Better Understanding of Demand for Weather Index Insurance among Smallholder Farmers under Prospect Theory*

Soye Shin†

University of Georgia

May 2018

Abstract

This study examines the relationship between risk parameters and weather index insurance demand among smallholder producers in Kenya under prospect theory. Using an experimental game and an auction, we elicited three prospect theory relevant risk parameters (risk aversion, loss aversion, and non-linear probability) and insurance demand. We show theoretically that loss averse individuals are less likely to purchase insurance and this effect is more prominent when they face high insurance premiums. We then estimate the effects of risk parameters on insurance demand. Consistent with the theoretical results, we find that loss aversion has a negative effect on insurance demand and this effect is enhanced when farmers understand basis risk and/or are offered insurance at high prices. Combining farmers’ context and theoretical predictions, we suggest that an insurance premium matters to insurance purchases in that farmers consider this upfront payment as an investment or a lottery focusing on outcomes from the insurance contract itself, irrespective of rainfall shocks.

Keywords: Index insurance, prospect theory, risk aversion, loss aversion

*Copyright 2018 by Soye Shin. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

†syshin@uga.edu. I am indebted to Nicholas Magnan, Sarah Janzen, and Conner Mullally for allowing me to use the data for this study and their support. This study is funded by 3ie through Phase 1 of Thematic Window 13: Agricultural insurance: assessing the impact of programmes targeted at smallholder farmers. I would like to thank our implementing partners for supporting the research, particularly the government of Kenya’s KCEP-CRAL leadership team, Acre Africa and the Kenya Promotions and Marketing Company (KPMC). In particular I wish to acknowledge the contributions of Moses Abukari, Joseph Alulu, Dennis Kaburu, Marup Hossein, Bilha Maina, Justin Muriuki, Sharon Onyango, Dickson Osewe and Patrick Sampao for assistance with implementation at various stages of the research project. All errors remain my own.
1 Introduction

Smallholder farmers are extremely vulnerable to climate variability which hampers crop and livestock productivity (Alinovi et al. 2010). For instance, significant income losses due to rainfall shocks result in sharp reductions in consumption (Dercon 2004; Dercon and Christiaensen 2011) that could cause adverse long-term effects on health and economic welfare. In developing countries, however, standard indemnity-based insurance is rarely available for smallholder farmers living in remote areas. As a result, weather index insurance (WII) has drawn much attention from development practitioners and policymakers as a promising way for smallholders to insulate themselves from climatic risk. Despite its potential merits, the uptake rate of WII has been low (Giné and Yang 2009; Binswanger-Mkhize 2012; Cole et al. 2013; Hill, Robles, and Ceballos 2016; J-PAL 2016) leaving economists to investigate determinants of insurance participation.

Among others, a handful of studies find that demand for WII appears to decrease with risk aversion (Giné, Townsend, and Vickery 2008; Hill, Hoddinott, and Kumar 2013; Cole et al. 2013). This pattern is surprising in that risk averse agents are generally found to be more likely to purchase standard indemnity insurance. To date, studies finding an inverse relationship between insurance uptake and risk attitudes have relied on Expected Utility theory (hereafter EU). However, farmers’ responses to new and complex insurance may not be well captured by a simple utility parameter (i.e., risk aversion), for which alternative approaches are needed (Babcock 2015).

This paper attempts to provide a richer view of the relationship between risk preferences and insurance demand using risk parameters from Prospect theory (Tversky and Kahneman 1979, 1992; hereafter PT): risk aversion, loss aversion, and non-linear probability weighting. Using experimentally-derived PT-based parameters from 239 smallholder farmers in Kenya’s arid and semi-arid lands (ASALs), we explore the relationship between insurance demand and three dimensions of risk preferences, plus other farmer characteristics.

We first randomly assigned one of two WII products (one with lower basis than the other) to the farmers and provided a brief explanation of the corresponding assigned product. We then elicited parameters for risk aversion, loss aversion, and non-linear probability weighting using the methodology developed by Tanaka, Camerer, and Nguyen (2010; hereafter TCN). Finally, we elicited demand at seven different prices using a multiple price list auction (Andersen et al. 2006), which is a modified version of a Becker-DeGroot-Marschack (BDM) auction (Becker, DeGroot, and Marschak 1964). The rich demand data set allows us to examine if farmers’ risk parameters respond to demand differently at various prices.

We build a PT-based theoretical model by assuming farmers’ reference points as initial wealth and examine if theoretical predictions of insurance participation are consistent with empirical results. We find that our theoretical predictions are supported by empirical evidence from our data, suggesting that a PT framework performs better than an EU framework in explaining index insurance demand. Specifically, we find that farmers are more likely to purchase insurance when they are more risk averse and less loss averse. This finding first implies that the perplexing inverse relations between EU risk aversion and index insurance demand reported in previous studies may be attributed to a confounding effect of risk aversion and loss aversion parameters.

The negative effect of loss aversion on insurance demand shows that farmers’ reference points are their initial wealth, therefore, insurance premiums matter. Examining farmers’ sensitivity to insurance premiums, we find that the negative effect of loss aversion becomes more pronounced when farmers are offered insurance at high premium levels. Our results indicate that smallholder farmers who have limited experience with insurance have incorrect views about insurance where an upfront payment of insurance premium is considered as an investment or a lottery that is expected...
to give some returns to farmers, rather than as a purchase of a risk-hedging device.

This study makes two primary contributions to the literature. First, we evaluate index insurance demand using a PT framework as opposed to an EU framework and show that the former model better explains index insurance choices of smallholder producers. If a single risk parameter based on EU fails to capture insurance decisions, previous findings that a risk taking individual takes up index insurance are not counterintuitive but a result of a confounding effect. Second, this paper sheds light on the index insurance promotion policies in developing economies by showing how smallholder farmers view premiums and, by extension, insurance products.

The rest of this paper proceeds as follows. Section 2 introduces the theoretical model. Section 3 describes the sample and weather index insurance products. Section 4 offers the experimental design and data collection process, including the follow-up visits to complete insurance sales. Section 5 presents results and Section 6 offers further discussion and some concluding remarks.

2 Theoretical Model

A large body of literature shows anomalies of insurance purchasing behavior that are inconsistent with EU (e.g., the preference for low deductibles or sub-optimal coverage) can be explained by preferences in alignment with PT. Under the PT framework, an individual's utility function consists of not only risk aversion (as EU) but also loss aversion and non-linear probability weighting, which is specified in (1) following Kahneman and Tversky (1992).

\[ U = \sum_{i=-m}^{n} \nu(x_i)\pi(p_i) \]

where \( \nu(x_i) = \begin{cases} x_i^{(1-\sigma)} & \text{for } x_i > 0 \\ -\lambda(-x_i)^{(1-\sigma)} & \text{for } x_i < 0 \end{cases} \) and \( \pi(p_i) = \exp\left(-(-\log p_i)^{\alpha}\right) \)

In (1), \( x_i \) are values that a prospect can take, which are sorted from smallest to largest with \( m \) negative and \( n \) positive values. \( p_i \) denotes an associated probability of each \( x_i \) that is translated into a subjective probability according to a decision weight function \( \pi(\cdot) \) derived by Prelec (1998). \( \nu(\cdot) \) is the value function that is contingent upon whether \( x_i \) are positive or negative. The parameter \( \sigma \) describes the degree of risk aversion, with \( \sigma > 0 \) for a risk averse individual, \( \sigma = 0 \) for a risk neutral individual, and \( \sigma < 0 \) for a risk taking individual. The parameter \( \lambda \) defines the degree of loss aversion, with \( \lambda > 1 \) for a loss averse individual. The parameter \( \alpha \) represents the non-linear probability weighting measure, with \( \alpha < 1 \) for an individual overweighting the tails of a probability distribution. Note that the PT model reduces to EU when \( \alpha = \lambda = 1 \). We will test the validity of the PT approach in 5.1.

For WII, the inverse relationship between insurance uptake and risk aversion shown in previous studies (Giné, Townsend, and Vickery, 2008; Hill, Hoddinott, and Kumar, 2013; Cole et al., 2013) is an anomaly that cannot be predicted by EU. One possibility to explain this puzzling relationship suggested by Hill et al. (2013) is that farmers may view purchasing standalone WII as adopting new technology rather than a risk hedging tool. This idea is based on empirical evidence that the main feature of index insurance, basis risk — the mismatch between actual losses and insurance payouts

---

1 See, among other, Pashigian, Schkade, and Menefee (1966); Johnson et al. (1993); Grace et al. (2003) (anomalies of insurance purchasing behavior); Köszegi and Rabin (2006, 2007, 2009); Du, Feng, and Hennessy (2016); Babcock (2015); Bulut (2016) (PT can provide an alternative framework to explain the anomalies).
—is a relatively new and complex concept (Gaurav, Cole, and Tobacman, 2011; Giné, Karlan, and Ngatia, 2013).

However, this inverse relationship may be a result of examining insurance purchasing decisions with an EU related single risk parameter (risk aversion) as opposed to three PT related risk parameters. The aforementioned studies elicit risk aversion using a Binswanger-type game (Binswanger, 1980) where one can possibly confound risk aversion and loss aversion. What if the negative effect of risk aversion on insurance demand is actually from a negative effect of loss aversion? This question motivates us to explore WII demand within a PT framework.

The loss aversion parameter captures an individual’s degree of sensitivity to losses than to gains of the same magnitude. Under the PT framework, what constitutes of losses and gains depends on not absolute levels of wealth but a reference point. The reference point provides a “status quo” relative to which individuals evaluate gains and losses in their decision making. Individuals with PT risk preferences, hence, tend to maximize gains and avoid losses rather than simply maximize the expected utility of final wealth. By extension, high loss aversion may induce people to focus more on minimizing the pain of a loss.

Where individuals anchor reference points, therefore, is a key factor to explain insurance purchase decisions. To identify testable hypotheses based on a theoretical model, we borrow an idea about the reference point from Eckles and Wise (2013). They argue that a choice of the reference point in mandatory insurance is different from a choice in non-mandatory insurance in that people only choose how much insurance to purchase in the former case while in the latter case they first need to decide whether or not to take up insurance before choosing how much to buy. Those are not obliged to insure view their reference point as their initial wealth while those who are view their reference point as their initial wealth less premium. Our sample farmers lend itself to the former case.

Given initial wealth as a farmer’s reference point, we describe the WII purchase choice within a PT framework by specifying simplified cases that fall into either the domain of gains or losses. We denote $W$ as the initial wealth (i.e., the reference point), $L$ as a crop loss, $I$ as an insurance payout the amount of which is the same as $L$, and $\rho$ as an insurance premium. We define $p$ as a probability of rainfall shocks and $q$ as a probability of basis risk. For simplicity, we do not distinguish negative (no insurance payout when a loss is realized) and positive (no loss but an insurance payout is realized) basis risk. The value function and decision weighting function are then defined as

$$
\nu(x_i) = \begin{cases} 
(x_i - W)^{(1-\sigma)} & \text{for } x_i > W \\
0 & \text{for } x_i = W \\
-\lambda(W - x_i)^{(1-\sigma)} & \text{for } x_i < W 
\end{cases}
\quad \text{and} \quad \pi(p_i) = \exp\left(-(-\log p_i)^\alpha\right) \tag{2}
$$

The four cases exist when a farmer purchases insurance.

1. There is a rainfall shock with probability $p$ and insurance payout $I$ is realized (i.e., no basis risk) with probability $(1 - q)$. In this case, the final wealth of the farmer is $W - \rho - L + I$ (where $L = I$) and the farmer feels a loss of as much as the paid premium $\rho$ given his reference point.

2. There is a rainfall shock with probability $p$ but no insurance payout is realized (i.e., basis risk) with probability $q$. In this case, the final wealth of the farmer is $W - \rho - L$ and the farmer feels a loss equal to $\rho + L$.

3. There is no rainfall shock (1 – $p$) and no insurance payout is realized (i.e.,
no basis risk) with probability \((1-q)\). In this case, the final wealth of the farmer is \(W - \rho\) and the size of the loss that the farmer feels is \(\rho\).

4. There is no rainfall shock with probability \((1-p)\) and insurance payout \(I\) is realized (i.e., basis risk) with probability \(q\). The final wealth of the farmer is \(W - \rho + I\) in which case the farmer feels a gain equal to \((I - \rho)\) (assuming that \(I\) is greater than \(\rho\)).

In summary, there are three possible outcome values that \(x_i\) takes with corresponding probabilities.

\[
x_i = \begin{cases} 
W - \rho - L & \text{with } pq \\
W - \rho & \text{with } (1-q) \\
W - \rho + I & \text{with } (1-p)q 
\end{cases} \tag{3}
\]

Following (1) and (2), an individual’s utility is specified as follows.

\[
U(\rho, L, I; p, q) = -\lambda(\rho + L)^{(1-\sigma)}\pi(pq) - \lambda\rho(1-\sigma)^{\pi(1-q)} + (I - \rho)^{(1-\sigma)}\pi((1-p)q) \tag{4}
\]

A farmer will purchase insurance when \(U > 0\) and will not when \(U < 0\). Based on theoretical model (4), we can predict an individual’s WII participation with respect to a marginal change in each risk preference parameter.

i. \(\frac{\partial U}{\partial \sigma} \leq 0\): WII participation with respect to a change in risk aversion is ambiguous.

ii. \(\frac{\partial U}{\partial \lambda} < 0\): Loss averse farmers are less likely to take up a WII product.

iii. \(\frac{\partial U}{\partial \alpha} \geq 0\): WII participation with respect to a change in nonlinear probability weighting is ambiguous.

Appendix A contains the derivations of comparative statistics. Note that we make predictions of WII participation based on our assumption of the reference point. We can test if the reference point is initial wealth by examining an effect of loss aversion on WII demand. There are two hypotheses to test.

**Hypothesis 1:** If the reference point of sample farmers is initial wealth, loss aversion has a negative effect on WII demand.

In the case where the reference point is initial wealth, the insurance premium affects the extent to which a farmer feels a gain/loss, and therefore insurance purchase is worthwhile/not worthwhile. For instance, farmers would experience a loss if no insurance payouts are made in absence of drought or insurance payouts are realized, but the amount is less than the premium. Also, loss averse farmers are more sensitive to the pain of a loss when they pay a premium before a shock is realized. Therefore, the loss aversion parameter dampens insurance demand.

**Hypothesis 2:** The negative effect of loss aversion becomes more pronounced among loss-averse farmers who face high insurance premiums.

If an insurance premium matters, a negative effect of loss aversion becomes significant for loss averse farmers when insurance is offered at high premiums. We can show this phenomenon theoretically by evaluating the derivative in ii at different values of \(\rho\). Suppose we have two levels of premiums with \(\rho_1 > \rho_2\). We can compare the absolute values of an individual’s marginal disutility with respect to \(\lambda\), conditional on two premiums.

\[
\begin{cases} 
|\frac{\partial U}{\partial \lambda}|_{\rho_1} > |\frac{\partial U}{\partial \lambda}|_{\rho_2} & \text{when } \sigma < 1 \\
|\frac{\partial U}{\partial \lambda}|_{\rho_1} < |\frac{\partial U}{\partial \lambda}|_{\rho_2} & \text{when } \sigma > 1
\end{cases} \tag{5}
\]
As long as the risk aversion parameter is less than 1, the magnitude of marginal disutility of loss aversion is larger at $\rho_1$, compared to $\rho_2$. This result implies that an individual who is not extremely risk averse (i.e., $\sigma > 1$) dislikes insurance products more when he/she faces a higher premium.

We will also test how basis risk knowledge interacted with risk preference parameters affects WII demand. Given that index insurance was a new and complex product and the sample farmers have limited experience with insurance, our prior is that the negative effect of loss aversion would be observed among farmers who understand the concept of basis risk.

Lastly, the ambiguous signs of the relations between other two risk parameters (risk aversion and nonlinear probability weighting) and WII demand suggest that directions of the associations should be established empirically. We will examine how WII demand varies with risk aversion and nonlinear probability weighting and interpret results within a context of sample farmers.

### 3 Sample and Weather Index Insurance Products

The data used in this paper have been collected as part of the evaluation of a broader randomized controlled trial (RCT) carried out in collaboration with ACRE Africa (Agriculture and Climate Risk Enterprise, ACRE hereafter), an insurance provider widely working in East Africa. Most people in the study area are subsistence farmers growing sorghum or green gram, with a smaller number growing millet, maize, cow peas, or pigeon peas.

Prior to the study, an aggregator has played a role as an intermediary between a large group of farmers and output markets by supplying a bundle of inputs on credit to smallholder farmers growing sorghum and/or green gram. To insulate herself from farmers’ default risk due to weather shocks, the aggregator purchases WII for the value of inputs through ACRE, and this cost is reflected in the price of the bundle. Because most farmers in our sample are working with the aggregator, we provide them with the chance to buy insurance for the projected value of sorghum and/or green gram production excluding the value of insured inputs. We focus on sorghum insurance because sorghum is the main crop to lead a transition from subsistence to commercial farming, yet one of the most vulnerable crops to droughts. Therefore, we only provide green gram insurance to farmers who are not planning to plant sorghum in the upcoming season.

The insurance products used in this study were generated using Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data (Funk et al., 2015). A high resolution (HR) product was generated using 5km x 5 km grid squares and a low resolution product (LR) was created using 10km x 10km grid squares. While the difference in demand for the LR and HR product is not the primary focus of this paper, we do randomly assign each farmer to one of the two products and account for this variation in our analysis. For ethical reasons, farmers purchasing the LR product through the auction were given a free upgrade to the HR product.

We collected data from 239 farmers, 191 of whom had previously worked with the aggregator. The others could begin working with the aggregator as part of the study. Participants have analogous characteristics irrespective of their partnerships with the aggregator in the past except that more household heads, projected net value of production, and growing sorghum with more acres as opposed to green gram are observed among farmers working with the aggregator. Table 1 presents the similarity between two types of farmers and descriptive statistics for overall sample
farmers we use for our analysis. Median landholding among the sample population is 3.5 acres, and 88.7 percent of farmers experienced at least two droughts during the recent five agricultural seasons. The median educational attainment is 8 years and 26 percent of farmers claimed to be illiterate. The age of participants ranges from 18 to 83 with the median of 38.

4 Experimental Design

We conducted the experiment and data collection in July 2017. The structure of each session was ordered as follows: (1) introduction to index insurance, (2) short survey on farmer and farm characteristics, (3) PT game, (4) experimental auction, (5) post experiment survey, and (6) game payout.

Three weeks later we conducted follow-up visits to complete transactions for those purchasing insurance through the auction. This considerable time gap was unavoidable given that all fieldwork had to cease leading up to and following the historically chaotic, and eventually nullified, 2017 Kenyan election. Most of the farmers did not fulfill their commitments they made in the auction, rendering the data no more credible than that from a hypothetical auction. More discussions are in subsection 4.4.

As one session takes about three and a half hours, we conducted two sessions per day. In one session we offered the LR product and in the other we offered the HR product, determined at random. Each session took place in an open space with a group of approximately 32 farmers.

4.1 Information Session

The information session was designed to be similar to an ACRE’s marketing strategy (business as usual) as much as possible to evaluate the effect of an intervention of the project, an experiential insurance learning game, which is not part of the analysis in this paper. The promoter, a person directly working with farmers for the aggregator, explained insurance needs within the farmers’ contexts (i.e., producing sorghum and green gram for a business) and introduced concepts of basis risk. However, information about probabilities and the triggering system was not provided based on ACRE’s previous experience that this is beyond the comprehension of farmers and often intimidates them. The only difference in the content of information across groups with HR and LR insurance was the size of the index area.

After the information sessions, subjects were assigned at random to one of the two games, the experiential learning game or the PT game. The two game sessions were conducted simultaneously, and to avoid any spillovers between groups, the sessions were held far from one another so the groups could not hear each other or interact in any way.

4.2 Prospect Theory Game

In the PT game, participants were given three series of pair-wise choices between two lotteries. The first two series contain 10 such choices, respectively, and the last series has 7 choices. Table 2

---

2 Under the sample frame that the aggregator provides, we initially had a plan to randomly assign individual farmers to each session, but this proved to be impossible. Therefore, lead farmers assigned individual farmers to a morning or afternoon session without knowing treatment types and any activities corresponding to the treatments.

3 The experiential insurance learning game is explained in Janzen et al. (2018).

4 Because insurance payments for values of inputs go to the aggregator, most farmers working with the aggregator did not know they have had insurance in the past.
illustrates the game’s entire payoff matrix. We reduce the number of game rounds for series 1 and 2 from 14 (the number of game rounds in TCN) to 10 for this game to save time.

[Table 2 about here]

Before the real game, we showed multiple progressive examples to help farmers better understand the game process. The game master first explained how the lottery works with a simple lottery with a single prospect by drawing a number between 1 and 10 from an envelope. For instance, if a lottery gives 10 Kenyan Shillings (KSH) when the drawn number is between 1 and 7, the game master drew a card and informed of which case farmers would receive 10 KSH. After practicing with another simple lottery with two prospects, the game master showed the following two lotteries and asked them which lottery they would choose.

<table>
<thead>
<tr>
<th>Lottery A</th>
<th>Lottery B</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 if 1 2 3 4 5 6 7</td>
<td>20 if 1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>20 if 8 9 10</td>
<td></td>
</tr>
</tbody>
</table>

If a farmer understands how the lottery works, he/she must know lottery B is less risky and always the better option. Once all farmers understood another example with two lotteries, farmers played 5 rounds of a practice series similar to the real game where lottery B is a riskier option and the risk degree becomes larger moving down the table. Farmers were told that each series would end once they switch to (or choose) lottery B, and the rationale of it (e.g., it is not rational that you switch back to a less risky option once you say you prefer a riskier lottery over a less risky lottery).

The game master then demonstrated how payouts are determined. By randomly drawing a card, he first selected a series and then a round of that selected series. Another card between 1-10 was then drawn to determine the game payout from the selected round. The average total payouts (184 KSH) is small enough relative to the actual price of insurance to avoid income effects on insurance purchases.

In each series, an enumerator asked the farmer round-by-round which lottery he/she preferred. Once the farmer chooses lottery B, the enumerator records the switching point and proceeds to the next series. We did not observe farmers having difficulty understanding this game procedure.

4.3 Auction

To elicit WII demand, we use a multiple price list auction (Andersen et al., 2006) in which farmers reveal their desired insurance coverage level at seven different prices. Once participants reveal how much insurance they would like to buy at each price, the sale price of insurance (premium) is randomly drawn from an envelope. When the drawn price is above the market price, we replace it with the market price and adjust the insurance quantity that farmers will buy accordingly. We did not tell farmers we would do this beforehand so that they would consider these higher prices to be possible.

The auction is semi-binding in the sense that farmers did not have to pay premiums right after the experiments, but they would not be allowed to purchase more than they agreed to in the auction during the follow-up visits. There are three reasons for this. First, it may not be reasonable

---

5Payouts are also calibrated to eliminate the situation where a farmer would pay money out of his/her pocket.
6At actuarially fair prices, insuring one acre of sorghum production costs approximately 3,600 KSH. We also checked for income effects by regressing insurance demand on total payouts and found no effect.
to compel farmers to buy WII on the first day they learn the products. Second, it is not reasonable to expect farmers to have adequate cash on hand, or in their mobile M-Pesa accounts, to make a purchase on the day of the auction. In either case, forcing them to complete a transaction on the day of the auction would likely depress demand. Third, the experiment was conducted before the period over which agricultural insurance is normally purchased due to constraints on grant spending and the need to complete fieldwork before the 2017 Kenyan general election.

We measure insurance quantities as total coverage amounts (in KSH) and premiums as a percentage of the amount covered. However, in pre-testing we found that the price stated in percentage terms is unfamiliar to farmers. We therefore stated premiums as the cost of a certain quantity of coverage. We offered units providing up to 5000 KSH of coverage at the following prices: 50, 150, 250, 350, 500, 750, and 1000 KSH. This way, farmers only need to state how many units of coverage they would like to buy at each price (partial units were not an option unless their projected net production values are less than 5000 KSH). We confirmed that both enumerators and farmers had no difficulty understanding the process during a second pilot study. To help farmers better understand the auction process, we conducted a practice auction for cookies before the real auction.

The auction was conducted iteratively as follows. An enumerator first assisted farmers with calculating the projected net value of sorghum produced by subtracting insured input values (i.e., inputs provided by the aggregator) from the projected total value. As mentioned, we only offered green gram insurance when a farmer did not plan to grow sorghum in the upcoming season. In this case, the enumerator calculates the projected net value of green gram production. Starting at the lowest price, the enumerator tells a farmer the number of insurance units needed to insure his/her total projected net value of produce and total cost of that many units, asking if the farmer would like to purchase those units of insurance. If the farmer says no, he/she decreases the number of units and the corresponding coverage level and again asks if the farmers would like to purchase the insurance. If the farmer agrees to the purchase, the enumerator proceeds to the next price and does the same things until either all prices in the list have been covered or a price is reached at which the farmer does not wish to purchase any insurance.

At each price, enumerators told farmers that insurance quantities are the maximum payouts they could receive when the weather is bad. Although the concept of basis risk was not directly explained to farmers in this statement, we think that farmers have learned the possibility of not fully recovering their insured losses with this insurance product. We make this argument based on the following reasons. One, farmers were told about basis risk briefly in the information session. Two, farmers obtained high scores of basis risk knowledge that we collected in a post-survey. We will come back to their basis risk knowledge in subsection 5.2.

After the actual insurance price was determined, the enumerator confirmed with the farmer that he/she has committed to purchase the amount of insurance at the selected price. Then, they left her/him with an informational pamphlet about index insurance with the price and quantity they agreed to buy.

At the conclusion of the auction, we conducted a post-survey to collect farmers’ attitudes towards WII and basis risk knowledge. The knowledge of basis risk was measured by asking four basis risk related questions to farmers and counting their number of correct answers. We also inform farmers offered the LR product that they will be upgraded to the HR product at no extra costs. Payments are made at the end of the experiment.

These values are in percentages of 5000 KSH (1%, 3%, 5%, 7%, 10%, 15%, and 20%). The market price is 15% of insurance coverage.
4.4 Follow-up visits

Prior to the follow-up visits in late August, all individuals indicating to purchase insurance were reminded via multiple text messages and phone calls of their commitment to purchase insurance via M-Pesa mobile money or in person. Because farmers were not paying, we organized two in-person visits and extended the payment deadline. In the end, only six of the 361 farmers (i.e., the overall number of farmers who said to purchase in the project) paid their premium. Even with evidence of low uptake rates of WII found in other studies, it is surprising that farmers did not purchase insurance at highly subsidized prices (e.g., the lowest premium equals to the 93% discount price of the market price of sorghum WII).

Most farmers cited the lack of cash after paying for pressing needs (e.g., school fees, medication) as the main reason for not being able to purchase. Indeed, payment was requested at the onset of the school year. In addition to the bad timing, we suspect that too much time passed (three weeks) between the intervention and planting time due to, as stated earlier, constraints on grant spending and fieldwork during the election.

Although WII demand from the auction did not translate to actual purchases, we can still learn about the relationship between risk preferences and demand under the assumption that the amount of hypothetical bias is not huge and equivalent to everyone irrespective of individuals’ risk preferences. Because most sample farmers already built trust with the aggregator for the input bundles it is hard to believe that farmers did not take this experiment seriously at all therefore the bias is huge. However, we cannot eliminate a possibility that the hypothetical bias systematically varies with risk preferences from the data. Therefore, any implications from our findings should take this possible limitation into account.

5 Empirical Results

5.1 Descriptive Analysis of Game Results

Using a combination of switching points from Series 1 and 2, we can estimate risk aversion ($\sigma$) and nonlinear probability weighting ($\alpha$) parameter. After obtaining an estimate of $\sigma$, we use the switching point in series 3 to identify the loss aversion parameter ($\lambda$). The distributions of risk preference parameters are presented in Figure 1. The distribution of non-linear probability weighting approximates to a normal distribution, but the distributions of other parameters do not.

The data shows that 64.4 percent of farmers are risk averse ($\sigma > 0$) and 66.5 percent exhibit loss aversion ($\lambda > 1$). Also, 69.9 percent of the sample overweights small probabilities and underweights large probabilities ($\alpha < 1$). The mean values of $\sigma$, $\alpha$, and $\lambda$ are 0.75, 0.89, and 3.99, respectively. A test of the validity of EU (as opposed to PT) rejects the null hypothesis that $\alpha = 1$ and $\lambda = 1$ (i.e., the null hypothesis that the PT utility function collapse to EU) at the 0.1% level. This result implies that the EU framework fails to adequately explain farmers’ risk preferences, and therefore how risk preferences relate to insurance demand.
5.2 Insurance Demand

5.2.1 WII Demand and Prospect Theory Risk Parameters

In this section, we test the first hypothesis in Section 2 that WII demand decreases with the loss aversion parameter by regressing quantity demanded on risk parameters, controlling for insurance price and a list of covariates. We have seven observations, one at each price, for each farmer, for a total number of 1,673. The model is specified as:

\[ Q_{ij} = \beta_0 + \beta_1 \sigma_i + \beta_2 \alpha_i + \beta_3 \lambda_i + \beta_4 \rho_{ij} + \beta_5 H R_i + \phi X_i + \theta_k + \epsilon_{ij}. \]  

(6)

In equation (6), \( Q_{ij} \) is the quantity of insurance demanded in KSH by farmer \( i \) at insurance premium level \( j \). The three risk attitude parameters include \( \sigma_i \) (risk aversion), \( \alpha_i \) (nonlinear probability weighting), and \( \lambda_i \) (loss aversion). \( \rho_{ij} \) is the insurance premium at which demand was reported and \( H R_i \) is the indicator for treatment status of being offered the HR product. \( X_i \) represent subjects’ characteristics including age, gender, household headship, years of education, a literacy indicator, land size, the number of droughts in the past five agricultural seasons, an indicator for loan availability, and indicator for having formal saving accounts, acres of the insured crop, anticipated harvest values of the insured crop, and an indicator for the insured crop being sorghum. We also control for enumerator fixed effects (\( \theta_k \)). Since we assigned insurance resolution by session, we cluster our standard errors at this level.

Effects of risk preference parameters from the estimation of equation (6) are in Table 3, column 1. We find that farmers are likely to buy more insurance when they are more risk averse and less loss averse. These effects are significant at the 10% level. A positive effect of risk aversion is consistent with the results that are observed in the indemnity-based insurance literature but inconsistent with outcomes from previous studies about index insurance. Inconsistency with the previous empirical evidence would not be surprising given that the evidence was found based on EU. As mentioned earlier, the inverse relation between WII demand and risk aversion is possibly due to the negative effect of loss aversion that is confounded with the EU risk aversion parameter. Although the positive effect of the risk aversion parameter is not theoretically confirmed, the negative effect of loss aversion among our sample farmers supports this confounding effect and, therefore suggests invalidity of an EU framework to explain index insurance demand.

Before testing the second hypothesis in Section 2 we examine if the negative effect of the loss aversion parameter is observed among farmers who understand the concept of basis risk using our measure of farmers’ basis risk knowledge. The mean value of the number of correct answers (k) of basis risk relevant questions is 2.97, and the median is 3. We create a dummy variable of high knowledge of basis risk which has a value of one if k is greater than the mean value 2.97. We first estimate equation (6) with this dummy variable and then estimate the same model by adding up interaction terms between k and risk parameters. The results are reported in column 2 and 3 of Table 3 respectively.

The effect of basis risk knowledge on WII demand is positive and significant (column 2) at the 10% level. This result shows that farmers who relatively better understand this new product are more likely to purchase than farmers who do not. The interaction term between k and \( \lambda \) has a significantly negative effect (column 3) at the 5% level, and its magnitude is about four times as

---

8 A dummy for loan availability and having formal saving accounts (irrespective of actual use) are included to control for liquidity constraints which certainly affect insurance purchases. One may argue that these variables are endogenous to risk preferences. However, we do not think this is a huge concern. Most farmers are members of informal saving-groups through which they save, and a simple ownership of a formal saving account only indicates whether an individual has access to formal financial services, which would increase his/her financial liquidity.
much as that of the effect of standalone loss aversion in column 1. These results imply that the
negative effect of loss aversion is more prominent among farmers whose knowledge on basis risk
is above the sample average. Indeed, knowing the concept of basis risk is critical in the negative
effect of loss aversion. The effect of standalone $\lambda$ in column 3 has a positive sign although it is
insignificant.

On the other hand, the positive effect of risk aversion is no longer significant when this
parameter is interacted with the basis risk knowledge variable. It is, however, worthwhile to note
that the magnitude of its positive effect becomes twice as much as that of the standalone risk
aversion parameter effect in column 1, implying that risk aversion still matters to some limited
extent for those who understand basis risk.

Overall, the outcomes in column 1 through 3 suggest that farmers’ knowledge of basis risk
is important in triggering PT related risk preference parameters in their choices, especially the
loss aversion. Indeed, the fact that farmers who have better understanding of basis risk are more
sensitive to loss aversion but not risk aversion is in line with the partial derivatives of theoretical
model (4) given that the model was constructed based on the assumption that individuals fully
understand basis risk.

5.2.2 WII Demand at Different Insurance Prices

In Section 2, we show that the marginal disutility of loss aversion becomes larger when an individual
faces a high premium $\rho_1$ than a low premium $\rho_2$ only when his $\sigma$ is less than 1. The rich demand
data for each individual allows us to test Hypothesis 2. Because the maximum value of $\sigma$ among
the sample farmers is 0.9, we use a full sample.

Examining how individuals’ WII demand differs conditionally on different levels of prices, we
evenly divide prices into two groups. Since the total number of price levels is an odd number and
the threshold between “low price” and “high price” is unlikely to be large for smallholder farmers
(i.e., a high budget constraint), we define the low insurance price as the first three prices from the
lowest (i.e., 50, 150, and 250 KSH) and the high insurance price as the rest of the four prices (i.e.,
350, 500, 750, and 1000 KSH). We then test for effects of risk parameters on WII demand at the
low and high insurance prices, separately, by estimating the following models.

\[
\left( Q_i \mid \rho_i = \text{Low} \right) = \beta_0 + \beta_1 \sigma_i + \beta_2 \alpha_i + \beta_3 \lambda_i + \beta_5 HR_i + \phi X_i + \theta_k + \epsilon_i. \quad (7a)
\]

\[
\left( Q_i \mid \rho_i = \text{High} \right) = \beta_0 + \beta_1 \sigma_i + \beta_2 \alpha_i + \beta_3 \lambda_i + \beta_5 HR_i + \phi X_i + \theta_k + \epsilon_i. \quad (7b)
\]

We report the results in Table 4. We find that the negative coefficient on $\lambda$ is significant at the
high insurance price while none of the risk parameters are significant at the low insurance price.
In addition to the results in Table 3, this finding supports our hypothesis that the reference point
is the initial wealth and therefore the insurance premium matters (Clarke, 2016) in the sample
farmers’ insurance purchase decisions, especially for those who have high degrees of loss aversion.

Why are these farmers relatively more sensitive to the pain of a loss from the premium than
the pain from the rainfall shocks? To answer this question, we need to understand how the subjects
frame WII given their specific context and what cases are included in the domains of gains and
losses relative to their reference points.

We first consider the fact that the sample farmers have limited experience with insurance. For
them the need to pay a premium before a shock is realized may not be as straightforward.

9Dercon et al. (2014) provide a training session about index insurance to Ethiopian farmers in which they explain
why their subjects need to pay premiums before knowing if rainfall shocks are realized.
they may view this upfront payment as an investment or a lottery with the hope of some return rather than the purchase of a risk management device. This misunderstanding of insurance implies that farmers may not account for the effects of insurance on overall income or consumption (Brown et al., 2008) in their decisions. In this narrow frame of WII, farmers only account for the insured crop risk and the outcome from the insurance contract itself.

Second, extending the theoretical model in Section 2, we identify five stylized cases that fall into either the domain of gains or losses. We use the same notations for parameters as the ones used in the model.

1. When a crop loss does not occur and an insurance payout is realized (i.e., positive basis risk), individuals feel a gain equal to \( (I - \rho) \) (assuming that \( I > \rho \)).

2. When a crop loss does not occur and no insurance payout is made, individuals feel a loss of as much as the paid premium, \( \rho \).

3. When a crop loss occurs but an insurance payment is partially made or not realized at all (i.e., negative basis risk), the final wealth is \( (W - \alpha L - \rho) \) where \( \alpha \in (0, 1] \). Individuals still feel a loss equal to \( (\alpha L + \rho) \) given their reference point.

4. When a crop loss occurs and the loss is fully insured, the size of the loss is \( \rho \) because individuals believe that insurance does not pay off enough to cover their “investment.”

5. When a crop loss occurs and an insurance payment exceeds the sum of the loss and the premium (i.e., positive basis risk), the individual experiences a gain.

In summary, farmers have two sources of a gain due to positive basis risk and three sources of a loss. We argue that the three loss outcomes are considerably more salient to the sample farmers than the two gain occasions given that we explicitly explained the concept of a negative basis risk event but did not mention positive basis risk events in the information session. We also note that farmers are only able to control the premium among these factors. As a result, those who are highly loss averse are likely to purchase insurance when facing high premiums to minimize the salient domain where a loss is experienced.

6 Discussion and concluding remarks

In this paper, we extend the scant knowledge of relations between risk parameters and index insurance demand. First, we find that prospect theory offers a better framework to explain farmers’ WII choices than expected utility theory. We also find a positive effect of risk aversion along with a negative effect of loss aversion, suggesting that the inverse relationship between the risk aversion parameter (elicited based on an EU framework) and index insurance demand could be due to a confounding effect of risk and loss aversion parameters.

We also offer a theoretical model based on prospect theory by assuming that farmers’ reference points relative to which they evaluate gains and losses are initial wealth. Based on the model, we establish two hypotheses to test if our assumption about the reference point is empirically supported. We find that farmers who are highly loss averse are less likely to buy index insurance and this negative effect becomes more prominent; 1) among farmers who better understand basis

\footnote{The reason is that the probability of a positive basis risk event is significantly small and that there is no educational value of emphasizing the positive basis risk in this experiment.}
risk (the main feature of index insurance), and 2) when farmers are offered the insurance products at high prices. Combined with theoretical predictions of index insurance participation, these results suggest that our sample farmers with limited experience in insurance have a significantly narrow view about insurance purchases where they consider a premium as an investment or a lottery with the hope for some return, irrespective of a realization of a rainfall shock.

Importantly, even though we were encouraged by farmers’ high take-up elicited in the auction, their choices do not translate to actual purchases. Despite logistic reasons to dampen the actual take-up, this study shows that farmers would essentially have no actual willingness to purchase insurance. Therefore, our findings are limited to insurance demand choices in a hypothetical setting for which more research about risk parameters and index insurance demand based on actual data is needed.

From these results, we can draw several critical policy implications. First, provision of insurance education programs focusing on broad frameworks of risk management is necessary. The focus of the programs should be to help farmers consider the effects of insurance on their overall income or consumptions. For instance, farmers would learn how insurance purchases could reduce welfare losses due to unexpected shocks and enhance income or consumption security. Second, a group-based index insurance plan, the basic concept of which is borrowed by micro-finance group lending, would be effective to increase WII demand (Dercon et al., 2014). Through sharing costs and benefits of WII, farmers decrease the pain of a loss due to an upfront payment of the insurance premium, which leads to increase in index insurance uptake.
References


Figures

Figure 1: The Distributions of Risk Preference Parameters
### Table 1: Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>Aggregator=1</th>
<th>Other Farmers Mean</th>
<th>Overall Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-1.25</td>
<td>41.58</td>
<td>40.59</td>
<td>13.19</td>
<td>18</td>
<td>83</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(2.26)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>-0.24</td>
<td>7.40</td>
<td>7.20</td>
<td>3.77</td>
<td>0</td>
<td>16</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.64)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literacy</td>
<td>0.07</td>
<td>0.69</td>
<td>0.74</td>
<td>0.44</td>
<td>0</td>
<td>1</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household head</td>
<td>0.19***</td>
<td>1.19</td>
<td>1.34</td>
<td>0.47</td>
<td>1</td>
<td>2</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.09</td>
<td>0.19</td>
<td>0.26</td>
<td>0.44</td>
<td>0</td>
<td>1</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land size</td>
<td>0.84</td>
<td>3.81</td>
<td>4.48</td>
<td>4.54</td>
<td>0.25</td>
<td>40</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought</td>
<td>0.10</td>
<td>2.73</td>
<td>2.81</td>
<td>1.10</td>
<td>0</td>
<td>5</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.18)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loan availability</td>
<td>0.01</td>
<td>0.67</td>
<td>0.68</td>
<td>0.47</td>
<td>0</td>
<td>1</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal saving</td>
<td>-0.04</td>
<td>0.71</td>
<td>0.68</td>
<td>0.47</td>
<td>0</td>
<td>1</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crop acre</td>
<td>0.48 ***</td>
<td>1.53</td>
<td>1.91</td>
<td>1.10</td>
<td>0.50</td>
<td>7.00</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net value</td>
<td>25,795.22***</td>
<td>30,888.75</td>
<td>51,503.34</td>
<td>69,558.86</td>
<td>1,552.50</td>
<td>430,000</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(7,829.25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.09 *</td>
<td>0.88</td>
<td>0.95</td>
<td>0.22</td>
<td>0</td>
<td>1</td>
<td>239</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** This table presents the balance check between farmers working and not working with the aggregator and summary statistics on key variables.

Aggregator=1; farmers working with the aggregator. Other Farmers; farmers not working with the aggregator.

Robust standard errors are in parentheses; *** p < 0.01, ** p < 0.05, * p < 0.1.
Table 2: Prospect Theory Game Payoff Matrix (in KSH)

<table>
<thead>
<tr>
<th>Series 1</th>
<th>Lottery A</th>
<th></th>
<th>Lottery B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Card 1-7</td>
<td></td>
<td>Card 8-10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Card 1-9</td>
<td></td>
<td>Card 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>248</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>278</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>317</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>373</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>447</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>545</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>635</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>894</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>1191</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>119</td>
<td>15</td>
<td>1787</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series 2</th>
<th></th>
<th>Card 2-10</th>
<th></th>
<th>Card 1-3</th>
<th></th>
<th>Card 4-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Card 1</td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>159</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>165</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>169</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>178</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>189</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>198</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>219</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>238</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>269</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>89</td>
<td>119</td>
<td>15</td>
<td>298</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series 3</th>
<th></th>
<th>Card 6-10</th>
<th></th>
<th>Card 5</th>
<th></th>
<th>Card 6-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Card 1-5</td>
<td>50</td>
<td>-8</td>
<td>59</td>
<td>-41</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>-8</td>
<td>59</td>
<td>-41</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>-8</td>
<td>59</td>
<td>-41</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>-8</td>
<td>59</td>
<td>-32</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>-16</td>
<td>59</td>
<td>-32</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>-16</td>
<td>59</td>
<td>-27</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>-16</td>
<td>59</td>
<td>-22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Index Insurance Demand

<table>
<thead>
<tr>
<th></th>
<th>Q</th>
<th>Q</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\sigma)</td>
<td>2728.0*</td>
<td>2512.1</td>
<td>-106.7</td>
</tr>
<tr>
<td></td>
<td>(1527.0)</td>
<td>(1604.5)</td>
<td>(3563.5)</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>4677.2</td>
<td>4272.2</td>
<td>955.3</td>
</tr>
<tr>
<td></td>
<td>(3151.3)</td>
<td>(3180.6)</td>
<td>(5724.1)</td>
</tr>
<tr>
<td>(\lambda)</td>
<td>-282.5*</td>
<td>-256.5</td>
<td>563.3</td>
</tr>
<tr>
<td></td>
<td>(156.6)</td>
<td>(161.0)</td>
<td>(334.6)</td>
</tr>
<tr>
<td>(\rho)</td>
<td>-26.1***</td>
<td>-26.1***</td>
<td>-26.1***</td>
</tr>
<tr>
<td></td>
<td>(2.84)</td>
<td>(2.85)</td>
<td>(2.85)</td>
</tr>
<tr>
<td>HR</td>
<td>4980.8***</td>
<td>4918.7***</td>
<td>5081.3***</td>
</tr>
<tr>
<td></td>
<td>(1519.1)</td>
<td>(1447.1)</td>
<td>(1445.5)</td>
</tr>
<tr>
<td>(D(k &gt; 2.97))</td>
<td>2936.9*</td>
<td>3046.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1625.8)</td>
<td>(5485.4)</td>
<td></td>
</tr>
<tr>
<td>(D(k &gt; 2.97) \times \sigma)</td>
<td>4047.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4538.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(D(k &gt; 2.97) \times \alpha)</td>
<td>4013.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5414.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(D(k &gt; 2.97) \times \lambda)</td>
<td>-1135.6**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(426.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>1673</td>
<td>1673</td>
<td>1673</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.483</td>
<td>0.485</td>
<td>0.489</td>
</tr>
</tbody>
</table>

Notes: Session clustered standard errors in parentheses;
* p < 0.1, *** p < 0.01, ** p < 0.05, * p < 0.1
Control variables are age, education, literacy, male, land size,
drought, loan availability, formal saving, acres of crop,
projected net value of production, crop, and enumerator fixed effects.
Table 4: Index Insurance Demand at Different Price Levels

|          | (Q | $\rho = L$) | (Q | $\rho = H$) |
|----------|-------------|-------------|
| $\sigma$| 3809.6      | 1916.8      |
|          | (2279.7)    | (1476.3)    |
| $\alpha$| 6137.9      | 3581.6      |
|          | (4605.7)    | (2970.7)    |
| $\lambda$| 30.7        | -517.4**    |
|          | (229.8)     | (184.1)     |
| HR       | 3019.5*     | 6451.7***   |
|          | (1546.4)    | (1955.3)    |
| Observations | 717         | 956         |
| R-squared | 0.586       | 0.374       |

Notes: Session clustered standard errors in parentheses;  
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$  
Control variables are age, education, literacy, male, land size,  
drought, loan availability, formal saving, acres of crop,  
projected net value of production, crop, and enumerator fixed effects.
Appendix A: Derivation of partial derivatives

Starting with equation (4), we take partial derivatives with respect to risk preferences.

1. Risk Aversion

\[
\frac{\partial U}{\partial \sigma} = \lambda \pi (pq)(\rho + L)^{(1-\sigma)} \ln(\rho + L) + \lambda \pi (1-q)\rho^{(1-\sigma)} \ln \rho - \pi (q - pq)(I - \rho)^{(1-\sigma)} \ln(I - \rho) \tag{8}
\]

Because the first two terms are positive and the last term is negative, the sign of this partial derivative is ambiguous. If the absolute value of the last term of (4), utility gain from the outcome due to positive basis risk, is less than the first two terms of (4), utility loss from the outcomes in the loss domain, then it must be true that \( \frac{\partial U}{\partial \sigma} > 0 \). This can be the case when farmers do not consider the outcome from a positive basis risk event. Given that we only introduce a negative basis risk case (where farmers do not receive insurance payouts for their losses even when they purchased insurance) in the information session, we think our sample farmers do not take positive basis risk into account in insurance purchase decisions.

2. Loss Aversion

\[
\frac{\partial U}{\partial \lambda} = -\pi (pq)(\rho + L)^{(1-\sigma)} - \pi (1-q)\rho^{(1-\sigma)} < 0 \tag{9}
\]

3. Nonlinear Probability Weighting

\[
\frac{\partial U}{\partial \alpha} = -\frac{\partial \pi (pq)}{\partial \alpha} \lambda (\rho + L)^{(1-\sigma)} - \frac{\partial \pi (1-q)}{\partial \alpha} \lambda \rho^{(1-\sigma)} \leq 0
\]

\[
+ \frac{\partial \pi (q - pq)}{\partial \alpha} (I - \rho)^{(1-\sigma)}
\]

where \( \frac{\partial \pi (m)}{\partial \alpha} = -(-\ln m)^\alpha \ln(-\ln m) \exp((-(-\ln m)^\alpha) \)

\( \frac{\partial \pi (m)}{\partial \alpha} \) can be positive or negative, and this term is not monotonically increasing or decreasing in \( m \). However, when probability \( m \) is smaller than about 0.36 the sign of this term is negative over \( \alpha \in (0, 0.5] \). If the probability of drought \( (p) \) is large (which is what sample farmers report) and the probability of basis risk \( (q) \) is significantly small, then the second and third terms of (10) are negative with the first term being positive. \( \frac{\partial U}{\partial \alpha} > 0 \) only when the magnitude of the first term is greater than the magnitudes of the second and third terms.