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Determinants of Livestock Insurance Demand: Experimental Evidence from Chinese Herders

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Abstract

We provide the first evidence about insurance preferences among herders in pastoral regions in China. We estimate herders' preferences for alternative insurance configurations based on a hypothetical and a consequential choice experiment, aiming to minimise hypothetical bias. Our results show that herders prefer the insurance plan in general with demand for livestock insurance increasing when insurance premiums decrease or payouts increase. The hypothetical bias only influences the willingness-to-pay estimates through the cost attribute, while the marginal rates of substitution of non-cost attributes remain largely unchanged. The hypothetical treatment nearly doubles the magnitudes of willingness-to-pay estimates for some insurance attributes.

Keywords: *China*; *choice experiments*; *hypothetical bias*; *livestock insurance*.

JEL classifications: *Q15, Q18, Q53.*

1. Introduction

Although agricultural insurance plays an important role in mitigating risk in agricultural production and sustaining agricultural development, the low demand for agricultural insurance concerns both policy-makers and academic scholars. Existing evidence indicates that agricultural insurance can defuse production losses (Akter *et al.*, 2017), mitigate price risk (Gardner *et al.*, 2001), reduce pesticide and fertiliser

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use (Mieno *et al.*, 2018), and optimise planting structure (Yu *et al.*, 2018). Moreover, agricultural insurance reduces the possibility of falling into poverty (Chantarat *et al.*, 2013) and smooths consumption (Kazianga and Udry, 2006). However, low participation in agricultural insurance limits these positive functions. It is important to understand the factors that affect farmers' agricultural insurance demand.

Climate risks strongly affect grassland-based livestock sectors around the world including pastoral China (Vroege *et al.*, 2019). For example, the major fire caused by drought in the pastoral area caused a total loss of over 100 million yuan in 2016 (Ministry of Agriculture of China, 2017). Livestock production is the major income source for herders in pastoral China, which accounts for 60% of total income (Ministry of Agriculture of China, 2018). Although the Chinese government has promoted livestock insurance for over 10 years, insurance covers only a small portion of herding farms. Therefore, it is critical to understand the low insurance demand and herders' preferences for different attributes of the insurance product.

The current implementation of the policy-oriented livestock insurance in pastoral China prevents the researchers from identifying which insurance attributes limit herders' purchase decisions because of the lack of variations in the key features of insurance products (e.g. premium and indemnity). The government started a pilot livestock insurance in the pastoral area in 2011. Although randomised controlled trials (RCT) could create different insurance products for different treatment groups (e.g. Belissa *et al.*, 2019; Matsuda and Kurosaki, 2019), RCT experiments in the field incur a high cost in the implementation and limit the applicability in a wide array of empirical contexts (Rosen *et al.*, 2006).

In the absence of RCT, attributed-based choice experiments (CEs) have been used to elicit farmer's preferences for insurance products. Tadesse *et al.* (2017) found that the average participant needs to be subsidised to buy insurance based on a CE applied to weather index insurance in Ethiopia. Liesivaara and Myyrä (2014) used a CE to identify the demand for crop insurance in Finland and found that the demand was higher among younger farmers and farms with more arable land. Akter *et al.* (2017) found that farmers in coastal Bangladesh are more likely to select standard crop insurance as opposed to index-based insurance, suggesting farmers' investment is influenced by their understanding of climate change risks and the utility of adaptation in addition to the insurance scheme design. Research has also identified gender differences in demand for insurance, which is mostly driven by trust in insurance institutions and financial literacy (Akter *et al.*, 2016).

Although CE is more popular, the results are subject to the influence of potential hypothetical bias from stated preference (e.g. Carson and Groves, 2007; Loomis, 2011; Vossler *et al.*, 2012; Bennett and Balcombe, 2012; Liu and Swallow, 2016; Penn and Hu, 2018). Hypothetical bias reflects the difference between hypothetical and real statements of value, where real statements of value can be approximated in experiments with binding economic commitments (List and Gallet, 2001). The literature suggests that choice experiments might over- or under-estimate average consumer willingness-to-pay (Penn and Hu, 2018; Svenningsen and Jacobsen, 2018; Sanjuán-López and Resano-Ezcaray, 2020). In the insurance market, Kesternich *et al.* (2013) concluded that the significance and signs of the estimated coefficients are similar in the real world and hypothetical choice experiments, even the magnitude is not statistically different with some exceptions. Several strategies have been used to mitigate the potential influence of hypothetical bias, including cheap talk, solemn oath, and consequentiality treatment (Murphy *et al.*, 2005; Morrison and Brown, 2009; Penn and Hu, 2018; Penn and Hu, 2019). Empirical evidence implies that consequentiality is important to motivate realistic preference representations (Carson and Groves, 2007; Kling *et al.*, 2012).

Few studies have investigated the role of consequentiality in eliciting insurance preferences (Sauter *et al.*, 2016; Vroege *et al.*, 2019). One possible reason is that the complete implementation of consequential treatment is expensive, especially for livestock insurance which has high coverage value. We develop a consequential treatment with a probabilistic payment to explore the existence and magnitude of hypothetical bias. While a fully consequential treatment requires a large implementation budget, our consequential treatment sets a real probability for each participant of enrolling in a specified livestock insurance plan based on the chosen CE scenario.

We make three contributions to the current literature. Ours is the first study to elicit pastoralists' preferences for livestock insurance in China and among the few studies in subsidised livestock production in pastoral areas. Compared to the widely studied crop insurance, livestock insurance receives less attention (Smith, 2016; Jensen *et al.*, 2017) and no existing studies focus on livestock insurance in the pastoral area (Birgit *et al.*, 2011; John *et al.*, 2019). Livestock production in pastoral areas is quite different from that in crop areas. Livestock is the most important property for herders and the major source of food and income (O'mara, 2012), which also highly relies on natural grassland and therefore is highly sensitive to climate risks (Thornton *et al.*, 2009). In addition, most herders reside in underdeveloped regions and thus are less likely to have other opportunities (e.g. off-farm employment) to mitigate agricultural risks (Hao *et al.*, 2015). Herders without proper insurance can easily fall into poverty under the increasing threat of climate change and other natural disasters.

Second, we develop a cost-effective consequential treatment to test the existence and magnitude of hypothetical bias in our insurance choice experiment. We randomly divided the sample into two groups. In the control group, a standard CE with hypothetical scenarios is administered. In the treatment group, we set a real probability for each participant of enrolling in a specified livestock insurance plan based on their chosen CE alternative. The consequential outcome is enforced through a bilateral contract between the participants (herders) and the research institution. This treatment provides a consequential CE to researchers with limited funding.

Third, methodologically, we develop a misclassification probability model to calibrate the willingness to pay (WTP) in the hypothetical treatment using the consequential treatment as the baseline. The misclassification probability acknowledges that the participants may not always choose the most preferred alternative in a choice scenario. The probability of not choosing the most preferred alternatives are explicitly estimated in the models. The unique characteristics of our subject pool also broadened the scope of the current literature on hypothetical bias in stated preference studies.

The remainder of the paper is organised as follows. Section 2 provides the research background and theoretical framework. Section 3 describes the experimental design and data. Section 4 presents the econometric models. Section 5 presents the results. Section 6 concludes the paper.

2. Background and Theoretical Framework

2.1. Background

Only 1.3% of the total population (18 million) live in the pastoral area of China, which accounts for 40% of the total land area, covering 268 counties in 13 provinces. This region produced about 30% of total beef and mutton production and 28% total milk production in 2017 (National Bureau of Statistics of China, 2018). Grazing livestock is the major farm enterprise with few additional forage inputs and is the major income source, accounting for 70% of total income. In addition to the role in economic development, pastoral China provides important ecosystem services, such as carbon storage (Dong *et al.*, 2020), adjusting climate (Amani-Beni *et al.*, 2018), water conservation (Ibáñez *et al.*, 2020), windbreak sand fixation (Mao *et al.*, 2011), improving soil (Dong *et al.*, 2006), and providing biodiversity (Stumpf *et al.*, 2020).

Frequent extreme weather events, especially drought and snow disasters, reduce hay and livestock production, create water shortages for both livestock and humans (Mwang'ombe *et al.*, 2010), and grassland ecosystem degradation (Li *et al.*, 2012). Moreover, lack of adaptation measures to weather risks exacerbates the vulnerability of herders and their production systems. For example, our field survey data show that while buying more hay and selling animals are the common adaptations to drought, only 50% of sampled herders had bought more hay in response to drought. About 12% of the herders had to sell animals and the rest have no adaptations.

The government started a pilot livestock insurance programme in the pastoral area in 2011. Before 2011, cattle and sheep were not covered by livestock insurance. Only 3% of dairy cattle were covered by livestock insurance in Inner Mongolia in 2011 with limited supply (Han, 2013). Only 20% of cattle and sheep were insured in the Qinghai pastoral area under the pilot livestock insurance programmes. In contrast, nearly 60% of pigs are insured in the crop area (Nan, 2018). The livestock insurance industry may not have a comprehensive understanding of herders' demand. During our field trip, herders reported that the current indemnity is too low compared to livestock prices and they would like to pay a higher premium to buy an insurance product with a higher indemnity. Herders also reported that waiting too long to receive indemnity makes them less likely to buy the current products. To address these issues, we carried out the first empirical study on the herders' preference for livestock insurance and provide evidence-based support to the current programme.

2.2. Theoretical framework

Below we outline a simple theoretical framework to guide our empirical analyses on the influence of insurance premium (denoted by c_i), indemnity (I), waiting time to receive indemnity (T), and additional requirement (R). The herder maximises expected net benefit by choosing the size of stock, q, to be insured. We assume there is probability π that no adverse conditions occur so that the herders' profit is $pq-(1/2)c_o(\theta)q^2-c_iq-Rq$, where p is the unit price, c_i is the insurance cost per livestock unit, R is the cost of additional requirement imposed on each livestock unit, and $(1/2)c_o(\theta)q^2$ represents all other cost per unit with $\theta\in[\underline{\theta},\overline{\theta}]$ capturing heterogeneity among herders. We assume a larger θ corresponds to a higher per unit cost (or less cost effectiveness) and $c_o'(\theta)>0$. There is a probability $1-\pi$ that adverse conditions (e.g., natural hazards) occur and the herders' profit is $(1-\delta)\beta^T Iq+\delta pq-(1/2)c_o(\theta)q^2-c_iq-Rq$, where $\delta(0\leq\delta<1)$ is the percentage remaining after the adverse conditions, $\beta(0<\beta<1)$ is the discount factor, and T is the time the herder needs to wait to receive the indemnity. A herder's expected net benefit function is[1]

$$ENB = \pi\left(pq - \frac{1}{2}c_o(\theta)q^2 - c_i q - Rq\right) + (1-\pi)\left((1-\delta)\beta^T Iq + \delta pq - \frac{1}{2}c_o(\theta)q^2 - c_i q - Rq\right).$$

The herder chooses q to maximise expected utility, which leads to

$$\frac{\partial ENB}{\partial q} = 0,$$

or

$$((1-\pi)\delta + \pi)p + (1-\delta)(1-\pi)\beta^T I - (c_i + R) - c_o(\theta)q^* = 0.$$

We first derive the relationship between the optimal insured stock size and the herder's type θ. Let

$$G(q^*) = ((1-\pi)\delta + \pi)p + (1-\delta)(1-\pi)\beta^T I - (c_i + R) - c_o(\theta)q^*.$$

According to the first-order condition and the implicit function theorem, we have

$$\frac{\partial q^*}{\partial \theta} = -\frac{\frac{\partial G}{\partial \theta}}{\frac{\partial G}{\partial q^*}} = -\frac{c_o'(\theta)q^*}{c_o(\theta)} < 0$$

since $c_o'(\theta)>0$ We find that herder with a higher θ (less cost-effective) will choose to insure a smaller stock. Similarly, we find that

$$\frac{\partial q^*}{\partial c_i} = -\frac{\frac{\partial G}{\partial c_i}}{\frac{\partial G}{\partial q^*}} = -\frac{1}{c_o(\theta)} < 0,$$

suggesting an increase in the insurance premium will lead to a smaller insured stock, or for a given minimum coverage requirement, fewer herders will choose to buy the insurance. Furthermore, we can derive

$$\frac{\partial q^*}{\partial T} = -\frac{\frac{\partial G}{\partial T}}{\frac{\partial G}{\partial q^*}} = \frac{(1-\delta)(1-\pi)\beta^T I \ln\beta}{c_o(\theta)} < 0$$

and

$$\frac{\partial q^*}{\partial I} = -\frac{\frac{\partial G}{\partial I}}{\frac{\partial G}{\partial q^*}} = \frac{(1-\delta)(1-\pi)\beta^T}{c_o(\theta)} > 0,$$

suggesting an increase in the waiting period will lead to fewer herders to buy the insurance and an increase in the indemnity will lead more herders to buy the insurance (Casaburi and Willis, 2018). The derivation of $(\partial\theta^*/\partial R)$ is similar to $(\partial\theta^*/\partial c_i)$ and we can infer that $(\partial\theta^*/\partial R)<0$, suggesting that a stricter insurance requirement leads fewer headers to purchase the insurance.

[1]We assume that farmers gain utility from an increase expected profits by assume the utility function is montonicly increase in the net profits (Chavas, 2004). Our analyses can then be used to how risk preference will influence insurance demand explicity.

3. Experimental Design and Data

3.1. Choice experimental design

We selected five attributes for our experimental insurance plan (Table 1) based on the preliminary field survey, pilot insurance policy, and consultation with agricultural and insurance experts. Our choice of insurance factors best reflects the most important aspects that influence herders' insurance choice, given current knowledge. A typical insurance product contains several fundamental attributes, such as what is insured, how much the insurance costs (i.e., the premium), how much the insurance pays (i.e., the indemnity), the conditions under which the payout occurs, and additional enrolment requirements. The cost attribute in our choice experiment represents the price premium in yuan per head per year. When other attributes are the same, a higher price premium reduces the insurance demand. Existing literature suggests that a cash constraint may impede farmers in buying insurance (McIntosh *et al.*, 2013). The pilot cattle insurance policy in Qinghai sets the premium at 18 yuan/head/year. The premium subsidy paid by the government is 102 yuan. We set the levels for the premium in our experiment at 36, 60, 120 and 200 yuan based on our discussion with local experts and current premium in the pilot cattle insurance policy. In our study region, the mortality rate of livestock is about 1%–5%. Thus, this interval includes the actuarial fair amount and in the choice experiment, we have relatively greater flexibility to set the premium levels compared to large scale, real insurance contracts.

Indemnity is another key attribute that may influence a potential insurer's decision in purchasing insurance. The pilot cattle insurance pays 2,000 yuan if the insured animals die in a year. Based on our preliminary survey, the market price of cattle is approximately 4,000 yuan per head, and herders in pilot areas complained that the 2,000 yuan indemnity is too low. Animal death triggers a payout in our experiment, and the herders were informed of this condition (i.e., animal death) for payout.

The minimum coverage for herders to enrol in insurance is also a key attribute. High transaction costs are commonly criticised as they cause an insufficient supply of agricultural insurance products (Poole, 2017), particularly in regions where small households are scattered over a large geographical region. To reduce high transaction costs, the insurance company requires minimum insurance coverage for herders to enrol. Setting a minimum coverage will reduce the adverse selection behaviour of herders (i.e., to insure less healthy animals, rather than those that are healthy). We set the minimum coverage levels at 25%, 50%, 75%, and 100% of the herd.

Requiring the insured animals to have an ear tag or a complete immunisation record helps prevent moral lapses among the herders. Animals with basic

Table 1
Attributes and levels in the choice experiment

Attributes	Levels
Premium (yuan per head)	36, 60, 120, 200
Indemnity (yuan per head)	3,000, 4,000, 5,000
Minimum insurance coverage	25%, 50%, 75%, 100%
Waiting time to receive indemnity	2 months, 6 months, 12 months
Additional requirement	Only ear tag, complete immunisation record

Table 2
An example of a choice experiment (translated from Chinese)

	Option A	Option B	Option N
Premium (yuan per head)	36 RMB (per cattle)	120 RMB (per cattle)	No Insurance
Indemnity (yuan per head)	3,000 RMB (per cattle)	4,000 RMB (per cattle)	
Minimum insurance coverage	100%	50%	
Waiting time to receive the indemnity	Receive indemnity in 12 months	Receive indemnity in 6 months	
Additional requirement	Ear tag required	Complete immunisation record required	
Your choice (Please √ your option)			

immunisation have an attached ear tag, which is a less stringent requirement than the provision of a complete immunisation record.

In our preliminary field trips, we noticed that herders prefer to receive indemnity soon after their animals die. A longer waiting time makes them less likely to buy insurance. Thus, we include the waiting time to receive indemnity as one attribute with three levels (2, 6 and 12 months). Table 1 lists the attributes and the corresponding levels we used during the choice experiment. A final set of 24 choice scenarios were selected using the Ngene programme to optimise the D-efficiency. Table 2 provides an example of the choice experiment (translated from Chinese).

We designed two experimental treatments that differed in consequentiality, that is, the hypothetical and consequential treatments. The consequential has a small probability of being consequential (only 1%) in our context. Herders are randomly assigned to one of the treatments, resulting in approximately one-half of the respondents in the hypothetical (113 respondents) and one-half in the consequential (116 respondents) groups. The randomisation enables us to focus on the difference between the hypothetical and consequential treatments. In the hypothetical treatment, we asked the participants to choose one of the scenarios while no actual payment would be made. Specifically, participants were told the following:

> Assume the insurance company provides the following two cow insurance plans with the features specified below. You can choose one of the insurance plans, or neither of them. You will be asked to make six different choices.

In a genuinely consequential treatment, a bilateral contract between the participants (herdsmen) and the research institution would be executed. Herders would need to pay the insurance premium. If the insured livestock dies, participants would be indemnified according to the insurance plan. However, it is too challenging to enforce the contract for all herders in the consequential treatment due to our research capacity and budget constraints. Therefore, each participant in our consequential treatment has a 1% chance of receiving compensation from the research institute. Even for a selected farm, we do not have the financial capacity to sign the contract for all the animals that the herder wants to insure. In an extreme case, if all cows died on a farm, our research budget would not allow us to cover all the costs. Therefore, we only require the herdsmen to pay the insurance premium for one animal and compensate the participants if any of the livestock die; we pay the participants' the specified insurance times the coverage probability. The expected premium and indemnity are the same for one insured animal and all insured animals assuming the probability of animal death is the same. Specifically, we told each participant the following:

> Assume the insurance company provides the following two cow insurance plans with the features specified below. You can choose one of the insurance plans, or neither of them. You will be asked to make six choices. To make the experiment more effective, we have the following incentive mechanism.
>
> We will randomly choose one of your six choices and sign an insurance contract with you according to the terms specified in the insurance plan you chose. Of course, you need to pay the insurance premium according to the plan. Note that you only have to pay the insurance premium of one cow; if any animal dies, we will confirm and compensate you accordingly. Even if you only insured one cow, we will compensate you if any cows die. Your compensation equals the insured amount*the coverage percentage. For example, if you choose an option that the insured amount is 500 yuan, and the coverage is 75%, if one of your cattle dies during the next year, we will compensate you 500*75% = 375 yuan, but not 500. This is fair, right? The expected premium and indemnity are the same for one insured animal and all insured animals assuming the probability of animal death is the same for all insured animals.
>
> You have a one percent chance of being chosen and we will randomly choose one of your choices after you finish all six questions, so please carefully answer each question

3.2. Sampling method and data description

We conducted the herdsmen survey in Qinghai and Gansu, China, in 2017. Qinghai and Gansu are the two major pastoral provinces, where grassland accounts for more than 20% of the total land cover (National Bureau of Statistics of China, 2017). A stratified random sampling strategy is used to sample the herders. We divide all the counties in an alpine meadow in Gansu into four quantiles according to annual income per capita. One county is randomly selected from each quantile. Similarly, Qinghai is divided into three terciles, and two counties are randomly selected from each group. We sample four counties in Gansu and six counties in Qinghai. After excluding the counties without grazing herders, the remaining townships in each county are divided into three terciles according to the per capita grassland area. One township is randomly selected from each group. We select 30 townships in the 10 counties. Similarly, one village is randomly selected from the higher per capita grassland area group and the other is from the lower group. Six households are randomly selected from each village. In total, our sample includes 360 households residing in 60 villages in 30 townships in 10 counties. We only conducted the choice experiment in the regions with cattle as major livestock rather than areas dominated by sheep. Thus, 229 herders participated in the choice experiment. The study area is shown in Figure S1.

The interviewees were trained to conduct the experiment following a standardised procedure. In addition to the choice experiment, we also interviewed the herders to collect major demographic information. Table S1 provides a list of variables used in the choice experiment and demographic surveys, with a brief description provided for each variable. Tables S2 and S3 (also online) summarise the choice experiment and demographic variables, respectively. To test the randomisation implementation, we also calculated the differences in these variables between the hypothetical group and consequential group (Tables S2 and S3). Results indicate that there is no significant difference between the hypothetical and consequential groups, which validates our treatment randomisation implementation.

4. Econometric Models

4.1. Basic models

Based on the random utility framework (McFadden, 1973; Hanemann, 1984), an individual i's utility from choosing an option j, U_{ij}, consists of an econometrically measurable component, V_{ij}, and a random component, ε_{ij}, which is unobservable to econometricians and assumed to be independently and identically distributed. The measurable component V_{ij} depends on the livestock insurance attributes excluding the insurance premium, denoted by $\boldsymbol{X_j}$, the socioeconomic characteristics of the individual i, denoted by $\boldsymbol{S_i}$, and the insurance premium c_j of choosing the option j. Note that $c_i = 0$ if one chooses the no insurance option. Specifically, individual i's utility from choosing an option j is:

$$U_{ij} = U(\boldsymbol{X_j}, \boldsymbol{S_i}, c_j) = V(\boldsymbol{X_j}, \boldsymbol{S_i}, c_j) + \varepsilon_{ij}.$$

The vector $\boldsymbol{X_j}$ can be decomposed into the indemnity I_j, minimum insurance coverage M_j, time to receive the indemnity after filing the claim T_j, and insurance requirement R_j. In the choice experiment questions, each subject considers three buying alternatives: buying one of two insurance plans (option A or B) or choosing the status quo (option N) of buying nothing. If the individual's choice implies her utility is higher for an alternative $j \in \{A, B, N\} \equiv J$, providing utility U_{ij} compared to all the other alternatives U_{ik} ($k \neq j, k \in J$), then the probability that individual i chooses alternative j is estimated by the following:

$$P_i(j) = \Pr(U_{ij} > U_{ik}, k \neq j, k \in J)$$

$$= \Pr(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}, k \neq j, k \in J) = \Pr(\varepsilon_{ij} - \varepsilon_{ik} > V_{ik} - V_{ij}, k \neq j, k \in J)$$

where Pr $(\cdot)$ is the probability operator. Based on the error structure, the probability can be simplified (McFadden, 1973) as follows:

$$P_i(j) = e^{V_{ij}} / \sum_{m \in J} e^{V_{\mathrm{im}}},$$

We assume that the utility function is separately additive, and the linear specification is as follows:

$$V_{ij} = \beta_c c_j + \beta_I I_j + \beta_M M_j + \beta_T T_j + \beta_R R_j + \beta_d ASC_j + \boldsymbol{\beta_s} ASC_j * \boldsymbol{S_i} + \varepsilon_{ij},$$

where β_c, the coefficient associated with an insurance premium c_j, is expected to have a negative sign according to our theoretical model. We expect that the indemnity I_j will have a positive influence, while other attributes, such as the minimum coverage

M_j, time of receiving payment T_j, and insurance requirement R_j, are imposing additional constraints compared to the respective baselines and thus would negatively influence one's utility based on our theoretical framework. ASC_j is the alternative specific constant (ASC) and equals 1 if the option is no insurance and 0 otherwise. Therefore, the set of coefficients $\boldsymbol{\beta}_s$ can be interpreted as the relative propensity of choosing no insurance option for the individual i with the demographic attribute S_i.

4.2. Presence of hypothetical bias and calibrating the results in the hypothetical treatment

In this section, we first test the presence of hypothetical bias by incorporating an interaction term of a treatment dummy variable and the cost attribute c_j, and an interaction term of the treatment dummy variable and the ASC. Adding interaction terms assumes that the utility functions for the two groups are different from each other, which is not consistent with economic theory as we should expect that the utility function remains the same among the two different experimental groups from random assignment. A common approach to account for the potential scale heterogeneity across different treatments (Haab, 1999; Carlsson and Johansson-Stenman, 2010; Fiebig *et al.*, 2010; Salisbury and Feinberg, 2010) is to incorporate a scale parameter in the hypothetical treatment to allow the scale parameter to vary compared to the consequential treatment. The mathematical form of incorporating a scale parameter σ_t in the hypothetical treatment is as follows:

$$P_i(j) = \Pr\left(U_{ij} > U_{ik}, k \neq j, k \in J\right)$$

$$= \Pr\left(V_{ij}/\sigma_t + \varepsilon_{ij} > V_{ik}/\sigma_t + \varepsilon_{ik}, k \neq j, k \in J\right) = \Pr\left(\varepsilon_{ij} - \varepsilon_{ik} > (V_{ik} - V_{ij})/\sigma_t, k \neq j, k \in J\right),$$

where $\Pr(\cdot)$ represents the probability operator, and can be further simplified as follows:

$$P_i(j) = \frac{e^{V_{ij}}}{\sum_{m \in J} e^{V_{\mathrm{im}}/\sigma_t}},$$

The scale parameter in the consequential treatment is normalised to 1. The scale parameter modelling approach can only proportionally scale the coefficient estimates, indicating that the marginal rate of substitution is unchanged in the hypothetical treatment. In the following, we illustrate an alternative method in which the observed choices are not necessarily the choice that provides the highest utility given a certain choice scenario when individuals are not sufficiently incentivised or strategically act in their decision makings. We then establish the link between the presence and the implications of hypothetical bias and develop a means to calibrate the estimation results in the presence of hypothetical bias.

Recall that individual i's probability of choosing an option j is as follows:

$$P_i(y=j) = P_i(y^*=j) = \Pr\left(U_{ij} > U_{ik}, k \neq j, k \in J\right)$$

$$= \Pr\left(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}, k \neq j, k \in J\right) = \Pr\left(\varepsilon_{ij} - \varepsilon_{ik} > V_{ik} - V_{ij}, k \neq j, k \in J\right)$$

which holds only if individual i always chooses the option that provides the highest utility in a choice question. We use y to indicate the observed choices while we use y^* to indicate the choice that provides the highest utility among the three options. The observed option y does not always match the option y^* such that $Pr(y=j|y^*=j)<1$, reflecting that individuals may not always choose the option that gives the highest utility in a given choice opportunity.

Theoretically, when the choice is incentive compatible, $Pr(y=j|y^*=j)=1$and $Pr(y=j|y^*=j\_)=0$, where we use $j\_$ to denote the option(s) other than j. Thus, according to the law of total probability,

$$Pr(y=j)=Pr(y=j,y^*=j)+Pr(y=j,y^*=j\_)=Pr(y=j|y^*=j)Pr(y=j^*)$$
$$+Pr(y=j|y^*=j\_)Pr(y^*=j\_)$$

In our context, if the observed option is A, then the probability option A is chosen when A provides the highest utility in $Pr(y=A|y^*=A)$. Similarly, the probability option A is chosen when the option B (or N) provides the highest utility in $Pr(y=A|y^*=B)$ (or$Pr(y=A|y^*=N)$). To proceed, we assume $Pr(y=j|y^*=j)=1, j=A,B,N$ in the consequential treatment, and the proportions of misclassification choices in hypothetical treatment are as follows:

$$Pr(y_i=A|y_i{}^*=B)=Pr(y_i=B|y_i{}^*=A)=\delta_1,$$

$$Pr(y_i=A|y_i{}^*=N)=Pr(y_i=B|y_i{}^*=N)=\delta_2,$$

$$Pr(y_i=N|y_i{}^*=A)=Pr(y_i=N|y_i{}^*=A)=\delta_3.$$

where δ_1 denotes the probability that the observed choice is one insurance option while the utility maximisation choice is the other insurance option; δ_2 denotes the probability that the observed choice is among the insurance options while the utility maximisation choice is the no insurance option; and δ_3 denotes the probability that the observed choice is the no insurance option while the utility maximisation choice is one of the insurance options.

Therefore, the probability when individual i is observed choosing option A is as follows:

$$\Pr(y_i=A)=\sum_{j\in\{A,B,N\}}\Pr(y_i=A,y_i{}^*=j)=Pr(y_i=A|y_i{}^*=A)Pr(y_i{}^*=A)$$
$$+Pr(y_i=A|y_i{}^*=B)Pr(y_i{}^*=B)$$
$$+Pr(y_i=A|y_i{}^*=N)Pr(y_i{}^*=N)=(1-\delta_1-\delta_2)\frac{e^{V_{iA}}}{\sum_{m\in J}e^{V_{im}}}$$
$$+\delta_1\frac{e^{V_{iB}}}{\sum_{m\in J}e^{V_{im}}}+\delta_2\frac{e^{V_{iN}}}{\sum_{m\in J}e^{V_{im}}}=\frac{((1-\delta_1-\delta_2)e^{V_{iA}}+\delta_1 e^{V_{iB}}+\delta_2 e^{V_{iN}})}{\sum_{m\in J}e^{V_{im}}}$$

Similarly, we have,

$$\Pr(y_i=B)=\sum_{j\in\{A,B,N\}}\Pr(y_i=B,y_i{}^*=j)=\frac{((1-\delta_1-\delta_2)e^{V_{iB}}+\delta_1 e^{V_{iA}}+\delta_2 e^{V_{iN}})}{\sum_{m\in J}e^{V_{im}}}$$

$$\Pr(y_i=N)=\sum_{j\in\{A,B,N\}}\Pr(y_i=N,y_i{}^*=j)=\frac{((1-2\delta_3)e^{V_{iN}}+\delta_1 e^{V_{iA}}+\delta_2 e^{V_{iB}})}{\sum_{m\in J}e^{V_{im}}}$$

We estimate the utility, as well as the probability parameters, in the hypothetical treatment based on the constructed probabilities equations. Note that this approach enables calibration of the utility parameters in the hypothetical treatment and estimation of the same set of utility parameters from the consequential and hypothetical treatments. We proceed by calculating the marginal willingness-to-pay estimates in both hypothetical and consequential treatments. In a linear, separately additive utility function, the marginal willingness to pay for a choice attribute equals the following:

$$mWTP = -\frac{\frac{\partial V}{\partial X}}{\frac{\partial V}{\partial C}}.$$

According to these equations, we calculate the $mWTP$ for the hypothetical and consequential treatments of each choice attribute, respectively. The confidence intervals are calculated using the bootstrap method as it is more robust to noisy data and misspecification of the model compared to the delta or the Krinsky Robb method (Hole, 2007).

5. Results

5.1. Main results

Table 3 lists the standard conditional logit estimation results for the basic models. Column (1) reports the results from the baseline model, which does not distinguish the two treatments with data from both treatments pooled together. Column (2) adds a term when the ASC interacts with a treatment dummy variable based on Column (1). Column (3) adds a term when the premium interacts with a treatment dummy variable based on Column (1). In Column (4), both the ASC and premium interaction terms are included. The results without the demographic variables are shown in Table S4 (online), which are consistent as shown in Table 3.

Consistent with our theoretical framework, the premium coefficient is negatively significant across all specifications, indicating a higher insurance payment decreases herders' WTP as expected. Herdsmen are less likely to choose an insurance scheme with a higher premium *ceteris paribus*. The amount of indemnity also significantly influences the herders' decision in an expected manner. The higher the expected indemnity, the more likely were the participants to choose the alternative. The magnitudes of the influence are similar across all specifications. An indemnity of 4,000 or 5,000 yuan is preferred to the baseline of 3,000 yuan, as the coefficients of both *Indemnity4000* and *Indemnity5000* are significantly positive across all specifications. However, the marginal utility of increasing an indemnity from 3,000 to 4,000 yuan is higher than that from 4,000 to 5,000 yuan, which is consistent with a decreasing marginal utility in indemnity.

With partial coverage, we expect herders to insure less healthy animals due to adverse selections. Our results show that the herders are more likely to buy the product if the coverage level is 100% while there is no significant difference between other levels, suggesting that the risk aversion to potential loss may override the potential benefit from the adverse selection from the herders' perspective. A new experimental design is needed to explicitly explore this possibility and our results are only able to provide some suggestive evidence. Also, our results may be influenced by the insufficient supply and high demand for livestock insurance in the pastoral area. Future research could explore the effects when participants are encouraged to consider the consequentiality of their choices explicitly on the insurance provision and adoption.

We find that the participants are more likely to enrol in an insurance option if indemnity is paid sooner. Lack of financial liquidity, or simply the discount factor, may encourage herders to prefer the product with a shorter waiting time. Our

Table 3
Preferences for livestock insurance: results from a standard conditional logit model

	(1)	(2)	(3)	(4)
Premium	−0.009***	−0.009***	−0.008***	−0.007***
	(0.001)	(0.001)	(0.001)	(0.002)
Premium_consequential			−0.004**	−0.006**
			(0.002)	(0.002)
ASC	−5.44***	−5.44***	−5.37***	−5.34***
	(0.828)	(0.828)	(0.822)	(0.830)
ASC_consequential		0.013		−0.268
		(0.170)		(0.203)
Indemnity4000	0.231***	0.231***	0.231***	0.232***
	(0.082)	(0.082)	(0.082)	(0.082)
Indemnity5000	0.334***	0.334***	0.335***	0.336***
	(0.090)	(0.090)	(0.090)	(0.090)
Coverage50	0.143	0.143	0.145	0.146
	(0.106)	(0.106)	(0.106)	(0.106)
Coverage75	0.110	0.110	0.113	0.114
	(0.113)	(0.113)	(0.113)	(0.113)
Coverage100	0.184*	0.184*	0.186*	0.188*
	(0.105)	(0.105)	(0.105)	(0.105)
Duration6	−0.223***	−0.223***	−0.224***	−0.225***
	(0.083)	(0.083)	(0.083)	(0.083)
Duration12	−0.628***	−0.628***	−0.629***	−0.630***
	(0.087)	(0.087)	(0.087)	(0.087)
Requirement	0.047	0.047	0.048	0.048
	(0.061)	(0.061)	(0.061)	(0.061)
Interactions of ASC with				
Familysize	0.066	0.066	0.064	0.066
	(0.042)	(0.042)	(0.042)	(0.042)
Gender	−0.765***	−0.766***	−0.785***	−0.768***
	(0.262)	(0.262)	(0.262)	(0.262)
Age	0.049***	0.049***	0.048***	0.049***
	(0.009)	(0.009)	(0.009)	(0.009)
Married	−0.748**	−0.747**	−0.739**	−0.749**
	(0.304)	(0.304)	(0.303)	(0.304)
Hukou	0.615*	0.616*	0.640*	0.628*
	(0.332)	(0.332)	(0.333)	(0.333)
Vleader	0.300	0.301	0.317	0.301
	(0.212)	(0.213)	(0.213)	(0.213)
Smartphone	1.988***	1.985***	1.953***	2.003***
	(0.511)	(0.513)	(0.511)	(0.513)
Trad. phone	2.154***	2.151***	2.121***	2.169***
	(0.505)	(0.507)	(0.505)	(0.507)
Write	−1.012***	−1.011***	−1.002***	−1.019***
	(0.344)	(0.344)	(0.343)	(0.344)
Read	−1.235***	−1.234***	−1.219***	−1.231***
	(0.244)	(0.245)	(0.244)	(0.245)
N	4,122	4,122	4,122	4,122
Log-likelihood ratio	−1241.0	−1241.0	−1238.6	−1237.7
df_m	21	22	22	23

Note: Column (1) reports the results from the baseline models, which do not distinguish the two treatments with data from both treatments pooled together. Column (2) adds a term when the ASC interacts with a treatment dummy variable based on Column (1). Column (3) adds a term when the premium interacts with a treatment dummy variable based on Column (1). In Column (4), both the ASC and premium interaction terms are included.

willingness-to-pay estimates suggest that factors other than the discount rate are likely to contribute to the large magnitude of the time preference we estimated from the model. Herders do not distinguish a mild additional requirement of an ear tag from a strong requirement of a complete immunisation record, which may reflect the free provision of livestock immunisation by the local government.

The ASC coefficients are negatively significant, indicating a tendency to choose an insured plan. The differences can be explained by several demographic variables. The negative coefficients of *gender, marriage, read* and *write* indicate that female and married herders and those who can read/write are more willing to choose insurance, which suggests female-headed households may face more risks, married families need more stable income flows, and those who can read/write may have more knowledge of the role or the importance of insurance. Older people, those with agricultural *hukou,* and those who use phones are less likely to buy an insurance product, indicating that when promoting livestock insurance in a pastoral area, more attention should be paid to seniors and people with agricultural *hukou*. People using cellphones, particularly those with smartphones, may have more opportunities to mitigate livestock risks, such as easy access to weather or other information, and they may have less incentive to buy livestock insurance.

Furthermore, based on Table 3, Column (2), our results show that the difference in the consequentiality does not influence the choice probability between the insurance or the status quo of no insurance. The interaction term of ACS and real treatment dummy is very small and insignificant at the 10% level. The consequentiality influences the willingness-to-pay estimates through the cost attribute (i.e., the premium). The cost coefficient associated with the ASC in the interaction terms is insignificant in both Columns (3) and (4) based on Table 3. In addition, because the ASC interaction terms are not significant in Columns (2) and (4), the hypothetical bias, if it exists, is unlikely to depend on the respondents' demographic characteristics. The premium interaction terms in Columns (3) and (4) are all negatively significant, indicating that in the consequential treatment, respondents are more sensitive to the insurance premium changes, consistent with a large body of literature regarding hypothetical bias (e.g., Liu and Swallow, 2016). In the Appendix S1, Table S5, we have also used the total estimated insurance cost instead of the per-head insurance cost. The total estimated insurance cost equals the per-unit cost times the stock size, and times the coverage. We find that using the total insurance cost has little influence on our results.

Herders' risk, ambiguity, and time preference may impact various decisions, such as pesticide use or insurance choices (e.g., Tanaka *et al*., 2010; Liu and Huang, 2013; Hou *et al*., 2020). In our survey experiment, we solicited herders' risk preferences using a simple approach. Since risk is not the primary research question and we were concerned about the level of complexity and time constraint, our risk preference elicitations are not incentivised and rely on a simple format instead of a more styled MPL approach used in Holt and Laury (2002) where risk coefficients can be precisely estimated as a utility parameter. Table S6 in the Online Appendix S1 illustrates our elicitation method. Herders were asked to choose between Option A: a lottery with a 50% chance of getting 100 yuan and 50% of getting 0 yuan and Option B: a fixed amount. The fixed amount is increasing in the choice number. A higher choice number indicates more risk-loving and vice versa. We use the first switching point (the first occurrence of a herder switching from A to B) whenever multiple switching choices are observed. Since the risk preference is correlated with various demographic attributes (e.g., Ward and Singh, 2015), we only interact with the risk preference variable with the alternative specific constant to highlight the role of risk preference. In the Appendix S1, Table S7 shows that the risk preference variables interacted with ASC are all positive though insignificant. Consistent with our expectations, our results show that risk-loving herders are more likely to choose the no insurance option. Our results are also consistent with Sauter *et al.* (2016) that risk preference is not of significant influence.

5.2. Comparing results of alternative models

Table 4 reports comparisons of the results from the basic, scale-heterogeneous, and misclassification probability models. We show the influence of hypothetical bias based on different model assumptions. Consistent with the results listed in Table 3, we find that the coefficient of the premium in the hypothetical treatment model is significantly smaller than the corresponding coefficient in the consequential treatment model. Note that the two coefficients cannot be directly compared as they are estimated in separate models, though our results are still consistent with the presence of hypothetical bias.

More importantly, both the scale-heterogeneous and misclassification models suggest the role of hypothetical bias. In the misclassification model, the estimated probabilities δ_1 and δ_3 are significantly different from zero, while δ_2 is insignificant from zero, which shows that utility misrepresentation may lead to hypothetical bias. Based on Table 4 Column (5), when the optimal choice is one insurance plan, the probability of observing another insurance plan is 13.9% and significantly different from zero. When the optimal choice is no insurance, the probability of observing choosing one insurance plan is close to zero. When the optimal choice is an insurance plan, the

Table 4
Estimation results from alternative models

	(1) HT	(2) CT	(3) POOL	(4) Scale Adjusted	(5) Mis. Prob.
Premium	−0.007***	−0.013***	−0.009***	−0.010***	−0.009***
	(0.002)	(0.002)	(0.001)	(0.0010)	(0.001)
ASC	−0.714	−4.368***	−5.442***	−5.691***	−6.359***
	(0.986)	(1.048)	(0.828)	(0.883)	(1.115)
Scale parameter in hypothetical treatment				0.781***	
				(0.071)	
δ_1					0.139***
					(0.049)
δ_2					0.001
					(0.002)
δ_3					0.331***
					(0.137)
Indemnity4000	0.188*	0.281**	0.231***	0.247***	0.280***
	(0.114)	(0.121)	(0.082)	(0.070)	(0.080)
Indemnity5000	0.327***	0.354***	0.334***	0.354***	0.432***
	(0.123)	(0.134)	(0.090)	(0.077)	(0.089)
Coverage50	0.100	0.204	0.143	0.155***	0.168
	(0.145)	(0.159)	(0.106)	(0.081)	(0.092)

Table 4
(*Continued*)

	(1) HT	(2) CT	(3) POOL	(4) Scale Adjusted	(5) Mis. Prob.
Coverage75	0.082	0.167	0.110	0.121	0.129
	(0.155)	(0.169)	(0.113)	(0.090)	(0.102)
Coverage100	−0.066	0.479***	0.184*	0.213*	0.238*
	(0.145)	(0.155)	(0.105)	(0.081)	(0.091)
Duration6	−0.126	−0.345***	−0.223***	−0.243***	−0.285***
	(0.115)	(0.122)	(0.083)	(0.073)	(0.084)
Duration12	−0.529***	−0.753***	−0.628***	−0.671***	−0.782***
	(0.119)	(0.129)	(0.087)	(0.077)	(0.088)
Requirement	−0.017	0.123	0.047	0.054	0.132
	(0.084)	(0.091)	(0.061)	(0.060)	(0.069)
Interactions of ASC with					
Familysize	0.141**	0.021	0.066	0.070	0.005
	(0.060)	(0.068)	(0.0416)	(0.015)	(0.002)
Gender	−0.551	−0.403	−0.765***	−0.801***	−0.518***
	(0.363)	(0.454)	(0.262)	(0.096)	(0.120)
Age	0.003	0.043***	0.049***	0.051***	0.058***
	(0.012)	(0.013)	(0.009)	(0.002)	(0.002)
Married	−1.121***	0.313	−0.748**	−0.734**	0.106
	(0.418)	(0.489)	(0.304)	(0.094)	(0.116)
Hukou	−0.242	0.764	0.615*	0.634*	0.617*
	(0.491)	(0.486)	(0.332)	(0.092)	(0.116)
Vleader	−0.452	0.947***	0.300	0.342	0.592
	(0.352)	(0.320)	(0.212)	(0.178)	(0.195)
Write	−1.229**	−1.076**	−1.012***	−1.087***	−1.179***
	(0.552)	(0.478)	(0.344)	(0.194)	(0.263)
Read	−1.058***	−1.194***	−1.235***	−1.310***	−1.366***
	(0.367)	(0.344)	(0.244)	(0.219)	(0.286)
Smartphone	N/A	−0.298	1.988***	1.987***	0.833***
	N/A	(0.630)	(0.511)	(0.102)	(0.135)
Trad. phone	N/A	0.200	2.154***	2.187***	1.307***
	N/A	(0.650)	(0.505)	(0.191)	(0.222)
N	2,088	2,034	4,122	4,122	4,122
Log-likelihood ratio	−634.5	−587.9	−1241.0	−1240.4	−1147.48
df_m	19	21	21	21	21

Note: This table shows the estimation results. Column (1) presents the results using only the hypothetical treatment data. Column (2) presents the results using only the consequential treatment data. Column (3) uses pooled data from both treatments. Column (4) incorporates a treatment specific scale parameter in the model while Column (5) calibrates the results estimated from Column (3) incorporating misclassification probabilities. Standard errors in parentheses.
$^{*}P < 0.10$, $^{**}P < 0.05$, $^{***}P < 0.01$.

probability of choosing no insurance is 33.3% and significantly different from zero (δ_3). Our estimated results suggest that in the hypothetical treatment (compared to the consequential treatment), approximately one-third of respondents with a true preference of preferring no insurance will choose one of the insured plans when the choice is not consequential. The misclassification model uncovers the root of the hypothetical bias in the choice experiment. Table S4 (online) also shows that the scale-heterogeneous and misclassification models estimated a payment coefficient that is similar in magnitude when compared to the pooled data.

Figure 1 shows the marginal willingness-to-pay estimates for different choice attributes in alternative insurance specifications. The willingness-to-pay estimates are also labelled for each variable. Consistent with our predictions, the confidence intervals are larger in the hypothetical treatment compared to those of the consequential treatment or the pooled regression. According to our misclassification model, an average respondent is willing to pay approximately 30 yuan more in premium to receive a 4,000-yuan indemnity compared to the baseline 3,000-yuan indemnity, and approximately 46 yuan more in premium to receive a 5,000-yuan indemnity compared to the baseline 3,000-yuan indemnity. An average respondent is also willing to pay for higher coverage, though only the 100% coverage is significant at a 5% level according to our willingness-to-pay estimates. An average respondent has a significantly lower willingness to pay for a longer waiting period to receive the indemnity. Compared to the

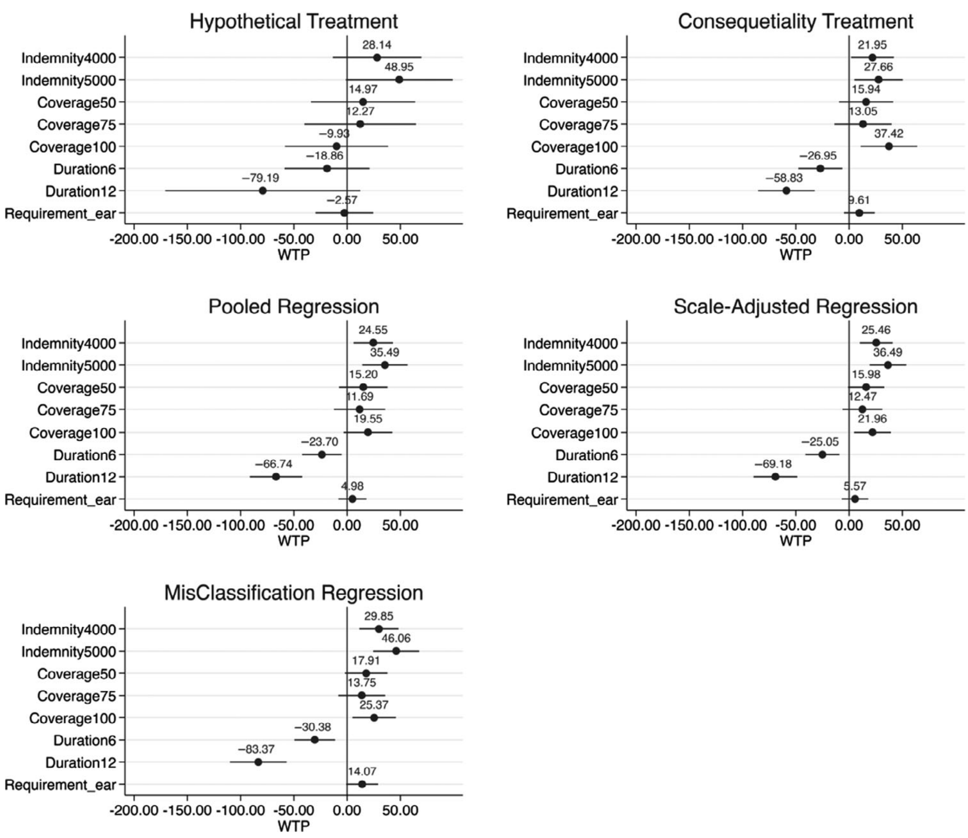

Figure 1. Willingness-to-pay estimates based on Table 4, with 95% bootstrap confidence intervals. *Notes*: The figure shows the willingness-to-pay estimates based on different sample selection and regression models. The 95% confidence intervals are based on Krinsky Robb Method bootstrapped 1,000 times

baseline of immediately receiving the indemnity, the respondent is willing to pay 30 yuan less to receive it in 6 months and 83 yuan less to receive the indemnity in 12 months. We find that the hypothetical treatment nearly doubles the magnitudes of the willingness-to-pay estimates for some cases. Although we have the same sample size in the hypothetical and consequential treatments, our results suggest the consequential treatment also leads to a more precise coefficient estimate by producing a smaller confidence interval around the mean.

6. Discussion and Conclusions

We implement a choice experiment to estimate the preference for alternative insurance contracts in pastoral China. Our results show that herders tend to choose an insurance plan and the demand for livestock insurance increases when the price premium decreases or the expected payout increases. We find that age, *hukou* status, and phone ownership have positive effects on choosing the no insurance option. Demographic characteristics such as being female, married, and able to read or write results in more willingness to choose one of the insurance options. We also find that the hypothetical bias is likely to influence the willingness-to-pay estimates through its interaction with the cost attribute. The hypothetical bias is unlikely to depend on the respondents' demographic characteristics.

Our results also indicate that in real payment, respondents are more sensitive to insurance premium changes, which is consistent with a large body of literature regarding hypothetical bias. Our misclassification model provides further explanations for the existence and influence of hypothetical bias during the choice experiment. Our estimates suggest that in the hypothetical treatment (compared to the consequentiality treatment), approximately one-third of respondents with a true preference for no insurance will choose one of the insured plans when the choice is not consequential.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Study area.
Table S1. Variable definition.
Table S2. Summary statistics on the attribute variables and randomization checks.
Table S3. Summary statistics on the attribute variables and randomization checks.
Table S4. Demand for Livestock Insurance, no demographic controls.
Table S5. Preferences for livestock insurance: results from a standard conditional logit model using estimated total insurance cost.
Table S6. Choices used to elicit Risk Preference
Table S7. Demand for Livestock Insurance, with risk preference.

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