputs, fixed assets, chemical fertilizers and agricultural machinery are the most important factors affecting agricultural output in China [1-3].

Agricultural insurance, as one of the effective ways to disperse agricultural external risks, will also have a profound impact on the input behavior of farmers' capital factors [4-7]. Thus, policy-based crop insurance is of a very important practical significance for the impact of capital factor input.

On the whole, the input of capital factors in agricultural production mainly includes chemical fertilizer, pesticide, machinery and so on. Based on this, this paper will explore the influence of policy-based crop insurance on farmers' capital factor input from three aspects, i.e., chemical fertilizer, pesticide and machinery.

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Although chemical fertilizers and pesticides have different functions for agricultural production, overapplication of pesticides has long been a problem [8-10]. For example, the study of Huang et al. [8] found that the phenomenon of excessive application of chemical fertilizer by small farmers is very common.

Qiu Huaguang et al. [11], based on the investigation of corn growers in Heilongjiang, Jilin, Shandong and Henan, found that the overapplication of chemical fertilizer per mu was as high as 10.4 kg. Zhang Yunhua et al. [10], based on the data of fixed observation points in rural areas across the country, found that one of the reasons for excessive fertilizer input was excessive application of nitrogen. According to the study of Mi Jianwei et al. [9], the problem of excessive pesticide application and low utilization rate generally exists in cotton farmers.

In 2017, the Ministry of Agriculture issued the "Action Plan for Zero Growth in Fertilizer Use by 2020" and "Action Plan for Zero Growth in Pesticide Use by 2020", which defined the main line of work of "stabilizing grain revenue, adjusting grain structure, improving quality and efficiency, and transforming the pattern", in order to achieve the goal of reducing the use of chemical fertilizers and pesticides.

The campaign for zero growth of the use of chemical fertilizers and pesticides achieved remarkable results in 2018. Therefore, the impact of policy-based crop insurance on fertilizer and pesticide inputs and whether it meets the goal of the Zero Growth Action on Fertilizer and Pesticide are worth discussing.

At present, there are different conclusions about the input amount of chemical fertilizer and pesticide in policy-based crop insurance. Some scholars believe that policy-based crop insurance contributes to the increase of pesticide and fertilizer inputs [12-13]. Some scholars hold opposite conclusions, believing that policy-based crop insurance helps reduce the input of pesticides and fertilizers [7].

Then, what is the impact of policy-based crop insurance on farmers' use of chemical fertilizers and pesticides? Existing studies generally use cross-sectional data or single crop analysis to address the above problems, and generally ignore the long-term effects of policy-based crop insurance on the application of fertilizers and pesticides by farmers and the effects on aggregate crops at the household level.

Based on this, this study empirically analyzed the impact of policy-based planting industry insurance on the "aggregate" input of chemical fertilizers and pesticides at the household level, based on the micro farmers' data of rural fixed observation points from 2009 to 2017 in Heilongjiang Province.

II. MATERIALS AND METHODS

2.1 Data Sources

In this paper, the micro data of farmers in Heilongjiang Province from 2009 to 2017 from the fixed observation point of the Ministry of Agriculture and Rural Affairs are used for analysis. The reason why

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the data of national rural fixed observation points of the Ministry of Agriculture and Rural Affairs were adopted as the analysis object was that the data of national rural fixed observation points were a rural survey which was established in 1984 with the approval of the Secretariat of the CPC Central Committee and was organized and guided by the Policy Research Office of the CPC Central Committee and the Ministry of Agriculture and continuously tracked in all provinces of the country. It refers to the most comprehensive and detailed long-term tracking panel data for the study of micro farmers' production, life, consumption, employment and other aspects.

The reason why we chose the micro household data of Heilongjiang Province as the analysis object is that Heilongjiang Province is the largest grain producing province in China. As early as 2008, Heilongjiang was included in the pilot scope of the national policy-based agricultural insurance premium subsidy. In Heilongjiang, the number of varieties of premium subsidies provided by the central government has increased from 6 at the beginning to 10 in 2019, and the number of participating farmers has increased from 1.0828 million in 2008 to 2.1789 million in 2019. The premium income of agricultural insurance has exceeded 3.5 billion yuan for four consecutive years. Heilongjiang has always been at the forefront of the country in both density and depth of agricultural insurance premium. Therefore, Heilongjiang Province is chosen as the main object of study in this paper.

2.2 Econometric Model Setting

In this paper, two-way fixed-effect model of panel data is adopted as the benchmark model to analyze the influence of policy-based crop insurance on the "aggregate" input of chemical fertilizers and pesticides at the household level. The specific setting model is shown in (1):

$$Y_{ijt} = \alpha + \beta agrinsurance_{ijt} + \gamma X_{ijt} + \mu_j + \tau_t + \tag{1}$$

In the formula, the explained variable Y_{ijt} represents the situation of farm household j living in village i in the year t. In this paper, the input amount per mu of chemical fertilizer and pesticide of farm household is used to represent the input of chemical fertilizer and pesticide of farm household, respectively. The key explanatory variable $agrinsuance_{ijt}$ indicates whether the farm household j living in the village i has purchased the policy-based crop insurance in the year t.

X_{ijt} is a group of control variables affecting farm household's input of chemical fertilizer and pesticide, including household head characteristics and family characteristics. μ_j is the individual fixing effect of farmers, τ_t is the time fixed effect. It should be noted that there may be endogeneity problems between whether farmers buy policy-based crop insurance and input of pesticides and fertilizers, i.e., buying policy-based crop insurance more significantly tends to increase or reduce input of fertilizers and pesticides.

Based on this, in order to reduce endogeneity problem as much as possible, instrumental variable

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model is adopted in this chapter to further analyze the influence of policy-based crop insurance on the "aggregate" input of fertilizers and pesticides at household level.

1. Explained variables. In this paper, the "aggregate" input per mu of chemical fertilizer and pesticide was selected as the explanatory variable. It should be noted that the "aggregate" input per mu at the household level of chemical fertilizer and pesticide refers to the amount of input per mu after the aggregation of various crops by farmers. That is, according to the input amount of eight kinds of crop fertilizers (wheat, corn, rice, soybean, potato, oil, sugar and cotton) and pesticides in the fourth part of the questionnaire of rural fixed observation points, the average input amount of fertilizer and pesticides per mu is calculated by "aggregate".

2. Core explanatory variables. Whether farmers buy policy-based crop insurance is the core explanatory variable in this chapter. As an effective way to disperse agricultural production risks, agricultural insurance can realize the externalization of agricultural production risks [14]. farmers' purchase of policy-based crop insurance indicates that it helps to spread the risks in agricultural production and operation. Therefore, this chapter chooses whether farmers are insured as the proxy variable of policy-based crop insurance.

3. Control variables. In this paper, according to existing literature [15], the characteristics of household heads and household characteristics are selected as the control variables affecting the "aggregate" input of chemical fertilizers and pesticides at the household level. Specifically, the characteristics of Householder mainly include Householder age, Householder gender, the education level of the Householder, and whether the Householder is a party member.

In this paper, the proportion of off-farm employment hours, total household income, mobile phone ownership and Internet connection are selected as household characteristics. Among them, Householder age refers to the actual age of the Householder and the educational level of the Householder refers to the actual educational level of the Householder, which is used to reflect the human capital of the household [16]. Whether the head of the household is a party member is used to reflect the social capital of the household [17].

In terms of family characteristics, the studies of many scholars show that non-agricultural employment is an important factor affecting farmers' factor input [18-20]. Therefore, this paper chooses the proportion of non-agricultural employment time as the influencing factor to measure the degree of non-agricultural employment of farmers. The total income of the family is an important variable that measures the endowment of the family, which is an important factor affecting the investment of farmers. Whether it has a mobile phone and whether to access the Internet reflects the level of rural information, which is also an important factor affecting the investment of farmers. Detailed variables are shown in Table I.

In Table I, the mean value of whether or not the core explanatory variable farmers have bought policy-based crop insurance is 0.137, which indicates that 13.7% of farmers have bought policy-based crop

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insurance on the whole. Further, Table II reports the changes of farmers' "aggregate" input in fertilizers and pesticides per mu from 2009 to 2017.

As shown in Table II, the input amount of chemical fertilizer and pesticide per mu shows an increasing trend on the whole. The input amount of chemical fertilizer reached the peak value of 126.726 yuan per mu in 2015 and then began to decline. In 2017, the input amount of chemical fertilizer per mu of farmers decreased to 109.771 yuan. This shows that Heilongjiang Province's zero growth in fertilizer use has achieved some results.

The changing trend of the input amount of pesticides per mu is not consistent with that of chemical fertilizers. From 2009 to 2017, the overall trend of the input amount of pesticides per mu shows an increasing trend. Although the input amount of pesticides per mu in 2016 decreased compared with that in 2015, the input amount of pesticides per mu in 2017 still increased.

TABLE I. Descriptive statistics of variables

Type	Segmentation variable	Substitute variables or measures	Mean value	Standard deviation
Dependent variable	Fertilizer input amount per mu	Total fertilizer input/total sown area	104.65	52.37
	Pesticide input amount per mu	Total fertilizer input/total sown area	16.07	9.798
Independen t Variable	Whether to buy policy-based crop insurance	Yes =1, no =0	0.137	0.343
	Householder age	Actual age of householder (year)	52.85	10.90
Characterist ics of the head of the household	Householder gender	Male =1, female =0	0.985	0.123
	Education of householder	Actual education of householder (year)	6.975	1.932
	Whether the householder is a party member	Yes =1, no =0	0.117	0.322
	Percentage of non-farm employment hours	Hours of non-farm employment divided by total hours of employment	0.336	0.361
Family characteristi cs	Family income	Take the log of total household income	10.611	0.804
	Whether with cell phone	Yes =1, no =0	0.304	0.460
	Whether with	Yes =1, no =0	0.168	0.373

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	Internet access			
Instrumental variable	Premium expenditure per household	Average premium expenditure per household in the village by excluding the sample households	34.691	152.732
	Average premium expenditure per mu	Average premium expenditure per household in the village by excluding the sample households	2.832	15.631

Note: It is calculated by the author according to the data of rural fixed observation points in Heilongjiang Province.

TABLE II. Change of input amount of chemical fertilizer and pesticide per mu

Year	Fertilizer input per mu (yuan)	Pesticide input per mu (yuan)
2009	84.373	12.141
2010	84.828	13.133
2011	98.179	14.141
2012	106.171	14.974
2013	113.303	15.690
2014	108.764	18.485
2015	126.726	19.040
2016	117.127	18.999
2017	109.771	19.375

Note: It is calculated by the author according to the data of rural fixed observation points in Heilongjiang Province.

III. EMPIRICAL RESULTS

Empirical estimation is carried out in this chapter. First, the bidirectional fixed effect of panel data is used for estimation. In view of the potential endogeneity between policy-based crop insurance and the "aggregate" input of fertilizers and pesticides per mu at the household level, the panel data two-stage least square method and high-order fixed model are used in this paper to discuss the potential endogeneity.

3.1 The Influence of Policy-Based Crop Insurance on Farm Household's Fertilizer Input

Table III reports the estimation results of the bidirectional fixed-effect model of the panel data for policy-based crop insurance on the "aggregate" input of fertilizers at the household level. Models (1) ~ (3) in Table III report the estimated results without considering the time fixed effect, and models (4) ~ (6) report the estimated results with the time fixed effect.

Among them, Model (1) and Model (4) in Table III are estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) and Model (5) add householder characteristics based on Model (1) and Model (4). Model (3) and Model (6) add family characteristics on the basis of Model (2) and Model (5).

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It can be concluded from Table III that the estimated coefficients of whether farmers bought policy-based crop insurance in Models (1) to (6) are all negative, passing the significance test at the 1% level, indicating that farmers who bought policy-based crop insurance are more inclined to reduce fertilizer input. In Table III, the estimated coefficients of other control variables, such as Householder age, Householder gender, Householder's education level, and whether the Householder is a party member, are all positive, but fail to pass the significance level test. it is therefore indicated that the characteristics of household head have a positive impact on chemical fertilizer input, but fail to pass the significance level test.

Among the family characteristics, only the estimated coefficient of the variable of total household income is positive and passes the significance level test, which indicates that every 1% increase in household income will increase the amount of chemical fertilizer input by 0.039%. Other family characteristic variables do not pass the significance level test.

TABLE III. Baseline regression of farm household's fertilizer input by policy-based crop insurance

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.141***	-0.153***	-0.154***	-0.136***	-0.158***	-0.155***
	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
Householder age		0.014***	0.011***		0.002	0.002
		(0.002)	(0.002)		(0.002)	(0.002)
Householder gender		-0.019	-0.063		0.002	-0.025
		(0.091)	(0.092)		(0.089)	(0.090)
Education		0.029***	0.019**		0.011	0.011
		(0.010)	(0.009)		(0.009)	(0.009)
Party member or nor		0.024	0.026		0.030	0.032
		(0.038)	(0.038)		(0.038)	(0.038)
Non-farm employment ratio			0.016			0.000
			(0.026)			(0.025)
Family income			0.132***			0.039**
			(0.017)			(0.019)
Whether with cell phone			-0.077***			-0.022
			(0.023)			(0.023)
Whether with Internet access			0.026			-0.033
			(0.028)			(0.028)
Constant term	4.543***	3.590***	2.483***	4.369***	4.211***	3.843***
	(0.008)	(0.157)	(0.228)	(0.020)	(0.163)	(0.255)
Time fixed effect	NO	NO	NO	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Observed value	8224	7376	7310	8224	7376	7310

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Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

3.2 Effects of Policy-Based Crop Insurance on Pesticide Input of Farmers

Table IV reports the estimation results of the bidirectional fixed-effect model of the panel data for policy-based crop insurance on the "aggregate" input of pesticide at the household level. Models (1) ~ (3) in Table IV report the estimated results without considering the time fixed effect, and models (4) ~ (6) report the estimated results with the time fixed effect.

Among them, Model (1) and Model (4) in Table IV are estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) and Model (5) add householder characteristics based on Model (1) and Model (4). Model (3) and Model (6) add family characteristics on the basis of Model (2) and Model (5).

It can be concluded from Table IV that the estimated coefficients of whether to purchase policy-based crop insurance in Model (1) to Model (6) are -0.265, -0.259, -0.273, -0.226, -0.236 and -0.243, respectively, which all pass the significance test at the 1% level. It is therefore indicated that the farmers who bought policy-based crop insurance are more inclined to reduce pesticide input. Other control variables in Table IV are basically consistent with those in Table III, which is unnecessary to go into details.

TABLE IV. Baseline regression of pesticide input to farmers by policy-based crop insurance

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.265***	-0.259***	-0.273***	-0.226***	-0.236***	-0.243***
	(0.045)	(0.048)	(0.047)	(0.043)	(0.047)	(0.047)
Householder age		0.025***	0.020***		0.003	0.004*
		(0.002)	(0.002)		(0.003)	(0.003)
Householder gender		-0.001	-0.047		0.045	0.022
		(0.113)	(0.114)		(0.111)	(0.113)
Education		0.045***	0.025**		0.009	0.006
		(0.012)	(0.012)		(0.012)	(0.012)
Party member or nor		0.029	0.026		0.039	0.036
		(0.048)	(0.048)		(0.047)	(0.047)
Non-farm employment ratio			-0.012			-0.029
			(0.032)			(0.032)
Family income			0.230***			0.096***
			(0.021)			(0.024)
Whether with cell phone			-0.082***			-0.004
			(0.028)			(0.029)
Whether with Internet			0.114***			0.014

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			(0.035)			(0.035)
Constant term	2.649***	1.003***	-0.975***	2.323***	2.057***	1.069***
	(0.010)	(0.195)	(0.283)	(0.023)	(0.202)	(0.319)
Time fixed effect	NO	NO	NO	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Observed value	8224	7376	7310	8224	7376	7310

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

3.3 Discussion on Potential Endogeneity

Considering the potential endogeneity of policy-based crop insurance and the "aggregate" input of fertilizers and pesticides per mu at the household level, this study uses the two-stage least square method of panel data and the high-order fixed-effect model to estimate the potential endogeneity.

Table V reports the two-stage least square estimation results of panel data of policy-based crop insurance on farmers' "aggregate" input of fertilizers per mu. Table VI reports the estimation results of high-order fixed effects of policy-based crop insurance on farmers' "aggregate" input of fertilizers per mu. Table VII and Table VIII respectively report the two-stage least square estimation results and the high-order fixed effect estimation results of panel data of policy-based planting industry insurance on the "aggregate" input of pesticides of farmers per mu.

In Table V, Model (1) ~ Model (3) reported the two-stage least square estimation results of panel data of policy-based planting industry insurance on the "aggregate" input of pesticides per mu of farmers, without considering the time fixed effect. Models (4) ~ (6) report the two-stage least squares estimation results of panel data, taking into account the time fixed effect.

Among them, Model (1) and Model (4) in Table V are estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) and Model (5) add householder characteristics based on Model (1) and Model (4). Model (3) and Model (6) add family characteristics on the basis of Model (2) and Model (5).

It should be noted that P values of LM test in models (1) to (6) are all equal to 0, indicating that there is no insufficient identification of instrumental variables. Instrumental variables are related to endogenous explanatory variables, but weak instrumental variables may still exist. The F value of Wald test is far greater than the critical value at the 10% level, so the null hypothesis of "redundancy of instrumental variables" is rejected. This shows that there is no weak instrumental variable in the estimation of instrumental variables. Since this paper takes two instrumental variables, namely, the premium per unit of sample households and the premium expenditure per unit of sample households without the sample households, the Sargan statistic with the over-identification of instrumental variables fails to pass the

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significance test. It is therefore suggested that there is no over-identification of instrumental variables in the selected two instrumental variables. Thus, it is appropriate for this study to select two instrumental variables, namely, the premium per unit of sample households and the premium expenditure per unit of sample households without the sample households, for whether farmers buy policy-based crop insurance.

In Table V, the estimated coefficients of whether to purchase policy-based planting insurance in Models (1) to (6) are all less than zero and pass the significance level test at the 1% level. This indicates that when the instrumental variables are taken into account, the estimated results of policy-based planting industry insurance on the "aggregate" input of fertilizers per mu of farmers are consistent with the baseline regression, that is, the less the "aggregate" input of fertilizers per mu of farmers who buy policy-based planting industry insurance is. In Table V, the estimated results of the control variables are basically consistent with the baseline regression, which will not be repeated here.

TABLE V. Regression of instrumental variables of policy-based crop insurance on farm household's chemical fertilizer input

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.545***	-0.947***	-1.045***	-0.825***	-1.213***	-1.226***
	(0.181)	(0.179)	(0.182)	(0.179)	(0.178)	(0.181)
Householder age		0.014***	0.011***		0.001	0.002
		(0.002)	(0.002)		(0.002)	(0.002)
Householder gender		0.002	-0.032		0.028	0.004
		(0.095)	(0.096)		(0.095)	(0.096)
Education		0.026***	0.014		0.007	0.005
		(0.010)	(0.010)		(0.010)	(0.010)
Party member or nor		0.014	0.012		0.017	0.016
		(0.040)	(0.040)		(0.040)	(0.040)
Non-farm employment ratio			0.003			-0.019
			(0.027)			(0.027)
Family income			0.127***			0.051**
			(0.018)			(0.020)
Whether with cell phone			-0.064***			-0.013
			(0.024)			(0.024)
Whether with Internet access			0.094***			0.049
			(0.032)			(0.033)
Time fixed effect	NO	NO	NO	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Observed value	8194	7307	7241	8194	7307	7241

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

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In Table VI, Model (1) is estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) adds householder characteristics based on Model (1). Model (3) adds family characteristics on the basis of Model (2).

Similar to the two-stage least-squares model of panel data, the LM test statistics in Model (1) to Model (3) pass the significance level test at the 1% level, indicating that there is no insufficient identification of instrumental variables. The F value of Wald test is far greater than the critical value at the 10% level, so the null hypothesis of "redundancy of instrumental variables" is rejected. This shows that there is no weak instrumental variable in the estimation of instrumental variables. The Sargan statistic with the over-identification of instrumental variables fails to pass the significance test. It is therefore suggested that there is no over-identification of instrumental variables in the selected two instrumental variables, namely, the premium per unit of sample households and the premium expenditure per unit of sample households without the sample households. Thus, it is appropriate for this chapter to select two instrumental variables, namely, the premium per unit of sample households and the premium expenditure per unit of sample households without the sample households, for whether farmers buy policy-based crop insurance.

It can be concluded from Table VI that the estimated coefficients of whether to purchase policy-based crop insurance in Model (1) to Model (3) are -0.825,-1.213 and -1.226, respectively, which all pass the significance test at the 1% level. It is therefore indicated that the farmers who bought policy-based crop insurance are conducive to reducing “aggregate” fertilizer input. Other control variables in Table VI are basically consistent with baseline regression, which is unnecessary to go into details.

TABLE VI. Regression of high-order fixed effects of policy-based crop insurance on farmers' chemical fertilizer input

	Model(1)	Model(2)	Model(3)
Whether insured	-0.825***	-1.213***	-1.226***
	(0.179)	(0.179)	(0.182)
Householder age		0.001	0.002
		(0.002)	(0.002)
Householder gender		0.028	0.004
		(0.095)	(0.096)
Education		0.007	0.005
		(0.010)	(0.010)
Party member or nor		0.017	0.016
		(0.040)	(0.040)
Non-farm employment ratio			-0.019
			(0.027)
Family income			0.051**
			(0.020)
Whether with cell phone			-0.013
			(0.024)

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Whether with Internet access			0.049
			(0.033)
Time fixed effect	YES	YES	YES
Individual fixation effect	YES	YES	YES
Observed value	8194	7307	7241

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table VII reports the estimation results of the two-stage least squares of the panel data for policy-based crop insurance on the "aggregate" input of fertilizers at the household level. To be specific, Model (1) ~ Model (3) reported the two-stage least square estimation results of panel data of policy-based planting industry insurance on the "aggregate" input of pesticides per mu of farmers, without considering the time fixed effect. Models (4) ~ (6) report the two-stage least squares estimation results of panel data, taking into account the time fixed effect.

Among them, Model (1) and Model (4) in Table VII are estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) and Model (5) add householder characteristics based on Model (1) and Model (4). Model (3) and Model (6) add family characteristics on the basis of Model (2) and Model (5).

Similar to Table V, firstly, this chapter tests the identification of instrumental variables, weak instrumental variables and excessive identification. As indicated from the results, the LM test statistics in Model (1) to Model (6) pass the significance level test at the 1% level, indicating that there is no insufficient identification of instrumental variables. The F value of Wald test is far greater than the critical value at the 10% level, so the null hypothesis of "redundancy of instrumental variables" is rejected. This shows that there is no weak instrumental variable in the estimation of instrumental variables. The Sargan statistic with the over-identification of instrumental variables fails to pass the significance test. It is therefore suggested that there is no over-identification of instrumental variables in the selected two instrumental variables, namely, the premium per unit of sample households and the premium expenditure per unit of sample households without the sample households.

In Table VII, the estimated coefficients of whether to purchase policy-based planting insurance in Models (1) to (6) are all less than zero and pass the significance level test at the 1% level. This indicates that when the instrumental variables are taken into account, the estimated results of policy-based planting industry insurance on the "aggregate" input of fertilizers per mu of farmers are consistent with the baseline regression, that is, the less the "aggregate" input of fertilizers per mu of farmers who buy policy-based planting industry insurance is. In Table VII, the estimated results of the control variables are basically consistent with the baseline regression, which will not be repeated here.

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TABLE VII. Regression of instrumental variables of policy-based crop insurance on pesticide input of farmers

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.554***	-0.532**	-0.721***	-0.848***	-0.769***	-0.806***
	(0.210)	(0.215)	(0.219)	(0.204)	(0.211)	(0.216)
Householder age		0.025***	0.020***		0.003	0.004
		(0.002)	(0.002)		(0.003)	(0.003)
Householder gender		0.006	-0.031		0.058	0.038
		(0.114)	(0.115)		(0.112)	(0.114)
Education		0.044***	0.022*		0.007	0.003
		(0.012)	(0.012)		(0.012)	(0.012)
Party member or nor		0.026	0.019		0.033	0.027
		(0.048)	(0.048)		(0.047)	(0.048)
Non-farm employment ratio			-0.018			-0.039
			(0.032)			(0.032)
Family income			0.226***			0.102***
			(0.022)			(0.024)
Whether with cell phone			-0.075***			0.001
			(0.029)			(0.029)
Whether with Internet access			0.149***			0.058
			(0.038)			(0.039)
Time fixed effect	NO	NO	NO	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Observed value	8194	7307	7241	8194	7307	7241

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table VIII reports the influence of policy-based crop insurance on farm household' "aggregate" pesticide input per mu under the high-order fixed-effect model. Among them, Model (1) is estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) adds householder characteristics based on Model (1). Model (3) adds family characteristics on the basis of Model (2). Similar to the two-stage least-squares model of panel data, the LM test statistics in Model (1) to Model (3) pass the significance level test at the 1% level, the F value of Wald test is far greater than the critical value at the 10% level, and the Sargan statistic with the over-identification of instrumental variables fails to pass the significance test. It is therefore suggested that there is no insufficient, weak and over-identification of instrumental variables in the selected two instrumental variables, namely, the premium per unit of sample households and the premium expenditure per unit of sample households without the sample households.

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It can be concluded from Table IV-VIII that the estimated coefficients of whether to purchase policy-based crop insurance in Model (1) to Model (3) are -0.848, -0.769 and -0.806, respectively, which all pass the significance test at the 1% level. It is therefore indicated that the farmers who bought policy-based crop insurance are conducive to reducing "aggregate" fertilizer input. Other control variables in Table VI are basically consistent with baseline regression, which is unnecessary to go into details.

TABLE VIII. Regression of high-order fixed effects of policy-based crop insurance on pesticide inputs of farmers

	Model(1)	Model(2)	Model(3)
Whether insured	-0.848***	-0.769***	-0.806***
	(0.205)	(0.211)	(0.216)
Householder age		0.003	0.004
		(0.003)	(0.003)
Householder gender		0.058	0.038
		(0.112)	(0.114)
Education		0.007	0.003
		(0.012)	(0.012)
Party member or nor		0.033	0.027
		(0.047)	(0.048)
Non-farm employment ratio			-0.039
			(0.032)
Family income			0.102***
			(0.024)
Whether with cell phone			0.001
			(0.029)
Whether with Internet access			0.058
			(0.039)
Time fixed effect	YES	YES	YES
Individual fixation effect	YES	YES	YES
Observed value	8194	7307	7241

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

IV. HETEROGENEITY ANALYSIS

In the baseline regression, the estimation results of panel data bidirectional fixed effect model, panel data two-stage least square model and high-order fixed effect model all confirm that policy-based crop insurance has a significant negative impact on farmers' "aggregate" fertilizer and pesticide input per mu. That is, farmers who buy policy-based crop insurance are more inclined to reduce the input of fertilizers and pesticides per mu.

However, there is a general heterogeneity among different farmers. Based on this, this chapter focuses on the impact of policy-based crop insurance on the "aggregate" input of fertilizers and pesticides per mu

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of farmers with different operating scales and different types of farmers from two perspectives, namely, the heterogeneity of the scale of land operation and the heterogeneity of the types of farmers insured.

4.1 Heterogeneity of Land Management Scale

Given the differences in the scale of peasant households' land operation, this chapter divides the scale of farmers' land operation into two categories: large-scale land operation group and small-scale land operation group. It should be noted that farmers' land scale operation is divided according to the operation conditions of sample farmers in different years. Specifically, the average land area of the small-scale land management group takes up 6.62 mu, and the average land area of the large-scale land management group covers 48.89 mu.

Table IX reports the estimated results of the "aggregate" input of fertilizers per mu of farmers by policy-based crop insurance considering scale heterogeneity. Model (1) ~ Model (3) in Table IX report the estimated results of adding the dummy variable of size heterogeneity under the bidirectional fixed effect model of panel data, and Model (4) ~ Model (6) report the estimated results of adding the dummy variable of size heterogeneity under the two-stage least square estimation of panel data.

Among them, Model (1) and Model (4) in Table IX are estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) and Model (5) add householder characteristics based on Model (1) and Model (4). Model (3) and Model (6) add family characteristics on the basis of Model (2) and Model (5).

According to Table IX, the estimated coefficients of whether to purchase policy-based crop insurance in Models (1) to (3) are all less than zero when dummy variables of farm household type are added. This indicates that, considering the heterogeneity of farm household types, farmers purchasing policy-based crop insurance tend to reduce the "aggregate" input of fertilizers per mu, and this conclusion is still true in the models (4) to (6) considering the potential endogeneity.

Similar to the baseline regression, the LM test statistics in Model (4) to Model (6) pass the significance level test at the 1% level, the F value of Wald test is greater than the critical value at the 10% level, and the Sargan statistic with the over-identification of instrumental variables fails to pass the significance test. This indicates that there are no insufficient, weak or excessive identification of instrumental variables in the selection of instrumental variables in the model, and the analysis of instrumental variables can be conducted.

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TABLE IX. Estimated results of fertilizer input of farmers by policy-based crop insurance considering scale heterogeneity

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.106***	-0.134***	-0.131***	-0.813***	-1.183***	-1.192***
	(0.038)	(0.038)	(0.037)	(0.179)	(0.180)	(0.182)
Householder age		0.000	0.001		0.000	0.001
		(0.002)	(0.002)		(0.002)	(0.002)
Householder gender		-0.010	-0.049		0.019	-0.014
		(0.089)	(0.090)		(0.094)	(0.095)
Education		0.012	0.011		0.008	0.005
		(0.009)	(0.009)		(0.010)	(0.010)
Party member or nor		0.030	0.030		0.018	0.014
		(0.037)	(0.037)		(0.040)	(0.040)
Non-farm employment ratio			-0.033			-0.043
			(0.025)			(0.027)
Family income			0.079***			0.081***
			(0.019)			(0.021)
Whether with cell phone			-0.021			-0.013
			(0.023)			(0.024)
Whether with Internet access			-0.023			0.055*
			(0.028)			(0.033)
Constant term	4.476***	4.372***	3.625***	——	——	——
	(0.023)	(0.164)	(0.255)	——	——	——
Time fixed effect	NO	NO	NO	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Size dummy variable	YES	YES	YES	YES	YES	YES
Observed value	8224	7376	7310	8194	7307	7241

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Given the estimated results of Table IX, Table X reports the estimated results for the small-scale and large-scale land operations groups. Among them, Model (1) is the bidirectional fixed effect model of small-scale land management group, and Model (2) is the bidirectional fixed effect model of large-scale land management group. Model (3) and Model (4) are the instrumental variable model estimation results of panel data of small-scale land operation group and large-scale land operation group respectively.

For the instrumental variables in Model (3) and Model (4), the identification test, the test of weak instrumental variables and the test of over-identification are overall passed. In Table X, the estimated coefficients of the small-scale land management group are less than zero in Model (1) and Model (3) and pass the significance test at the 1% level, indicating that the purchase of policy-based planting insurance by

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small-scale farm household helps reduce their input of fertilizers.

In Model (2), the estimated coefficient of whether to purchase policy-based crop insurance is -0.009, which fails to pass the significance level test. In Model (4), given the potential endogeneity, the estimated coefficient of whether to purchase policy-based crop insurance is 0.033, which also fails to pass the significance level test.

The possible reason is that farmers invest in fertilizers to increase yields. For large-scale farmers, the current stage of agricultural insurance is mainly cost insurance, compensation is the basic physical and chemical costs. The aim of large-scale farmers, therefore, is to achieve higher yields, not to lose nothing. Thus, even if farmers take out agricultural insurance, they will still spend more on fertilizer. There is no significant increase in chemical fertilizer input by large-scale farmers who buy policy-based crop insurance, which may be due to the low degree of compensation and insufficient guarantee level of current agricultural insurance.

TABLE X. Estimated results of fertilizer input of farmers of different scales by policy-based crop insurance

	Model(1)	Model(2)	Model(3)	Model(4)
Whether insured	-0.140***	-0.009	-1.128***	0.033
	(0.051)	(0.058)	(0.192)	(0.416)
Householder age	0.001	0.006*	0.002	0.006*
	(0.003)	(0.003)	(0.003)	(0.003)
Householder gender	0.009	-0.017	0.054	-0.019
	(0.111)	(0.151)	(0.118)	(0.152)
Education	0.007	0.004	0.005	0.004
	(0.012)	(0.015)	(0.013)	(0.015)
Party member or nor	0.030	0.005	0.007	0.005
	(0.049)	(0.055)	(0.052)	(0.055)
Non-farm employment ratio	0.061*	-0.043	0.062*	-0.043
	(0.033)	(0.041)	(0.035)	(0.041)
Family income	-0.035	0.257***	-0.035	0.259***
	(0.025)	(0.038)	(0.026)	(0.041)
Whether with cell phone	-0.046	-0.007	-0.041	-0.007
	(0.029)	(0.037)	(0.031)	(0.037)
Whether with Internet access	-0.037	0.016	0.103**	0.014
	(0.039)	(0.043)	(0.049)	(0.043)
Constant term	4.686***	1.317***	——	——
	(0.331)	(0.472)	——	——
Time fixed effect	YES	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES
Observed value	3665	3645	3533	3515

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

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Table XI reports the estimated results of the "aggregate" input of pesticides per mu of farmers by policy-based crop insurance considering scale heterogeneity. Model (1) ~ Model (3) in Table XI report the estimated results of adding the dummy variable of size heterogeneity under the bidirectional fixed effect model of panel data, and Model (4) ~ Model (6) report the estimated results of adding the dummy variable of size heterogeneity under the two-stage least square estimation of panel data.

Consistent with Table IX, Model (1) and Model (4) in Table XI are estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) and Model (5) add householder characteristics based on Model (1) and Model (4). Model (3) and Model (6) add family characteristics on the basis of Model (2) and Model (5).

According to Table XI, the estimated coefficients of whether to purchase policy-based crop insurance in Models (1) to (3) are all less than zero when dummy variables of farm household type are added. This indicates that, considering the heterogeneity of farm household types, farmers purchasing policy-based crop insurance tend to reduce the "aggregate" input of pesticides per mu, and this conclusion is still true in the models (4) to (6) considering the potential endogeneity.

Similar to the baseline regression, the LM test statistics in Model (4) to Model (6) pass the significance level test at the 1% level, the F value of Wald test is greater than the critical value at the 10% level, and the Sargan statistic with the over-identification of instrumental variables fails to pass the significance test. This indicates that the selection of instrumental variables in the model is scientific, and there are no insufficient, weak or excessive identification of instrumental variables in the selection of instrumental variables in the model.

TABLE XI. Estimated results of pesticide input of farmers by policy-based crop insurance considering scale heterogeneity

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.231***	-0.238***	-0.241***	-0.854***	-0.780***	-0.808***
	(0.044)	(0.047)	(0.047)	(0.205)	(0.213)	(0.218)
Householder age		0.003	0.004		0.003	0.004
		(0.003)	(0.003)		(0.003)	(0.003)
Householder gender		0.046	0.020		0.062	0.039
		(0.111)	(0.113)		(0.112)	(0.114)
Education		0.009	0.006		0.007	0.003
		(0.012)	(0.012)		(0.012)	(0.012)
Party member or nor		0.039	0.036		0.033	0.028
		(0.047)	(0.047)		(0.047)	(0.048)
Non-farm employment ratio			-0.032			-0.038
			(0.032)			(0.032)

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Family income			0.100***			0.100***
			(0.024)			(0.025)
Whether with cell phone			-0.004			0.001
			(0.029)			(0.029)
Whether with Internet access			0.015			0.057
			(0.035)			(0.039)
Constant term	2.306***	2.043***	1.050***	——	——	——
	(0.027)	(0.204)	(0.321)	——	——	——
Time fixed effect	NO	NO	NO	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Size dummy variable	YES	YES	YES	YES	YES	YES
Observed value	8224	7376	7310	8194	7307	7241

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table XII reports the estimated results for the small-scale and large-scale land operations groups. Among them, Model (1) is the bidirectional fixed effect model of small-scale land management group, and Model (2) is the bidirectional fixed effect model of large-scale land management group.

Model (3) and Model (4) are the instrumental variable model estimation results of panel data of small-scale land operation group and large-scale land operation group respectively. For the instrumental variables in Model (3) and Model (4), the identification test, the test of weak instrumental variables and the test of over-identification are overall passed. In Table XII, the estimated coefficients of the small-scale land management group are less than zero in Model (1) and Model (3) and pass the significance test at the 1% level, indicating that the purchase of policy-based planting insurance by small-scale farm household helps reduce their input of pesticides.

In Model (2) and Model (4), the estimated coefficients of the large-scale land management group are both less than zero and pass the significance test at the 1% level. This suggests that, similar to small-scale farmers, the purchase of policy-based crop insurance by large-scale farmers helps reduce their pesticide input. Furthermore, the estimated coefficients of purchasing policy-based crop insurance in Model (1) are compared with those in Model (2), Model (3) and Model (4). It is found that purchasing policy-based planting insurance for large-scale farmers reduce the "aggregate" input of pesticides per mu to a higher degree than that for small-scale farmers, and this conclusion is still valid when considering the potential endogeneity.

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TABLE XII. Estimation of pesticide input of farmers of different sizes by policy-based crop insurance

	Model(1)	Model(2)	Model(3)	Model(4)
Whether insured	-0.155**	-0.336***	-0.875***	-1.457***
	(0.066)	(0.075)	(0.236)	(0.562)
Householder age	0.002	0.007*	0.003	0.006
	(0.004)	(0.004)	(0.004)	(0.004)
Householder gender	0.113	0.001	0.147	0.056
	(0.142)	(0.196)	(0.145)	(0.205)
Education	-0.018	0.033*	-0.020	0.024
	(0.016)	(0.019)	(0.016)	(0.021)
Party member or nor	0.028	0.009	0.011	0.004
	(0.063)	(0.071)	(0.064)	(0.074)
Non-farm employment ratio	-0.129***	0.067	-0.129***	0.069
	(0.042)	(0.053)	(0.043)	(0.055)
Family income	0.054*	0.074	0.052	0.030
	(0.032)	(0.049)	(0.033)	(0.055)
Whether with cell phone	-0.006	-0.003	-0.002	0.004
	(0.037)	(0.048)	(0.038)	(0.050)
Whether with Internet access	0.187***	-0.108*	0.288***	-0.091
	(0.050)	(0.056)	(0.060)	(0.058)
Constant term	1.770***	0.958	——	——
	(0.424)	(0.614)	——	——
Time fixed effect	YES	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES
Observed value	3665	3645	3533	3515

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

4.2 Heterogeneity of Types of Insured Farmers

In addition to the heterogeneity of farmers' land management scale, there is also the heterogeneity of their own types. Based on this, this chapter is based on the classification basis of farm household differentiation (Policy Research Office of the CPC Central Committee, Office of Rural Fixed Observation Points, Ministry of Agriculture, 1997; Zhang Chen et al., 2019). To be specific, more than 80% of the total household income accounted for by agricultural income is classified as pure farmers, 20%-80% of farmers are termed as part-time farmers, and less than 20% of farmers are termed as non-farmers.

Table XIII reports the estimated results of policy-based crop insurance on the "aggregate" input of fertilizers per mu at the household level (considering the heterogeneity of household types). Table XIII in model (1) ~ (3) report the estimated results by adding the virtual variables of heterogeneity in farm household type (under bidirectional fixed effect model for panel data), model (4) ~ (6) report the estimation results by adding dummy variables of household type heterogeneity under two-stage least square estimation of panel data.

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Among them, Model (1) and Model (4) in Table XIII are estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) and Model (5) add householder characteristics based on Model (1) and Model (4). Model (3) and Model (6) add family characteristics on the basis of Model (2) and Model (5).

According to Table XIII, the estimated coefficients of whether to purchase policy-based crop insurance in Models (1) to (3) are all less than zero when dummy variables of farm household type are added. This indicates that, considering the heterogeneity of farm household types, farmers purchasing policy-based crop insurance tend to reduce the "aggregate" input of fertilizers per mu, and this conclusion is still true in the models (4) to (6) considering the potential endogeneity.

Similar to the baseline regression, the LM test statistics in Model (4) to Model (6) pass the significance level test at the 1% level, the F value of Wald test is greater than the critical value at the 10% level, and the Sargan statistic with the over-identification of instrumental variables fails to pass the significance test. This indicates that there are no insufficient, weak or excessive identification of instrumental variables in the selection of instrumental variables in the model, and the analysis of instrumental variables can be conducted.

TABLE XIII. Estimating results of fertilizer input of farmers by policy-based crop insurance considering the heterogeneity of farm household types

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.126***	-0.150***	-0.146***	-0.822***	-1.215***	-1.224***
	(0.038)	(0.038)	(0.038)	(0.181)	(0.181)	(0.184)
Householder age		0.001	0.002		0.001	0.002
		(0.002)	(0.002)		(0.002)	(0.002)
Householder gender		0.002	-0.030		0.030	0.004
		(0.089)	(0.090)		(0.095)	(0.096)
Education		0.013	0.012		0.007	0.005
		(0.009)	(0.009)		(0.010)	(0.010)
Party member or nor		0.030	0.032		0.017	0.015
		(0.038)	(0.037)		(0.040)	(0.040)
Non-farm employment ratio			-0.017			-0.021
			(0.026)			(0.028)
Family income			0.051***			0.053**
			(0.019)			(0.021)
Whether with cell phone			-0.024			-0.014
			(0.023)			(0.024)
Whether with Internet access			-0.033			0.050

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			(0.028)			(0.033)
Constant term	4.323***	4.203***	3.714***	——	——	——
	(0.024)	(0.164)	(0.259)	——	——	——
Time fixed effect	NO	NO	NO	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Type dummy variable	YES	YES	YES	YES	YES	YES
Observed value	8224	7376	7310	8194	7307	7241

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table XIV reports the influence of policy-based crop insurance on the "aggregate" input of fertilizers per mu of farmers under different types of farmers. Among them, Model (1) is the estimation result of bidirectional fixed effect model of pure farm household’s panel data, Model (2) is the estimation result of bidirectional fixed effect model of part-time household’s panel data, and Model (3) is the estimation result of bidirectional fixed effect model of non-farm household’s panel data. Model (4) is the estimation result of the least square estimation model for the panel data of pure farmers, Model (5) is the estimation result of the least square estimation model for the panel data of part-time farmers, and Model (6) is the estimation result of the least square estimation model for the panel data of non-farmers. Among them, the identification test of instrumental variables, the test of weak instrumental variables and the test of overidentification in models (4) to (6) are overall passed.

As shown in Table XIV, the estimated coefficients of pure farmers are less than zero in Model (1) and Model (4) and pass the significance test at the 1% level, which indicates that for pure farmers, purchasing policy-based planting industry insurance helps reduce their fertilizer input per mu. The estimated coefficients of the part-time farmers are all less than 0 in Model (2) and Model (5), and pass the significance level test, indicating that for the part-time farmers, purchasing policy-based crop insurance could also help reduce their input of fertilizers per mu. The estimated coefficients of non-farmers in Model (3) and Model (6) are all less than 0 and pass the significance level test, which indicates that for non-farmers, purchasing policy-based crop insurance can also help reduce their input of fertilizers per mu.

By comparing the estimated coefficients of pure farmers, concurrent farmers and non-farmers, it can be found that the purchase of policy-based crop insurance has the greatest reduction in the "aggregate" input of fertilizers per unit area for non-farmers, followed by pure farmers and concurrent farmers. The main reason why purchasing policy-based planting insurance has the lowest reduction in the "aggregate" input of chemical fertilizer per mu for part-time farmers is that part-time farmers must consider both non-agricultural employment and agricultural operation. In order to ensure the yield, they are more inclined to increase the input of chemical fertilizer compared with non-farm farmers and pure farmers.

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TABLE XIV. Estimated results of fertilizer input of different types of farmers by policy-based crop insurance

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.218**	-0.128**	-0.146**	-1.114***	-0.624***	-5.370***
	(0.104)	(0.054)	(0.071)	(0.387)	(0.234)	(1.808)
Householder age	0.007	-0.002	0.003	0.007	-0.002	0.003
	(0.006)	(0.004)	(0.003)	(0.006)	(0.004)	(0.006)
Householder gender	-0.079	0.003	-0.018	-0.047	0.025	-0.035
	(0.298)	(0.189)	(0.090)	(0.304)	(0.192)	(0.196)
Education	0.013	0.003	0.014	-0.009	0.005	-0.015
	(0.027)	(0.018)	(0.011)	(0.029)	(0.018)	(0.025)
Party member or nor	0.146	-0.006	0.028	0.113	-0.016	-0.025
	(0.099)	(0.059)	(0.042)	(0.102)	(0.060)	(0.094)
Non-farm employment ratio	0.100	-0.059	0.102***	0.122	-0.058	0.140**
	(0.098)	(0.039)	(0.030)	(0.101)	(0.040)	(0.067)
Family income	0.251***	0.089**	0.004	0.207**	0.092**	0.093
	(0.082)	(0.037)	(0.022)	(0.085)	(0.038)	(0.057)
Whether with cell phone	-0.042	-0.024	-0.021	-0.020	-0.034	0.031
	(0.062)	(0.040)	(0.029)	(0.064)	(0.041)	(0.066)
Whether with Internet access	0.087	-0.032	-0.072*	0.243*	-0.003	0.093
	(0.105)	(0.042)	(0.038)	(0.125)	(0.044)	(0.100)
Constant term	1.436	3.597***	4.017***	——	——	——
	(0.006)	(0.004)	(0.003)	——	——	——
Time fixed effect	YES	YES	YES	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Observed value	2092	3292	1926	1967	3103	1758

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table XV reports the estimated results of policy-based crop insurance on the "aggregate" input of pesticide per mu at the household level (considering the heterogeneity of household types). Table XV in model (1) ~ (3) report the estimated results by adding the virtual variables of heterogeneity in farm household type (under bidirectional fixed effect model for panel data), model (4) ~ (6) report the estimation results by adding dummy variables of household type heterogeneity under two-stage least square estimation of panel data.

Among them, Model (1) and Model (4) in Table XV are estimated results with only the core explanatory variable (whether to purchase policy-based crop insurance or not) added. Model (2) and Model (5) add householder characteristics based on Model (1) and Model (4). Model (3) and Model (6) add

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family characteristics on the basis of Model (2) and Model (5).

Similar to the baseline regression, the LM test statistics in Model (4) to Model (6) pass the significance level test at the 1% level, the F value of Wald test is greater than the critical value at the 10% level, and the Sargan statistic with the over-identification of instrumental variables fails to pass the significance test. This indicates that there are no insufficient, weak or excessive identification of instrumental variables in the selection of instrumental variables in the model, and the analysis of instrumental variables can be conducted.

According to Table XV, the estimated coefficients of whether to purchase policy-based crop insurance in Models (1) to (3) are all less than zero when dummy variables of farm household type are added. This indicates that, considering the heterogeneity of farm household types, farmers purchasing policy-based crop insurance tend to reduce the "aggregate" input of pesticides per mu, and this conclusion is still true in the models (4) to (6) considering the potential endogeneity.

TABLE XV. Estimated results of pesticide input of farmers by policy-based crop insurance considering the heterogeneity of farm household types

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.229***	-0.236***	-0.239***	-0.861***	-0.775***	-0.804***
	(0.044)	(0.047)	(0.047)	(0.206)	(0.214)	(0.219)
Householder age		0.003	0.004		0.003	0.004
		(0.003)	(0.003)		(0.003)	(0.003)
Householder gender		0.041	0.017		0.056	0.035
		(0.111)	(0.113)		(0.112)	(0.114)
Education		0.009	0.007		0.006	0.003
		(0.012)	(0.012)		(0.012)	(0.012)
Party member or nor		0.041	0.038		0.034	0.029
		(0.047)	(0.047)		(0.047)	(0.048)
Non-farm employment ratio			-0.038			-0.040
			(0.033)			(0.033)
Family income			0.100***			0.100***
			(0.024)			(0.025)
Whether with cell phone			-0.003			0.003
			(0.029)			(0.029)
Whether with Internet access			0.012			0.056
			(0.035)			(0.039)
Constant term	2.302***	2.038***	1.011***	——	——	——
	(0.028)	(0.203)	(0.324)	——	——	——
Time fixed effect	NO	NO	NO	YES	YES	YES

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Individual fixation effect	YES	YES	YES	YES	YES	YES
Type dummy variable	YES	YES	YES	YES	YES	YES
Observed value	8224	7376	7310	8194	7307	7241

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table XVI reports the influence of policy-based crop insurance on the "aggregate" input of fertilizers per mu of farmers under different types of farmers. Among them, Model (1) is the estimation result of bidirectional fixed effect model of pure farm household's panel data, Model (2) is the estimation result of bidirectional fixed effect model of part-time household's panel data, and Model (3) is the estimation result of bidirectional fixed effect model of non-farm household's panel data. Model (4) is the estimation result of the least square estimation model for the panel data of pure farmers, Model (5) is the estimation result of the least square estimation model for the panel data of part-time farmers, and Model (6) is the estimation result of the least square estimation model for the panel data of non-farmers. Among them, the identification test of instrumental variables, the test of weak instrumental variables and the test of overidentification in models (4) to (6) are overall passed.

As shown in Table XVI, the estimated coefficients of pure farmers are less than zero in Model (1) and Model (4) but fail to pass the significance level test, which indicates that for pure farmers, purchasing policy-based crop insurance cannot significantly reduce their input of pesticides per mu.

The possible reason is that the insurance liability of policy-based crop insurance covers the economic loss of crops caused by diseases and pests. However, compared with drought, flood, hail and other natural disasters, the degree of disaster of pure farmers' agricultural management sometimes cannot meet the claim settlement standard of policy-based crop insurance. farmers tend to take the initiative in disaster relief by applying pesticides, so policy-based planting industry insurance does not significantly reduce the pesticide input of pure farmers.

The estimated coefficients of the part-time farmers are all less than 0 in Model (2) and Model (5), and pass the significance level test, indicating that for the part-time farmers, purchasing policy-based crop insurance could also help reduce their input of pesticides per mu. The estimated coefficients of non-farmers in Model (3) and Model (6) are all less than 0 and pass the significance level test, which indicates that for non-farmers, purchasing policy-based crop insurance can also help reduce their input of pesticides per mu. By comparing the estimated coefficients of part-time farmers and non-farmers, it can be found that the purchase of policy-based farming insurance has the highest reduction degree on the "aggregate" input of pesticides per mu for non-farmers, followed by part-time farmers.

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TABLE XVI. Estimated results of pesticide input of different types of farmers by policy-based crop insurance

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.255**	-0.187***	-0.186**	-0.434	-0.623**	-2.239**
	(0.120)	(0.070)	(0.080)	(0.434)	(0.298)	(1.118)
Householder age	0.009	0.004	0.001	0.009	0.004	0.001
	(0.007)	(0.005)	(0.003)	(0.007)	(0.005)	(0.004)
Householder gender	0.022	0.024	0.039	0.029	0.044	0.037
	(0.343)	(0.243)	(0.102)	(0.341)	(0.245)	(0.121)
Education	0.056*	-0.036	-0.014	0.051	-0.035	-0.025
	(0.030)	(0.022)	(0.012)	(0.032)	(0.023)	(0.016)
Party member or nor	0.096	-0.008	0.024	0.089	-0.017	0.003
	(0.114)	(0.075)	(0.048)	(0.115)	(0.076)	(0.058)
Non-farm employment ratio	0.086	-0.030	0.009	0.091	-0.029	0.024
	(0.113)	(0.050)	(0.034)	(0.113)	(0.050)	(0.042)
Family income	-0.100	0.162***	-0.077***	-0.108	0.164***	-0.045
	(0.094)	(0.048)	(0.025)	(0.096)	(0.048)	(0.035)
Whether with cell phone	0.063	-0.035	-0.036	0.067	-0.044	-0.015
	(0.071)	(0.052)	(0.033)	(0.072)	(0.052)	(0.041)
Whether with Internet access	-0.028	0.021	0.096**	0.004	0.049	0.159**
	(0.121)	(0.053)	(0.043)	(0.141)	(0.056)	(0.062)
Constant term	2.403**	0.740	3.131***	——	——	——
	(1.102)	(0.644)	(0.336)	——	——	——
Time fixed effect	YES	YES	YES	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Observed value	2092	3292	1926	1967	3103	1758

	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)	Model(6)
Whether insured	-0.255**	-0.187***	-0.186**	-0.434	-0.623**	-2.239**
	(0.120)	(0.070)	(0.080)	(0.434)	(0.298)	(1.118)
Householder age	0.009	0.004	0.001	0.009	0.004	0.001
	(0.007)	(0.005)	(0.003)	(0.007)	(0.005)	(0.004)
Householder gender	0.022	0.024	0.039	0.029	0.044	0.037
	(0.343)	(0.243)	(0.102)	(0.341)	(0.245)	(0.121)
Education	0.056*	-0.036	-0.014	0.051	-0.035	-0.025
	(0.030)	(0.022)	(0.012)	(0.032)	(0.023)	(0.016)
Party member or nor	0.096	-0.008	0.024	0.089	-0.017	0.003
	(0.114)	(0.075)	(0.048)	(0.115)	(0.076)	(0.058)
Non-farm employment ratio	0.086	-0.030	0.009	0.091	-0.029	0.024
	(0.113)	(0.050)	(0.034)	(0.113)	(0.050)	(0.042)

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Family income	-0.100	0.162***	-0.077***	-0.108	0.164***	-0.045
	(0.094)	(0.048)	(0.025)	(0.096)	(0.048)	(0.035)
Whether with cell phone	0.063	-0.035	-0.036	0.067	-0.044	-0.015
	(0.071)	(0.052)	(0.033)	(0.072)	(0.052)	(0.041)
Whether with Internet access	-0.028	0.021	0.096**	0.004	0.049	0.159**
	(0.121)	(0.053)	(0.043)	(0.141)	(0.056)	(0.062)
Constant term	2.403**	0.740	3.131***	——	——	——
	(1.102)	(0.644)	(0.336)	——	——	——
Time fixed effect	YES	YES	YES	YES	YES	YES
Individual fixation effect	YES	YES	YES	YES	YES	YES
Observed value	2092	3292	1926	1967	3103	1758

Note: The figures outside the brackets are the estimated coefficients, and the figures inside the brackets are the standard deviations under the coefficients. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

V. CONCLUSION

Given the panel data of farmers from 2009 to 2017 at fixed observation points in rural areas of Heilongjiang Province, this paper explores the impact of policy-based crop insurance on farmers' "aggregate" input of pesticides and fertilizers per mu. Further, considering the potential endogenous and heterogeneous problems between policy-based crop insurance and the "aggregate" input of pesticides and fertilizers, a comprehensive analysis is carried out from two dimensions of land scale heterogeneity and farm household type heterogeneity. The research conclusion shows that:

First, policy-based crop insurance has a significant negative impact on farmers' fertilizer input per mu. In the baseline regression, the estimation results of panel data bidirectional fixed effect model, panel data two-stage least square model and high-order fixed effect model all confirm that policy-based crop insurance has a significant negative impact on farmers' fertilizer input per mu.

Furthermore, considering the heterogeneity of land operation scale, policy-based crop insurance has a significant negative impact on the fertilizer input per mu of small-scale farmers, while a positive but not significant impact on the fertilizer input per mu of large-scale farmers. The possible reason is that large-scale farmers, whose business objective is to achieve increased yields, are more inclined to increase fertilizers to achieve increased yields.

Given the heterogeneity of farm household types, whether pure farmers, part-time farmers or non-farmers, purchasing policy-based crop insurance can help reduce their per mu chemical fertilizer input, and the per mu chemical fertilizer input of non-farmers can be reduced to the maximum extent.

Second, policy-based crop insurance has a significant negative impact on farmers' input of pesticides per mu. In the baseline regression, the estimation results of panel data bidirectional fixed effect model, panel data two-stage least square model and high-order fixed effect model all confirm that policy-based crop insurance has a significant negative influence on farmers' per mu pesticide input.

Furthermore, given the heterogeneity of land operation scale, policy-based crop insurance has a significant negative impact on the per mu pesticide input of both small-scale farmers and large-scale farmers, and reduces the per mu pesticide input of large-scale farmers to a greater extent. Given the heterogeneity of farm household types, purchasing policy-based crop insurance can help reduce the per mu pesticide input of part-time farmers and non-farmers, but the reduction degree of per mu pesticide input of pure farmers is not significant.

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