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Does Past Experience in Natural Disasters Affect Willingness-to-Pay for Weather Index Insurance? Evidence from China

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Abstract

Although numerous index insurance pilot programs have been conducted in China, little is known about Chinese farmers' willingness to pay for index insurance. By using a field survey of small farm households in China's Heilongjiang Province, which suffered a large flood in the summer of 2013, this paper explores farmers' willingness to pay (WTP) for a hypothetical rainfall index insurance product, with a special interest in whether farmers affected by the flood are willing to pay more than those where not.

Key words: index insurance, willingness-to-pay, natural experiment

1. Introduction

Rural households in China, as in other developing countries, are exposed to the risk of natural disasters such as droughts and floods. It is estimated that over 20% of the farmland in China was adversely affected by natural disasters between 1979 and 2004, causing a high of \$18 billion in crop losses in 2004 (Belete, et al., 2007). The majority of Chinese farmers are relatively poor smallholders engaged in rain-fed crop production, who are especially vulnerable to extreme weather variations and natural disasters. Like small farm households in other developing countries, Chinese farmers have developed various mechanisms to cope with the risks, such as savings, formal and informal credit, diversification of agricultural production activities, informal insurance and involvement in non-farm activities. However, these strategies cannot fully smooth consumption, and therefore are far from ideal risk coping strategies (Fafchamps and Lund, 2003, Fafchamps, et al., 1998, Jalan and Ravallion, 1999, Kazianga and Udry, 2006, Ligon, et al., 2002).

Agricultural insurance has been promoted in China with substantial government subsidies since 2007. By 2009, Chinese agricultural insurance had grown to more than 160 agricultural insurance products offered in all corners of China and covering many different crops and livestock breeds (Stutley, 2011, Zeng and Mu, 2010). Agricultural insurance in China today is available mainly in the form of multi-peril crop insurance (MPCI), which indemnifies farmers based on their verifiable crop production losses. MPCI, however, is well-known to suffer from structural problems endemic to many loss-based agricultural insurance contracts, including moral hazard, adverse selection and systemic risk (Barnett and Mahul, 2007, Miranda and Farrin, 2012, Skees, 2008). Due to these problems, MPCI has not been actuarially sustainable in China, and its growing use among Chinese farmers has depended heavily on massive government support (Dick and Wang, 2010). Currently, government subsidies cover 70% or more of the premium (Belete, et al., 2007, Stutley, 2011, Yanli, 2009, Zeng and Mu, 2010).

Due to the high costs associated with MPCI, there has been a growing interest in index insurance among Chinese agricultural policymakers. Index insurance is widely believed to offer a lower-cost alternative to MPCI that should be especially attractive to developing countries. Index insurance, unlike MPCI, indemnifies the insured based on the objectively observed value of an index that is correlated with the losses, such as rainfall. Since the insured cannot influence the observed value of the index and information regarding the actuarial properties of the index is publicly available, index insurance is generally free of moral hazard and adverse selection problems. Index insurance is also less expensive to administer since the contract is standardized and there is no need to individually tailor the contract or verify losses (Barnett and Mahul, 2007, Miranda and Farrin, 2012, Miranda and Gonzalez-Vega, 2010).

In May 2012, the China Insurance Regulatory Commission (CIRC) established a nationwide policy supporting the development of new agricultural insurance products including, most notably, weather index insurance. As a result, weather index insurance products have started to appear in China, mostly in the form of micro-insurance sold directly to individual rural households to manage production risks. Index insurance

pilot programs in China have been restricted to small selected areas, often at the county level, and none have reached a commercial sustainable scale (Stutley, 2011). Since index insurance is relatively new in China, little empirical research has been conducted to study contract design or farmers' willingness-to-pay for index insurance.

In the summer of 2013, Heilongjiang Province, a major grain producing area in China, was stricken by a serious flood. More than 2,500,000 hectares of farmlands were affected and thousands of farmers became homeless. The flood provides an opportunity to explore whether farmers who suffered losses have a higher willingness to pay for an excess-rainfall index insurance contract than those who did not suffer losses.

The primary contributions of this paper are: (1) to our knowledge, our paper represents the first natural experiment to estimate Chinese farmers WTP for weather index insurance; (2) our paper provides an estimate of Chinese farmers' WTP for excess rainfall index insurance, which has not been systematically investigated in China; and, (3) our paper examines how past experience with a natural disaster and government disaster relief affect farmers' demand for weather index insurance. The findings will inform government policymakers and private insurers when designing weather index insurance contracts or choosing appropriate levels for premium subsidies.

2. Literature Review

People's demand for insurance is often modeled in an expected utility maximization framework. Based on this framework, a risk averse individual would fully insure if the insurance is provided at actuarially fair premium (Kriesel and Landry, 2004). However, the prediction of full insurance is at odds with empirical evidence. Various studies show that individuals often tend to neglect low-probability, high-impact natural disasters or underestimate their possibility of being a disaster victim (Kunreuther, 1984, Kunreuther, 1996, Kunreuther, et al., 2013).

Numerous studies have examined the demand for multiple-peril crop insurance, with a special interest in understanding factors affecting farmers' crop insurance take-up decisions. Empirical studies using data from both developed and developing countries find that farmers are not eager to insure against frequent, low impact perils. Adoption of crop insurance is positively correlated with the impact of disasters, level of insurance coverage, the level of yield volatility, the amount of government subsidy and farmers' trust for the government (Cai, et al., 2009, Fraser, 1992, Garrido and Zilberman, 2008, Sherrick, et al., 2004). Farmers who are more risk averse or perceive greater yield risk are more likely to participate in crop insurance (Sherrick, et al., 2004). Farmers burdened with larger debts are also more likely to purchase crop insurance and willing to pay a higher premium (Patrlck, 1988). Free ad hoc government disaster relief significantly undermines farmers' incentive to purchase crop insurance, as government relief is expected to partially or even entirely cover disaster losses (Van Asseldonk, et al., 2002, Wang, et al., 2012).

Numerous studies have also examined the demand for weather index insurance, many of them in India, where weather index insurance has been available for many years (Hazell, 2010). Demand for weather index insurance is generally found to be highly price

sensitive, with substantial premium subsidies required for take-up of the product (Cole, et al., 2008, Giné, et al., 2010, Giné, et al., 2008, Hill, et al., 2013, Kong, et al., 2011, Musshoff, et al., 2008). Farmers' education, wealth, risk aversion and familiarity with the insurance product are significant factors affecting small rural households' take-up decision of weather index insurance. Basis risk is another important factor affecting farmers' willingness-to-pay.

Basis risk reduces demand for index insurance, especially when the premium is high (Giné, et al., 2008, Hill, et al., 2013). A study in Germany finds that an individual farmer's willingness-to-pay for weather index insurance depends on both geographic basis risk (the distance between the farm and the reference weather station) and production basis risk (the specification of the weather index) (Musshoff, et al., 2008).

The trust people have in the insurance product and the organization involved in selling and managing it also influences demand for index insurance, especially in developing countries (Patt, et al., 2009). Credit constrained farmers are less likely to purchase index insurance, so a short-term loan combined with the index insurance might increase the take-up rate as it enables credit-constrained farmers to pay the premium (Giné, et al., 2008). Very few studies directly estimate a farmers' WTP for weather index insurance. An exception is a survey of small farm households in India, which finds out that average WTP of local farmers for weather index insurance is around 8.8 percent of the maximum payout of the insurance product (Seth, et al., 2009).

Research on index insurance in China is generally rare. A field study in western and central China interviewed more than 1,000 farm households and found a strong interest in rainfall insurance (Turvey and Kong, 2010). Another study in western China finds that Chinese farmers' demand for drought insurance is fairly elastic and a substantial discount or subsidy is required in order to widely spread weather index insurance (Kong, et al., 2011).

3. Experiment Design

We wish to determine if recent experience with a flood increases a farmers' WTP for a hypothetical rainfall index insurance product. The flood is treated as a natural experiment, which eliminates sample selection biases and helps identify the causal relationship between treatment effect (experience in a large flood) and the outcome (interest in rainfall index insurance). By comparing the WTP for rainfall index insurance between farmers from treatment (flood-affected) group and control (non-affected) group, we can determine whether recent experience with a natural disasters influences farmers' attitude toward index insurance products.

The field survey was conducted in Tongjiang City, Heilongjiang Province of China. Tongjiang is located on the west bank of Heilongjiang River, the world's tenth longest river, and its tributary Songhua River. The proximity to large rivers makes Tongjiang vulnerable to floods. In the summer of 2013, northeastern China suffered the worst flood in decades. Tongjiang was one of the places most seriously affected by the flood. The section of Heilongjiang River near the city reached its highest recorded level in history, leading to the breaching of dikes and submersion of villages and farms, and rendering

thousands of people homeless. The city's Agricultural Bureau estimated that 77,000 hectares of farmland in Tongjiang were affected by the flood, causing a loss of 370,000 tons of agricultural product at an economic loss of RMB 720 million¹.

The field survey was conducted in July 2014. 234 farm households from ten villages were interviewed. The survey questionnaire was prepared in English, and then translated into Chinese. The survey was conducted by two Chinese-speaking authors of this paper and two Chinese graduate students from Nanjing Agricultural University. Each interview took between 30 minutes and one hour, with the interviewer reading the questions to farmers and recording their answers on a paper questionnaire.

The questionnaire asks detailed information about household's demographic characteristics and household assets. Questions about households' previous purchase of agricultural insurance are included to test farmers' familiarity and acceptance of formal insurance. We ask farmers to identify the major risks faced by the household and methods they use to manage those risks. The survey also includes questions about the 2013 summer flood, such as whether the household was affected by the flood and the total loss from the flood.

In order to measure farmers' willingness to pay for a hypothetical rainfall index insurance product, we first explained the concept of rainfall index insurance to farmers as follows:

Weather index insurance is a new kind of insurance different from MPCI, which you have been familiar with after several years of purchase. Weather index insurance does not pay indemnity to you based on your actual losses. Instead, it indemnifies you based on an index that is related to agricultural production output such as rainfall. The index would be objectively measured by government weather station. For example, if you purchase the rainfall index insurance, you will receive indemnity automatically when rainfall in this area is higher or lower than the number pre-agreed in the insurance contract. The indemnity you receive is based on the difference between the actual index and the pre-agreed number. The larger the difference is, the more you can receive from insurance company. However, you cannot receive indemnity from rainfall index insurance if you have crop losses because of other disasters or accidents except for floods or droughts. Neither can you receive indemnity if the measured rainfall is within the range written in the contract, even when you experience actual losses from floods or droughts.

After explaining how rainfall index insurance works, a quiz was administered to test whether the respondent fully understood the concept of rainfall index insurance. The respondent was then asked if he/she was willing to purchase this insurance. If the respondent answered affirmatively, we then performed a bidding game to reveal the farmer's WTP. A bidding game is a contingent valuation (CV) format in which individuals are iteratively asked whether they are willing to pay for a certain amount. The amount is raised or lowered depending on whether the respondent is or is not willing to pay for the previously offered amount. The bidding stops when the iterations converge to a

¹ CCTV (2013) September 5, 2013 <http://english.cntv.cn/program/china24/20130905/101614.shtml>

point estimate of willingness to pay (Haab and McConnell, 2002).

In our survey, each farmer was asked to indicate, with ‘Yes’ or ‘No’, whether he/she are is willing to pay a premium rate of RMB10 per RMB100 of coverage (i.e., maximum indemnity) provided by the hypothetical index insurance contract, assuming a coverage level of RMB200, the same as currently available on the market. The game ends if the respondent’s reply is ‘Yes’, otherwise the premium rate is lowered to RMB8 per RMB100 of coverage. The game continues in the same fashion with the subsequent premium rates of RMB6, RMB4 and finally RMB2 per RMB100 of coverage.

4. Estimation Methodology

The econometric estimation is conducted in two stages. In the first stage, a binomial logit model is used to check whether farmers who were affected by the 2013 flood have a higher tendency to purchase the hypothetical weather index insurance. In this model, the dependent variable is whether the respondent is interested in purchasing the rainfall index insurance. The probability that a farmer chooses to purchase the hypothetical weather index insurance ($z_i = 1$) can be expressed as:

$$P(z_i = 1) = \frac{\exp(\alpha f_i + \beta x_i)}{1 + \exp(\alpha f_i + \beta x_i)}$$

where x is the set of financial and personal characteristics of each farm household, such as age, education, wealth, degree of risk aversion and past experience in conventional crop insurance. f is a binary variable representing whether the household was affected by the 2013 flood. We expect to find that farm households affected by the 2013 flood will be more interested in the rainfall index insurance and therefore will be more willing to purchase the insurance. In other words, we expect estimates of α to be significantly positive.

In the second stage, we use a two-limit tobit model to estimate farmers’ WTP for the hypothetical rainfall index insurance since the WTP is censored from both below (zero) and above (RMB10). In the two-limit tobit model, the observable variable y_i is defined as:

$$\begin{aligned} y_i &= L \text{ if } y_i^* \leq L \\ y_i &= y_i^* \text{ if } L \leq y_i^* \leq U \\ y_i &= U \text{ if } y_i^* \geq U \end{aligned}$$

where:

$$y_i^* = x_i' \beta + \varepsilon_i, \quad \varepsilon_i \sim N(0, \sigma^2)$$

y_i^* is a latent variable, x_i is a vector of independent variables, β is a vector of parameters to be estimated, and ε_i are residuals assumed to be indecently and normally distributed with mean zero and variance of σ^2 .

The parameters can be estimated by maximizing corresponding likelihood function(Maddala, 1986):

$$L(\beta, \sigma) = \prod_{y_i=L} \Phi\left(\frac{L - x_i' \beta}{\sigma}\right) \prod_{y_i=y_i^*} \frac{1}{\sigma} \phi\left(\frac{y_i - x_i' \beta}{\sigma}\right) \prod_{y_i=U} \left[1 - \Phi\left(\frac{U - x_i' \beta}{\sigma}\right)\right]$$

where ϕ and Φ are the standard normal density function and distribution function

respectively. Since it is possible that farmers' true value of WTP lies on any values between the WTP provided in the bidding game, an interval censored model would also be used to check the robustness of the result from the tobit model.

5. Data Description

We visited ten villages, of which seven were affected by the 2013 flood. 234 households were interviewed in the field survey. Excluding one respondent with incomplete data, the data collected from 233 households was retained for used in econometric estimation. Among the 233 households, 120 were from flood-affected villages and 113 were from non-affected villages. The questionnaire contains information about household financial activities over the preceding three years, past experience in agricultural insurance and other insurance products, risk attitudes, the importance of different risk coping mechanisms, experience with the 2013 flood, and household demographic information. Means and standard deviations of major variables are presented in Table 1.

Table 1: Description of Explanatory Variables and Corresponding Descriptive Analysis with the Relative Frequency of Binary Variables.

	Total	Flooded Villages (Treatment Group)	Non-flooded Villages (Control Group)	t-test Result
Gender (male = 1)	0.983 (0.130)	0.975 (0.157)	0.991 (0.0941)	-0.016 (0.95)
Age of Household Head	46.88 (9.521)	48.14 (10.33)	45.54 (8.424)	2.602* (-2.10)
Year of Education of Household Head	8.120 (2.286)	8.242 (2.238)	7.991 (2.339)	0.251 (-0.84)
Household Size	3.893 (1.314)	4.033 (1.489)	3.743 (1.084)	0.290 (-1.69)
Number of Laborers	1.914 (0.805)	1.842 (0.860)	1.991 (0.738)	-0.149 (1.42)
Number of Family Members Below 18 or Above 65	0.991 (0.991)	1.017 (1.085)	0.965 (0.886)	0.052 (-0.40)
Number of Unhealthy Family Members	0.326 (0.599)	0.358 (0.671)	0.292 (0.512)	0.066 (-0.84)
Amount of Netloan (Thousand RMB)	162.3 (125.1)	154.7 (123.7)	170.4 (126.6)	-15.65 (0.95)
Purchased Crop Insurance, 2011-2013	0.502 (0.501)	0.233 (0.425)	0.788 (0.411)	-0.554*** (10.11)
Purchased Other	0.442	0.400	0.487	-0.087

Insurance, 2011-2013	(0.293)	(0.264)	(0.320)	(0.065)
Watch Local Weather	0.974	0.950	1	-0.050*
Forecast	(0.159)	(0.219)	(0)	(2.43)
Local Weather Forecast	0.970	0.958	0.982	-0.024
is Accurate	(0.171)	(0.201)	(0.132)	(1.07)
Belief in a Future Flood,	0.498	0.492	0.504	-0.013
2015-2020	(0.501)	(0.502)	(0.502)	(0.19)
Natural Disaster Is	0.966	0.983	0.947	0.036
Major Source of Risk	(0.182)	(0.129)	(0.225)	(-1.53)
Level of Risk Aversion	2.893	2.883	2.903	-0.019
	(0.826)	(0.747)	(0.906)	(0.18)
Number of Crops	1.657	1.725	1.584	0.141
Grown	(0.709)	(0.733)	(0.678)	(-1.52)
Agricultural Production	0.979	0.975	0.982	-0.007
Is Major Source of	(0.145)	(0.157)	(0.132)	(0.38)
Income				
Total Household Asset	3.854	3.708	4.009	-0.301
	(2.029)	(2.031)	(2.024)	(1.13)
Farmlands Grown	2.476	3.311	1.590	1.721***
(Hundred mu ²)	(3.120)	(3.936)	(1.472)	(-4.37)
Importance of	3.197	3.083	3.319	-0.235
Government Relief	(1.524)	(1.559)	(1.484)	(1.18)
Importance of Crop	3.210	3.192	3.230	-0.038
Insurance Indemnity	(1.487)	(1.557)	(1.414)	(0.20)
Percentage of Farmers	0.386	0.417	0.354	0.063
Willing to Purchase	(0.032)	(0.045)	(0.045)	(0.064)
Index Insurance				
Distance from Each	6.035	5.669	6.890	-1.221
Village to Heilongjiang	(2.583)	(2.227)	(3.687)	(1.841)
River (km)				
Observations	233	120	133	

The average surveyed household consists of four individuals and cultivates 247.6 mu of agricultural lands. As farmers are often reluctant to provide detailed financial information, the total value of household assets was elicited with an ordered categorical variable with 7 classes, with 1 being “below RMB 50,000” and 7 being “higher than RMB 300,000”. Among the 233 surveyed farm households, 98% depend on agriculture as their primary source of income and 96.6% indicated that a natural disaster is their major production risk.

Past purchase of insurance can affect farmers’ attitude towards insurance in a number of ways. It familiarizes farmers with the concept of insurance and how it works. It also increases farmers’ trust in the insurance company, especially if the farmer has received an indemnity in the past, after a disaster or accident. In the questionnaire we

² 1 mu = 666 m²

asked farmers if they had purchased crop insurance, medical insurance, and life insurance over the past three years (2011–2013). 51% of surveyed farmers purchased crop insurance at least once, and 44.2% of farmers purchased other insurance products (life insurance, commercial health insurance or auto insurance) at least once during 2011-2013.

We tested household's risk preference by doing a self-assessment survey, which is easier to implement than controlled laboratory methods and elicits risk preference highly correlated with that measured by controlled laboratory method (Dohmen, et al., 2011, Hardeweg, et al., 2013, Reynaud and Couture, 2012). The self-assessment financial risk tolerance question in this survey originated from the U.S. Federal Reserve Board's Survey of Consumer Finances (Gilliam, et al., 2010, Nielsen, et al., 2013). Farmers were asked to choose the financial risks they are willing to take in exchange for the returns corresponding to the following four choices: (1) take substantial financial risks and expect to earn substantial returns; (2) take above average financial risks and expect to earn above average returns; (3) take average financial risks and expect to earn average returns; (4) not willing to take any financial risks. The higher the choice number is, the more risk averse the respondent is. The average choice is 2.89, which means that farmers tend to take average financial risks and expect to earn average returns.

To elicit the importance of government relief and insurance, farmers were asked to scale how important government relief and crop insurance are in recovering from a natural disaster, with 1 meaning "very important" and 5 meaning "not important at all". It is expected that farmers who place greater importance on insurance will be most likely to purchase index insurance, and that farmers who place greater importance on government relief will be less likely to purchase index insurance. The average importance score is 3.2 for government relief and 3.21 for insurance. The scores indicate that government relief and insurance are moderately and equally important to farmers.

Since rainfall index insurance payouts depend on weather, we asked farmers how frequently they watch local weather forecasts. Farmers were also asked to elicit how accurate they believe local weather forecast is. It is expected that farmers who watch weather forecast more frequently or have more positive attitudes regarding their accuracy will be more likely to purchase weather index insurance. The data shows that farmers in sampled villages watched weather forecasts very frequently and that they felt the forecasts were accurate.

Farmers were also asked to assess the likelihood of a flood over the following five years. 49.8% of surveyed farmers held the belief that it is possible to have another flood in the following five years (2015-2020).

The percent of farmers expressing an interest in purchasing weather index insurance was 42% among farmers from flooded villages and a lower 35% among farmers from non-flooded villages.

6. Empirical Results

A. Natural Experiment Test

A natural experiment eliminates sample selection and identifies causal relationship between treatment effects and outcomes by changing the variable of interest while controlling other factors balanced. The comparison of the means of key variables between the treatment and control group is required in order to check whether an experiment design qualifies as a natural experiment. If the differences between the two groups are insignificant, an experiment design is often believed to have successfully balanced subjects' characteristics across groups (Angrist and Pischke, 2008). If the means of major characteristics of farmers from flood affected (treatment group) and non-affected (control group) villages are similar except for their attitude towards the index insurance, we can assume our survey qualifies as a natural experiment.

Means of key variables and the results of t-tests are listed in Table 1. The t-test shows that mean difference of most explanatory variables are insignificant between treatment and control group. Therefore we can conclude that the survey qualifies as a natural experiment.

Farmers in the treatment and control groups have different characteristics in age, past crop insurance purchases, frequency of watching weather forecasts, and land ownership. Household heads in flooded villages are 2.6 years older than that in non-flooded villages, but this difference is small relative to the average age of 45 years.

The significant difference in crop insurance participation can be explained by the special marketing channels. In China, crop insurers often market their products through local village officers or village committees instead of selling them directly to each individual farmer. If crop insurance is not available in a village, an individual farmer is unable to purchase crop insurance even with a strong willingness to buy. This is also reflected in our sample: 18% of farmers who had not purchased agricultural insurance during 2011–2013 said the main reason was that they did not know how to purchase crop insurance or where to purchase it. Another reason is the low premium and low level of protection. The crop insurance contract sold in Tongjiang is uniform. Farmers only need to pay RMB3/mu for crop insurance because the majority of the premium is covered by government subsidies. If no natural disaster listed in the contract occurs during the insured year, the contract is automatically renewed for the following year for free. The contract can be renewed twice without paying extra premium if no disaster occurs. In other words, the annual average premium for crop insurance is only RMB1/mu if no natural disasters occur in three consecutive years. Meanwhile, the protection provided by crop insurance is relatively low. The maximum coverage for rice growers is RMB200/mu, which only accounts for a third of rice production inputs exclusive of labor. This low premium-low protection policy means that crop insurance may not adequately protect farmers from production risks. The insignificance of crop insurance has been reflected in our data: farmers felt that on average, insurance is “not that important” for recovering from a natural disaster. Therefore, the difference in crop insurance participation between treatment group and control group is statistically significant, but economically insignificant since both the premium and maximum indemnity take only a small proportion of farmers' income, and therefore are less likely to have a significant effect on farmers' decision making.

Farmers in flooded villages watch local weather forecasts more frequently. However,

their feelings of accuracy are indifferent. Farmland owned and actually cultivated are also different between treatment group and control group. In our survey, households in treatment group have more farmlands on average than control group, but farmlands in control group are more productive. Considering that the crops and farming practice in each household in the surveyed area are very similar because of climate and geographic characteristics, we can assume that the total annual crop output in treatment and control group is similar.

The most important concern regarding our experimental design is the potential for endogeneity problems. Proximity to large rivers often indicates larger risk exposure to floods, which could lead to a higher awareness of potential disasters and a greater interest in insurance or other risk management mechanisms. A study on National Flood Insurance Program in U.S. finds that all else equal, coastal homes further from the shoreline are less likely to purchase flood insurance (Kriesel and Landry, 2004). If this is the case, it would be difficult to distinguish whether farmers' difference in WTP for rainfall index insurance comes from their recent experience in floods or from their higher awareness of potential disasters.

To solve this endogeneity problem, we need to know physical distance from Heilongjiang River to farmland and house owned by individual farm household in the surveyed area. If there is no significant difference in distance from household to Heilongjiang River between treatment and control group, we can assume that the difference in WTP stems from their past experience in the flood rather than their risk perception. However, datasets like this are unavailable. Distance from the center of each village to Heilongjiang River was used instead because in the surveyed villages, houses are all built in the center of a village, with the farmlands owned by villagers surrounding that location. We compared the physical distance from each village to Heilongjiang River in order to determine whether there is a significant difference in locations of surveyed villages. The location of each village (longitude and latitude) was obtained from Google Earth and the distances from villages to Heilongjiang River are calculated by ArcGIS.

The last row of Table 1 displays the distances from surveyed villages to Heilongjiang River. The average distance from non-flooded villages to Heilongjiang River is 6.89 km (4.28 miles), which is slightly larger than the average distance from flooded areas (5.67 km or 3.52 miles). The t-test shows that the mean-difference of distance to Heilongjiang River is not significantly different from 0, which indicates that the non-flooded villages are not significantly farther away from Heilongjiang River than flooded villages, and we can assume that there is no village-level heterogeneity in risk attitude.

B. Regression Results

The empirical results of logit, tobit and censored interval model are exhibited in Table 2. The logit model shows that farmers' interest in a rainfall index insurance program is significantly affected by their experience in the 2013 flood. Farmers who were affected by the 2013 flood are more willing to purchase rainfall index insurance. Since the results of t-test presented in Table 1 indicate that treatment group and control group are indifferent in most variables other than their experience in the 2013 flood, we

conclude that past experience in a natural disaster does change farmers' interest in an index insurance product which is designed to protect them from the same disaster in the future. This difference is more likely to result from a higher awareness of the necessity of insurance rather than a higher prediction on future disaster. The proportion of farmers expecting a future flood is not significantly different between treatment and control group, but 118 out of 120 flooded farmers admit that after experiencing the flood, they felt that crop insurance is important in managing production risks. However, the experience in the flood has no impact on farmers' WTP for the rainfall index insurance.

Interest in and WTP for rainfall index insurance is also significantly affected by farmers' belief in a future flood and the household assets. Farmers who believe that another flood is highly likely to happen in the future five years (2015-2020) are significantly more willing to purchase rainfall index insurance, and they are willing to pay a higher premium for the insurance. The amount of loan also affects farmers' WTP for index insurance. The more debt farmers take, the more likely they are going to purchase index insurance and the more they are willing to pay, though the magnitude of impact is very limited. Household assets are measured by a categorical variable, ranging from 1, less than RMB50,000 (or \$8,000), to 7, more than RMB300,000 (or \$50,000). The negative coefficients indicate that richer families are less likely to purchase rainfall index insurance. This can be explained by their higher ability to self-insure against income fluctuations, as self-insurance serves as a substitute of market insurance (Ehrlich and Becker, 1972). Farmers' dependency on government disaster relief is measured by an ordered 5-point categorical variable, with the basement level being "government relief is very important to me to recover from a natural disaster". The positive coefficients suggest that farmers who are less dependent on government relief are more interested in rainfall index insurance, which indicates complementarity between government relief and insurance and is consistent with findings in the literature. Farmers who are less dependent on government disaster relief also have a higher WTP for index insurance compared with farmers who think government relief is very important for them to recover from an adverse weather shock.

Table 2: Factors Affecting Farmers' Interest in and WTP for Rainfall Index Insurance

	Logit Model	Tobit Model	Interval Censored Model
Dependent Variable	Willing to Purchase	WTP	WTP
Affected by 2013 Flood	1.091** (0.464)	9.123 (5.867)	9.206 (6.221)
Amount of Netloan (Thousand RMB)	0.003* (0.002)	0.027 (0.018)	0.033* (0.020)
Watch Local Weather Forecast	1.467 (1.483)	14.106 (15.835)	15.606 (16.608)
Weather Forecast is Accurate	0.955 (1.069)	17.809 (14.517)	17.223 (15.259)

Belief in a Future Flood, 2015-2020	1.236*** (0.355)	14.409*** (4.926)	16.867*** (5.469)
Household Asset (50,001-100,000)	-2.316*** (0.661)	-28.595*** (9.056)	-29.134*** (9.578)
Household Asset (100,001-150,000)	-2.311*** (0.651)	-22.945*** (8.414)	-24.735*** (9.032)
Household Asset (150,001-200,000)	-1.236** (0.616)	-10.613 (7.873)	-10.355 (8.286)
Household Asset (200,001-250,000)	-2.386*** (0.795)	-25.915** (10.598)	-26.389** (11.204)
Household Asset (250,001-300,000)	-0.901 (0.767)	-7.968 (9.783)	-8.949 (10.350)
Household Asset (above 300,000)	-2.165*** (0.665)	-19.789** (8.511)	-18.954*** (8.919)
Crop Insurance is quite important	0.947 (0.584)	10.725 (7.563)	11.542 (8.008)
Crop Insurance is important	0.846 (0.577)	8.711 (7.582)	7.844 (7.999)
Crop Insurance is moderately important	0.144 (0.570)	3.800 (7.369)	4.281 (7.776)
Crop Insurance is not important	0.934* (0.538)	8.949 (7.140)	9.153 (7.563)
Government Disaster Relief is quite important	1.440** (0.580)	16.906** (7.892)	16.936** (8.345)
Government Disaster Relief is important	1.722*** (0.614)	21.081** (8.353)	21.224** (8.875)
Government Disaster Relief is moderately important	0.684 (0.654)	8.617 (8.474)	8.726** (8.970)
Government Disaster Relief is not important	1.268** (0.552)	16.049** (7.534)	16.993** (8.020)
Purchased Crop Insurance, 2011-2013	0.488 (0.408)	7.421 (5.318)	8.260 (5.654)
Purchased Other Insurance, 2011-2013	0.228 (0.355)	3.250 (4.558)	3.850 (4.830)
Constant	-8.035 (5.020)	-36.041 (60.857)	-34.695 (63.965)
sigma		23.901*** (4.059)	25.111*** 4.426
Observations	233	233	233
Pseudo R2	0.210	0.097	
chi2	65.275	55.124	57.04

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Predicted Probability of Being Interested in Rainfall Index Insurance

	Predicted Probability of Wiling to Purchase Rainfall Index Insurance	Expected WTP (RMB/mu for every RMB100 indemnity)	
		Tobit Model	Interval Censored Model
Entire Sample		7.762	7.963
Flooded Villages (Treatment Group)	0.474*** (0.067)	8.265	8.343
Non-flooded Villages (Control Group)	0.232*** (0.054)	7.228	7.560

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3 presents the predicted probability of being interested in rainfall index insurance and expected WTP. Holding all other variables at their means, the average probability of being willing to purchase index insurance in flooded villages is 0.474, which is more than twice of the probability in non-flooded villages, which is 0.232. Based on tobit model, farmers' average WTP is RMB7.76/mu for every RMB100 indemnity from rainfall index insurance. Farmers from flooded villages are willing to pay RMB8.27/mu for every RMB100 indemnity, which is 14.38% higher than 7.23/mu, the average WTP of non-flooded farmers, though this difference is statistically insignificant. The results from interval censored model are slightly higher than those from the tobit model. Flooded farmers are willing to pay 10.32% more for the hypothetical rainfall index insurance than non-flooded farmers, but the difference is still insignificant.

7. Summary and Conclusions

Weather index insurance is receiving growing attention from the Chinese central government, and several pilot programs have been established in different regions of China. In this paper we identify some of the factors influencing farmers' willingness to pay for weather index insurance with the intent of informing future agricultural policy. In particular, we assess whether farmers' interests in index insurance and their WTP are affected by recent experiences with natural disaster. We do so by comparing farmers who differed in whether they recently suffered losses from a flood, but who otherwise share similar demographic and financial characteristics. We find that farmers from flooded villages are twice as likely to purchase index insurance as farmers from non-flooded villages. However, the mean WTP for index insurance is around RMB7.8/mu for every RMB100 of coverage, with no significant difference between those who did and did not experience losses group.

However, whether our conclusion generalizes beyond the study areas is naturally questionable. The farm households in Northeast China that were surveyed for this paper

are more homogenous with regard to climatic and geographic characteristics than farm households in other parts of China. Farmers in the surveyed region also own more arable land than other Chinese farmers and use more machinery. A survey of a larger and more diverse sample of farm households is needed to gain a fuller understanding of the effects of natural disaster on Chinese farmers and their WTP for rainfall index insurance.

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