An empirical study of the key factors affecting herders' purchasing decision on weather index insurance—A case study from inner Mongolia autonomous region, China

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ABSTRACT

The weather index insurance for mutton sheep (WIMS) is the first weather index insurance product that addresses the increased feeding cost-related risk of grassland animal husbandry herders in China. In 2019, the WIMS was implemented as a pilot project in 11 county regions of Xilin Gol League, Inner Mongolia, China. Since the implementation of this product, the purchasing rate has varied from region to region, as the highest purchasing rate was 84.3%, while the lowest was only 1.8%. This research uses the double hurdle model to identify the factors affecting herders' purchasing behavior. This paper reports a survey study of 535 participants herders in the Xilin Gol League. The result indicates that herders' age, disaster risk evaluation, insurance awareness, pasture area, and neighborhood purchasing decision significantly impact herders' purchasing propensity. Disaster evaluation, insurance awareness, pasture area and location significantly impact the purchasing degree of herders. The study suggests that young herders and herders with large pasture areas should be motivated to purchase insurance. In addition, new methods should be applied for the publicity of this insurance product; Investments should be focused on the automatic weather monitoring station projects in pastoral areas to reduce the basis risk of the insurance.

1. Introduction

Developing countries, including China, have recently adopted agriculture insurance as a scientific and efficient risk management tool. Agriculture insurance plays an essential role in alleviating the disaster's aftermath, incurring the cost of production, improving food security and changing farmers' production behaviors (Bertram-Huemmer and Krahnert, 2015; Barnett and Mahul, 2007; Hess et al., 2005; Skews and Collier, 2008; Skews et al., 2006; Lee et al., 2017; Brans et al., 2010). But the development and expansion of traditional agricultural insurance (or indemnity insurance) are hindered by moral risk, adverse selection induced by information asymmetry and the high premium cost per unit. These factors are the more severe obstacles to traditional agricultural insurance in developing countries with a large proportion of scattered small farmers (Zhou, 2012; Chai and Zhao, 2016; Barnett et al., 2008; Jensen et al., 2016; Ye et al., 2017; Chantarat et al., 2013; Miranda and Farrin, 2012).

In the past decade, weather index insurance has been quickly promoted worldwide with the support of the World Bank and other international organizations. Weather index insurance is considered an effective risk management tool and a substitute for traditional agricultural insurance because it reduces conventional agriculture insurance's high transaction costs and information asymmetry problems (Sun et al., 2016). The most fundamental difference between traditional and index insurance has two aspects (Tappi et al., 2022; Dalhaus et al., 2018; Ceballos et al., 2019; Clarke, 2016; Clarke et al., 2012; Gallagher et al., 2010; Hazell and Hess, 2010): first, the traditional agricultural insurance claim is settled with the yield or income losses caused by the disaster, but, for the weather index insurance payout is based on the observed and

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measured index, e.g., precipitation or temperature, and it indicates that the insurer should claim as agreed when the pre-determined index triggers the threshold value; second, since the methods of payout for the weather index insurance, the insurance providers do not need to send claim worker to evaluate losses on individual fields which reduce the cost of claim verification and the time.

In May 2019, the Commission for Deepening Overall Reform of the CPC Central Committee passed the Guidelines on Accelerating the High-quality Development of Agricultural Insurance to promote the high-quality development of agriculture insurance in China. It also stipulated that the government should expand agricultural insurance coverage and gradually implement index insurance. In July 2019, the WIMS was formally included in the “Insurance Award and Subsidy for Local Advantageous and Special Agricultural Products” and “government-subsidized agricultural insurance product” projects by the Ministry of Finance of China and the Inner Mongolia government. The WIMS is China’s first index insurance product for pasture animal husbandry. Unlike other international livestock index insurances, the WIMS target the risk of the increased cost borne by mutton sheep herders because harsh weather conditions such as snow disaster and drought could increase the feeding cost due to mutton sheep hamsters engaged in pasture animal husbandry production in closed or semi-closed sheds.

Since 2019, the WIMS pilot project has been carried out across all the counties of Xilin Gol League, Inner Mongolia Autonomous Region. But some counties have a varied participation rate of insurance. Abaga county has the maximum insurance participation rate of 84.3%, while Wulagai Administrative Area has a minimum of 1.8%. Based on the questionnaire data of 535 herders in eight counties of Xilin Gol League, the paper applies the Double-Hurdle model to identify the factors affecting the purchasing behavior of herders. Our results improve the understanding of what factors affect herders' purchasing decisions. The application of the concept of this study can inform the rest of the grassland to cover the risk, provide new insights into the index insurance system, and decision support to improve the risk management level in pasture animal husbandry.

2. Theoretical framework

In this study, herders' purchasing behavior includes purchasing propensity and purchasing extent. Purchasing extent depends on the actual happening of purchase propensity. Therefore, there exists time precedence between the two parts (Guo, 2020; Cole et al., 2014). Meanwhile, this study assumes no essential difference among factors affecting herders' purchase propensity and purchase extent, which means the same elements can affect both.

According to consumer behavior theory, consumers’ purchasing behavior can be affected by multiple factors (Liu, 2014; Deaton and Muellbauer, 2015; Liu, 2016). Generally, productivity development level and the nature of production relations play a vital role, while these factors can be divided into three categories, consumer individual, economic and environmental factors. Consumer individual factors are mainly physiological, psychological, and behavioral factors. For example, consumer gender, age, or other physiological traits are physiological factors, while consumer intrinsic factors such as cognition and personality are psychological factors. Behavioral factors specifically include information collection and product evaluation. Economic factors, which mainly include consumer income and product price, are the primary factors that restrict consumer behavior and exert a binding effect on consumer behavior. Environmental factors encompass all physical and social factors in external world of consumers, which can be classified into macro-environmental and micro-environmental factors according to the space coverage and the number of people covered. Additionally, due to the nature of the insurance product, the paper incorporates the risk factors into the analysis framework. Therefore, this study concludes that individual, economic, environmental and risk factors altogether decide the purchasing behavior of herders for the WIMS, and these factors impact their purchase propensity and purchase extent to different degrees and directions (Figure 1).

2.1. Based on the theoretical framework, this paper assumed the following hypotheses:

H. The individual, economic, environmental, and risk factors significantly impact the purchasing behavior of herders on the WIMS.

3. The data source and variable selection

3.1. Data source

The data was collected from 594 herders in eight counties of Xilin Gol League in August 2019 and August 2020 through the field survey. The eight counties include Xilinhhot City, Xiwu Banner, Wulagai Administrative Area, Dongwu Banner, Abaga Banner, Lan Banner, Sonid Right Banner and Xianghuang Banner. The number of mutton sheep raised in the above eight counties accounts for 69% of the gross number of mutton sheep in the Xilin Gol League. The research group randomly selects 2–3 Sumu (town) in each county and then at least selects two Gacha (village) in each Sumu as the sampling site for the face-to-face questionnaire interviews. And we took verbal consent from our participants. The questionnaire contains herders' individual and family characteristics, pasture, machinery, other resource endowments, animal husbandry production income, cost, credit, purchasing of the WIMS, etc. Excluding the invalid questionnaires, The total of valid questionnaires are 535. 277 have purchased the WIMS, and the remaining 258 herdsmen have not yet purchased such insurance. Table 1 shows the number of distributed questionnaires in each region:

3.2. Variable selection

In this paper, the dependent variable is the purchasing propensity and purchasing extent of herdsmen for WIMS. The purchasing propensity is whether the herders choose to purchase the insurance. If they decide to buy, it is denoted as 1; if not, it is represented as 0. The purchasing extent is the ratio of insured mutton sheep to the total number of mutton sheep.

According to the theoretical framework, the independent variables mainly include individual factors, economic factors, environmental factors, and risk factors:

(1) Individual factors: Most emerging research considers individual factors are the main influencing factors of the purchasing behavior of farmers (herdsmen) for the index insurance, which includes farmers' age, education level, year of grazing experience, insurance cognition, access to information, publicity acceptance, and the evaluation of natural disaster extent (Ayako and Takashi, 2019; Cole et al., 2013; Cai et al., 2015; Takahashi et al., 2016; Hill et al., 2013; Bageant and Barrett, 2018; Jensen et al., 2014a; Miura and Sakurai, 2012). We set up five questions to identify the cognition of herdsmen about WIMS, “whether herdsmen were aware of insurance product nature, as government-subsidized agricultural insurance”, “whether they were aware of the covered types of disasters”, “conditions to trigger claim settlement”, “duration of insurance” and “maximum amount of premium”. Meanwhile, the answers to the above five questions were used as a reference to judge the cognition extent of weather index insurance for mutton sheep among herdsmen. This study also considered the subjective evaluation of surveyed herdsmen about the extent of local natural disasters in the recent three years as a variable of individual factors. It examined the influence of herdsmen purchasing behavior on weather index insurance for mutton sheep.

(2) Economic factors: There is enormous research that concludes that economic factors, such as price, income, credit amount and
cultivated area, affect the demand for index insurance (Cole et al., 2013; Chantarat et al., 2009; Gine et al., 2007; Karlan et al., 2014; Jensen et al., 2014b; Jensen et al., 2017). But this study does not consider the price factor due to the limited data availability of insurance prices and the character of government-subsidized insurance for the WIMS. Actually, according to our survey data, among 277 insured herdsmen, only four feel dissatisfied or very dissatisfied with the price of WIMS. The proportion of this group accounts for only 1.4% of the total surveyed herdsmen. While out of 258 uninsured herdsmen, only 7 attribute the price reason to not purchasing the WIMS, which accounts for 2.7% of the total uninsured population. Therefore, it is assumed that the insurance price is not the main factor affecting herdsmen’s purchasing behavior. We concluded that the price no-affecting herdsmen’s purchasing behavior is consistent with some research on identifying the factors affecting the weather index insurance of farmers (Matsuda and Kurosaki, 2019).

(3) Environmental factor: The WIMS has been implemented in scarcely populated pastoral areas, and our survey reflects that most insurance companies have established branch offices in each Sumu (town). Thus, those herdsmen closer to villages and towns with concentrated administrative, education, sanitation, and economic conditions can easily acquire information about the insurance product and are more likely to purchase the insurance. In addition, most of the publicity work of WIMS relies on the government cooperation staff in Sumu (town) and Gacha (village), and herdsmen or whose family members hold public office can better understand the insurance policy. Consequently, they are more likely to purchase weather index insurance early. Additionally, referring to some studies on farmers participating in agricultural cooperatives, the paper considers that neighbor purchasing decisions may also affect herdsmen purchasing the WIMS (Ma and Abdulai, 2016).

(4) Risk factors: This paper classifies the risk factors into objective, subjective and region risk conditions. Specifically, after 2000, the local government of Inner Mongolia initiated substantial people-benefit projects, mainly including the construction and repairing of covered sheds in pastoral areas. Improved production facilities in pastoral areas vigorously mitigate the risks of natural disasters. Therefore, the shed’s area measures the objective risk during the study. Additionally, the cost paid by herdsmen to purchase pure commercial life insurance is considered an indicator to measure their subjective risk conditions. Considering the abundance of grassland resources in Xilin Gol League, the research site has typicality and integrity in coverage type (Ye et al., 2017). Meanwhile, this research conclusion derived by grass experts illustrates that different pasture types respond differently to climate factors (Li et al., 2003; Chen et al., 2001; Xu et al., 2003; Li and Shi, 2000). The clause of the WIMS makes risk division for all banner counties in Xilin Gol League with regional location and pasture type and stipulates the proportion of claim amount in drought and snow disasters. Based on this WIMS policy, this paper divides the research area in Xilin Gol League into four parts. The central part includes Abaga Banner and Xilinhot City. The northeastern part covers Xiwu Banner, Dongwu Banner and Wulagai Administrative Area, and the northwestern part contains Xisu Banner and Dongsu Banner. The southern part encompasses Lan Banner and Huang Banner. Later we assigned dummy variables by using the south part as the base group to these banner counties according to their respective locations and pasture types. The risk conditions in different regions will significantly affect the herdsmen’s purchasing behavior of weather index insurance for mutton sheep.

4. Selection of empirical model

Many herdsmers in the survey sample have no propensity to purchase the WIMS. The Tobit model (which treats the behavior decision and degree decision as a decision process simultaneously) is mainly used for solving the degree (or density) of individual behavior problems in this circumstance (Tobin, 1958). However, the behavior and degree decisions
are two processes with time precedence. Therefore, the Tobit model cannot solve the two decision-making stages problem (Chu, 2015; Shi et al., 2018).

According to our theoretical analysis, the herders purchasing behavior of WIMS is considered a complete process consisting of two decision-making stages. In the first stage, herdsmen decide whether to buy the WIMS according to their conditions, known as “purchasing propensity”. In the second stage, those herdsmen who have made the purchasing decision in the first stage need to consider the number of sheep to be covered, known as the “purchasing extent”. That means, for those herdsmen without purchasing the WIMS, the explained variables in the second stage are truncated at 0. Therefore, the Double-Hurdle model is more suitable for adapting to empirically test the various factors affecting the purchasing behavior of herdsmen on the WIMS. The double hurdle model, proposed by Cragg in 1971, contains the idea that an individual's decision on the extent of participation in an activity is the result of two processes: the first hurdle, determining whether the individual is a zero type, and the second hurdle, determining the extent of participation given that the individual is not a zero type (Engel and Moffatt, 2015).

In the first stage, the herdsmen purchasing propensity of WIMS is assumed to be a selection process. We presume herdsmen are risk neuters like farmers (Abdulai and Huffman, 2014), and their production objective is to increase wealth. Then the purchasing decision of herdsmen is mainly driven by the expected wealth growth potentially brought by WIMS purchasing. Supposing potential wealth growth brought by the purchasing of WIMS is \( D_M^i \), and the expected wealth growth in the absence of WIMS is \( D_N^i \), herdsmen will buy the WIMS if \( D_M^i > D_N^i \).

\[ D_M^i = Z_i\beta + \mu_i, \quad D_N^i = \begin{cases} 0, & \text{if } D_M^i \\ 1, & \text{if } D_M^i > D_N^i \end{cases} \] (1)

If the herdsmen \( i \) purchases the WIMS, \( D_i = 1 \), and if the herdsmen \( i \) does not purchase the WIMS, \( D_i = 0 \). \( Z_i \) indicates the non-vector metrix for the demographic characteristics, land resources and credit of the herdsmen, etc. \( \beta \) is the coefficient to be estimated. \( \mu_i \) is a random disturbance term which is the binary standard normal distribution with mean as 0 and variance as 1.

In the second stage, the herdsmen who bought the WIMS in the first stage have to choose how many sheep they will cover (Eq. (2)). That means if and only if \( D_i^* > 0 \), \( Y_i = Y_i^* \), the second stage happens. \( Y_i \) is the purchasing extent of herdsmen in the second stage, which is an observable continuous variable.

\[ Y_i^* = Z_i\alpha + \nu_i \] (2)

According to Cragg (1971), the maximum likelihood estimation values in the first-stage decision model and second-stage number model can be obtained using probit and truncated regression models, respectively.

In the end, the likelihood function of the Double-Hurdle model is written as Eq. (3):

\[
L(\alpha, \beta, \sigma) = \prod_{i=1}^{n} \left[ 1 - \Phi(Z_i\beta) \right]^{1-\delta_i} \prod_{i=1}^{n} \Phi(Z_i\beta) \frac{1}{2\sigma^2} \exp \left[ \frac{-(Y_i - Z_i\alpha)^2}{2\sigma^2} \right] \Phi(Z_i\alpha)
\] (3)

5. The results of the empirical model

5.1. Statistical description for variables

The statistical description and analysis of individual, economic, environmental and risk factors are presented in Table 2.
thousand mu is the mean of pasture area among all surveyed herdsmen. And the mean of pure income from animal husbandry and credit amount is 6.86 ten thousand yuan and 1.94 ten thousand RMB, respectively. The mean shed area is 3.49 hundred square meters, and the mean of commercial life insurance expenditure is 0.34 ten thousand yuan. The mean of insurance cognition extent among herdsmen is 2.24, suggesting a low level of cognition about WIMS among all surveyed herdsmen. The mean of the neighbor purchasing decision is 0.55, and the evaluation of disaster extent in the recent three years is 3.46, indicating that all surveyed herdsmen consider that the local area has suffered moderate disaster risk in the recent three years.

5.2. Empirical results and analysis

The Double-Hurdle model is estimated, and the results are shown in Table 3:

(1) Individual factor variables: Age significantly impacts purchase propensity, indicating that older herdsmen are more likely to purchase the index insurance. But our result is inconsistent with the study of Abdulai and Huffman (2014), which reported that young farmers are more likely to participate in the weather index insurance scheme relative to old farmers. The possible explanation is that, compared with the young herdsmen, the old herdsmen maybe be less able to accept new things. Still, they have rich grazing experience and a stronger understanding of the risks of grassland animal husbandry. Therefore they are more likely to purchase the WIMS. As expected, cognition has a significant positive impact on herdsmen’s purchase propensity and purchase extent. The herdsmen with better knowledge of the WIMS are more likely to buy the index insurance, and our results are consistent with some relevant research (Cole et al., 2013; Cai et al., 2015; Takahashi et al., 2016; Hill et al., 2013). In the meantime, they tend to cover more insurance for mutton sheep after making the purchase decision. Furthermore, herdsmen who consider that the local region has suffered severe natural disaster risk in three years are more likely to purchase insurance and insure more animals.

(2) Economic factor variables: Pure income from animal husbandry and the credit amount is non-significant in purchase propensity and purchase extent. While the pasture area is significant in purchase propensity and purchase extent. Inconsistent with relevant research on farmers purchasing decisions for weather index insurance ( Giné et al., 2007; McIntosh et al., 2013), those herdsmen with a smaller pasture area are more likely to purchase the WIMS. One possible explanation is that fundamental differences exist between planting and pasture animal husbandry. For the planting industry, a larger cultivated area represents higher risk exposure. However, for the pasture animal husbandry industry, a larger pasture area denotes more abundant fodder resources since pasture is the foremost fodder source of livestock under the same conditions. Therefore, the herdsmen with smaller pasture areas have more demand for weather index insurance to disperse risk than the herdsmen with larger pasture areas.

(3) Environmental factor variables: The variable of distance to the closest Sumu does not pass the significance test in both purchase propensity and purchase extent. The experience of holding public office has a significant impact on purchase propensity. Herdsmen whose neighbours purchased the WIMS are more likely to make the same choice. Santeramo (2019) concluded that the indirect experience from other farmers is likely to reduce imperfect knowledge and act as a catalyst for farmers to participate in the agricultural insurance scheme.

(4) Risk factor variables: The shed area and commercial life insurance are non-significant in the purchase propensity and extent. The coefficients of the variables representing the northeastern and northwestern regions are positive and significantly different from zero in the purchasing propensity stage, suggesting that relative to herdsmen in the southern region, herdsmen in the northeastern and northwestern regions are more likely to purchase the WIMS. It could be due to the underwriting work of WIMS in different regions of Xilin Gol League where various companies operate. After long-term sustained investments, companies in the northeastern and northwestern region enjoy an edge over counterparts either in the undertaking, implementing and promoting the agricultural insurance business or the availability of workforce and material resources.

5.3. Robustness test

This study used the Heckman model to test the factors influencing herdsmen’s purchase behavior of mutton sheep weather index insurance. This test was adopted to examine the robustness of the Double-Hurdle model results and avoid possible biased estimates caused by sample selective bias and self-selection problems. At the first stage of the Heckman model, the Probit model calculates the inverse mills ratio $\lambda$ (IMR) based on identifying the influencing factors of herdsmen’s purchase propensity for the mutton sheep weather index insurance. In the second stage, the influencing factors of herdsmen’s insurance purchase extent are further analyzed through the OLS model by introducing $\lambda$ as an instrument variable. Meanwhile, to avoid the multicollinearity resulting from identical explanatory variables with the two-stage equation, the Heckman model requires the first-stage model to include at least one explanatory variable that satisfies the exclusive requirement. It influences the first-stage dependent variable while not influencing the second-stage dependent variable. Based on the above benchmark model conclusions, this study uses whether neighbors buy insurance as an instrument variable, which is incorporated into the Heckman model for analysis. Since the two-column model is identical to the first-stage procedure of the Heckman model (analysis of purchase propensity influencing factors), this study only lists the estimation results of the second-stage Heckman model in Table 4:

Estimation results in Table 4 indicate that the purchase extent estimates with the Heckman and the Double-Hurdle model are consistent regarding influence direction, coefficient size and significance, indicating the robustness of the results. Meanwhile, $\lambda$ is insignificant, clear evidence of the absence of selective sample bias.
6. Conclusions and policy suggestions

Weather index insurance products are considered an effective risk management tool for farmers in low-income countries. Take-up rates remained low, becoming a major problem limiting the sustainability of weather index insurance (Smith and Watts, 2009). Like other weather index insurance products, the weather index insurance for mutton sheep is also facing problems by the low and varied take-up rate.

Based on the 535 questionnaires, this paper analyzes the factors affecting herdsmen purchasing behavior toward the WIMS. It is concluded that herdsmen purchasing behavior is composed of the purchase propensity and purchase extent. Empirical results indicate that pasture area, insurance cognition extent, neighbor purchase decision, and disaster risk evaluation all significantly impact herdsmen’s purchase propensity. Insurance cognition extent, pure income from animal husbandry and region affects the herdsmen’s choice for the number of insured sheep in various directions and degrees.

Based on the empirical analysis, this paper provides some suggestions for raising the take-up rate of the WIMS. Firstly, more efforts should be made to motivate those herdsmen who are young and have large pasture areas. Secondly, new ways should be found to promote WIMS. For instance, the principle of the claim for the WIMS can be disseminated via diverse media, like video, WeChat and broadcast at the end of the insurance period to dispel the misunderstandings of the herdsmen who still hold the wait-and-see attitude. The combination of weather index insurance and the financial institutions’ loan projects is a critical way to effectively improve the insurance participation rate (Clarke et al., 2012; Carter et al., 2016). This method could not only reduce the risk of losses for financial institutions caused by the default risk of farmers but also alleviate the insurance premium burden of farmers by reducing the operating costs of insurance companies. Promotion of the participation rate of weather index insurance can also be emulated. When paying premiums, the insurer can directly provide the insured with three options of premium payment methods: cash, labor, or a combination of cash and labor (Tadesse et al., 2015).

Furthermore, this paper does not consider basis risk and its impact on the demand for the WIMS. However, the basis risk has an essential effect on the take-up of farmers (Hill et al., 2016; Jensen et al., 2016; Elabd et al., 2013; Jensen et al., 2018). With the deepening of the cognition of herdsmen for the WIMS, the basis risk will have a substantial impact on the purchasing behaviour of herdsmen in the future. Therefore, the government should increase the investment in meteorological infrastructure and improve herdsmen’s low insurance participation rate caused by basis risk.

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