Article

The Impact of Cost-of-Production Insurance on Input Expense of Fruit Growing in Ecologically Vulnerable Areas: Evidence from Shaanxi Province of China

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Abstract: Planting fruit trees in ecologically vulnerable areas is an effective approach to achieving the goal of ecological protection and improving farmers' livelihoods. However, in ecologically vulnerable areas, farmers still face agricultural production risks such as natural disasters, diseases, and pests. In order to help fruit growers avoid these risks and ensure the sustainability of their livelihoods, the Chinese government has launched cost-of-production (COP) insurance in these areas. Although previous studies have shown that the purchase of revenue- or yield-based crop insurance will change insured farmers' input expense of chemicals in agricultural production, the existing literature lacksa discussion on how COP insurance affects the input expense of chemicals in fruit growing. Here, we address the existing research gap from both theoretical and empirical aspects by conducting surveys in 1051 households of fruit growers in the Shaanxi province of China. Theoretical deduction reveals that the COP insurance on input expenditure of chemicals can have an increasing effect. Using the 2SLS model and empirical analysis, we found that the insured fruit growers spent more on using chemical fertilizers and pesticides compared to non-insured fruit growers. These findings demonstrate that the COP insurance's positive marginal incentive to apply more input expense of chemicals in production dominates the negative moral hazard effect.

Keywords: cost-of-production insurance; input expense; sustainability of fruit grower' livelihood

1. Introduction

In the past two decades, sustainable development and environmental protection have been regarded as the core goals of social development worldwide [1]. In ecologically vulnerable areas of developing countries, farmers' livelihoods activities are often at the core of the contradiction between economic growth and environmental protection. Ways to improve the living standards of the people in these areas, protect the local ecological environment, and promote the sustainable development of rural areas have always been the concern of government departments and scholars in developing countries. Therefore, appropriate policy tools are required to achieve a win-win outcome that promotes both farmers' income increase and natural ecological protection in ecologically vulnerable areas.

In China, as a supporting tool of the ecological protection plan, the government has launched cost-of-production (hereinafter called COP) insurance for fruit growing in ecologically vulnerable areas. The aim of launching COP insurance in those areas is to increase farmers' abilities to resist the production risks of fruit growing (e.g., natural disasters, diseases, and insect pests), and improve their livelihood sustainability. Farmers' input expense of chemical fertilizers and pesticides is key to determining the amount of COP insurance claims after the occurrence of productive risks [2,3]. Moreover, as a "green box" policy allowed by WTO to support agricultural development and guarantee

farmers' income, most developed countries and developing countries have implemented crop insurance programs (i.e., crop insurance is considered to have less effect on trade-distorting by the WTO) [4–6]. Over the past decades, crop insurance has been growing in both coverage and premium income [2,7,8]. In China, 68% of villages have purchased crop insurance and 80% of farmers have a positive attitude towards crop insurance [9]. The premium income of crop insurance increased from RMB 13.568 billion (RMB 1 is equal to around USD 0.15) in 2010 to RMB 81.493 billion in 2020 according to official statistics of the China Banking and Insurance Regulatory Commission, with an average annual growth rate of 18.99%. Therefore, the continuous development of crop insurance, as a risk management tool, has been widely recognized by farmers all over the world.

In recent years, academia has been paying attention to the impact of crop insurance on farmers' use or expense of chemical fertilizers and pesticides, because the use of these chemicals affects the ecological environment (e.g., agricultural non-point source pollution). To date, most scholars have investigated the impact of revenue- or yield-based crop insurance on chemicals' use, and a few scholars have focused on the impact of COP crop insurance on these chemicals' use or expense. Horowtiz and Lichtenberg [10] and He et al. [2] theoretically proved that crop insurance may have both positive and negative effects on the chemicals' input amount or expense of insured farmers on agricultural production. Their respective empirical analysis, based on data from crop farmers in the United States and the Philippines, show that the purchase of crop insurance will significantly promote the growth of chemicals' (such as pesticides and fertilizers) use and the expense on agricultural production. On the contrary, Babcock and Hennessy [11], Smith and Goodwin [12], Goodwin et al. [13], and other empirical analyses using the data of crop farmers in different regions of the United States show that the chemicals' input use in agricultural production is lower than that of farmers without insurance. Some scholars have shown that farmers' purchase of revenue- or yield-based crop insurance has no significant impact on their chemicals' input use in agricultural production, or has little or no direct impact, or has both positive and negative effects. For example, Quiggin et al. [14] found that crop insurance has a negative impact on the input use of farmers' chemicals, but the impact is not significant. Goodwin and Smith [15] concluded that the implementation of a federal crop insurance program has little impact on the input use of chemicals in agricultural production. Weber et al. [16] showed that crop insurance had no direct impact on farmers' input use in agricultural production, while Roll [17] found that crop insurance had both positive and negative impacts on farmers' chemical input use in agricultural production. The above studies show that the empirical analysis of the impact of existing crop insurance on farmers' input use in agricultural production has not reached a unanimous conclusion.

Thus, the theoretical mechanism of influence between COP insurance purchase and chemical inputs in fruit growing is still not yet fully understood. COP fruit growing insurance is different from the introduction of revenue- or yield-based crop insurance in developed countries (such as the United States) and the widespread use of COP crop insurance in China and other developing countries (such as the Philippines).When natural disasters, diseases, and insect pests cause damage to the insured farmers' fruit growing, the insurance company compensates them for the total input expense of chemical fertilizer and pesticide, compared to COP crop insurance that only compensates part of the input expense of chemicals [18]. To date, there is also little empirical evidence on how and to what extent COP insurance affects chemical inputs in fruit growing. The use of COP fruit growing insurance is expected to play an important role in ecologically vulnerable areas of China. Like Shaanxi, a few provinces in many ecologically vulnerable areas of China (such as Gansu and Qinghai), are now preparing for offering COP insurance to fruit growers. The potential expansion in the uptake of COP fruit growing insurance is a positive signal that it is necessary to further study the possible consequence of the insurance on input expense. Such consequences ultimately affect the ecological environment since COP fruit growing insurance influences chemical fertilizer and pesticide application, which in turn could cause pollution of nearby bodies of soil and water. A polluted environment threatens

farmers' livelihood sustainability (i.e., soil quality degradation and water pollution reduce agricultural output benefits) in the long run.

Our study makes significant contributions to the current scholarly literature. Firstly, it sheds new light on theoretical analysis of COP insurance's purchase and chemical inputs in fruit growing. Secondly, it fills the gap in the literature by providing empirical analysis based on survey data from the Shaanxi province of China. Thirdly, it provides an important opportunity to advance the understanding of the relationship between COP insurance's implementation and fruit growers' environmentally friendly behavior in ecologically vulnerable areas. Moreover, it offers some insights for other developed countries that have gradually started to implement COP insurance in the field of crop production. For example, in the United States and Canada, private insurers have recently carried out COP insurance [2].

The remaining article is structured as follows. Section 2 introduces the study area, survey method, and data source. Section 3 describes basic empirical results and robust test. Section 4 analyzes and discusses the empirical results. Section 5 presents the conclusion of this article and provides forward corresponding policy suggestions.

2. Theoretical Framework

In this section, we carry out a theoretical deduction for revealing how COP insurance affects the input expense of chemicals in fruit growing. Our work builds upon the Cobb-Douglas production function that was developed by Charles W. Cobb and Paul H. Douglas in the second quarter of the 20th century [19]. Theoretically speaking, a rational person always tends to pursue utility maximization when making decisions. In addition, decision-makers should look forward to the current situation and future development and respond to the possible gains and losses. When it comes to agricultural production decision-making, farmers always pursue utility maximization in agricultural production, that is, selecting an appropriate input expense to maximize the utility of the economic return. However, as far as farmers are concerned, it is impossible to confirm whether natural disasters, pests, and diseases will occur in the future. Hence, the original intention of farmers to purchase COP insurance is to minimize the economic losses caused by disasters and to maximize the income achieved by agricultural production in the current year. In fact, after purchasing COP insurance, farmers raise their expectations of higher income. Within such expectations, COP insurance promotes the increase in farmers' immediate consumption of production. As a part of this consumption, input expenses will also increase accordingly. It should be noted that the final performance of farmers to improve the amount of input in agricultural production can be effectively measured by monetary capital.

This article establishes a farmer production model to study the decision-making behavior of production input when farmers participate or not in COP fruit growing insurance, so as to demonstrate that the participation of COP fruit growing insurance will promote farmers to spend more on production input. It is assumed that farmers can freely choose to participate or not in COP fruit growing insurance in a period of the production cycle. Meanwhile, it is assumed that in the production cycle, whether farmers participate in the COP fruit growing insurance or not, their agricultural production risks are the same. In addition, it is assumed that the agricultural production behavior of farmers is similar to that of general enterprises, and the goal is to maximize the interests. Therefore, farmers can always balance the long-term and short-term interests and pursue reasonable production arrangements [20], that is, a farmer's production behavior can be expressed by the Cobb–Douglas production function as follows:

$$Y = AL^{\partial}K^{\beta} \tag{1}$$

s.t. $A > 0$, $L > 0$, $K > 0$, $0 < \partial < 1$, $0 < \beta < 1$.

In Equation (1), Y is the farmers' benefits from fruit production. A represents the current production technology level of farmers and assumes that it will remain unchanged in the short term. L represents the amount of labor input of farmers. The labor input

in China's agricultural production mainly comes from within the household at present, showing the characteristics of "non-employment" [21]. In the short term, the amount of labor within the household will not change, so this article also assumes that L will remain unchanged in the short term. K is the capital input (i.e., input expense) in fruit growing. ∂ and β are separate elasticity coefficients of labor input and capital input, respectively.

In order to simplify the analysis, $C(C > 0)$ is assumed to be the insurance premium of farmers' COP fruit growing insurance. The probability of risk occurrence within the scope of the insurance company's natural compensation is p $(0 < p < 1)$. If the risk p occurs, the insurance will compensate (assuming that there is no deductible) and the compensation rate is $\lambda(0 < \lambda \leq 1)$, so the compensation that farmers can get from the insurance company is λK. With these assumptions, some equations can be derived.

Firstly, considering the situation of not buying COP insurance, farmers choose their agricultural input expense. Then the net income of farmers without insurance is:

$$W_1 = -K_1 p + (Y - K_1)(1 - p) = AL^{\partial} K_1^{\beta}(1 - p) - K_1 \tag{2}$$

Therefore, the equilibrium conditions for the maximum production target of the farmers without insurance are as follows:

$$\frac{\partial W_1}{\partial K_1} = \beta AL^{\partial} K_1^{\beta-1}(1 - p) - 1 = 0 \tag{3}$$

Secondly, in the case of purchasing COP insurance, farmers choose their agricultural input expense K_2. Then the net income under the condition of farmers participating in the COP insurance is:

$$W_2 = (\lambda K_2 - K_2 - C)p + (Y - K_2 - C)(1 - p) = AL^{\partial} K_2^{\beta}(1 - p) + \lambda K_2 p - K_2 - C \tag{4}$$

Therefore, the equilibrium conditions for maximizing the production target under the condition of farmers' participation are as follows:

$$\frac{\partial W_2}{\partial K_2} = \beta AL^{\partial} K_2^{\beta-1}(1 - p) - 1 + \lambda p = 0 \tag{5}$$

Comparing Equations (3) and (5), the following equation holds:

$$\beta AL^{\partial} K_1^{\beta-1}(1 - p) - 1 = 0 = \beta AL^{\partial} K_2^{\beta-1}(1 - p) - 1 + \lambda p \tag{6}$$

Because $\lambda p > 0$, $A > 0$, $L > 0$, $0 < \partial < 1$, and it has been assumed that A, L will remain unchanged in the short term, so, there is an inequality equation:

$$\beta AL^{\partial} K_1^{\beta-1}(1 - p) > \beta AL^{\partial} K_2^{\beta-1}(1 - p) \tag{7}$$

Furthermore, Equation (7) can be derived as the following:

$$K_1^{\beta-1} > K_2^{\beta-1} \tag{8}$$

Because $K > 0$ and $0 < \beta < 1$.

Therefore, based on the above deduction, we can obtain $K_1 < K_2$, that is, after farmers participate in COP insurance, they will increase input expense in fruit growing.

The above theoretical analysis and deduction show that the production input expense of farmers participating in COP fruit growing insurance is higher than that of farmers not participating in the insurance. We will now empirically test such a conclusion by using survey data from Shaanxi, China.

3. Materials and Methods

3.1. Study Area

Our study focused on three counties (Luochuan, Yangling, and Chenggu)in Shaanxi province, which is located in the hinterland of China, across the temperate, warm temperate, and subtropical climate zones(see Figure 1).Shaanxi province has one of the most ecologically vulnerable areas in China. Historically, severe soil erosion, sandification, and other environmental problems have frequently appeared. Therefore, Shaanxi province is the main region for implementing the national program of ecological protection in China [18].
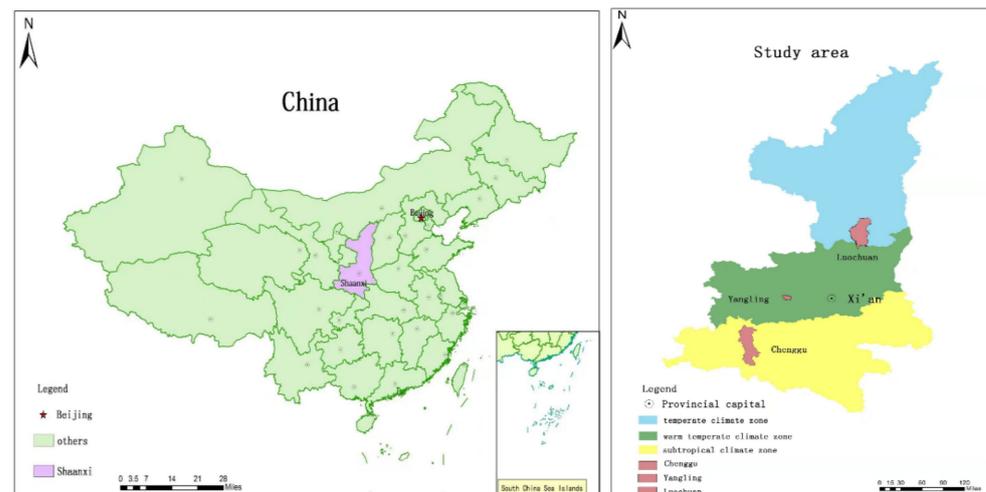

Figure 1. Locations of surveyed counties in the Shaanxi province of China.

The main type of topography includes hilltops and steep slopes at our study sites, which are most likely to experience severe soil erosion and other adverse effects on the environment [20]. In order to protect the ecological environment and enhance the sustainability of local farmers' livelihood in our study areas, the government of Shaanxi province launched COP insurance for apple, kiwi, and citrus planting in Luochuan, Yangling, and Chenggu in recent years. The aim of choosing these three counties as pilot areas of COP fruit growing insurance is to expect COP insurance to be one part of ecologically conservation programs. Additionally, the study area is also the main implementation region of COP fruit growing insurance in the entire nation.

The COP fruit growing insurance in China is mainly covered by the state-owned enterprise PICC (People's Insurance Company of China) and has been promoted in China's ecologically vulnerable areas to some degree. COP fruit growing insurance belongs to commercial insurance and fruit growers can choose to buy it voluntarily. The local government usually subsidizes 40% of the insurance premium, and the remaining 60% needs to be paid by fruit growers themselves. In addition, PICC is responsible for compensating the direct input expense (i.e., input cost of chemical pesticides and fertilizers in total) of fruit farmers after the occurrence of natural disasters, pests, and diseases.

3.2. Survey Method and Data Source

This survey is divided into two stages. The first stage was a household survey conducted in July 2019, which was to collect information on the farmers. The second stage was a telephone follow-up survey after the end of fruit picking in October 2019, where the input expense of farmers in this year was tracked again. In order to ensure the quality of data, the research group used a multi-stage stratified sampling method to collect data. Firstly, considering the geographical location and pilot areas of COP fruit planting factors, Luochuan County (northern Shaanxi, temperate climate zone), Yangling County (central Shaanxi, warm temperate climate zone), and Chenggu County (southern

Shaanxi, subtropical climate zone) were selected as sample collection areas. Secondly, three towns were chosen randomly in both Luochuan and Chenggu counties. Only two towns in Yangling were engaged in kiwi fruit cultivation because they are viewed as ecologically vulnerable areas by the local government. As a result, these two towns in Yangling were non-random samplings. Thirdly, three sample villages were chosen randomly in every town. Finally, 60–75 rural households were chosen randomly from each village, and the head of the household was chosen from each household for a one-to-one questionnaire survey. A total of 1051 valid surveys were obtained.

We investigated and obtained information on the economic and social characteristics, production, and management of every household. We collected farmers' participation in COP fruit growing insurance in detail including the reasons for participation and non-participation, the indemnity amounts received by insurance participation, and the economic losses suffered by non-insurance participation. It should be noted that Chinese farmers generally do not have the habit of recording the input amounts of chemical pesticides and fertilizers in detail and they usually record the input expense of chemicals in agricultural production. Therefore, we focused on the investigation of the farmers' input expense of chemical pesticides and fertilizers in a production cycle.

The data in this article are derived from the household field survey with the theme of "fruit growers' COP insurance purchase" carried out by the research group in Shaanxi province of China in 2019. For this study, the sample objects can be considered under the same analytical framework. Those three kinds of fruits (i.e., citrus, apple, and kiwi) not only have the basically same production cycle, but also their production and operation risks (i.e., low temperature, hail and other natural disasters, diseases, and insect pests will have a serious impact on their growing) are similar. Due to the growing process similarities concern, it is feasible to analyze the effect of COP insurance on three kinds of fruits on input expense. Therefore, taking such three kinds of fruits in Shaanxi province as the research samples can eliminate the interference of the period factors caused by different fruits' growth cycles, thus avoiding the estimation bias caused by the lack of comparability of the research objects as much as possible.

3.3. Econometric Model and Variable Selection
3.3.1. Econometric Model

In order to confirm and analyze the role of COP insurance in promoting fruit farmers to increase production input expense, this article establishes the following econometric model.

$$E_i = b_0 + b_1 Insurance + b_2 X_i + \mu_i \tag{9}$$

E_i is the dependent variable, which represents the logarithm of the production input average expense (i.e., RMB) per Mu (1 Mu is equal to 666.67 square meters) of chemical fertilizers and pesticides by the farmer i. The reason for taking the logarithm value of input expense is to eliminate the negative impact of excessive data on the analysis, that is, eliminating the possible influence of dimension and heteroscedasticity on the dependent variable. *Insurance* is the core explanatory variable, which indicates the COP fruit growing insurance purchase of the farmer i. If the COP insurance is purchased, the value is 1, otherwise, the value is 0. X_i is a vector of control variables, including farmer i' s household characteristics (e.g., population members of the household), household-head's characteristics (e.g., household-head's age), orchard land characteristics (e.g., actual planting area of the orchard), region, and other factors that may have a potential impact on farmers' input expense on agricultural production. μ_i is the independent and identically distributed residual term. The definitions of explanatory variables are given in the following section.

3.3.2. Variable Selection
Core Explanatory Variable

The core explanatory variable *Insurance* is whether the fruit growers purchased a COP fruit growing insurance in 2019.

Control Explanatory Variables

The control variable *Income* is the logarithm of the annual income of the farmers in 2018. Because the range of sample farmers' income is very wide, in order to eliminate the negative impact of variability on the analysis, this study takes the logarithm of sample farmers' annual income in 2018 to reduce the absolute value of the data. In general, farmers with higher annual income have more disposable income, so they have abilities to spend more inputs on agricultural production in order to receive better economic returns.

The control variable *proportion* is the proportion of agricultural income in the total income of the interviewed farmers in 2018, which is expressed as a decimal of 100%. With the continuous development of China's market economy, the income sources of Chinese farmers' families have diversified, both from agricultural operation income and non-agricultural income (e.g., they travel to the city to engage in construction, housekeeping, and other service work in their spare time). Therefore, household agricultural income accounts for a large proportion of the total income, which means that household economic income depends on agriculture, and it will increase input costs to obtain better economic returns.

The control variable *Members* is the total household population of the surveyed farmers. The larger families usually have higher consumption expenditure, and thus more factors of production need to be invested in exchange for more economic income to support the consumption of the entire family. Therefore, the household size will also affect the production input expense of fruit growers.

Three control variables, which reflect the household-head's characteristics, are used to indicate the differences of fruit growers. The control variable *Gender* is the gender of the head of household, which is a binary variable. If the head of a rural household is a male, the value is 1, and if the head of a rural household is a female, the value is 0. The control variable *Age* is the age of the head of the rural household(unit: year). The control variable *Education* is the educational years of the head of the household. In the patriarchal system in rural China, the head of the household is the main decision-maker of family economic activities, and the behavior result of the head of the rural household is generally closely related to their years of education. Therefore, the educational years of the head will also have an impact on the input expense of family agricultural production.

The control variable *Area* is the actual orchard planting area (unit: Mu in Chinese) of the surveyed farmers in 2019. The size of the orchard affects the farmers' input expense of agricultural production. A larger orchard usually requires a higher level of agricultural production input for fruit growers. The control variable *Distance* is the average distance (unit: km) from the orchard to the nearest road in 2019. The transportation cost is also a part of the production cost, so the distance from the orchard to the nearest road will also affect the input expense for fruit growers. The control variables *Yangling* and *Luochuan*, which reflect the natural conditions of the study area, respectively represent Yangling County and Luochuan County. These two variables are binary variables. *Yangling* is set to 1 if the farmer plants fruit trees in Yangling and 0 otherwise. Similarly, *Luochuan* is set to 1 if the farmer plants fruit trees in Luochuan and 0 otherwise. Compared to Chenggu County, the frequency of extreme weather in Yangling and Luochuan is higher, and there are more diseases and pests. Therefore, the regional variables will also have an impact on the input expense of agricultural production. The definitions and basic statistical values of the above variables are shown in Table 1.

Table 1 shows the average values of the main variables. Comparing the average value of variables *Input, Income, Proportion, Members, Gender,* and *Education* between the uninsured and insured fruit growers, we find thatthese average values of uninsured fruit growers are not only lower than those of the insured fruit growers but also lower than the those of the entire interviewed fruit growers. In contrast, the age of the uninsured farmers and the average distance between the orchard and the nearest road is not only higher than those of the insured fruit growers but also higher than those of the total fruit growers. The descriptive statistical results show that, in terms of the average values of the main variables, there are significant differences between the insured and uninsured fruit growers.

Table 1. List of variables.

Variable Type	Variable Name	Unit	Definition	Mean and SD Uninsured Obs.	Mean and SD Insured Obs.	Mean and SD Total Obs.
Dependent variable	Input	RMB per Mu	Logarithm of farmers' input expense of fruit growing in 2019	3.113 (0.322)	3.377 (0.259)	3.142 (0.326)
Core independent variables	Insurance		1 = the interviewed farmers purchased COP fruit growing insurance in 2019 and 0 otherwise	0 (0)	1 (0)	0.109 (0.312)
Control independent variables	Income	RMB	Logarithm of the annual income of the interviewed farmers in 2018	4.576 (0.737)	4.636 (0.957)	4.583 (0.764)
	Proportion	Decimals of the hundred	Proportion of agricultural income in total income of the surveyed farmers in 2018	0.623 (0.524)	0.785 (0.365)	0.641 (0.511)
	Members		Total members of household population	4.092 (1.336)	4.435 (1.208)	4.129 (1.327)
	Gender		1 = gender of the head of household is male and 0 otherwise.	0.969 (0.179)	0.983 (0.131)	0.971 (0.175)
	Age	Year	Age of head of household	53.506 (9.909)	49.974 (9.923)	53.120 (9.967)
	Education	Year	The number of years of education for the head of household is calculated from the first grade of primary school.	8.661 (3.210)	9.322 (3.213)	8.734 (3.215)
	Area	Mu	The actual planting area of the orchard in 2019	7.469 (7.974)	13.219 (8.634)	8.098 (8.234)
	Distance	Kilometers	The average distance between the orchard and the trunk road in 2019.	2.003 (2.921)	1.293 (1.945)	1.925 (2.838)
	Yangling		1 = the farmers are in Yangling District and 0 otherwise	0.252 (0.434)	0.200 (0.402)	0.246 (0.431)
	Luochuan		1 = the farmers are in Luochuan County and 0 otherwise.	0.318 (0.466)	0.783 (0.414)	0.369 (0.483)
	Chenggu		1 = the farmers are in Chenggu County and 0 otherwise.	0.429 (0.495)	0.017 (0.131)	0.384 (0.487)

Note: Obs. is the observed value, and the total Obs. is 1051; mean is average; SD is the standard deviation shown in brackets.

3.3.3. Endogenous Test

There is a challenge that the behavior of insurance purchase variable, *Insurance*, might be endogenous to estimate Equation (9). The *Insurance* variable, in the field of insurance study, is generally considered to be endogenous because of adverse selection. If a farmer who has some private information about the risk probabilities, self-selects into insurance (i.e., to purchase insurance), then adverse selection occurs [2]. In fact, a farmer's personal insurance purchase and other behaviors can be affected by their own private information. In our context, taking a fruit grower as an example, they may hold some private information that their orchard has a high occurrence probability of severe risk events in the coming year. As a result, such a farmer would prefer purchasing insurance for the sake of risk aversion. In order to correct for this potential endogeneity bias, we use the instrumental variable method for two-stage estimation to solve this problem.

To address the potential selection bias and guarantee the chosen instrumental variable could not be contaminated by a farmers' private information, we use the COP fruit growing insurance participation rate of other farmers, who live in the same village and their age groups are also the same to be as an instrumental variable. Within the study's framework, a household head can be a representative of a rural household in China. As a result, a farmer refers to a head of a rural household in the process of our endogenous test. Furthermore, in ecologically vulnerable areas, the ages of those people who plant fruit trees are mainly from 30 to 70 years old, and thereby we divide the following four age groups: 40 years old and below, 41–50 years old, 51–60 years old, and over 60 years old. There are peer effects among farmers who live in the same village. In the process of purchasing insurance, peer effects come from interactions between peer groups (farmers) in the same village. For example, if a farmer's peers (i.e., neighbors, friends, or relatives) in the same village purchase COP fruit growing insurance, then they learn directly from their peer groups to buy the same insurance. The peer effects affect a farmer's decision-making about COP insurance purchase. Giesbert and Steinefound that there exist peer effects of purchasing agricultural insurance among peer groups in the same village [22]. Moreover, in our context, an insured farmer's input expense on agricultural production has no direct relationship with his or her insured peers' participation rate of COP fruit growing insurance. Therefore, it is appropriate to select the COP fruit growing insurance participation rate of a farmer's peers in the same village as the instrumental variable of his or her participation in COP fruit growing insurance.

4. Results

4.1. Basic Empirical Results

Before the empirical analysis, we conducted a collinearity test on the core explanatory variables and control variables to ensure that the estimated results of the model will not be biased. The results show that the maximum value of the variance expansion factor (VIF) is 1.78, which is far less than its critical value of 10 [23,24]. Therefore, there is no collinearity among the explanatory variables, so it can be directly modeled. All the empirical analysis results are shown in Table 2.

Table 2. OLS and 2SLS estimation results.

Variable	OLS		2SLS	
	Coefficient	Robust Std. Err.	Coefficient	Robust Std. Err.
Insurance	0.074 ***	0.027	0.295 **	0.121
Income	0.065 ***	0.019	0.065 ***	0.019
Proportion	0.068 *	0.038	0.067 *	0.035
Members	0.018 ***	0.006	0.016 **	0.006
Gender	0.068	0.043	0.070 *	0.041
Age	−0.002 **	0.001	−0.002	0.001
Education	0.008 ***	0.003	0.007 ***	0.003
Area	−0.004 ***	0.001	−0.005 ***	0.001
Distance	−0.002	0.003	−0.002	0.003
Yangling	0.195 ***	0.022	0.179 ***	0.025
Luochuan	0.406 ***	0.023	0.365 ***	0.032
Obs.	1051		1051	
F-Value	67.60 ***			
F-Value/One Stage			12.59 ***	
Instr.-Var. T-Value			4.94	
DWH Chi2			3.62 *	
DWH F-Value			3.51 *	
Wald Chi2-Value			671.42	

Note: *, ** and *** are significant at the levels of 10%, 5%, and 1%, respectively. The following tables share the same meanings regarding asterisks.

Firstly, we use the ordinary least square method (hereinafter called OLS) to analyze the influence of the participation of COP insurance on the production input of fruit growing. In Table 2, columns (1) and (2) are estimated coefficients and corresponding variance robust standard errors through using the OLS method. The results show that the effect of COP fruit growing insurance participation on farmers' production investment is positive and significant at a 1% statistical level, with a regression coefficient of 0.074.

Secondly, as the endogenous problem mentioned above, we use the two-stage least square method (hereinafter called 2SLS) to investigate the impact of COP fruit growing insurance participation on farmers' production input expense. In Table 2, columns (3) and (4) are the estimation coefficient and the corresponding heteroscedasticity robust standard error after using the instrumental variable. The bottom Durbin–Wu–Hausan endogeneity test results show that the *p*-value is significant at a 10% statistical level, which rejects the original hypothesis that there is no endogeneity problem in the model [25–27], that is, the variable *Insurance* has endogeneity. In the first stage of 2SLS, F-value (12.59) is significant at the statistical level of 1%. According to the useful "rule of thumb"regarding the weakness of instruments, when the F-value is greater than 10, it can refute the null hypothesis of "the existence of weak instrumental variables" [28,29]. Therefore, we know that there is no problem regarding the existing weak instrumental variables in this study. The results of the 2SLS estimation show that the participation of COP insurance significantly promotes the increase in farmers' input expense in fruit growing by 29.5% at the statistical level of 5%.

4.2. Robust Test

In order to test the reliability of the previous estimation results, we test the robustness of the previous empirical results from the replacement robustness test model. As mentioned earlier, farmers' participation in COP fruit growing insurance has self-selection behaviors. Hence, in order to avoid sample selection bias, we use the propensity score matching method (hereinafter called PSM) to test the robustness of the previous estimation results [30,31]. The Caliper Matching and Kernel Matching methods are used for re-estimation [30–33]. In Table 3, we find that the estimated values of treatment effects on the treated group are all the same (i.e., 3.38), and their *t*-values all fall between 1.96 and 2.576 (i.e., treatment effects are significant at the 5% level). These results show that, after participating in COP insurance, farmers' input expense of fruit growing increased significantly, by 3.38%, at the 5% level. Overall, we strongly believe that the robustness checks provided significantly strong confirmation of the results provided by the baseline model.

Table 3. PSM estimation results.

Matching Method	Treatment Effects	*t*-Value
Caliper matching	3.38 **	2.06
Kernel Matching	3.38 **	2.15

Note: ** is significant at the levels of 5%.

5. Discussion

5.1. Discussion of Core Explanatory Variable

The above OLS and 2SLS empirical results show that the participation of COP fruit growing insurance can promote an increase in farmers' input expense. Insured fruit growers spend more than 29.5% (2SLS's estimation result) per Mu on chemical fertilizers and pesticides than uninsured farmers. The empirical result indicates that the input-expense-increasing effect of COP insurance—meaning the marginal incentives to apply more input expense due to input expense being the main determinant for expected indemnity amounts—dominates the input-expense-decreasing effect of COP insurance that comes from the traditional moral hazard effect in yield- or revenue-based crop insurance [2,34]. Most previous studies, which investigated the effects of yield- or revenue-based crop insurance products on farmer input expense, showed that the traditional moral hazard

effect of insurance plays a role in decreasing eventual input expense utilized by insured farmers [11–13,34,35]. Unlike other studies that investigated the effects of yield- or revenue-based crop insurance, our theoretical deduction and empirical results reveal that the positive input expense increases the effect of COP insurance. In other words, our studies reject the popular viewpoints that found the insured farmer has less incentive to spend on inputs (i.e., traditional moral hazard effect of crop insurance).

Furthermore, consistent with previous research that examines the input expense of COP crop insurance [2], our empirical results also verified that the effect of COP fruit growing insurance can be positive. The reason is that the COP fruit growing insurance can allow the insured fruit growers to receive compensation for the direct input expense of chemical fertilizers and pesticides when disasters covered by the insurance occur. Uniquely different from yield- or revenue-based crop insurance, the indemnity payments of COP fruit growing insurance are explicitly linked to the total chemical fertilizers and pesticides cost of farmers in China. If farmers are no longer concerned about input expenses to be sunk cost of agricultural production due to the occurrence of risk, then their enthusiasm for production can be driven by COP fruit growing insurance. Therefore, the COP fruit growing insurance can effectively disperse the risk and improve the ability of insured farmers to recover production. Moreover, the selling price of fruit products in the market follows the commercial rule that commodities of high quality usually lead to high prices. As a result, if the insured farmers spent more on inputs in fruit growing, then they can expect more economic returns through widening the difference between the selling price and input expense of fruit products, even if more inputs expense might be considered to have some cost-increasing features [36].

5.2. Discussion of Control Variables

Empirical results of control variables are also worth discussing. Firstly, annual income has a significant positive role in promoting farmers' production investment, that is, the annual income of households increases by 1% and the input expense of fruit growing increases by 0.06%. This is because the disposable income of farmers with higher annual income increases accordingly. Therefore, such farmers usually have more spare funds to continue to invest.

Second, farmers whose agricultural income accounts for a large proportion of total income pay more attention to agricultural production, so they have a high degree of dependence on agricultural management. Therefore, under the same conditions, such farmers will spend more on agricultural production.

Third, the total number of family members has a significant positive impact on the input expense of farmers. The reason is that the labor force in a larger family is relatively sufficient, and the farmers will appropriately spend more on chemical fertilizers and pesticides.

Fourth, farmers from male-headed households were found to spend more on chemical fertilizers and pesticides than farmers from female-headed households. We also found the household income from male farmers might be more dependent on fruit growing compared to female farmers. Given that the selling price of fruit is much higher than input cost, male farmers have additional marginal incentives to spend more on inputs because it is generally believed that more inputs expense in fruit growing means yield-increasing with high quality in China. As a result, male farmers spend more on inputs than female farmers.

Fifth, the number of years of education for the head of household were found to have a significant positive effect on the farmers' input expense for fruit growing. The longer the head of household has been educated, the more input costs farmers would spend for fruit growing. Householders with longer years of education may have a greater ability to analyze problems and understand the fruit growing process, which brings in higher economic returns through greater spending on chemicals.

Sixth, orchard areas were found to have significant negative impacts on input expense for fruit growing, that is, with the increase in the orchard planting area, farmers' input expense for fruit growing decreases. The possible explanation is that, in addition to natural

disasters, pests and diseases, and other productive risks, China's fruit growers' agricultural income is also affected by fruit market price fluctuations, product marketing, and other uncertainties, that is, the production and sale of fruit by Chinese farmers are entirely determined by the market. Although the COP fruit growing insurance can help fruit growers to resist productive risks, fruit growers cannot effectively deal with fruit sales market risk. Therefore, the fruit growers with larger orchards could intend to reduce input expense to properly control the fruit yields due to their perception of risk aversion about the fruit selling market.

Lastly, the weather in Yangling and Luochuan has a significant positive impact on the farmers' input expense for fruit growing. The possible reason for this is that compared to Chenggu with a mild climate, there is more extreme weather and a high incidence of diseases and insect pests in these two counties, which may lead to more frequent application of chemical fertilizers and pesticides. It is also the frequent investment in chemicals that increase the farmers' input expense in both locations.

All these results reveal that the relevance of the provided theoretical framework for the purchase of COP insurance for fruit growers' input expense increases.

6. Conclusions

This article studies the correlation between the purchase of farmers' COP insurance and input expense in fruit growing. Firstly, our theoretical model demonstrates that the participation of COP insurance can promote fruit growers to increase production investment. Secondly, using the model of 2SLS and the empirical analysis, we found that the insured fruit growers spent more on using chemical fertilizers and pesticides compared to non-insured fruit growers.

The results of this study have important policy-making implications for the Chinese government to find a balance between maintaining fruit growers' livelihood and protecting the ecological environment in ecologically vulnerable areas. The theoretical and empirical results in this article show that the implementation of COP fruit growing insurance is helpful to increase the input expense of fruit growers and stabilize the sustainability of their family livelihood. After the purchase of COP fruit insurance, the increase in chemical fertilizers and pesticides in fruit growing may have unintended negative consequences for the ecological environment. For example, the run-off of excess chemicals, which cannot be absorbed by fruit trees, would pollute soil and water nearby, thereby reducing the effectiveness of the implementation of the ecological protection plan. Hence, policy-makers should focus on the benefits of COP fruit growing insurance to the sustainable livelihood of fruit growers in ecologically vulnerable areas, and at the same time, try to eliminate the potential disadvantages of COP fruit growing insurance to ecological protection.

In China, with the continuous growth of personal income, peoples' demand for healthy and green food is also increasing. As a result, the Chinese government should seize this favorable market opportunity to promote farmers to plant organic fruits in ecologically vulnerable areas through increasing financial subsidies for premiums, technical support for planting, certification of organic fruits, construction of marketing channels, and infrastructure construction. If such methods can be carried out, then it is not only conducive to the livelihood sustainability of fruit growers in ecologically fragile areas but also can better promote the long-term implementation of the ecological protection plan(i.e., reducing the pollution of chemical pesticides and fertilizers in orchards and the surrounding environment).We also recommend conducting a comparative study across various vulnerable areas in China for further studies.

Author Contributions: Conceptualization, T.L., L.C. and X.L.; methodology, T.L., L.C. and X.L.; validation, T.L. and L.C.; formal analysis, T.L., L.C. and X.L.; investigation, T.L., L.C. and X.L.; resources, T.L.; data curation, T.L., L.C. and X.L.; writing—original draft preparation, T.L. and L.C.; writing—review and editing, T.L., L.C., S.L., H.C. and H.J.; visualization, T.L. and L.C.; supervision, T.L. and L.C.; project administration, T.L. and L.C. are co-first and co-corresponding authors. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author on reasonable request. The data are not publicly available due to the privacy of the participants since we informed them that data will not be published to the public.

Conflicts of Interest: The authors declare no conflict of interest.

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