Experimental games to teach farmers about weather index insurance: Experimental protocol and pre-analysis plan

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Note: This revised plan contains minor edits to the August 29, 2017 version. We made edits based on comments from a team member writing the code for analysis before being aware of any results.

1 Overview

In this study we evaluate demand for weather index insurance (WII) among smallholder producers in Kenya's arid and semi-arid lands (ASALs), focusing on the role of basis risk. We estimate demand for two different products exhibiting differences in basis risk (i.e. mismatch between WII payouts and actual losses) and test an innovative "experiential" approach to teach producers about basis risk and WII as a risk management tool. Our novel extension approach consists of an insurance game based on the one developed by Cai and Song (2017) and modified for weather index insurance, clearly illustrating basis risk to participants.

Unlike many agricultural innovations, learning about insurance products and other risk reducing technologies can take a long time. If shocks that result in payouts are infrequent, individuals who purchase insurance may not see that it pays out in bad years until a bad year occurs. Furthermore, for risks that are highly covariate, such as drought, one might not be able to readily learn from their peers. Thus, providing the opportunity for farmers to rapidly experience different outcomes with and without insurance could be an effective way to educate and increase demand (Cai and Song, 2017). Learning about index insurance (as opposed to indemnity insurance) is further complicated because there is a wider range of outcomes. With indemnity insurance, a farmer will be compensated an amount corresponding to their loss.[1] With index insurance, compensation may differ substantially from a farmer's own loss, and in some cases a farmer experiencing a loss will receive no compensation whatsoever.[2] Our games are intended to accelerate the learning process in a simulated environment.

An aggregator working in Tharaka South sub-county of Tharaka Nithi county currently works with smallholder farmers to help them access output markets, and in some cases supplies farmers ("program farmers") with a bundle of inputs to grow sorghum and/or green gram with deferred payment. Included in the input package is mandatory WII for the value of *inputs*. This "status quo" insurance contract was developed by Acre Africa using ARC2 data in 2013. In our study, program farmers and 30 additional farmers are given the chance to buy insurance. For farmers with mandatory input insurance as part of their input package, this will be additional insurance to for the value of sorghum and/or green gram *production*. Green gram insurance is only offered to farmers who indicate that they will not be planting sorghum during the upcoming season. This WII product was developed by Acre Africa specifically for this study using the CHIRPS dataset (Funk et al., 2015).

During the experiment, demand for two unique insurance products will be compared. These products differ in the amount of basis risk they present, holding all else constant. CHIRPS data can be downloaded at a resolution of 5x5 km; the true product uses this level of resolution for the index area. We call this high resolution (HR) index insurance. A second product developed by Acre Africa averages the high resolution CHIRPS data to create a broader index area (10x10 km). We call this low resolution (LR) index insurance.

We employ a 2x2 randomized control trial in which farmers are randomly assigned a contract type (HR or LR), and are randomly exposed to either a basic information treatment or the basic treatment plus the insurance game. There are two versions of the game, one calibrated for each

[1] This is of course setting aside the possibility of failure on behalf of the insurer.

[2] Or, on the contrary, a farmer who does not experience a loss may receive payment.

insurance product. The primary outcome of interest is demand for WII, which we measure in two ways: (1) quantity of insurance demanded across a variety of prices elicited using a multiple price list auction (Anderson et al., 2007), which is a modified version of a Becker-DeGroot-Marschack (BDM) auction (Becker, DeGroot, and Marschak, 1964), and (2) actual purchases at the offered price. We also test farmer understanding of and attitude towards weather index insurance and basis risk at the time insurance is offered. Following treatment, all farmers will have the opportunity to purchase the HR insurance product, and receive randomized discounts through the auction to do so.

We make two primary contributions. First, **we examine whether farmers are sensitive to basis risk by comparing demand for two insurance products that differ only by resolution.** Basis risk is considered to be one of the greatest barriers to index insurance adoption (Carter et al., 2014), yet relatively little is known about how sensitive farmer demand is to it.[3] We believe this is an important question given continual efforts to improve the resolution of index insurance products. If such improvements do not increase farmer demand it would suggest that commercially-viable improvements in basis risk might not induce higher uptake of WII on their own. Previous studies have used distance from weather stations as a proxy for basis risk, and in some cases found that demand is quite sensitive it, particularly when the price is high (Hill, Hoddinott, and Kumar, 2013). However, it is possible that distance from weather stations is correlated with unobservables that affect demand. Our design offers a transparent way to measure sensitivity to basis risk, albeit at only two different levels.

Our second contribution is to evaluate the use of insurance games as an extension tool in the promotion of WII, and in particular, to help farmers understand basis risk. **We will analyze how a game focused on basis risk alters demand for insurance, and how individual or peer experiences in the game affect demand for insurance.** Games have been used to study insurance demand in other contexts, including projects in Kenya (Janzen and Carter, 2013), Ethiopia (Norton et al., 2014), and Peru (Boucher and Mullally, 2010). Elabed and Carter (2015) use a compound lottery to estimate the effect of basis risk on insurance demand, but in the hypothetical. Cai and Song (2017) found that playing insurance games in China led to a 48% increase in yield insurance uptake (an increase of 9 percentage points), and that random shocks experienced within the games also increased insurance demand. Like Cai and Song (2017), we incorporate games into extension rather than using them solely as a research tool. Our games differ from Cai and Song (2017) in several important ways. First, our games are incentive compatible (payouts are based on game results) in an attempt to increase salience. Second, our games simulate WII, as opposed to standard indemnity insurance, and highlight the role of basis risk.

2 Experimental Design

The study relies on a randomized control trial with a 2x2 design where farmers are randomly assigned to an insurance contract type (HR or LR), and to either a basic information treatment or the basic information treatment plus and experimental game. Those assigned to the basic information treatment will also play games to elicit prospect-theory (PT) based risk parameters (Tanaka, Camerer, and Nguyen, 2010). In other words, farmers will be assigned to one of the following:

[3] McIntosh, Povel, and Sadoulet (2016) and Elabed and Carter (2015) provide evidence from games, Jensen, Barrett, and Mude (2016), Hill, Robles, and Ceballos (2016) and Mobarak and Rosenzweig (2012) provide evidence using actual purchase decisions.

1. LR insurance, basic insurance information, PT game
2. LR insurance, basic insurance information, insurance game
3. HR insurance, basic insurance information, PT game
4. HR insurance, basic insurance information, insurance game

The basic insurance information is purposefully simplistic. While farmers working with the aggregator have had insurance, most do not know this because it is the aggregator that purchases insurance to cover the inputs it has sold to farmers on credit to cover its own investment.

The promoter will focus on the farmers' transition from subsistence to commercial farming, and explain to farmers that because they are now producing sorghum and green gram as a business, they need to protect that business. The promoter will explain that with WII it is possible the farmers will not receive a payout even if they have a poor crop, but will not go into detail about probabilities. They will also not explain the system of triggers to farmers, as they believe that this is beyond the comprehension of program farmers, and will intimidate them. They will, however, explain the size of the index area since this is how the two contracts differ.

For the analysis presented here, the PT game serves a placebo to replace the insurance game for the basic information treatment group. The PT game lasts about as long as the insurance game, which means farmers in all treatment groups would have been equally fatigued and impatient at the end of treatment, will have all participated in a game with the possibility of winning money, and will have spent an equal amount of time interacting with enumerators. We will use data from the PT for a separate, tangentially related study.

2.1 Weather index insurance game

The game uses maps specifically designed to teach farmers about basis risk. Maps consist of "farms" and grid squares. Before the game, one of the farms on the maps is randomly assigned to each individual farmer and used to calculate each farmer's payout throughout the game. The payout is contingent upon two factors: production value, and for all farmers that buy insurance, insurance payouts and premiums. Production value for an individual farm is determined at the farm level, while insurance payouts are determined at the square level, which reflects the main feature of index insurance.

In order to heighten the realism of game outcomes, nine maps were drawn with the same CHIRPS weather data used to design the LR and HR insurance products. Specifically, we use data from nine different years, corresponding to nine total game rounds (two practice rounds followed by two real rounds).[4] The maps from LR and HR differ only in the size of their grid squares, with the large-square maps determining insurance payouts for farmers with LR insurance and the small-square maps determining payouts for HR insurance. The nine maps were presented year by year, in the same order, in both types of insurance games.

There are three levels of rainfall depicted in the maps: "bad" (brown), "medium" (yellow), and "good" (green). Farms and squares each take on one of these three colors, with farms not necessarily being the same color as the square containing them. Mismatches between farm and square are cases of basis risk events.

[4]The chosen years are 1988, 1990, 1991, 1995, 2002, 2004, 2007 and 2011 because the probabilities of basis risk was closest to the average in those years.

At the beginning of each year, a random insurance price is selected from the following values: 100; 200; 500; 700; 1,000; 1,500; and 2,000 game shillings.[5] Farmers are then asked whether they would like to purchase zero, one, or two units of insurance at the drawn price. After each farmer decides how much insurance to purchase, a map displayed farm-level outcomes. Bad years, medium years, and good years (at the farm level) pay out 5,000, 7,000, and 10,000 shillings, respectively. Once all farm-level outcomes are revealed, a second map showing both farm and square results is shown. One unit of insurance pays out 2,500 shillings in a bad year (at the square level), 1,500 in a medium year, and nothing in a good year. These values were chosen so that two units of insurance fully compensates a farmer for the maximum possible loss.

The most a farmer can earn in a round is 149 KSH (having purchased two units of insurance at 100 each then experienced good farm rain and bad square rain). The least a farmer can earn is 10 KSH (having purchased two units of insurance at 2,000 each with bad farm rain and good square rain). To avoid dynamic game play, farmers are told at the beginning of the game that payouts will be based on a single randomly selected round, excluding the two practice rounds. Further details of game design, including example maps, can be found in Appendix A. The protocol for the game can be found in Appendix B.

Experimental games are often played for real earnings in order to incentivize and motivate participants. Cai and Song (2017) use a non-incentivized game in order to avoid income effects. Their game does result in substantially higher insurance relative to a non-game information treatment, although the difference is not statistically significant at conventional levels. However, incentivized game play has been shown to differ from non-incentivized play (see Jaspersen (2016) for a recent review), meaning that participants treat non-incentivized games differently and may not learn as much, or not learn the same things. Smith (1982) goes so far as to state that economic experiments must involve real payouts to be considered experiments. Because we want farmers to face real (albeit small) risks in the game, we opt to use real payouts. To mitigate income effects, average game payouts across treatments (including the PT game played by the basic information group) are calibrated to be equal. Furthermore, the amount of money given to farmers is very small relative to the actual price of insurance. At actuarially fair prices, insuring one acre of sorghum production costs approximately 3,600 KSH. Thus, we do not believe the income effect will result in differences in auction bids or eventual insurance purchases.

3 Sample and Data Collection

We worked with 487 farmers in Tharaka South sub-county. Our sample of farmers consists of 457 farmers who previously worked with the aggregator, and 30 farmers who had not worked with the aggregator previously but will become program farmers through this study. The farmers targeted for the study are semi-subsistence producers with no more than 10 acres of land.

We conducted two sessions in a day. Each day, one session was randomly assigned to the LR product and the other was assigned to sell HR product. In each session, we worked with the aggregator to assemble groups of approximately 32 farmers from various villages at a central location. Each day's participants were drawn from different groups of villages, while sessions locations were chosen to be as convenient as possible for participants. Gathering farmers in this manner is standard procedure for the aggregator. We had initially intended to have farmers assigned at random to a morning or afternoon session. However, this proved to be impossible. Instead, assignment of individual farmers to morning or afternoon sessions was left up to a lead farmer,

[5] One hundred game shillings equals one real shilling (100 KSH = 1 USD). We use these higher amounts to more closely resemble actual payouts and insurance prices.

although the lead farmer was unaware of which treatment type would take place in any given session.

In either session, once all 32 farmers were gathered, the promoter provided them with the basic insurance information treatment. After that, the farmers were randomly assigned to one of the two treatments (i.e. insurance game or PT game) by drawing a numbered card from an envelope. Activities for the two groups in each session took place simultaneously and separately, with enough space between groups to avoid spillovers during session activities. Groups of between one and three farmers worked with a single enumerator to complete PT or insurance game activities, depending on treatment received.

The order of activities for recruitment of aggregator clients is as follows:

First visit

1. Using the list provided by the aggregator, the representative of the aggregator contacted the lead farmer of each farmer group.
2. The representative of the aggregator requested that lead farmers would invite farmers to the study who were members of the group and who would be able to make a decision about whether they would buy insurance on behalf of the household.
3. Lead farmers informed group members that they have been selected to participate in an activity about agriculture, but did not inform them of their treatment status. They also informed them of time and place of activity.
4. Lead farmers informed farmers that they would be offered an opportunity to purchase insurance at a discounted price. The members were told that if they wanted insurance, they would be asked to commit to purchasing the insurance during the activity. However, the members were also told that no sales of insurance would take place at the activity. Instead, each member will pay at the beginning of the planting season.

Recruitment of the 30 non-aggregator clients proceeds in a very similar manner, except that contact and organization of individual farmers is the responsibility of local extension officials.

Information session (approximately 2 days later)

1. At the meeting place, if the farmer was not initially present for the activity, the survey team visited or called them to encourage them to come.
2. All farmers attended the basic information session conducted by the aggregator's representative.
3. After the session, they were randomly assigned to treatment groups by drawing numbered cards from an envelope.
4. In each group, informed consent was acquired and demographic data were collected.
5. All farmers participated in assigned game (PT or insurance)
6. The experimental auction was conducted for all farmers.
7. At the conclusion of the auction, enumerators conducted a brief survey on their understanding of insurance and basis risk.

Follow-up visit (2 months later)

Follow up visits are planned following the August 8th election. The team will follow-up only with households who said they would buy insurance during the auction (at the randomly selected subsidized price). During the follow-up visit, only the HR product will be offered. Farmers originally assigned to the LR product during the auction were told that they would actually be buying HR insurance when given the chance to do so.

The process will be as follows:

1. All individuals will be reminded, via text message, of the total value of insurance they committed to buy at the auction. The text message will be approximately read (in Kiswahili): Hello (insert name), you said you would purchase (insert quantity of insurance) units of insurance at price (insert drawn price) per unit. We will complete this transaction on Sept (insert date). The text message will be sent by Acre Africa in late August 2017.

2. During a follow-up call in early September, conducted by a representative of the aggregator, farmers will be encouraged to fulfill their commitment, and asked to confirm their willingness to buy the original amount stated at the auction. If a farmer says that he or she no longer wants to purchase the amount stated at the auction, he or she will be given the chance to decrease the total amount of insurance. In other words, farmers will only be told that they may adjust the value insured if they state that they no longer wish to purchase the amount of insurance requested at the auction. In the event that a farmer wants to change the amount of insurance purchased, he or she may purchase less coverage, but not more.

3. Two subsequent follow-up calls will be made by a representative of the aggregator prior to September 9th to remind the farmer of the commitment, the transaction time and location.

4. Meetings to be organized by Acre Africa and the aggregator will take place in mid September for final transactions.

5. Transaction data will be recorded and shared with the research team.

4 Research Questions

We are interested in answering the following research questions:

1. Are farmers sensitive to basis risk?
   (a) Is demand for HR insurance higher than for LR insurance?

2. Does experiential learning (the game) affect demand for insurance?
   (a) Does playing the game increase or decrease demand for WII?
   (b) Does playing the HR game have a different effect on demand for HR insurance than playing the LR game has on demand for LR insurance?
   (c) Do negative basis risk events (to the farmer and to others) in the game decrease demand for WII?
   (d) Do positive basis risk events (to the farmer and to others) in the game increase demand for WII?

3. Does experiential learning (the game) affect attitudes toward and knowledge of insurance?

(a) Does playing the game alter attitudes/understanding?

(b) Do negative basis risk events (to the farmer and to others) in the game alter attitudes/understanding?

(c) Do positive basis risk events (to the farmer and to others) in the game alter attitudes/understanding?

5 Power calculations

We calculated minimum detectable effects (MDEs) for two outcomes: (1) the decision to buy any insurance, and (2) quantity of insurance purchased at a set of prices described below. There are no data from our study area besides insurance purchase at the market rate, which is essentially non-existent. Therefore we calculated MDEs using simulated data.

To generate the simulated data we first created a cultivated area distribution using a Poisson density function with a mean of 3 acres, closely approximating average land holdings reported by the aggregator. We then used estimates of input and production value from the aggregator to calculate input and production value for each farmer. Finally, we randomly assigned WTP to individual farmers as a percentage of the actuarially fair premium using a Poisson distribution with a mean of 5 percent of the value insured, 2.5 percentage points lower than the actuarially fair price and 10 percentage points below the market price. We chose this particular distribution of WTP so that its right tail would fall below the market price while the mean would be above zero. To calculate the quantity of insurance purchased, we set insurance demand at the value of inputs (mandatory) if WTP was below the drawn price, and set insurance demand at the value of production if WTP was above the drawn price.

With our simulated data, we used the *clustersampsi* package in Stata to calculate MDEs for the proportion of farmers with positive demand at each price point in our auction (1, 3, 5, 7, 10, 15, and 20 percent premium). We then calculated MDEs for the quantity of insurance purchased at each price. Our MDEs were calculated conditions reflecting our initial research design: treatments individually assigned to 500 farmers at the individual level, with groups of five farmers each working with a single enumerator. We therefore cluster standard errors at the group level, and assume 25 clusters of five farmers each in each arm. We assign an ICC of 0.05, resulting in a design effect of 1.2. We assume that control variables have a correlation of 0.1 with outcome variables.

At very low prices (below the actuarially fair price) we are unlikely to detect treatment effects because there is a high base take-up rate. At the actuarially fair price of 7 percent, the baseline probability of purchasing any insurance is 23 percent and the MDE is 18 percentage points. At a 10 percent premium, baseline take up is 10 percent and the MDE is 11 percentage points. At the market premium of 15 percent, baseline take up is zero and the MDE was six percentage points.

To calculate the MDE for quantity of insurance purchased, we assigned a random price to each group of five individuals playing the game together, with an equal probability of each price being drawn. We then used the amount purchased at this price to calculate a sample mean and standard deviation, and used the same ICC and correlation with covariates as before. Mean uptake in the control group was 65,870 KSH, and the MDE was 24,469 KSH. These MDEs appear high when put in terms of standard deviations, but we believed they were possible given the extremely low levels of purchased insurance (essentially zero) in the sample area.

6 Data

6.1 Insurance demand

We measure demand for insurance using a semi-binding auction as well as actual uptake of insurance. WII is a new product to these farmers, and asking them to pay potentially large sums of money for WII the first day they learned about it did not seem reasonable. Also, our auctions took place before the normal period over which insurance is purchased (this was due to both constraints on grant spending and the August 8, 2017 election in Kenya). Although we encourage farmers to fulfill their commitments, the auction is semi-binding in that we cannot compel farmers to follow through on their auction commitments when the time comes to make an actual purchase. However, we limit discrepancies between the auction and actual transaction data by not allowing farmers to purchase more insurance than what was demanded at the auction. This and other details of the auction and follow-up visits are discussed below.

The semi-binding auction takes place immediately after the insurance game or PT game. The auction relies on a multiple price list format similar to that of Lybbert et al. (2013). Our auction design makes it possible to elicit quantity demanded of a good or service at various prices, and can be made non-hypothetical by drawing a random price that determines actual transactions. In India, Cole et al. (2016) show that a binding auction for a fixed amount of WII coverage results in uptake rates similar to those of a design in which each farmer faces a single randomly-assigned price. We extend the approach of Cole et al. (2016) by allowing producers to choose their desired coverage level at several prices.

Insurance quantities are coverage amounts (in shillings), and premiums (prices) are measured as a percentage of the amount covered. During piloting, we found that farmers were confused by quantity and price when stated as monetary amounts that could take on any value. After piloting different ways to auction WII, we opted to sell "units" of insurance. Each unit provides KSH 5,000 of coverage. Prices of insurance are percentages of 5,000 KSH (50, 150, 250, 350, 500, 750, and 1,000 KSH), and farmers state how many units of coverage they would like to buy at each price.

The auction unfolds as an iterative process in which an assistant first tells a farmer how many units of insurance it would take to insure her entire crop value, and how much this would cost, at a very low price (e.g., 50 KSH). The farmer then typically agrees to insure the entire value of her crop at that price. The assistant then proceeds to raise the price of a unit of insurance to successively higher levels, while the farmer states a desired number of insurance units at each new price. Once all prices in the list have been covered or a price is reached where the farmer has zero demand for insurance, a single price is randomly selected as the actual price. The enumerator then confirms with the farmer that they have committed to purchase the amount of coverage they said they wanted at that price.

At the conclusion of the auction, farmers offered the LR product are told that during their follow-up visits they will be purchasing an insurance product that is better than what they saw during the game or basic information session, and that the product being sold uses a 5x5 km resolution rather than 10x10. In the follow-up visit made by the promoter, each farmer is reminded about the price that was drawn during the game session and the quantity of insurance they said they would purchase at that price. Farmers are not allowed to purchase more than they said they would during the auction at the drawn price, but are allowed to purchase a smaller quantity than originally pledged. In section 7.3 we explain how we address potential hypothetical bias. The complete auction protocol can be found in Appendix C.

6.2 Attitudes towards and knowledge of insurance

Knowledge of insurance and basis risk will be measured using the following brief series of true/false questions on a survey administered immediately following the auction:

1. If I buy rainfall insurance, I will always receive money back at the end of the season, regardless of the weather.
2. It is possible to receive an insurance payout even if I have received enough rain on my fields.
3. To determine how much rain has fallen, the insurer measures average rainfall over larger squared areas, not at a single farm.
4. The smaller squared area the insurer uses to measure rainfall, the greater the similarity between rainfall measured by the insurer and rainfall on my fields.

The number of correct replied will be totaled to form a knowledge index.

Attitudes regarding insurance will be measured using the following brief series of questions where respondents can choose to agree or disagree:

1. I feel like I have enough information to make an informed decision about purchasing rainfall insurance.
2. Rainfall insurance is a valuable service.
3. The information shared during today's activities was difficult to understand.

Questions (1) and (2) above will be used independently as outcome variables in the analysis described in section 7.4. Question (3) is intended to help us determine whether farmers understood the experiment and auction. Because the basic information group played a potentially confusing TCN game, we cannot use this group as a basis of comparison for those who played the insurance game.

6.3 Household demographics

During the survey preceding receipt of treatment, we collected data on a limited number of farmer characteristics. These data will help us describe our sample, test for balance across treatments, and improve precision. Second, treatment effects may vary by farmer characteristics, and it is possible to exploit heterogeneous WTP for novel products to improve targeting and make subsidies more efficient (Lybbert et al., 2013). We therefore are interested in correlations, causal or not, between several key farmer characteristics and WII demand. Third, while using farmer characteristics as control variables is not necessary to estimate the effects of our interventions without bias, it can improve precision if farmer characteristics are correlated with insurance demand, as we expect them to be.

The demographic survey took place privately as individuals were randomly assigned to treatment groups after the information session. This survey covered:

1. gender
2. age

3. religion
4. formal education level
5. literacy
6. primary occupation
7. landholdings (owned)
8. anticipated sorghum (or green gram if no sorghum) area to plant this season (in land area)
9. anticipated sorghum (or green gram if no sorghum) yield this season (in land area)
10. anticipated sorghum (or green gram if no sorghum) price this season (in KSH)
11. anticipated total value of sorghum (or green gram if no sorghum) this season (in KSH)
12. number of last 5 seasons in which fields did not get enough rain
13. if household could secure a loan for the upcoming season if needed
14. possession of a formal savings account

6.4 Game variables

As Cai and Song (2017) demonstrated, outcomes within an experimental game can influence real life decisions. In this game, a number of outcomes are possible based on farmers' decisions and random weather events. Because we are most interested in basis risk, we will differentiate between good and bad basis risk events, occurring for both the farmer and others in his session, as explanatory variables in some of our econometric analysis (see section 7.5 below).

7 Econometric Approach

For this impact evaluation we are primarily interested in the impact of two interventions on demand for insurance: an experimental game and WII resolution, as well as their interaction. To analyze impacts on demand for insurance, we begin the following subsection by employing the auction data to analyze demand curves. In section 7.2, we propose some alternative approaches for analyzing impact on demand while still using the auction data. In section 7.3, we assess actual purchase decisions (rather than the auction data). In section 7.5, we focus on the game and evaluate the impact of an individual's game experience on demand.

In addition to demand, we are also interested in knowledge and understanding regarding insurance. In the final subsection (7.4) we shift our attention from impacts on demand to impacts on knowledge about and attitudes towards WII.

7.1 Demand curve analysis

In this section we will employ the auction data to analyze demand curves. We begin with strong assumptions regarding functional form, and move toward a more flexible approach.

7.1.1 Linear parallel demand curves

We begin by assuming that demand for insurance is linear. In order to accommodate testing for an impact of the experimental insurance game or insurance resolution, we will estimate demand as a function of treatment status where G_i denotes insurance game, HR_i denotes the high resolution insurance product, P_i denotes price, and $\mathbf{X_i}$ is a vector of covariates (see details in section 7.6). By including the interaction term, $G_i \times HR_i$, the omitted category is the non-game low resolution treatment group.

$$Q_i = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \beta_4 P_i + \mathbf{X_i'} \beta_{\mathbf{x}} + \varepsilon_i \tag{1}$$

This allows for the estimation of four parallel demand curves, where each treatment is allowed a unique intercept, but all share the same slope (β_4).

Because the degree of basis risk differs between the products and the game is designed to teach farmers about basis risk, it is possible that the game would increase demand for HR insurance and decrease demand for LR insurance. We do not, therefore, want to test for average game effects for our whole sample ($\beta_1 + 0.5\beta_3$). It is also possible that the game decreases demand for both products, especially if basis risk is perceived to be too high. Instead we will test the hypothesis of a zero average effect of the game on demand for HR insurance ($\beta_1 + \beta_3 = 0$), and whether the average effect of the game on insurance demand is the same for farmers offered HR and farmers offered LR insurance ($\beta_3 = 0$). The latter hypothesis can also be interpreted as testing whether the average impact on insurance demand of being offered the HR product is the same regardless of having played the insurance game.

The aggregator shared very little information about basis risk with participants in the basic information sessions. In the auction, enumerators did not elaborate on what the farmers were bidding on beyond what was explained by the aggregator. Therefore it is possible that in the absence of the game, there will be no difference in demand between LR and HR insurance ($H_0 : \beta_2 = 0$). Whether farmers can readily assess product quality without extensive training is a highly relevant question for index insurance policy, as emphasis is increasingly being placed on designing insurance products with lower basis risk.

7.1.2 Linear non-parallel demand curves

Equation 1 can be expanded to test whether the interventions affect not only the intercept, but also the slope of the demand curve. We do this by interacting price P_i with G_i, HR_i and $G_i \times HR_i$.

$$\begin{aligned} Q_i = {} & \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \beta_4 P_i \\ & + \beta_5 (G_i \times P_i) + \beta_6 (HR_i \times P_i) + \beta_7 (G_i \times HR_i \times P_i) + \mathbf{X_i'} \beta_{\mathbf{x}} + \varepsilon_i. \end{aligned} \tag{2}$$

This approach offers more flexibility than the previous approach. We will use this increased flexibility to test whether parallel shifts in demand, changes in prices sensitivity, or some combination of both is driving treatment effects on demand for insurance.

More specifically, we will test the hypothesis of no shift in demand for the HR product as a result of playing the insurance game ($\beta_1 + \beta_3 = 0$), as well as the hypothesis of no change in price sensitivity of demand for the HR product as a result of playing the game ($\beta_5 + \beta_7 = 0$). Furthermore, we will test whether the shift in demand caused by offering the HR product is equal for the game and non-game groups ($\beta_3 = 0$), and whether the change in price sensitivity caused by offering the HR product is identical for the game and non-game groups ($\beta_7 = 0$). Similarly, we will test the hypothesis of no shift in demand when offering the HR product ($\beta_2 = 0$) or no change in price sensitivity ($\beta_6 = 0$), both in the absence of the game.

7.1.3 More flexible demand curves

It is quite likely that the demand curves will not be linear. If a scatter plot shows that demand is highly nonlinear in price we may use another functional form where price enters the demand function nonlinearly (e.g., quadratic or logarithmic). Another alternative is to use a linear spline. We plan to compare alternative models using the Bayesian information criterion (BIC).

7.2 Alternative approaches to studying demand

In this section we propose several alternatives to estimating demand curves that still leverage the richness of the auction data. One reason to do this is the possibility that effects are stronger at certain points on the demand curve. For example, it seems plausible that demand above the market price will be near-universally zero and/or demand at very low prices is universally high. If this is the case, treatment effects will be small or even non-existent for high and low prices, and the average effect may ignore important impacts at other (more policy-relevant) premium levels. This suggests focusing on policy relevant premium levels, which we do by looking at quantity demanded (section 7.2.1), the probability of any insurance uptake (section 7.2.2), and the probability of fully insuring (section 7.2.3) at several specific prices.

7.2.1 Demand at policy relevant premium levels

From a policy perspective, we are most interested in how each intervention affects demand at the market price, or at levels close enough to the market price where subsidies could realistically close the gap. Among the premium levels at which we elicited demand, these policy relevant levels are half of the market premium (7 percent of the value insured), two thirds of the market premium (10 percent), and the full market premium (15 percent).

Here we re-estimate equation 1 only using quantity demanded at those premium levels (rather than at all premium levels while controlling for P_i):

$$(Q_i|P_i = 7) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{3a}$$

$$(Q_i|P_i = 10) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{3b}$$

$$(Q_i|P_i = 15) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{3c}$$

In 3a, 3b, and 3c, $\beta_1 + \beta_3$, β_2 and β_3 have the same interpretation as in 1. However, in this approach we can see if the estimated impacts vary with price (i.e. do the estimated coefficients vary across 3a, 3b, and 3c).

7.2.2 Probability of *any* insurance uptake

Getting farmers to purchase insurance for the first time can be a substantial hurdle, but an important one. While insurance may not be as easy to learn about as other technologies (if rain is sufficient and no payouts are made, the farmer does not learn if insurance works), farmers may still wish to initially purchase a small quantity to familiarize themselves with the product before fully insuring. Therefore we would like to know what the effects of the game and/or insurance resolution are on the probability of purchasing any insurance. Here, we are considering insurance purchases along the extensive margin. We do this in two ways. First, we consider an average impact controlling for the premium:

$$I(Q_i > 0) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \beta_4 P_i + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{4}$$

As stated earlier, we are most interested in the policy-relevant premiums of 7, 10, and 15 percent. In our second approach we allow the effect to vary with price by estimating the following:

$$I(Q_i > 0 | P = 7) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{5a}$$

$$I(Q_i > 0 | P = 10) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{5b}$$

$$I(Q_i > 0 | P = 15) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{5c}$$

Equations 5a, 5b, and 5c model the probability of purchasing any insurance, beyond the input insurance required by the aggregator at half the market price, 2/3 of the market premium, and at the full market premium level respectively. Because the outcomes here are binary, there will be very little noise, again potentially resulting in better inference than we can achieve under previously stated specifications.

7.2.3 Probability of *full* insurance uptake

We are also interested in the effects of the game and/or insurance resolution on the probability of purchasing full insurance. We do this in two ways parallel to the above. First, we consider an average impact controlling for the premium:

$$I(Q_i = \bar{Q}_i) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \beta_4 P_i + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{6}$$

As stated earlier, we are most interested in the policy-relevant premiums of 7, 10, and 15 percent. In our second approach we allow the effect to vary with price by estimating the following:

$$I(Q_i = \bar{Q}_i | P = 7) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{7a}$$

$$I(Q_i = \bar{Q}_i | P = 10) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{7b}$$

$$I(Q_i = \bar{Q}_i | P = 15) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{7c}$$

Equations 5a, 5b, and 5c model the probability of purchasing full insurance, beyond the input insurance required by the aggregator at half the market price, 2/3 of the market premium, and at the full market premium level respectively. Because the outcomes here are binary, there will again be very little noise, again potentially resulting in better inference than we can achieve under earlier specifications.

7.2.4 Willingness to pay for partial or full insurance

Finally, we can estimate the effect of the interventions on willingness to pay (WTP). This puts treatment effects in subsidy equivalents directly, without relying on a linear relationship between price and quantity demanded (as in equations 1 and 2 above). However, to do this we need to choose fixed quantities of coverage at which to make comparisons. Two natural levels of coverage to compare WTP are full coverage and any coverage. As discussed above, the auction was an iterative process during which we would expect most farmers to fully insure at very low prices. As the price increases, we would expect the amount of coverage purchased to eventually fall to zero. As outcome variables we will therefore use (a) the maximum price at which a farmer fully insures $(MaxWTP_i, Q_i = \bar{Q}_i)$, and (b) the maximum price at which a farmer bought any insurance at all $(MaxWTP_i, Q_i > 0)$.

$$(MaxWTP_i, Q_i > 0) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_\mathbf{x} + \varepsilon_i. \tag{8a}$$

$$(MaxWTP_i, Q_i = \bar{Q}_i) = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_\mathbf{x} + \varepsilon_i. \tag{8b}$$

For farmers who opt out of insurance at every price, we will assume that their maximum willingness to pay is zero. Since free insurance cannot make a farmer worse off, this seems like a reasonable assumption. For farmers who never choose full insurance, we will assume that they would fully insure at a price of zero.

As in section 7.2.2, analyzing the data in this way offers the potential benefit of reducing noise. Farmers were allowed to respond with any quantity of coverage up to the amount of full coverage they said they needed. Enumerators worked carefully with farmers to determine the maximum amount of coverage a farmer would need based on their acreage and expected yield. Furthermore, the aggregator claimed before data collection that she did not work with farmers with more than 10 acres. But the response was not strictly bounded, and enumerator error or abnormally large farms could lead to outliers in coverage desired. In contrast, WTP is strictly bounded by the range of premiums posed to the farmer (1, 3, 5, 7, 10, 15, and 20 percent). WTP data will therefore have very little noise.

7.3 Actual purchase decisions

Our primary use of data for actual purchase decision data will be to validate the auction data. We are prioritizing use of the auction data to capture insurance demand for three reasons. First, the auction data include quantity of coverage demanded at each price, whereas the data on actual purchases include quantity demanded at a single price for each sample farmer. By using the auction data, we should therefore be able to obtain more precise estimates of all parameters of interest. Second, auction data were collected before farmers could discuss insurance purchases with each other, limiting potential spillover or peer effects that could bias treatment effects. Third, the LR product will not be offered to farmers when they make their actual purchase decisions, making it impossible to evaluate the effect of offering LR versus HR on demand for insurance with actual purchase data.

Let $Actual_i$ be the quantity of insurance purchased at price P_i during the actual transaction by farmer i. Let Q_i be the quantity of insurance coverage requested by farmer i at price P_i during the auction. We will validate the auction data by estimating the following model using the subsample of farmers initially assigned to the HR product that declared in the auction that they would purchase at least some insurance at the selected price, pooling actual and auction purchase data. Analysis is limited to the price selected at random for purchase by each farmer i.

$$Q_i = \gamma_0 + \gamma_1 G_i + \gamma_2 Actual_i + \gamma_3 (Actual_i \times P_i) + \gamma_4 P_i + \mathbf{X_i'}\gamma_{\mathbf{x}} + \varepsilon_{ij} \tag{9}$$

In order to test the hypothesis that there is no hypothetical bias, we test the joint hypothesis that $\gamma_2 - 1 = \gamma_3 = 0$. If we fail to reject this hypothesis, we will analyze models that use quantity of coverage demanded as the dependent variable under the assumption that the auction data are free of hypothetical bias. However, it is very possible that farmers facing high prices purchased less insurance in reality than they said they would in the auction. Therefore, if we reject the joint hypothesis just described, we will test whether $\gamma_2 + (\gamma_3 \times P_i) = 1$ at each price in the data set. We will limit our analysis of the auction data to the set of prices for which we fail to reject this hypothesis.

In addition to validating the auction data, we will use the actual uptake data to conduct a full analysis of the effects of the game, repeating all game-specific hypothesis tests discussed above. However, since only one product was sold during actual transactions, we will not test any hypotheses related to LR versus HR insurance. In addition, all hypotheses will be tested using the subset of farmers initially offered the HR product.

7.4 Knowledge and attitudes

An alternative outcome of interest is knowledge about insurance, WII in particular, and basis risk. To test for the impact of the interventions on knowledge we will consider K_i, the number of correct answers on a brief insurance test (described in section 6.2). Using K_i as our dependent variable, we estimate:

$$K_i = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{10}$$

By summing the answers across questions into a single score, we can avoid testing multiple hypotheses. An analysis of individual questions will also be conducted, but this analysis will be considered exploratory.

In addition, we may be interested in attitudes regarding insurance. For attitudes, it is not as straightforward to create an aggregate “attitudes” score. We will therefore estimate the impact of treatment on attitudinal questions independently.

$$A_i = \beta_0 + \beta_1 G_i + \beta_2 HR_i + \beta_3 (G_i \times HR_i) + \mathbf{X_i'}\beta_{\mathbf{x}} + \varepsilon_i. \tag{11}$$

7.5 Game experience

There are multiple ways that playing the game might affect insurance demand. It could be that playing the game helps farmers learn about insurance, but what happens to them in the game does not matter. Or, it could be that experiencing insured and uninsured shocks in a simulated environment does affect insurance demand, as found by Cai and Song (2017). Furthermore, given that this is index insurance, negative and positive basis risk events could also affect demand. Because the game is played in small group settings, it is possible that *others'* game outcomes affect demand. There are a number of ways we can construct this analysis. Given that this is testing mechanisms, rather than intervention impact, we consider this line of analysis exploratory and omit details from this pre-analysis plan.

7.6 Control variables

We have limited data that can be used as control variables to improve precision, if these variables are correlated with outcomes. For regressions with demand as the outcome variables (equations 1 through 9) we will control for:

1. gender
2. age
3. religion
4. formal education level
5. literacy
6. primary occupation (farmer or not)
7. landholdings (owned)
8. anticipated sorghum (or green gram if no sorghum) area to plant this season (in land area)
9. number of last 5 years fields did not get enough rain
10. if household could secure a loan for the upcoming season if needed
11. possession of a formal savings account

For equations 10 and 11 we will control for:

1. gender
2. age
3. formal education level
4. literacy

If any indicator variables has over 90 percent of observations taking on the same value it will not be used as a control.

7.7 Heterogenous treatment effects

Demand for insurance is likely mitigated by wealth. It is possible that for the poorest farmers, the game will have no effect because they cannot purchase insurance at all. We will therefore re-estimate models in equations 1 and 3a through 9 allowing effects to vary by wealth. To proxy for wealth we will use landholdings, and assign an indicator variable for having more land than the median sample farmer.

Treatment effects are also likely mitigated by farmers' ability to understand the game and/or auction, which could effect both demand, knowledge, and attitudes. We will therefore re-estimate the models in equations 1 and 3a through 11 accounting for heterogeneity in ability to understand the components of the experiment. Literacy is likely the best proxy for understanding, and we will use this variable to test for heterogenous treatment effects if it splits the sample into a group no larger than 70 percent of the sample and a group no smaller than 30 percent. If it does not, we will use whether a farmer is above the sample median in terms of formal education level.

7.8 Statistical inference

7.8.1 Clustering

Our research design consists of a 2x2 experiment in which one randomization was carried out across game and information sessions (i.e. LR versus HR insurance) whereas the second randomization was done within sessions (assignment to the insurance game or the prospect theory game). Hypothesis testing for effects identified by the randomization across sessions will rely on the wild cluster bootstrap with six-point weights as described by Webb (2013). For example, the average effect of offering HR on insurance demand among farmers not playing the game is identified by comparing farmers only receiving the basic information treatment in HR and LR sessions, and therefore inference on this effect must account for clustering. For effects identified by comparisons across sessions, the method of Webb (2013) should result in valid inference despite the small number of clusters. For hypothesis testing of effects identified by randomization within sessions we will not account for clustering. For example, the average effect of playing the game on demand for HR insurance is identified by comparing game players to non-game players in HR sessions. Since the game treatment was randomized within sessions, inference on the game effect among farmers offered HR insurance can be done out without accounting for clustering. Inference on effects identified by within-session randomization will be based on robust standard errors (estimated using the "robust" option in Stata's "regress" command).

Our main motivation for using two modes of inference is that the wild cluster bootstrap may result in a loss of power when testing hypotheses based on the within-session randomization. However, if the bootstrap approach and inference based on robust standard errors yield similar levels of precision for effects identified by the randomization within sessions, we will only report results based on the wild cluster bootstrap.

7.8.2 Multiple hypothesis testing

For several sets of hypotheses tests we will control for the false discovery rate, taking into account dependencies among specific hypotheses. Equations 3a, 3b, and 3c each test whether treatment has an effect on demand at a specific price over the range of policy relevant prices. Because we are testing the same hypothesis at multiple prices, we will control for false discovery rate among these three regressions within, but not across coefficients. The same goes for the set of equations 5a, 5b, and 5c, and also 7a, 7b, and 7c.

In equations 8a and 8b we estimate whether treatments affect farmer WTP for insurance. We pick two natural quantities at which to capture WTP: (1) any insurance and (2) full insurance. Because we are testing the same hypothesis at two different quantities we will control for the false discovery rate among these regressions, but not across coefficients. For all other regressions we are testing a single hypothesis with a single equation, and thus do not adjust inference for multiple hypothesis testing.

8 Cost effectiveness analysis

We will calculate the cost of implementing the experimental games based on the person-hours necessary, subsidies provided, and cost of materials. We will then calculate cost effectiveness ratios for increases in (a) total insurance demanded, and (b) number of farmers with positive demand for insurance at the actuarially fair premium and the market premium.

In addition, we will compare the cost effectiveness of each treatment to the estimated marginal effect of price on (extensive and intensive) demand. If we assume that the marginal cost per treated individual is constant for all treatcments, and that our model specifications have accurately captured the effect of price on demand, then comparing cost effectiveness to the marginal effect of price allows to evaluate our treatments relative to an equivalent subsidy.

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Appendix A: Experimental game details

To construct the maps for our experimental game we used CHIRPS rainfall data from 1981 to 2015 at 84 points throughout Tharaka Nithi county, spaced at a resolution of 5x5 km. We call these High Resolution (HR) "weather stations" (although they are no physical weather stations), with each representing a HR index area. We randomly selected 840 coordinate pairs within Tharaka Nithi county to represent farms. We assigned each farm a simulated rainfall amount which was a weighted average of the surrounding HR rainfall stations rain. We weighted rainfall at the farm level according to distance ($\frac{1}{distance^5}$) so that farm level weather most resembled that of nearby weather stations. We then added a random component to each farms rain, multiplying weighted rainfall by a number drawn from a uniform distribution between 0.4 and 1.6 to reflect the idiosyncratic nature of farm level weather and ensure that on average farmers would have at least one potential basis risk event over the course of the game.

We then created the Low Resolution (LR) grid, with 10x10 index areas. We used GIS to visually ensure that as many LR index areas as possible were constituted of four HR areas. This gave us 28 LR stations. For LR stations constituted of four HR areas, their new coordinates were simply averages of the four HR areas. For LR areas constituted of two or three HR areas, their new coordinates had to be calculated separately to ensure that they still fit into the grid of LR areas.

Because CHIRPS data is at 5x5 km resolution, we needed to create aggregate rainfall data for 10x10 km areas. Using averages of HR areas results in a narrower distribution of rainfall outcomes for 10x10 km index areas than 5x5 km index areas, whereas that would not necessarily be the case if the CHIRPS data was at lower resolution. To obtain a distribution that did not move LR rainfall towards the mean we randomly selected one HR squares within each LR area to represent it.

In a given year rainfall was classified as green (good rainfall), yellow (modest rainfall), or brown (poor rainfall) based on the simulated rainfall amount received at the farm level. At the farm level, each of these rainfall levels corresponds to a value of production. The payouts for each rainfall level were calculated so that full insurance would perfectly offset the difference between the farm outcome and the green outcome, if the index area outcome matched the farm outcome (i.e. insurance payouts from Acre's policy were used to calculate farm level production values for the game). A map showing farm level outcomes can be found in figure 1.

Each farm was assigned to its closest LR and HR weather station depending on the version of the game being played. To determine insurance outcomes for each index area, we used trigger information from Acre. Triggers were determined using CHIRPS satellite data and designed for sorghum. Acre splits the growing season into four periods with different triggers for each (germination, vegetative, flowering, pre-harvest). Insurance payouts in the game are determined on a sliding scale according to how many triggers were met and to what degree at the corresponding weather station. To reflect Acre's deductables, we subtracted 10 percentage points from each period's payout. If the total payout for the season would be less than 10 percent, no payout is given.

We chose the three rainfall levels so that the distribution of game payouts roughly matches the distribution of real insurance payout ranges. Brown index areas correspond to a payout (after deductible) of 15 percent or more of the value insured. Yellow index areas correspond to 0-15 percent payout after deductible. Green index areas correspond to no payout after deductible. Negative basis risk, or a disadvantageous mismatch between farm and index area, occurs when rainfall at the farm is less for the corresponding index area (e.g. a brown farm in a yellow or green square, or a yellow farm in a green square). Positive basis risk occurs when rainfall at the farm level is less than rainfall for the corresponding index area (e.g. a green farm in a yellow or brown square, or a yellow farm in a brown square). A map showing both farm level and index area outcomes with HR insurance can be found in figure 2. A map showing outcomes for the same year with LR insurance can be found in figure 3.

Once the maps were created for all 35 years of CHIRPS data we selected nine years to use for game (two practice rounds and seven real rounds). We wanted most years to satisfy three criteria:

1. include all three weather outcomes at least somewhere in the country
2. negative basis risk is higher with LR insurance than with HR insurance
3. positive basis risk is no higher with HR insurance than with LR insurance
4. positive basis risk is no higher with HR than negative basis risk is with LR

Based on these criteria, we chose the years 1988,1990, 1991, 1993, 1995, 2002, 2004, 2007, and 2011.

Next, we picked 22 farms from the 840 available to assign to farmers during the game. While we were expecting 16 farmers per game, we selected 22 in case more farmers were in a session. We selected farms for which overall basis risk would be higher with LR insurance than HR insurance, and negative basis risk was (marginally) higher than positive basis risk. To avoid confusion we did not select farms that were on an edge between two index areas, or too close to another selected farm.

The final distribution of basis risk evens for the chosen years and farms was as follows:

1. LR negative basis risk: 0.268
2. LR positive basis risk: 0.162
3. HR negative basis risk: 0.177
4. HR positive basis risk: 0.157

Figure 1: Farm level outcome map

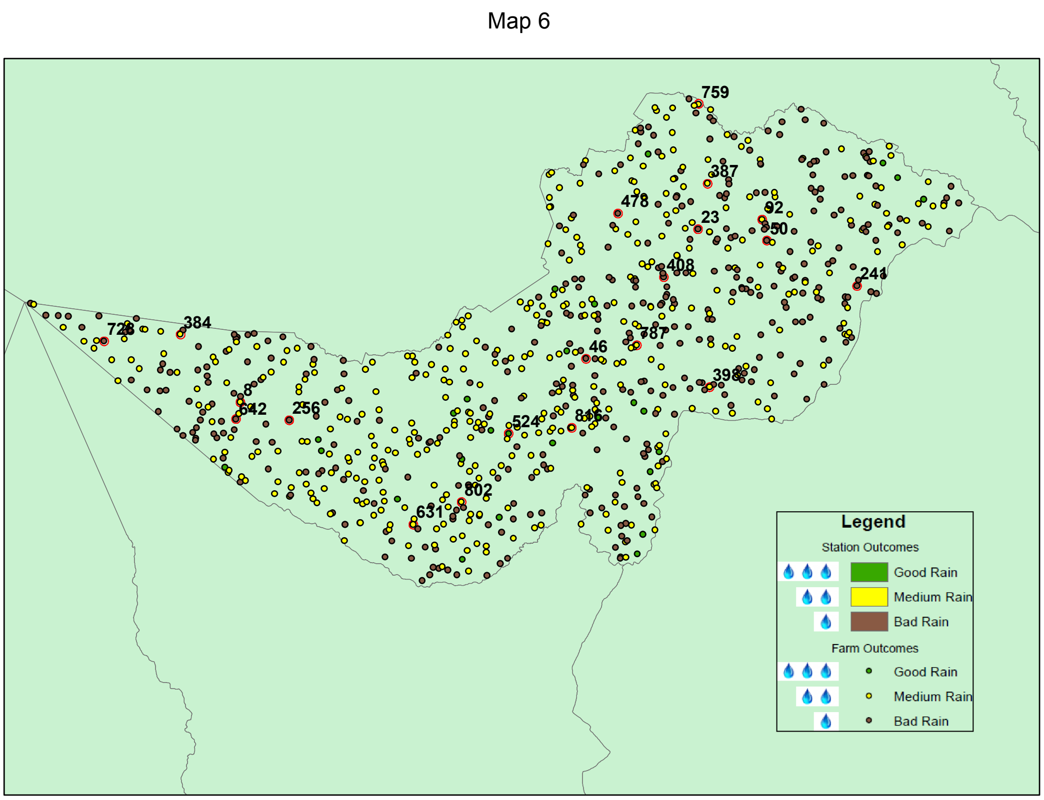


Figure 2: Farm and index area outcome map (high resolution)

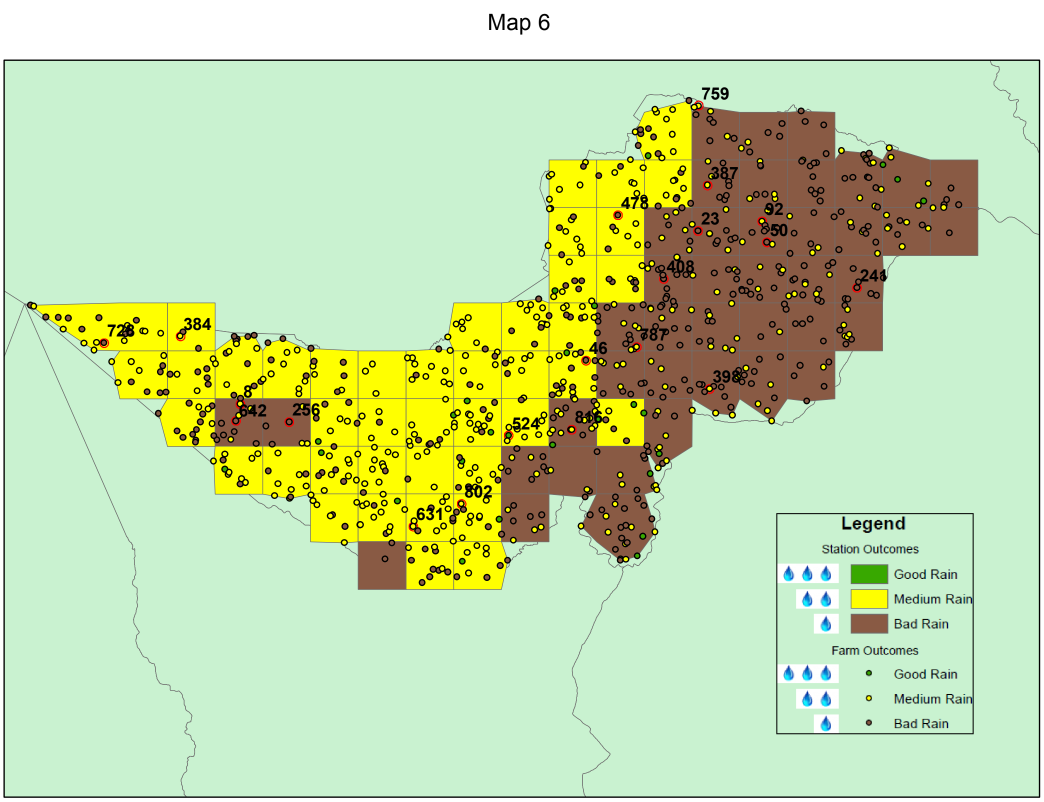
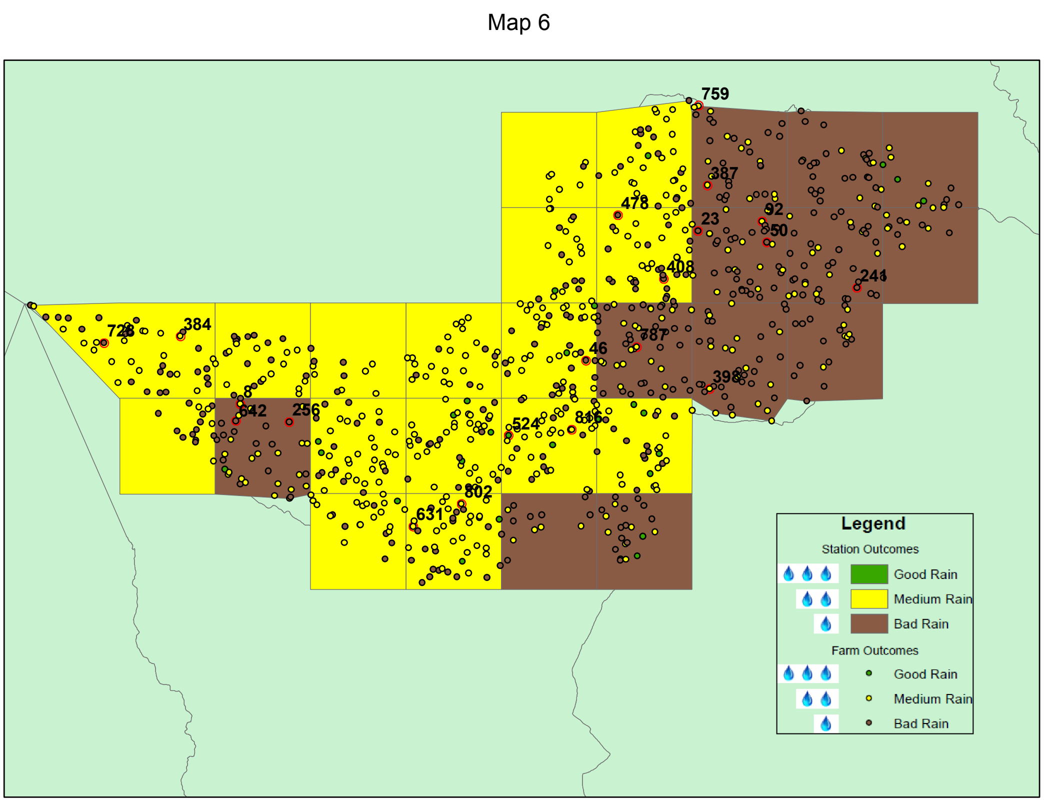


Figure 3: Farm and index area outcome map (low resolution)



Appendix B: Experimental game protocol

The game was administered by a Game Master, who served as a master of ceremonies for the game, explaining it to all participants. Assistants worked with sets of two farmers to ensure they understood the game, explain outcomes round by round, and enter their choices into the game worksheets. The following is the text used during training and game administration:

This document is to be read by the Game Master (GM) in a way that is accessible to participants, except for sections that directly address Assistants.

1. Introduction

[ASSISTNATS: Each farmer will receive a numbered piece of paper to help identify him/her during the exercises. Each farmer will be assigned to an assistant (2 farmers per assistant). Once assigned a farmer, the assistant should introduce himself politely and ask the farmer to have a seat with him. When everyone seat, game master starts the session.]

GAME MASTER (GM): Thank you for coming. My name is (NAME), and I am working with a team of researchers from Nairobi and America. The purpose of this visit is to learn about how farmers like you understand and appreciate crop insurance. If you decide to participate in the study, you will play in some entertaining games. You will earn a minimum of 120 KSH for participating. On top of that you will have a chance to earn money in the games. No one will leave with less money than they came in with. Before beginning the game, your assistants will now ask you a few questions.

[ASSISTANTS: You will have a packet for each participant that contains (1) the human subjects form, (2) the introductory questionnaire, (3) the game worksheets, (4) auction bid sheets, and (5) exit questionnaire. Begin by reading the farmer the informed consent form and asking if he/she agrees to participate. If so, either have the farmer sign or sign on his/her behalf is the farmer consents and is unable to sign. If the farmer agrees, begin the survey.]

Is everyone finished? Great! We are ready to explain the insurance product.

2. Basic Introduction without Games

Have any of you heard of insurance before? What do you know about it, if anything?

[ASSISTANTS: If they have heard of insurance before, continue to the next paragraph. If not, state the following: Insurance is a product you can buy to protect you when bad things happen. You pay a fee each year or season, and if something bad happens, you receive a payout. You must pay the fee even if nothing bad happens, which is how the insurer is able to cover their costs. There are many kinds of insurance, like motorbike insurance, life insurance, and health insurance, for example.

Our colleague described agricultural insurance to you today. Specifically, he described "Weather based Index Insurance (WII)". WII is insurance you can purchase before the beginning of an agricultural season. If rainfall is poor in your area and you have purchased WII, you will receive a payment to compensate you for your likely losses. Recall that WII does not pay out based on the losses on your farm, or the rainfall on your farm, but based on the overall rainfall in your area.

We would like to show you one insurance product for this game. Then you will play insurance games to help you better understand how the insurance works. In each round of the games, you will choose whether to buy the insurance and see how much you will earn from both your harvest and your insurance payout depending on rainfall.

1. How insurance payouts are calculated

This is a map of your county [Map with dots]. The black dots represent farms. WII divides a given region into many squares [Map with dots and squares]. [5X5 GROUP: The squares are 5km by 5 km. 5 kilometers is about from X location to Y location. 10X10 GROUP: The squares are 10 km by 10 km. 10 kilometers is about from X location to Y location.] Satellites estimate the amount of rainfall in each square. The cameras on the satellites are no strong enough to see the amount of rainfall on individual farms; they can only estimate it for larger areas. Insurance payouts are based on the amount of rainfall in the squares.

Now, we will explain how insurance payouts are decided using a [WII] map. A farm can receive good rain, medium rain, or poor rain. On the map, 'Green' means rainfall is good, 'Yellow' means rainfall is medium, and 'Brown' means rainfall is bad. Let's see what rainfall farms receive [Display maps with rainfall]. Those with Green farms had good rainfall. Those with yellow farms had medium rainfall. Those with brown had poor rainfall.

WII payouts are based on the overall rainfall calculated for the square where a farm is located. Just like for the farms, there are three outcomes for the squares: Green, Yellow and Brown. Green means rainfall was good overall in the square, Yellow means rainfall was medium overall in the square, and Brown means rainfall was bad overall in the square.

Let's see what the rainfall outcomes measured for the squares are [Display rainfall results in [WII] squares]. If a farmer's square is Green, he will not receive any payout because the overall rainfall in his/her square is good. If a farmer's square is Yellow and he bought insurance, he will receive a medium sized payout. If a farmer's square is brown and he bought insurance, he will receive a larger payout. Once again, insurance payouts depend only on the overall rainfall in the square where a farm is located, not on the rainfall the farm itself receives. Therefore, to best protect farmers from poor rainfall, the overall rainfall in the square should be as close to possible as the rainfall on the farm.

2. How to earn money in the game

Before playing the game, I will go over how you earn money in the game. In the game, you all expect to earn 10,000 KSH from your production of sorghum and green gram. You draw a card that indicates what farm you have on the map. The game has seven rounds; each round is like a short rain season. In each round, you will decide how much insurance to purchase, if any, before planting. The price of the insurance products will vary round by round. After you make your insurance decision, we will reveal rainfall for that round of the game. If the rain on your farm is good (green), you earn 10,000 KSH. If it is medium (yellow) you earn 7000 KSH. If it is bad (brown) you earn 5000 KSH.

In this game, you can buy one or two units of insurance, or none at all if you think the price is too high. One unit of insurance will pay you 1500 KSH if your square gets medium rain (yellow), or 2500 KSH if your square gets bad rain (brown). Remember, you don't get any payout if your square gets good rain. If you buy two units of insurance, then you need to pay 3,000 KSH because one unit of insurance costs 1500 KSH, but the insurance payout also doubles. Two units of insurance will pay you 3000 KSH if your square gets medium rain (yellow), or 5000 KSH if your square gets bad rain (brown).

[ASSISTANTS: Go over these values with the farmers until they understand.]

Your assistant will walk you through each round of the game, record your decisions and tell you the outcome of each round. After we are done playing all seven rounds of the game, we will select one of these rounds at random. We will divide the payout of the selected round by 100 and add this calculated value to your participation fee, 100 KSH.

Now let us determine which farm on the map is yours. Please draw a card with a farm number on it [Display map with farm numbers]. Please match the number on your card to the farm in the map. Can everyone find your farm? Great! Let's begin! Before we begin the seven rounds of the game, we will do a few practice rounds for you to better understand how the game works.

[ASSISTANTS: You will fill out the game worksheets as the game proceeds]

3. Insurance practice game with the [WII]

First, you are going to play one round game where you will decide how many units of insurance you want to purchase the [WII] product. Suppose you are given the [WII] product for free. That means the insurance premium in this round is Ksh 0. Please tell your assistant if you will accept one unit of the [WII] for free. [ASSISTANTS: If your farmers decide to accept, please circle "Yes" in the column marked "Accept?"].

Did everyone accept the insurance? [Game master: If someone did not accept the free insurance, ask them why. Explain to the group that because is insurance will pay them if rain is medium or bad, and the insurance costs nothing to them, it is a good idea to take the insurance].

Now, we will show you a randomly chosen map that shows the rainfall for this round of the game. [Display Map 1 with farm rainfall outcomes.] Now please check whether rainfall is good (Green), medium (Yellow) or bad (Red) on your farm? Please draw a circle in the column marked "Farm Rainfall". [Assistant: Help the participant find their farms on the map and draw a circle in the column marked "Farm rainfall".]

Did everyone check? Great. Now, please check your overall rainfall outcomes measured for the squares. [Display Map 1 with station rainfall outcomes.] Please draw a circle your rainfall outcome in the column marked "Square Rainfall". [Assistant: Help the participant find their square on the map and draw a circle in the column marked "Square Rainfall".] We can help you calculate your expected payoff based on your outcomes. Since there is no price in this round, only parts you need to pay attention to are "Farm Rainfall" and "Rainfall Outcome".

[ASSISTANTS: Calculate their payout by referring to the "Payout Reference Table". Explain step by step with simple words. The conversation starts like that: You earn Ksh * for harvest value, because your farm rainfall is (Green/Yellow/Brown). You receive Ksh * for insurance payout, because the rainfall outcome is Yellow (Brown). (Or, You don't receive insurance payout, because the rainfall outcome is Green). Since the insurance price is Ksh ?, your final payout is ?] [ASSISTANTS: Then go through what kind of net income they would have received if they made different insurance decisions. If they purchased 2 units, what would have happened if they purchased 1, or no insurance?]

Do you understand how this insurance works? Let's move on to another practice round.

[Conduct the second practice round where every process is exactly the same as the first practice round except that we let a farmer draw a random number for insurance price and ask them how many units of insurance they would like to purchase at the drawn price.]

4. Insurance game with the REAL money

Now, you are going to play 7 rounds of the same game but with prices and real money involved. In each of the 7 rounds, you are asked to choose how many units of insurance you want at the drawn price. The price of the insurance product is randomly chosen in each round. You still have farms in the same location as before. Note that the outcomes from previous rounds do not affect the next rounds. That means, you always start a new round. At the end of the games, we will randomly select one round as your binding round. Then, we will divide the payout of the selected round by 100. Your final payouts will be your show-up fees plus your calculated payout of the one randomly chosen round among 7.

Now, let's begin the round 1. Remember, your final payout with real money is going to be decided among these 7 rounds of the game. We will show you the price of the insurance product [Ask a farmer to blindly pick a price from the envelope]. Please tell your assistants whether you would like 0,1, or 2 units of insurance. [ASSISTANTS: Select 0/1/2 according to how many units of insurance your farmer would like to buy. [ASSISTANTS: Write down the price in the column marked "Price" and circle the number of units they want to buy. Then write the total cost under "Insurance Cost"].

Now, we will show you a randomly chosen map that shows the rainfall for this round of the game. [Display the next map with rainfall outcomes.] Now please check whether rainfall is good (Green), medium (Yellow) or bad (Red) on your farm? Please draw a circle in the column marked "Farm Rainfall". [Assistant: Help the participant find their farms on the map and draw a circle in the column marked "Farm rainfall".] Did everyone check? Great. [Display the next map with square outcomes.] Now, please check your overall rainfall outcomes measured for the squares. Please draw a circle your rainfall outcome in the column marked "Square Rainfall". [Assistant: Help the participant find their square on the map and draw a circle in the column marked "Square Rainfall".] We can help you calculate your expected payoff based on your outcomes. If you bought the insurance you need to subtract the price of the insurance from your payout. Then, pay attention to "Farm Rainfall" and "Square Rainfall".

[ASSISTANTS: Calculate their payout by referring to the "Payout Reference Table". Explain step by step with simple words. The conversation starts like that: You earn Ksh * for harvest value, because your farm rainfall is (Green/Yellow/Brown). You receive Ksh * for insurance payout, because the rainfall outcome is Yellow(Brown). (Or, You don't receive insurance payout, because the rainfall outcome is Green). Since the insurance price is Ksh ?, your final payout is ?]

(Same procedures go on for rest of the rounds.)

5. Closing

Now, we are going to draw a number for round which will be binding. We have prepared seven cards from number 1 to 7. [GM: Shows each card separately and announce the number as you hold up the card for everyone to see.]

We will mix up these cards and place them in an envelope. The number card that is drawn will be the binding round at which your payout from the game is decided. [GM: Have one of the farmers draw a card. Hold up and announce the drawn card.]

Ok, the drawn number is [NUMBER]. Your assistants will help you calculate your payout from the binding round. The calculated value will be your game payout of this binding round. [ASSISTANTS: Divide the net income of the binding round by 100 (e.g., If your farmer's payout for round [NUMBER] is KSH 12500, you divide KSH 12500 by 100. The final payout from the game will be KSH 125).]

Now, your assistants calculate your final payout by adding your game payouts to your participation fees. [ASSISTANTS: Calculate your farmer's final payout by adding his/her game payout to his/her show-up fee, and record the final number in the game worksheet.

The payout transaction will take place at the end of the all sessions we have prepared.

Appendix C: Experimental auction protocol

The auction was administered by the Game Master who administered the game. He led farmers and assistants though the various training rounds of the auction. The Assistants worked with the same two farmers as in the game, working through the various exercises in the auction, explaining farmers' outcomes, and recording bids into a worksheet. The following is the text used during enumerator training and auction administration:

This document is to be read by the Game Master (GM) in a way that is accessible to participants, except for sections that directly address Assistants.

1. Introduction

Now you will have the opportunity to buy the [WII sorghum/green gram but mainly, sorghum insurance] product that we introduced in the previous session. This policy has been designed by and will be sold by ACRE. Because this is an educational session to teach you about the benefits of insurance, we will provide varying levels of subsidies, determined by a lottery. Some of you will receive a higher subsidy than others, and some will not receive any subsidy it all depends on the lottery. Please remember that this subsidy will only apply to one seasons worth of insurance. If you buy insurance next season, it will only be offered at the market price.

This auction will be binding, but you will not have to pay today. You will sign an agreement to buy the amount of sorghum insurance you desire today, and a representative from ACRE will visit you in a couple days to collect payment. Therefore, take this auction seriously, but do not worry about paying today.

As in the previous session, you will work with an assistant in this session. At any point if you have questions, you should ask your assistant. We will show you one insurance product offered by ACRE that resembles the insurance product our team previously described to you.

The best strategy for this auction is to state the true amount of insurance you would purchase at each price. The auction does not work well if you state that you will only purchase insurance at very low prices to try to get a deal. The eventual prices of the insurance products are determined by a draw from an envelope, not by your bids. You will purchase insurance at the corresponding price drawn from the envelope if and only if you bid at least that much. You will not pay more or less than the price drawn from the envelope. Therefore, state exactly how much you are actually willingly to buy at each price.

This next point is very important: Nobody else's choices affect whether or not you will purchase insurance or the price you will pay for insurance. Only your own decisions and the prices drawn from the envelopes will affect whether or not you buy insurance, and how much insurance you buy.

This may seem complicated, but we will do a practice auction that should make things clear. Before we move on, your assistants will ask you about output and input values for sorghum (if you grow sorghum) or green gram (if you grow green gram ONLY) you expect this short rain season.

Has everyone finished? Great, lets move on to the first practice auction.

[Conduct Example auction using cookies: Farmers did a round where their bids can lead them to purchase real cookies with real money. We gave them small participation fees that could be used for this practice auction. The assistants asked how many cookies their farmers would like to buy at four different prices from Ksh 1 to Ksh 10. Then, we let one farmer draw a price card from an envelope to decide the revealed price. Farmers bought the number of cookies that they said they had wanted to purchase at the drawn price.]

2. Real Auction for WII

Now you are going to actually bid on WII insurance as you did for cookies before. Your bids are a commitment to pay real money for a real insurance policy. You will decide how many units of insurance you would like to purchase for your sorghum, given different prices. This may not be as easy as bidding on cookies, because you are more familiar with cookies than insurance. However, your assistants will help you to understand how this auction works. If you have any questions during the auction, feel free to ask your assistants. Remember that it is important you bid the true amount of insurance you would like to purchase at each price.

The coverage of 1 unit of insurance is Ksh 5,000. This means if you bought 1 unit of insurance, you can receive at maximum Ksh 5000 when rainfall is bad. If you bought 2 units of insurance, you can receive a maximum of Ksh 10,000 when rainfall is bad, and so on. However, you may not receive the full payout, or even receive no payout, even if you bought insurance. This payout depends on the overall rainfall for your squared area, not on your farm. Also remember that even when there is a drought, you can usually harvest something. Insurance is meant to make up the difference between what you expected to harvest and what you actually harvested. You will bid on the product to purchase and receive up to Ksh 500,000 worth of protection. This is 100 units. In addition, the price of 1 unit of insurance ranges from Ksh 50 to Ksh 1,000.

In the introduction of the auction, your assistants asked you output values for sorghum or green gram you expected to harvest, right? Based on the value, your assistants will help you to calculate how much it will cost to insure for sorghum at the different prices.

ASSISTANTS: Start from "Expected net value of sorghum produced". Suppose the value is Ksh 28,300. This value is between 25,000 (5 units of insurance) and 30,000 (6 units of insurance). Then, by referring the price table, start the conversation like: "[Farmer name], you said your net production value from sorghum is Ksh 28,300, right? Ok, lets start with the first price. The price of 1 unit of insurance is Ksh 50. If the maximum amount of insured is Ksh 25000, which is close to your harvest value, Ksh 28300, you need to buy 5 units of insurance, right? Then, you need to pay Ksh 250 because you buy 5 units with Ksh 50 per unit. Are you comfortable to pay Ksh 250 to be insured at maximum Ksh 25000? [In this moment, ASSISTANT should emphasize that Ksh 25000 is the maximum amount that the farmer can receive when bad rainfall happens.] If Ksh 250 is too expensive for you, you can decrease the units of insurance you buy. [If a farmer says he/she wants to buy 4 units of insurance] Ok, if you buy 4 units then now you will pay Ksh 200 but, your maximum payout when rainfall is bad is Ksh 20000. Are you comfortable to pay Ksh 200 to be insured at maximum Ksh 20000? [Same procedure goes on until the farmer decides.]

Now, the price of 1 unit of insurance is Ksh 100. You bought 4 units when the price was Ksh 50, because your maximum amount of insured was Ksh 20000. If you still want to buy 4 units then now you need to pay Ksh 400 because the price is now Ksh 100 per unit. Are you comfortable to pay Ksh 400 to be insured at maximum Ksh 20000? [In this moment, ASSISTANT should emphasize that Ksh 20000 is the maximum amount that the farmer can receive when bad rainfall happens.] If Ksh 400 is too expensive for you, you can decrease the units of insurance you buy. [If a farmer says he/she wants to buy 3 units of insurance] Ok, if you buy 3 units then now you will pay Ksh 300, but your maximum payout when rainfall is bad is Ksh 15000. Are you comfortable to pay Ksh 300 to be insured at maximum Ksh 15000?" [Same procedure goes on until the farmer decides not to buy any insurance.]

Now that you have made your decisions, we will determine the actual price of WII insurance for sorghum. One farmer will draw a price card for the sorghum insurance product. Remember that these prices are subsidized by the research team from Nairobi. Some groups will receive higher subsidies that others it all depends on what price we draw out of the hat. If you buy insurance next year, it will not be subsidized.

[GM: Have a farmer pull out the card from the envelope for Price of WII insurance for sorghum. Hold up the card and announce the price.]

The drawn price of 1 unit insurance for sorghum is [P]. If you said you would like to purchase at least one unit of the WII insurance for sorghum at this price, you purchase that number of units of the insurance by paying [P] per unit. If you said you did not want to buy any quantity of the WII insurance for sorghum at this price, you will not buy any WII insurance.

Now, for those who end up purchasing insurance products, your assistants will collect your contact information to notify Acre of your purchase decision. The agents of Acre will visit you later to help you complete the contract. We will also leave you with an informational pamphlet about index insurance with the price and quantity you agreed to buy so that you can remember the commitment you made.

We only have one auction left. This is for a product that does not yet exist for farmers in your area, but that Acre is considering developing. We therefore want to know how much you value this product.

3. Hypothetical Auction for AYI

Now you are going to bid hypothetically on a slightly Yield Insurance (AYI). Area Yield Insurance is similar to Weather Index Insurance, but is based on the actual yields of an area instead of rainfall outcomes. While Weather Index Insurance uses overall rainfall for your squared area to determine if you receive a payout, Area Yield Insurance uses the overall yield of farms in your squared area to determine whether you receive a payout.

If your areas overall yield for that season is bad, you receive a payout if you purchased insurance at the beginning of that season. Whether you receive a payout does not depend on the yield of your farm, but on the overall yield of your area. While Weather Index Insurance only protects you against drought, AYI protects you against any event that damages the yields of an area. This could be pests, disease, drought, hail, etc. This insurance product is not yet available because it takes time to design, so you will not make an actual purchase based on the results of this auction, but you should bid realistically because the results of this auction may help develop future AYI products.

[The subsequent process is same as the auction for WII except that the auction for AYI is hypothetical.]

4. Purchase and Closing

We thank you very much for your time and interest throughout the exercise. Please turn in your bid sheets to your assistant. Your assistants will ask some final questions [Second survey] and complete the fully binding contract to purchase what you agreed to in the auction. You are free to go when you complete the second survey and the contract.

[To the 10x10 participants only]: Recall that the insurance product you bid on today was based on square areas 10 km by 10 km. In reality, ACRE does not sell this product; we were using it as part of our experiment. You will actually be sold a product which is identical in every way, but the squares are 5 km by 5 km. This means that the area in which you are grouped to receive insurance payouts is smaller, and that you are more likely to receive a payout when you have a drought. Therefore, you will receive a slightly better product at the same price you agreed to in the auction.