The Impact of Index Insurance and Joint Liability on Borrowing and Risk Taking among Smallholder Farmers: Evidence from a Framed Field Experiment in Tanzania

Richard Gallenstein, The Ohio State University, Gallenstein.6@osu.edu

Jon Einar Flatnes, The Ohio State University, Flatnes.1@osu.edu

John Dougherty, The Ohio State University, Dougherty.148@osu.edu

Mario Miranda, The Ohio State University, Miranda.4@osu.edu

Abdoul Sam, The Ohio State University, Sam.7@osu.edu

Selected Paper prepared for presentation at the 2017 Agricultural & Applied Economics Association Annual Meeting, Chicago, Illinois, July 30-August 1

Abstract

Recent literature has raised skepticism about joint liability as an effective financial tool for increasing economic growth and profitable investment decisions as well as the demand for index insurance as a useful financial tool for smallholder farmers. Using a framed field experiment in rural Tanzania, I investigate how joint liability and index insurance affect demand for agricultural loans and risk taking among smallholder farmers. I find that joint liability and index insurance both increase risk taking yet without a clear complementarity. I also find that index insurance increases demand for agricultural loans while joint liability reduces demand. Lastly I find that insurance that covers both the value of the loan and income has a larger positive effect on risk taking than insurance purely covering the value of the loan.

1. Introduction

Developing economies, particularly those in sub Saharan Africa, tend to be highly dependent upon their agricultural sector which often provides a high proportion of GDP and an even higher proportion of employment and income. Considering this, economic transformation in the agricultural sector is believed be one of the keys to economic development in the developing world (Transformation 2014). A vital component to economic development in the agricultural sector is the adoption of new technology which has been shown to improve livelihoods and reduce poverty among small farmers (Bourdillon et al. 2003; Mendola 2007; Kijima, Otsuka and Sserunkuuma 2008). One important barrier to the adoption of new technologies is access to credit which can ease budget constraints and allow farmers to smooth out lumpy input purchases (Croppenstedt, Demeke and Meschi 2003). In recent decades the advent of innovative financial technologies has provided promising solutions to the unique challenges faced in agricultural smallholder lending. These are joint liability and index insurance.

Joint liability contracts leverage social collateral in lieu of physical and financial collateral, rely on group selection and monitoring to overcome informational asymmetries, and reduce transaction costs by dealing with farmer based borrowing groups (FBBGs) rather than widely distributed individual farmers (Stiglitz 1990; Besley and Coate 1995; Ghatak and Guinnane 1999). These characteristics of joint liability have been widely credited for the rapid expansion of microcredit in the developing world over the past couple decades. However, a growing body of literature has begun to call into question the effectiveness of joint liability for expanding access to credit as well as promoting profitable yet risky investments. Recent evidence from the Philippines suggests that joint liability has no discernable effect on default rates while decreasing demand for loans relative to individual liability (Gine & Karlan, 2014). Gine et al. 2010, using a series of framed field experiments find that joint liability lending, by acting as a form of insurance within the group, resulted in increased risk taking. These results however conflict with other results that show that peer monitoring can over compensate and reduce risk taking and profitability (Fischer, 2013). A further concern about joint liability arises particularly in the context of agricultural lending where frequent systemic shocks such as droughts overwhelm the intra-group insurance of the contract structure. In fact, joint liability contracts may even exacerbate the negative consequences of systemic shocks as it pulls all individual group members into default even if some could have repaid under an individual liability scheme (Besley and Coate 1995). These challenges facing joint liability raises questions about how joint liability effects risk taking in agricultural lending as well as the relative advantages of joint liability over individual liability particularly in an agricultural lending context fraught with systemic shocks.

The second financial technology, index insurance, offers a promising tool for managing systemic shocks and may be highly effective when used in combination with joint liability loan contracts perhaps even offering positive interaction effects on risk taking. Index insurance, more specifically index based rainfall insurance (IBRI), has been widely considered a promising tool for managing systemic risks (Barnett & Mahul, 2007; Miranda, & Vedenov, 2015). IBRI policies make insurance payouts based on the observation of an objective rainfall index such as rainfall and bypasses considerable challenges that faces agricultural indemnity based insurance (Miranda & Farrin, 2012). Joint liability lending and IBRI, properly combined and purposefully integrated into agricultural lending policies may provide the risk management necessary to allow agricultural development banks and MFI’s to lend small holder farmers and incentivize these farmers to adopt profitable yet risky production technologies.

To date, the intersection of joint liability lending and index insurance and their potential for successful integration is largely unexplored. Index insurance has primarily been investigated as an insurance product for individual farmers or in relation to its effect on technology adoption directly. By and large demand for index insurance has been low among individual farmers without heavy subsidization (Giné and Yang 2009; Gine, Townsend and Vickery 2008; Banerjee, Duflo and Hornbeck 2014) with one recent notable exception in northern Ghana (Karlan, Osei and Udry 2013). The positive impact of index insurance on technology adoption has been well documented (Mobarak and Rosenzweig n.d.; Karlan et al. 2013) yet the largely persistent low demand has been a source on confusion among development economists (Binswanger-Mkhize 2012). However, offering index insurance to meso-level institutions such as banks as a component of their portfolio risk management has not been sufficiently explored to date despite considerable expected benefits for the lenders (Miranda and Gonzalez-Vega 2010; Miranda and Farrin 2012b).

In this research I seek to investigate the interaction of joint liability lending contracts and index insurance. Specifically, I will investigate the impact of joint liability and index insurance on two factors in credit markets: the decision to borrow and the level of risk taking in agricultural activities. I make four contributions to the microfinance literature by investigating, (1) how joint liability effects demand for loans and risk taking in an agricultural lending context, (2) how index insurance affects borrowing and risk taking, (3) how index insurance interacts with joint liability and exploit potential product synergies, and (4) how index insurance that covers the value of a loan or a loan and income effect these decisions. To address these issues, I employ a methodology that is growing in usage and popularity in development economics, the framed field experiment (Giné et al. 2010; Flatnes 2014; Fischer 2014). I conducted this framed field experiment on smallholder farmers in Dodoma, Tanzania in the spring of 2016.

2. Framed Field Experiment Design

To evaluate the impact of index insurance, joint liability, and their interaction on risk taking in agricultural lending, we conducted a framed field experiment with small farmers in rural Tanzania. Framed field experiments are laboratory experiments conducted among a population relevant to the topic under investigation and framed in terms of the topic of interest. The experimental component provides a high degree of control over the data generating process and improves our ability to ensure internally valid results for a range of treatments (discussed below). By conducting the experiment "in the field" we improve the external validity of the results in so far as the experiment is conducted with people with experience and relevance to agricultural lending. We further bolster the external validity by framing the experiment in terms of agricultural lending, helping the participants to understand the game in those terms and allowing us to elicit behavior that more closely matches behavior with real agricultural loans. Our experiment focuses on eliciting the impact of index insurance, joint liability, and their interaction on risk taking and borrowing decisions. We therefore designed the experiment to include these two decisions and excluded other potentially relevant decisions such as strategic default, effort, credit diversion, or other considerations. By focusing on the decisions of interest, we ensure that we capture behavior related to these outcomes while maintaining an experiment that is easily understood by the participants and produces tractable data to identify the relevant treatment effects.

We conducted our experiment with a sample of 407 small holder farmers in rural Tanzania. This was distributed throughout 40 experimental sessions, each including 8 – 16 participants and took roughly 4 hours to complete. At each session we would begin with providing a basic description of the activities and elicited each participants oral consent to participate while providing each with a written participation form detailing key features of what consent implied. Following their consent, we took pictures of each person for use in the social network survey and then proceeded with a detailed description of the experiments. We then proceeded to play five treatments which lasted roughly 3 hours. After completing the experiment, we conducted individual survey with each participant which included a social network survey to be described below. At the end of each session we provided each participant with an incentive payment and thanked them for their time. Peanuts, cookies and a soda were given to each participant during the duration of the experiment as an additional thank you for participating and to improve moral.

In the remainder of this section we will introduce the basic experimental set up and then describe each of the seven treatments in detail.

2.1 Basic Experimental Set Up

Participants were told that they have access to 1 acre of quality land and had to choose how to invest in their land. They were told that they had been pre-approved for an agricultural loan from a local microfinance bank. If they chose to borrow, they would receive a 50,000 TZS loan, enough to buy all necessary inputs for one acre of sunflower cultivation. If they chose to not borrowing they would use traditional sorghum seeds, known for low yields but low yield variability. We simplified the non-borrowing scenario to be riskless so that those choosing not to borrow would receive 100,000 TSH[1] with certainty. For those choosing to borrow, they would then face a decision regarding how to invest their loan where the decision affected the expected payout and risk of their resulting income. We simplified this decision into two options: (1) A risky project choice, i.e. choosing to cultivate with a high yielding variety seed and (2) a safe project choice, i.e. choosing to cultivate with a drought resistant crop. These project differed by yields that they experience under various idiosyncratic and systemic productions shock outcomes where the risky project had the highest expected return but also the highest variance with the highest chance of default. The shocks were determined by draws of colored balls from two bags. One bag represented idiosyncratic shocks and each individual drew their own ball from this bag with replacement. The idiosyncratic shock was framed as a crop disease that only affects some farmers but not others. The bag had 10 colored balls where 7 green ball represented good individual outcomes, 1 yellow ball represented poor individual outcomes, and 2 red ball indicated a very poor individual outcome. The systemic shock was framed as a drought and was simulated by one of the group members drawing a ball from a different bag on behalf of their group. This second bag contained 7 blue balls and 3 black balls where a blue ball indicated good rains and a black ball indicated drought and the outcome of this draw applied to each member of the group. The risky project received a large yield, 600,000 TZS[2], only when the farmer experienced good rainfall and a good idiosyncratic yield (good/good outcome) and 0 TZS otherwise. The safe project received 300,000 TZS under the good/good outcome but also received 250,000 TZS with good rains and a poor idiosyncratic shock or under a drought and good idiosyncratic shock while experiencing 0 TZS elsewhere. We assume no strategic default so if the participant can repay they do and the loan

[1] All values given here are meant to reflect real values that farmers may face in agricultural production and are reported in Tanzanian Shillings (TSH). However during the game they will receive fake game money, not real money. Cash payouts of real money will be given at the end of each session.

[2] All parameter values were based off focus group discussion about the yields and prices of sunflower produced in the area. Farmers and loan officers reported that a “very good yield” for one acre was 7-8 bags which would sell for roughly 60,000 TZS each. We assumed that a high yielding variety would beat these yields and so assumed the yield to be 10 bags selling at the same price. The other values were calibrated in a similar way.

repayment amount is deducted from their yield incomes to generate their total income. When choosing safe, the participant repays 77% of the time compared to 49% when choosing risky. We repeated this process for five rounds which represented five consecutive growing seasons. To simulate dynamic incentives, a common feature of microfinance lending, an individual or group (depending on the treatment) would be barred from borrowing in the subsequent rounds following a default. Figure 1 provides an English language version of the payout table used as a reference to explain the basic experiment set up to the participants during the explanation. The table illustrates the yield and income outcomes as well as the probabilities of each outcome, the loan repayment amounts, and the instances of default.

After the completion of the introduction, each participant was invited to join one of three enumerators to play 2 practice rounds of the experiment to familiarize themselves with the basic set up. Later, teach participant would have one practice round for each of the treatments as well. After the practice round, the participants would indicate their borrowing decision. The borrowers would be formed randomly into groups of two or three. There were three privacy boxes set up in each experimental session. One by one, these groups of two or three would come up to the boxes with each group member going to one box accompanied by an enumerator. Here, the participant would make their risk taking decision and draw their idiosyncratic outcome for each of five successive seasons. Their choices, shock outcomes, and total incomes were then recorded by the enumerator on the participant's game sheet.

After the completion of all the treatments, farmers were compensated for their participation via cash payments based on the total incomes from a randomly selected round from a randomly selected treatment. These cash payouts also acted as an incentive mechanism to ensure more realistic behavior in the experiments.

2.2 Experimental Treatments

The impact of insurance and joint liability on borrowing and risk taking are investigated by observing these decisions under a variety of treatments that vary the loan contract structure. By comparing the borrowing and risk taking decisions under these various treatments, we find the impact of the unique contract features on these outcomes. The experiment includes a total of seven treatments while only five were played in any given session.

Treatment 1 was played first followed by four treatments, played in order. Although playing the games in order raises the possibility of introducing an ordering bias, pretesting demonstrated strong improvements in comprehension when the games following a logical progression therefore a fixed order was chosen over a random order. Treatments 2 and 5, which correspond to individual and joint liability respectively, were played in each session. Sessions were then randomly assigned to use either treatments 3 and 6 or 4 and 7. Treatments 3 and 6 refer to individual and joint liability loans with index insurance covering the value of the loan. Treatments 4 and 7 refer to individual and joint liability loans with index insurance covering the value of the loan plus some income. All treatments that include insurance assume the insurance to be coupled with the loan where the farmer pays the insurance premium through repaying a larger amount to the bank. The increased loan repayment amounts roughly correspond to the original loan principle plus interest plus the actuarially fair premium plus a load. Each treatment is described in detail below and Table 1 presents an overview of the treatments.

Treatment 1: Framed Risk Preference Game

Treatment 1 is designed to be a framed risk preference game and is used in the analysis to determine the CRRA risk aversion coefficients for the sample, rather than included in the analysis as a treatment. We refer to this as a framed risk preference game because the game is played without dynamic incentives, joint liability, or insurance, which leaves the borrowing and risk taking decisions to effectively be decisions of static risk exposure. The game was played for three seasons where participants were not barred from borrowing in subsequent seasons even if they default. Table 2 shows the net payouts, expected payouts and the CRRA range implied by a decision to not borrow, choose safe, or choose risky in the risk preference game. The CRRA ranges are used later to determine the individual CRRA coefficient values for each participant in the sample.

Treatment 2: Individual Liability

Treatment 2 follows the basic experimental set up exactly and serves as the baseline or control case for the analysis. The treatment is played for five seasons and defaulters are barred from future borrowing. The payout structure is displayed in Figure 1.

Treatment 3: Individual Liability with Loan Coverage Index Insurance

Treatment 3 adds an insurance component to the agricultural loan. The insurance policy covers the value of the outstanding loan in the case of drought therefore eliminating default in the case of a systemic shock. The premium for the insurance is priced into the loan amount resulting in a higher repayment amount of 90,000 TZS. The payout structure is displayed in Figure 2. The insurance includes basis risk in that it pays out based on the systemic shock and not based on losses. Therefore, there are instances of losses for which there is no payout (downside basis risk) and one instance of a payout when there are no losses (upside basis risk). The upside basis risk event occurs for the safe project under a systemic shock and a good idiosyncratic outcome. In this case the participant keeps the entire yield income and does not have to repay the loan. The insurance reduces the expected income for both the safe and risky project choices however the reduction is more stark for the risky project choice due to the absence of the upside basis risk event present for the safe project. We do not include basis risk through imperfect rainfall measurement i.e. the insurance if and only if there is a drought.

Treatment 4: Individual Liability with Loan and Income Coverage Index Insurance

Treatment 4 was identical to Treatment 3 with the addition of an insurance policy that covers the value of the loan as well as pays some small level of income to the participant in excess of the loan. We are calling this higher coverage level: loan and income coverage. Alternatively, it could be considered over-insurance is it insured more than the value of the loan. The payout structure is displayed in Figure 3. The same basic features arise in this treatment as with treatment 3 including the presence of upside and downside basis risk, a higher repayment amount, and lower expected income. This treatment will allow us to analyze the impact of insurance across coverage level as well as determine if there is a differential impact of insurance coverage that exceed the loan amount for an insured agricultural loan.

Treatment 5: Joint Liability

The joint liability treatment followed the same procedure as treatment 2 with the addition of shared responsibility for repaying the group loan. To simulate joint liability, the loan repayment status of each individual was determined by the performance of the group. If a circumstance arises where one group member would default and the other is able to repay their loan, they must do so. These calculations were done by the enumerators and simply reported to the participants.

Treatment 6: Joint Liability with Loan Coverage Index Insurance

Treatment 6 was identical to Treatment 5 with the addition of index insurance with loan coverage as described in Treatment 3.

Treatment 7: Joint Liability with Loan and Income Coverage Index Insurance

Treatment 7 was identical to Treatment 6 with the addition of index insurance with loan coverage as described in Treatment 4.

3. Data

3.1 Sample Frame

The objective of a framed field experiment is to simulate a realistic scenario for participants that have real experiences with the circumstances being simulated. Therefore, the sample frame was chosen with reference to the central features of the research questions and game designs. We therefore developed a working relationship with Vision Fund Tanzania, a microfinance bank with close ties to the international aid NGO World Vision, who gave us access to the farmer group microfinance clients. We further sought to work in an area with high risk of drought so that our participants would have experiences with drought and therefore be able to the relate to the framing of the experiment. For this reason, we chose to work in the drought prone Dodoma region in central Tanzania where Vision Fund had a number of farmer group microfinance clients. Working with Vision Fund Tanzania Dodoma office we identified a sample of 60 farmer groups composed of roughly 600 farmers to comprise the sample population. This sample included the vast majority of their total clients in the region. We choose to hold experimental sessions with one borrowing group at a time to ensure that we capture any social capital the exists within real borrowing groups as this social capital is likely to impact behavior in the joint liability treatments. We conducted 16 sessions to pre-test the experiment, utilizing around 200 farmers. This resulted in our final experimental sample of 407 farmers from 41 farmer groups.

3.2 Descriptive Statistics

In addition to the experiments, we also conduct an individual survey with each participant. The survey includes questions on basic individual and household characteristics, loan history, and a social network survey. Descriptive statistics are presented in Table 3. The individual and household characteristics include age, gender, education level (measured in years of schooling), literacy, household size, village leadership role, source of income other than agriculture, and total number of acres owned. These were collected to serve as control variables in the regression analysis and allow us to describe the sample population. We find that our sample has a mean age of roughly 40 years old and have 6.4 years of schooling. The majority are household heads while just below half were women (47%). They have relatively large land holding for smallholder farmers with an average of 13.4 acres of land owned. The majority have income sources other than farming although they have little experience with agricultural lending (1.8 years of prior experience). The loans that these groups receive from Vision Fund Tanzania are joint liability loans and anecdotally, many farmers reported disliking joint liability lending. This is reflected in 59% of the sample expressing a preference for individual liability loans.

We used the frame risk preference game (Treatment 1) to elicit participants' constant relative risk aversion coefficient based on the cutoff ranges found in Table 2 and found a population mean CRRA coefficient of 0.57 or moderately risk averse[3].

To measure the level of social capital within the group we conducted a social network survey. We took pictures of each participant after securing their consent to participate. We then uploaded these pictures into our computer based survey. Then during the survey, we asked six questions in which the responded would indicate the other members of the group (through pointing to their picture on the screen) for whom the question applied. The six questions included two questions intended to measure the level of social ties (family and friendships), two questions to measure trust, and two questions to measure the shame or guilt that may result when failing to repay the loan in joint liability. The questions can be found in the appendix. These questions were used to create two social capital indexes, one measuring social capital between the members in the entire session and one measuring social capital between members of a randomly assigned group within the experiment. To create the social capital indexes, we took the average across questions of the proportion of individuals indicated within each question. The indexes are intended to measure the social capital that is pledged as collateral in the joint liability contract that is, it measures the potential disutility of failing to repay one's own in joint liability. We included social ties, trust, and shame questions in the indexes so that we could capture the full extent of the disutility of failure to repay

[3] To specifically define each person's CRRA coefficient using their responses to the risk prefence game we did the following. First, we found the proportion of the population choosing not borrowing, safe, and risky respectively. Then we assumed a Weibull distribution of CRRA coefficients and calibrated the parameters of the Weibull distribution such that it matched the probability density corresponding to each range. Then we calculated the mean CRRA value from the distribution within the ranges specified by Table 2. We found that those choosing to not borrow had an expected CRRA value of 0.8, those choosing safe 0.59, and those choosing risk 0.49. We assigned these values to each decision of not borrow, safe or risky in the three seasons of the risk preference game and took the average across the three seasons to calculate the individual level CRRA coefficient.

in joint liability. The average social capital index at the session level is 0.18 and the average at the group level is 0.16.

4. Results

4.1 Characterizing Risk and Borrowing Decisions

To gain a general understanding of the results from the framed field experiment, we first look at the average borrowing and risk taking decisions from each treatment presented graphically in Figure 4. A few noticeable trends appear in the data. First, there is a clear positive impact of insurance on borrowing for both individual and joint liability. The effect is also larger for the insurance offering income coverage ("Over Ins" in the Figure). It is also clear that the income coverage increases the borrowing rate for individual liability to a greater extent than for joint liability. There is not a noticeable differential impact of insurance on individual or joint liability. Joint liability appears to reduce borrowing compared to individual liability. Second, in the risk taking decision, largely the same trend emerges. Risky project choice increases with insurance and to a greater extent with income coverage. There is a noticeable increase in the level of risk taking for joint liability as compared to individual liability. Finally, there is not an easily distinguishable differential impact of index insurance on individual or joint liability.

We follow up on this graphical look by conducting mean t-test comparisons to elicit the statistical impacts of insurance and joint liability at the means in our data. These results are presented in Table 4. Here, Treatment 2 serves as the control for Treatments 3, 4, and 5 while Treatment 5 serves as the control for Treatments 6 and 7. Panel A reports the results for borrowing and Panel B for risk taking decisions. The trends presented graphically in Figure 4 are largely confirmed here. Insurance and over insurance both increase borrowing and are significant for individual and joint liability. The increase of over insurance appears to be much larger for individual liability than for joint liability. Joint liability decreases borrowing as well. For risk taking, again both insurance and over insurance increase risk taking under both individual and joint liability. The impact of insurance appears to be greater for joint liability than for individual liability. Joint liability also increases risk taking although to a much lower extent than insurance. From this initial look at the data, there appears to be robust impacts of index insurance and joint liability as separate financial technologies and a potential positive interaction effect on risk taking.

Going deeper into these results we generated transition tables which show the percentages of decision changes for individual and joint liability between without insurance and with insurance treatments. The transition tables can be found in Table 5 and Table 6. Table 5 displays the transition for individual liability. On the y axis are the decisions possible for individual liability and on the x axis are the decisions possible for individual liability with insurance. The rows can be interpreted as follows, taking the first row, "Not Borrow" as an example: The first cell is interpreted as the percentage of individuals who did not borrow without insurance who then went on to also not borrow with insurance. The second cell in that row is likewise the percentage of those that did not borrow without insurance yet proceeded to borrow and choose safe. The rest of the cells follow the same pattern.

A number of interesting results appear from this analysis. First, we see that insurance induces a larger percentage increase in borrowing than it does a decrease. The percentage of not borrowers that transitioned to borrowing with insurance is almost 70% (72 individuals) while the percentage of safe borrowers and risky borrowers that transitioned to not borrowing with insurance is 10% (25 individuals) and 10% (5 individuals) respectively. For safe borrowers without insurance, the majority remained with safe under insurance (50% or 120 individuals) yet the majority of those that switched moved to risky (41% or 99 individuals). A majority of risky borrowers also remained risky borrowers under insurance yet 10% moved to not borrowing with insurance and 24% moved to safe. Table 6 displays the same results for joint liability which can be interpreted similarly.

Comparing the transition tables for individual and joint liability provides with a number of interesting observations. First, a larger percentage of non borrowers under joint liability remain non borrowers with insurance as compared to individual liability. This indicates that there is some unique characteristic about joint liability that deters some from entering the market. This may be the risk of losing social capital pledged as collateral on the loan. Or this could be the effect of the cost of the implicit insurance that joint liability contracts provide. Second, for individual liability there is a greater transition from not borrowing to safe borrowing than risky borrowing. However, for joint liability there is a greater transition from not borrowing to risky borrowing with the addition of insurance. This may be due to risk rationing related to social collateral. Notice that a larger number of people do not borrow in joint liability compared to individual and that that greater number comes from a large reduction in the number of safe borrowers. Perhaps what we see hear is that otherwise safe borrowers are risk rationed out of the market due to the fear of losing social collateral, yet when insurance is introduced, these actual safe borrowers enter the market and go straight to risky borrowing. A third observation is the difference between the behavior of safe borrowers without insurance. For both individual and joint liability, roughly 50% remain safe with the addition of insurance. However, under joint liability a greater percentage transitions to not borrowing and fewer transition to risky borrowing as compared to individual liability. This may be due to the confounding influences of the insurance interacting with joint liability. For example, the insurance may be perceived as increasing the cost of the joint liability by increasing the cost of loan repayment in the case of repaying another's loan. These differences are small though and may not be significant. The most striking observation comes by comparing the transitions for risky borrowers without insurance. For joint liability 85% of risky borrowers stay as risky borrowers which is compared to a much smaller 65% for individual liability where 24% move to safe. Therefore we see that those taking risky in joint liability are more resolute regarding their risk taking as compared to individual liability[4].

4.2 Empirical Strategy

The borrowing decision will be investigated using a linear probability model of the binary borrowing decision variable on treatments and control. This utilizes data only from the first round of each game and therefore uses a smaller sample size than the risk taking decision considered later. We use only the first round due to the experimental design in which participants were asked whether they wished to borrow just once before each treatment and their decision to borrow was then maintained throughout the treatment (unless they defaulted). Therefore, considering their borrowing decision for the first round only is appropriate.

The LPM model for the borrowing decision is modeled as follows:

$$B_{i,t} = \theta + \theta_1 II_t + \theta_2 II_t * OI_t + \theta_3 JL_t + \theta_4 JL_t * II_t + \theta_5 JL_t * II_t * OI_t + \theta_6 SSC_{i,t} + \theta_7 RA_i + \theta_8 X_i + \epsilon_{i,t}$$

Where *i* indicates individual, t indicates Treatment, JL_t is a dummy variable indicating the presence of joint liability, II_t is a dummy variable indicating the presence of index insurance, $II * OI_t$ is a dummy variable indicating the presence of index insurance with income coverage, $JL_t * II_t$ is an interaction term between joint liability and index insurance, $JL_t * II_t * OI_t$ is an interaction term between joint liability, index insurance and index insurance with income coverage, X_i are individual characteristics, SSC_i is an index of social capital between each individual and the other members in the session, GRP is a group fixed

[4] One potential source for this phenomenon is a result of the fixed order. Some individuals choose risky project choice until they defaulted after which they switched to safe for all remaining games. The placement of the T2 as the second experiment in order, causes this phenomenon to be captured completely by this treatment.

effect, and RA_i is the risk aversion coefficient calculated from Treatment 1. We will consider models both with and without the income coverage variables included.

As a robustness check for our LPM regression results we also conduct an individual fixed effects model which will control for all variation in the data other than the treatment effects and allow us to most cleanly identify the treatment effects.

To analyze the risk taking decision we first use a linear probability model and then a Heckman sample selection model. The LPM model regresses a binary variable indicating the choice of the risky project on the treatments and other control variables as specified below.

$$RISK_{i,t,r} = \alpha + \beta_1 II_t + \beta_2 II_t * OI_t + \beta_3 JL_t + \beta_4 JL_t * II_t + \beta_5 JL_t * II_t * OI_t + \beta_6 GSC_{i,t} + \beta_7 RA_i + \beta_8 X_i + GRP + R_t + \epsilon_{i,t,r}$$

Where *r* indicates round, $RISK_{i,t,r}$ is the risk level ($RISK \in \{0,1\}$, with 1 indicating risky project choice), and $GSC_{i,t}$ is an index of social capital between each individual and the other members in their borrowing group. The probit model is restricted to the sample participants that chose to borrow which results in a truncated data problem. The truncated data may introduce bias in the LPM model specification results from a non random selection process into borrowing. To control for this potential selection bias we also conduct a Heckman (1979) sample selection model.

The Heckman model is a two stage approach that controls for the selection bias by using a first stage regression to model the selection process. The second stage controls for the bias in the error terms induced by the selection by including the inverse mills ration from the first stage regression. In our case, the selection equation is the decision to borrow as follows:

$$B^*_{itr} = \theta + \theta_1 II_t + \theta_2 II_t * OI_t + \theta_3 JL_t + \theta_4 JL_t * II_t + \theta_5 JL_t * II_t * OI_t + \theta_6 EX + \theta_7 SSC_{it} + \theta_8 RA_i + \theta_9 X_i + GRP + R + \epsilon_{itr}$$

$$= \theta' \boldsymbol{Z_{itr}} + \epsilon_{itr}$$

B^*_{itr} is the continuous latent variable of borrowing which is not observed and EX is an exclusion restriction which will be discussed in more detail below. However we do have $B_{itr} = 1$ if $B^*_{itr} \geq 0$ and 0 otherwise. If we assume that ϵ_{itr} is distributed following a standard normal distribution we can specify the probability of borrowing given the covariates $\boldsymbol{Z_{itr}}$ as:

$$Prob(B_{itr} = 1|\boldsymbol{Z_{itr}}) = Prob(\epsilon_{itr} \leq \theta' \boldsymbol{Z_{itr}}|\boldsymbol{Z_{itr}}) = \Phi(\theta' \boldsymbol{Z_{itr}})$$

Where $\Phi(\theta'\boldsymbol{Z_{itr}})$ is the probability of falling below $\theta'\boldsymbol{Z_{itr}}$ on the standard normal distribution. Establishing this probability will be able to allow us to specify how to control for the selection in the second stage.

The second stage model of risk taking is in fact a model of the expected value of the risk taking decision conditional on having chosen to borrow. Therefore the error term in second stage equation is conditional on $B_{itr} = 1$ which is the source of the bias in the second stage when not controlled for. The second stage equation is stated as follows:

$$E[RISK_{i,t,r}|B_{itr} = 1]$$
$$= \alpha + \beta_1 II_t + \beta_2 II_t * OI_t + \beta_3 JL_t + \beta_4 JL_t * II_t + \beta_5 JL_t * II_t * OI_t + \beta_6 GSC_{i,t} + \beta_7 RA_i + \beta_8 X_i + GRP + R_t + E[u_{i,t,r}|B_{itr} = 1]$$

$$= \beta^{'}\boldsymbol{V_{itr}} + E[u_{i,t,r}|B_{itr} = 1]$$

Here we can control for the effect of the selection on the error term through the inclusion of the inverse mills ratio in the regression model as follows:

$$E\left[RISK_{i,t,r}\middle|B_{itr} = 1\right] = \beta'\boldsymbol{V_{itr}} + \rho\sigma\frac{\phi(\theta'\boldsymbol{Z_{itr}})}{\Phi(\theta'\boldsymbol{Z_{itr}})} = \beta'\boldsymbol{V_{itr}} + \alpha\lambda_{itr}$$

Where λ_{itr} is the inverse mills ratio and we assume the error terms are jointly normally distributed with means 0 and variance $\begin{pmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{pmatrix}$. For the first stage to successfully control the bias in the second stage it must include an exclusion restriction that impacts the selection decision but does not impact the second stage outcome, and therefore not itself being correlated with the error term. As the exclusion restriction, we use a carefully designed survey question called the "borrowing game" which we developed during the process of pre-testing the experiment in the field. We sought a variable that would affect the participant's decision to borrow yet have no direct impact on the risk taking decision. We noticed during pretesting and informal conversations that many participants borrowed because they were borrowers in real life and this "seemed" like the right thing to do. Although all the farmers were real borrowers, some seemed to take this reality into the framed game environment more seriously than others. We considered this as a latent propensity to borrow based upon a direct correlation to real life experiences of borrowing. This phenomenon however should have no direct correlation with the risk taking level as the risk taking levels were both framed in terms of seed types not readily available or widely used among the population. Therefore, this propensity to borrow appeared to be the most striking example of a valid exclusion restriction. To capture this phenomenon, we designed a survey question meant to elicit the propensity to borrow. The question provided a very simple framed agricultural loan borrowing question in which the participant is presented with a scenario in which they may choose to borrow or not. In this question design, unlike the experiment, the decision to borrow involved no risk and both choices resulted in the exact same payout at the end with certainty leaving no real difference between borrowing and not borrowing (the full question can be found in the appendix). The propensity to borrow should therefore be the main driving factor behind a decision to borrow in this borrowing game.

As with the borrowing decision we also perform a robustness check by using an individual fixed effects model which will control for all variation in the data other than the treatment effects. This will be the most robust results if there is no evidence of sample selection from the Heckman sample selection model.

4.3 Empirical Results: Borrowing Decision

Table 6 presents the results for the borrowing decision. The table includes LPM models with and without differentiated effects of income coverage and includes individual fixed effects models as a robustness check of the LPM model results. Model 1 shows LPM model results considering the impact of insurance without differentiating between the two coverage levels. We find an 11% increase in borrowing in the presence of index insurance which is highly significant. These results are confirmed in the comparable individual fixed effects model in Model 3. Joint liability has a significant and negative impact on borrowing of roughly 7% which is again confirmed in the individual fixed effects model. The interaction of joint liability and index insurance is negative although statistically in insignificant. We also find that risk aversion significantly reduces borrowing while social capital with the members of the session significantly increases borrowing, which runs counter to the understanding of social capital serving as a form of collateral in joint liability lending. Moving to Model 2, we again find a positive and significant impact of insurance on borrowing of roughly 9%. There is an additional positive impact of the income coverage or almost 6% however this additional impact is insignificant (p-value=0.17). The negative impact of joint liability is identical to Model 1. There is a positive interaction effect between joint liability and insurance in general although the magnitude is very small in insignificant. The interaction between joint liability and income coverage is negative and marginally insignificant (p-value=0.17).

Taken together these results suggest a positive impact of index insurance on borrowing and this impact appears to be driven by a disutility associated with losing access to the loan through the dynamic incentive. Within each round, the insurance, particularly the loan coverage, simply reduces the expected value of the loan by introducing a premium paid in the good states. Therefore, from a static perspective, index insurance should reduce utility from the loan and reduce borrowing. However, the increase suggests that farmers value future access and are in a sense, default averse which is driving the positive impact of insurance on borrowing. This interpretation is bolstered by the insignificant impact of the income coverage level of insurance. When the insurance coverage level exceeds the value of the loan, the insurance acts to smooth static consumption levels across good and bad states which should increase utility for the most risk averse agents and increase borrowing. However, we find no statistically significant positive impacts of this additional coverage which supports our claim that avoiding default is the primary driver of the positive impact of insurance on borrowing. We also find a robust negative impact of joint liability on borrowing which is consistent with other recent research. Although joint liability also reduces default which should increase borrowing, other mechanisms appear to be operating in joint liability that offset the default reduction benefits of joint liability. Other mechanisms may include the threat of lost social collateral as a result of being unable to repay, resentment or disutility associated with needing to help others repay, or a general dislike of joint liability stemming from personal experiences with joint liability through Vision Fund Tanzania.

4.4 Empirical Results: Risk Taking Decision

Our first step in the analysis of the risk taking decision is to provide supporting evidence to the validity of the exclusion restriction for the Heckman sample selection model. In Table 7 we present results to suggest that the borrowing game is a valid exclusion restriction. First, to establish relevancy of the viable, i.e. the correlation between the exclusion restriction and the selection decision, we ran two probit models of the borrowing decision on the borrowing game. Model 1 has no covariates while Model 2 includes group fixed effects and other covariates. In both models that is a statistically significant positive relationship between the borrowing game and the borrowing decision which appears to be robust to the inclusion of an array of covariates. The strong correlations confirm relevancy. To provide evidence to the exogeneity of the exclusion restriction we also regress risk taking on the borrowing game along with a number of covariates. Although a significant correlation does not necessarily demonstrate that the exclusion restriction is invalid in that it may impact risk taking through the borrowing decision, no significant correlation would provide evidence of exogeneity. We find a statistically insignificant correlation between the borrowing game and risk taking, further supporting its validity.

Table 8 presents LPM model, Heckman model, and individual fixed effects model results for the impact of insurance and joint liability on risk taking. Across all three model specifications we find a large, positive, and significant impact of insurance on risk taking of roughly 30% when we pool insurance coverage levels and roughly 27% when we separate out the impact of the income coverage. There is an additional impact of the income coverage between 5 and 8% although this is only significant in the Heckman selection model. Across each treatment we fail to find a significant impact of joint liability on risk taking with only a small marginal increase of roughly 3%. The interaction between insurance and joint liability tends to be positive across model specification while the interaction of income coverage and joint liability is negative. Yet both are statistically insignificant. We do find risk aversion and being female to have a significant and negative impact on risk taking across models.

The Heckman sample selection model was used to control for a selection bias into the pool of borrowers. Beleiving the response to the borrowing game survey question be to a valid exclusion restriction, the results from the first stage of the Heckman model can be used to evaluate the actual presence of selection in the sample. We report the “athrho” parameter from the Heckman regression as a measure of the selection bias. The athrho is a numeric estimation of the true rho which is the coefficient on the inverse mills ration. A significant athrho indicates a significant impact of the inverse mills ratio thereby indicating the presence of selection into the sample of borrowers. The athrho coefficient is not significant in either model which indicates no evidence of selection in our model. Based on this observation, the Heckman model is not strictly necessary which leaves the individual fixed effects models reported in Model 5 and 6 as the most robust results.

Taken together, these results suggest a strong positive impact of insurance on risk taking with limited evidence of an additional impact of income coverage. We fail to find evidence for an impact of joint liability or a statistically significant interaction effect despite there being some mild evidence suggesting such a positive interaction effect in the mean t-test comparisons in Table 4. We now turn to investigating heterogenous treatment effects.

4.5 Empirical Results: Heterogeneous Treatment Effects

In Table 9 we report results for heterogeneous treatment effects. We focus on heterogeneity across risk aversion as risk aversion is a key driver of demand for insurance. Because we found no evidence of selection into borrowing, we chose to use the individual fixed effects model to investigate the heterogeneous treatment effects for risk taking and borrowing. We also focus on the pooled impact of insurance and refrain from looking at the separate impact of income coverage on behavior.

In Panel A of Table 9 we consider heterogeneous treatment effects for risk taking. In Model 1 we present the fixed effects model of risk taking on insurance, joint liability, and the interaction term for individuals with risk aversion levels below the mean of 0.57, i.e. the portion of the sample with the lowest levels of risk aversion. In Model 2 we run the same model with those above the mean. We find that interesting heterogamous effects emerge. First, both models have robust impacts of insurance on risk taking yet the impact is 13 percentage points higher for the high risk averse sample. Second, the impact of joint liability appears to vary considerably across levels of risk aversion. Joint liability reduces risk taking by 11% for individuals with low risk aversion while it increases by 11% for those with high levels of risk aversion. This variation across risk aversion levels may help explain the small and insignificant impact of joint liability on the total sample. Lastly, we find a large positive and significant interaction effect between index insurance and joint liability for individuals with low levels of risk aversion but a small, negative, and insignificant interaction effect on high risk averse individuals. The heterogeneous impact of insurance across risk aversion level is supportive of our intuition developed in our discussion of the borrowing decision that participants have an aversion to default. Considering this, participants are averse to the risk of defaulting which implies that the addition of default reduction tools such as insurance or joint liability will have a positive impact on risk taking. We find this here in a strong and positive impact of insurance and joint liability on risk taking among those with high levels of risk aversion. However, for those with low levels of risk aversion, therefore less concerned with the risk of default, insurance has a smaller impact and joint liability becomes negative. The change in sign for joint liability may suggest that at low levels of risk aversion other mechanisms present in joint liability come to dominate its impact on default. The significant interaction term suggests that for those with low levels of risk aversion, insurance has a significantly larger impact on risk taking under joint liability than under individual liability and that joint liability has a negative impact alone but close to zero impact when introduced into an insured loan.

In Panel B of Table 9 we consider heterogeneous treatment effects for borrowing. In Model 1 we look at the treatment effects for those with risk aversion levels below the mean and Model 2 those above the mean. Here we find that insurance has a large, positive and significant impact on borrowing for high risk averse participants but no significant impact on low risk averse participants. Alternatively, joint liability has a large, negative, and significant impact on low risk averse participants and no impact on the high risk averse participants. Lastly, the interaction effect are similar in magnitude and both significant yet different in sign with a positive impact on the low risk averse participants and a negative sign on the high risk averse participants. The interaction terms suggest that insurance has a strong positive impact in joint liability for the low risk averse but no impact in individual liability. Insurance then has a much smaller impact on joint liability by comparison to individual liability for the most risk averse. Following the interpretation above we can interpret these differential impacts as follows. Participants are risk averse primarily to default and therefore those with high levels of risk averse respond favorably to insurance. However, other mechanisms are at play in joint liability that dampen the impact of joint liability on borrowing despites its positive impact on repayment. At high levels of risk aversion, index insurance has a smaller impact on joint liability because the other mechanisms diminish the impact of the insurance. At low levels of risk aversion, participants are concerned less about the risk of default, therefore insurance has no independent impact on borrowing and joint liability has a negative impact as the other mechanism dominate concerns over default. However, insurance does have a positive impact on borrowing in joint liability by counteracting the other mechanisms at play in joint liability.

The other mechanism involved in joint liability include social penalties related to group members repaying each other's' loan in the case that one member cannot repay. In the case that a participant has to pay another's' loan, they may not only incur the cost of that payment but may also resent having to help which would increase the cost of repayment (we anecdotally observed this resentment in the field). Alternatively, when a participant's loan is repaid by another member, they may face lost social capital or shame over their inability to repay. Insurance will interact with these mechanisms in three ways. First, insurance will increase the cost of the social penalties due to the premium. The premium will increase the amount that one member may need to repay for another by increasing the loan repayment amount, this would increase the resentment and shame social penalties. Second, because the insurance repays the loan during a systemic shock, it will should reduce the likelihood of the states in which social penalties occur. Third, the cost of the premium will also increase the likelihood of default in good systemic outcome states. This framework may shed light on the heterogeneous affects that we observe.

At high risk aversion levels concerns over default dominate concerns over social penalties. This being the case, insurance increases borrowing and increases risk taking as these individuals are more inclined to not borrow or choose safe in the absence of the insurance. The impact of insurance is smaller under joint liability due for these individuals because the introduction of insurance into joint liability increases the cost of the social penalties which and increases the likelihood of default in the good systemic states. For the low risk averse, there is less averse to defaulting which reduces the impact of insurance on borrowing and on risk taking. In this case, concerns over the social penalties inherent in joint liability dominate the aversion to default resulting a negative impact of joint liability on borrowing and then on risk taking. Insurance has a positive interaction effect on joint liability then due to the reduction in the likelihood of experiencing the social penalties due to the full repayment that occurs in systemic shocks.

4.6 Empirical Result: Repayment and Total Income

Although the primary outcomes of interest in this experiment are borrowing and risk taking, in this last section we will also turn to repayment rates and total income. Repayment rates are of the greatest interest to banks while total income is of greatest interest to farmers, making these meaningful outcomes to analyze. However, because the experiment abstracts away from factors affecting repayment and income other than borrowing and risk taking, these results cannot be taken to directly predict outcomes in real lending. The results can be used to illustrate interesting mechanism at work in the interaction between index insurance and joint liability that are worth discussing.

In Table 10 Panel A, we present linear probability model results for the impact of our treatments on default probability. We find that insurance and joint liability both significantly reduce default rates, with a larger impact of joint liability than insurance. Income coverage has no impact on default rates. Interestingly, there is a positive interaction between insurance and joint liability. Although at first this appears counter intuitive, given that both technologies are intended to reduce default rates, their interaction can increase default given certain parameter settings. In the case of our experiment, the index insurance can increase default under joint liability due to the size of the insurance premium. In bad states the insurance repays the loan in full and therefore reduces default in that state. However, 70% of the time there is a positive systemic outcome and in that state it is more difficult for a joint liability group to repay their loan given the price of the insurance premium incorporated into the loan repayment amount. This interaction effect actually increases default.

To illustrate these effects more formally Figure 5 presents simulation results based on the empirical analysis. Panel A shows the repayment rates for individual liability lending graphed vs risk aversion. The graph includes repayment rates for individual liability and individual liability with insurance and consider both the purely mechanistic impact of the contracts as well as the impact factoring in changes in risk taking levels. Panel B shows the same results yet for joint liability. For individual liability, insurance has a considerable positive impact on repayment across risk aversion levels, with the highest impact on the least risk averse. The least risk averse will tend to choose the risky project which has a higher exposure to the systemic shock which reduces repayment rates under individual liability and results in a higher impact of insurance here. Factoring in the behavioral change in the form of increased risk taking, we find that insurance still increases repayment yet to a mildly lower extent for the least risk averse. For joint liability the insurance also increases repayment for the least risk averse yet actually reduces repayment for the most risk averse. This counter intuitive effect is the result of the effect of the premium on repayment in the good systemic states. In good rainfall seasons, the price of the premium makes repayment of the group more difficult when multiple members experience idiosyncratic shocks. In the unique parameters of our experiment, when two out of three group members experienced an idiosyncratic shock, the third member could repay the groups' loan only if they had taking the risky project choice and was successful as the income from the safe project was insufficient for the group to repay. Therefore, repayment rates decrease as risk aversion increases due to the more risk averse farmers choosing safe and reducing their ability to repay for the group when bad idiosyncratic shocks occur.

In Table 10 Panel B, we present OLS results for the impact of our treatments on total income. Insurance significantly increases income although the income coverage is not significant. Joint liability also increases income. However, the interaction of insurance and joint liability is negative and significant indicating that insurance has a smaller impact on incomes when introduced into a joint liability loan. Model 4 demonstates that the significant negative interaction is driven by a strong negative impact of income coverage on joint liability. The positive impact of insurance on income is driven by two factors. First insurance increases borrowing and risk taking, both of which increase expected income. Second, insurance reduces default which allows participants to remain longer in these higher income states. These two effects outweigh the cost of the premium. Joint liability also increases income although to a smaller extend. The increase is likely due to a significant reduction in default which offsets the negative impact of joint liability on borrowing and the costs of repaying other group members' loans. The negative interaction between insurance and joint liability is driven by two factors. First, the income coverage insurance is very expensive and this premium costs reduces good state incomes significantly. Second, when income coverage insurance is couple with joint liability, default rates increase in good systemic states and this increase in default reduces incomes by forcing participants into the low income non-borrowing state.

5. Conclusions

Development economists and microfinance institutions are still seeking to fully understand and optimize microfinance contracts that both improve loan repayment rates and drive the kinds of high return investments that allow borrowers to achieve sustained economic growth. We seek to contribute to this effort by investigating the separate and interaction effects of two predominant financial technologies relevant to agricultural microfinance: index insurance and joint liability. Particularly, we are interested in their effects on borrowing and risk taking where risk taking improved expected returns. To study these effects, we conducted a framed field experiment in rural Tanzania which included treatments of index insurance, joint liability, and their interaction.

Our experimental results demonstrated a few overarching impacts. First, index insurance unambiguously and robustly improved borrowing and risk taking. Second, joint liability reduced borrowing and had a mildly positive impact on risk taking. Third, although we fail to find a clear interaction effect of insurance and joint liability for the full sample, we do find a strong positive interaction on risk taking for individuals with low levels of risk aversion. By analyzing repayment and total income, we find a potential downside of interacting these two financial technologies. The high insurance premium can help push the whole joint liability group into default in good systemic outcome states, thereby reducing repayment rates at certain levels of risk aversion and having a negative interaction effect on total farmer income.

The implications of our work for policy making and practitioners are mixed. In seeking to increase investments in high return projects, index insurance and joint liability both improve risk taking and for some there appears to be a positive interaction affect, reinforcing this increase in profitable investments. However, we show that at high premium rates for insurance, coupling the two can actually increase default rates in good systemic states and reduce total farmer income. These results can be interpreted to suggest that an optimal microfinance contract include an individual liability structure with index insurance due to the increase in borrowing rates, risk taking, and repayment. This would be particularly true for populations with high levels of risk aversion. This could reinforce recent trends of microfinance institutions switching from joint liability to individual liability loan contract structures. Adding an insurance component to these loans may help MFIs to achieve a more optimal contract, increase repayment, and promote the kinds of profitable investments that will spur long term income growth.

6. References

Banerjee, A., E. Duflo, and R. Hornbeck. 2014. "(Measured) profit is not welfare: evidence from an experiment on bundling microcredit and insurance." :31.

Barnett, B.J., and O. Mahul. 2007. "Weather Index Insurance for Agriculture and Rural Areas in Lower-Income Countries." *American Journal of Agricultural Economics* 89(5):1241–1247.

Besley, T., and S. Coate. 1995. "Group lending, repayment incentives and social collateral." *Journal of Development Economics* 46(1):1–18.

Binswanger-Mkhize, H.P. 2012. "Is There Too Much Hype about Index-based Agricultural Insurance?" *Journal of Development Studies* 48(2):187–200.

Bourdillon, M., P. Hebinck, J. Hoddinott, B. Kinsey, J. Marondo, N. Mudege, and T. Owens. 2003. "Assessing the Impact of High Yielding Varieties of Maize in Resettlement Areas of Zimbabwe."

Croppenstedt, A., M. Demeke, and M.M. Meschi. 2003. "Technology Adoption in the Presence of Constraints: the Case of Fertilizer Demand in Ethiopia." *Review of Development Economics* 7(1):58–70.

Fischer, G. 2014. "Contract structure , risk sharing and investment choice Contract Structure , Risk Sharing , and Investment Choice."

Flatnes, J.E. 2014. "The role of collateral in joint liability group lending : Evidence from a framed field experiment in Tanzania ∗." :1–33.

Ghatak, M., and T.W. Guinnane. 1999. "The economics of lending with joint liability: theory and practice." *Journal of Development Economics* 60(1):195–

Giné, X., P. Jakiela, D. Karlan, J. Morduch, S. American, E. Journal, A. Economics, and N. July. 2010. "Microfinance Games." *American economic journal. Applied economics* 2(3):60–95.

Gine, X., R. Townsend, and J. Vickery. 2008. "Patterns of Rainfall Insurance Participation in Rural India." *The World Bank Economic Review* 22(3):539–566.

Giné, X., and D. Yang. 2009. "Insurance, credit, and technology adoption: Field experimental evidencefrom Malawi." *Journal of Development Economics*

89(1):1–11.

Karlan, D., R. Osei, and C. Udry. 2013. “Agricultural decisions after relaxing credit and risk constraints *.” :1–64.

Kijima, Y., K. Otsuka, and D. Sserunkuuma. 2008. “Assessing the impact of NERICA on income and poverty in central and western Uganda.” *Agricultural Economics* 38(3):327–337.

Mendola, M. 2007. “Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh.” *Food Policy* 32(3):372–393.

Miranda, M., and D. V Vedenov. 2015. “INNOVATIONS IN AGRICULTURAL AND NATURAL DISASTER INSURANCE.” 83(3):650–655.

Miranda, M.J., and K. Farrin. 2012a. “Index Insurance for Developing Countries.” *Applied Economic Perspectives and Policy* 34(3):391–427.

Miranda, M.J., and K. Farrin. 2012b. “Index Insurance for Developing Countries.” *Applied Economic Perspectives and Policy* 34(3):391–427.

Miranda, M.J., and C. Gonzalez-Vega. 2010. “Systemic Risk, Index Insurance, and Optimal Management of Agricultural Loan Portfolios in Developing Countries.” *American Journal of Agricultural Economics* 93(2):399–406.

Mobarak, A.M., and M. Rosenzweig. “Informal Risk Sharing , Index Insurance and Risk-Taking in Developing Countries.”

Stiglitz, J.E. 1990. “Peer Monitoring and Credit Markets.” *The World Bank Economic Review* 4(3):351–366.

Transformation, A.C. for E. 2014. “2014 African Transformation Report: Growth with Depth.”

Tables and Figures

Figure 1: Uninsured Agricultural Loan

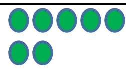
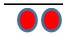
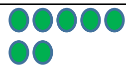
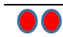
Risk Level (Repayment)		Crop Payout		Total Income After Repayment	
					
Not Borrow:		**100,000**	**100,000**	**100,000**	**100,000**
Safe (60,000)		**300,000**	**250,000**	**240,000**	**190,000**
		**250,000**	**0**	**190,000**	**0, Default**
		**0**	**0**	**0, Default**	**0, Default**
Risky (60,000)		**600,000**	**0**	**540,000**	**0, Default**
		**0**	**0**	**0, Default**	**0, Default**
		**0**	**0**	**0, Default**	**0, Default**

Figure 2: Insured Agricultural Loan | Loan Coverage

Risk Level (Repayment)		Crop Payout		Total Income After Repayment	
		🔵🔵🔵🔵🔵🔵🔵	⚫⚫⚫	🔵🔵🔵🔵🔵🔵🔵	⚫⚫⚫
Not Borrow:		**100,000**	**100,000**	**100,000**	**100,000**
Safe (90,000)	🟢🟢🟢🟢🟢🟢🟢	**300,000**	**250,000**	**210,000**	**250,000**
	🟡	**250,000**	**0**	**160,000**	**0**
	🔴🔴	**0**	**0**	**0, Default**	**0**
Risky (90,000)	🟢🟢🟢🟢🟢🟢🟢	**600,000**	**0**	**510,000**	**0**
	🟡	**0**	**0**	**0, Default**	**0**
	🔴🔴	**0**	**0**	**0, Default**	**0**

Figure 3: Insured Agricultural Loan | Loan Coverage

Risk Level (Repayment)		Crop Payout		Total Income After Repayment	
		🔵🔵🔵🔵🔵🔵🔵	⚫⚫⚫	🔵🔵🔵🔵🔵🔵🔵	⚫⚫⚫
Not Borrow:		**100,000**	**100,000**	**100,000**	**100,000**
Safe (120,000)	🟢🟢🟢🟢🟢🟢🟢	**300,000**	**250,000**	**180,000**	**300,000**
	🟡	**250,000**	**0**	**130,000**	**50,000**
	🔴🔴	**0**	**0**	**0, Default**	**50,000**
Risky (120,000)	🟢🟢🟢🟢🟢🟢🟢	**600,000**	**0**	**480,000**	**50,000**
	🟡	**0**	**0**	**0, Default**	**50,000**
	🔴🔴	**0**	**0**	**0, Default**	**50,000**

Table 1: Treatment Descriptions

	Individual Liability	Joint Liability
No Dynamic Incentive	Treatment 1	
No Insurance	Treatment 2	Treatment 5
Loan Coverage	Treatment 3	Treatment 6
Loan + Income Coverage	Treatment 4	Treatment 7

Table 2: Framed Risk Preference Game

	Systemic Outcome	Idiosyncratic Outcome	Probability	Net Payout	Expected Payout	CRRA Range
Not Borrow			100%	100,000	100,000	[0.67 , ∞]
Safe	Rain	Good	49%	240,000	170,800	[0.49 , 0.67]
	Rain	Poor	7%	190,000		
	Rain	Very Poor	14%	0		
	Drought	Good	21%	190,000		
	Drought	Poor	3%	0		
	Drought	Very Poor	6%	0		
Risky	Rain	Good	49%	540,000	264,600	[-∞ , 0.49]
	Rain	Poor	7%	0		
	Rain	Very Poor	14%	0		
	Drought	Good	21%	0		
	Drought	Poor	3%	0		
	Drought	Very Poor	6%	0		

Table 3: Descriptive Statistics

Variables	N	Mean	Std. Error
Individual Characteristics			
Age (years)	404	39.5	0.56
Education (years)	404	6.4	0.14
Household Head (1=yes, 0=no)	404	0.7	0.02
Female (1=female, 0=male)	404	0.47	0.02
Household Size (number of members)	401	4.6	0.47
Total Acres Owned (acres)	404	13.4	0.75
Other Source of Income (1=yes, 0=no)	403	0.67	0.02
Number of Past Seasons Borrowed	402	1.8	0.06
Preference for Individual Loans	403	0.59	0.02
CRRA Coefficient	407	0.57	0.01
Session Social Capital Index	400	0.18	0.01
Group Social Capital Index	395	0.16	0.01

Figure 4: Borrowing and Risky Project Choice Averages

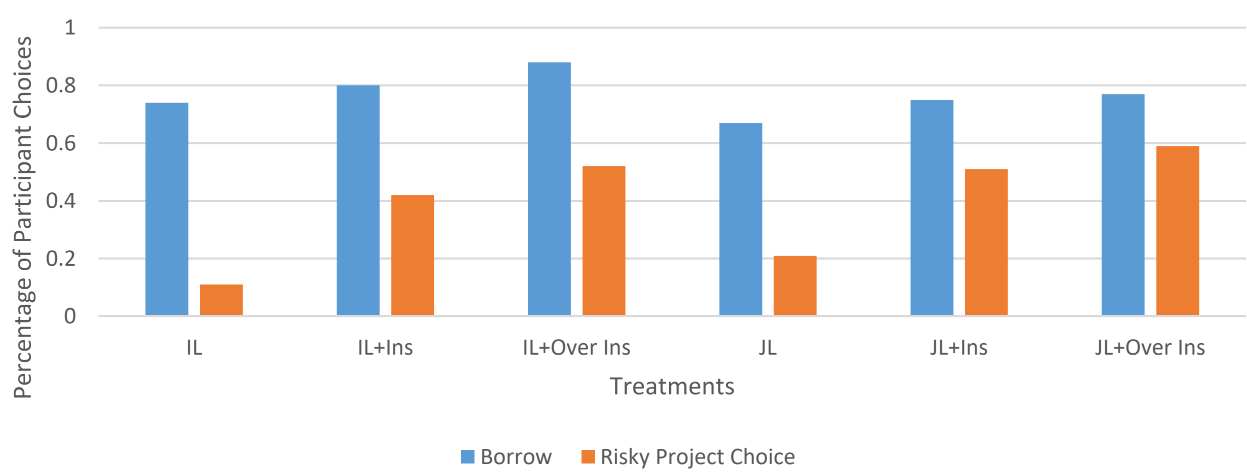


Table 4: Mean Outcome Variables

Comparison	Control	Treatment	Difference
A. Borrowing Decision			
Impact of Ins in Individual Liability	Treatment 2 0.74	Treatment 3 0.81	0.07*
Impact of Over Ins in Individual Liability	Treatment 2 0.74	Treatment 4 0.89	0.15***
Impact of Joint Liability	Treatment 2 0.74	Treatment 5 0.67	-0.07**
Impact of Ins in Joint Liability	Treatment 5 0.67	Treatment 6 0.75	0.08*
Impact of Over Ins in Joint Liability	Treatment 5 0.67	Treatment 7 0.77	0.09**
B. Risk Taking Decision			
Impact of Ins in Individual Liability	Treatment 2 0.18	Treatment 3 0.43	0.25***
Impact of Over Ins in Individual Liability	Treatment 2 0.18	Treatment 3 0.53	0.35***
Impact of Joint Liability	Treatment 2 0.18	Treatment 5 0.21	0.03**
Impact of Ins in Joint Liability	Treatment 5 0.21	Treatment 6 0.51	0.30***
Impact of Over Ins in Joint Liability	Treatment 5 0.21	Treatment 7 0.59	0.38***

p<0.1 *,p<0.05 **, p<0.01 ***

Table 5:
Individual Liability Transition Table

		Individual Liability Lending with Insurance			
		Not Borrowing	Safe	Risky	Total
Individual Liability Lending Without Insurance	Not Borrow	0.31	0.37	0.32	105
	Safe	0.1	0.5	0.41	249
	Risky	0.1	0.24	0.65	49
	Total	60	175	168	403

Table 6:
Joint Liability Transition Table

		Joint Liability Lending with Insurance			
		Not Borrowing	Safe	Risky	Total
Joint Liability Lending Without Insurance	Not Borrow	0.49	0.21	0.3	133
	Safe	0.13	0.51	0.36	211
	Risky	0.09	0.05	0.85	59
	Total	97	138	168	403

Table 6: Borrowing Decision – Probit Model -- Marginal Effects				
Variables	Model 1 OLS	Model 2 OLS	Model 3 FE	Model 4 FE
Index Insurance	0.11***	0.085***	0.11***	0.085***
Index Insurance + Income Coverage	-	0.056	-	0.05
Joint Liability	-0.07**	-0.071**	-0.067**	-0.067**
Joint Liability + Insurance	-0.02	0.013	-0.024	0.004
Joint Liability + Insurance + Income Coverage	-	-0.063	-	-0.055
Risk Aversion	-1.15***	-1.15***	-	-
Session Level Social Capital	0.32***	0.32**	-	-
Session Fixed Effects	YES	YES	NO	NO
Individual Fixed Effects	NO	NO	YES	YES
N	1558	1558	1614	1614

p<0.1 *,p<0.05 **, p<0.01 ***

Notes: Clustered robust standard errors at individual level

Table 7: Testing Relevance of Exclusion Restriction --Exclusion Restriction on Borrowing – LPM Model			
Variables	Model 1 Borrow	Model 2 Borrow	Model 3 Risk Taking
Borrowing Game	0.09***	0.078***	0.007
Controls	NO	YES	YES
Group Fixed Effects	NO	YES	YES
N	1610	1465	1148

p<0.1 *,p<0.05 **, p<0.01 ***

Notes: Clustered robust standard errors at individual level

Table 8: Risky Project Choice

Variables	Model 1 LPM	Model 2 LPM	Model 3 Heckman	Model 4 Heckman	Model 5 Individual FE	Model 6 Individual FE
Index Insurance	0.32***	0.28**	0.30***	0.26***	0.30***	0.27***
Index Insurance + Income Coverage		0.077		0.08*		0.054
Joint Liability	0.024	0.025	0.03	0.03	0.02	0.02
Joint Liability + Insurance	0.012	0.053	-0.02	0.054	0.03	0.054
Joint Liability + Insurance + Income Coverage		-0.076		-0.071		-0.047
Risk Aversion	-0.96***	-0.96***	-0.89***	-0.9***		
Group Level Social Capital	-0.03	-0.033	-0.02	-0.02		
Education	0.01	0.01	0.01	0.01		
Female	-0.1***	-0.1***	-0.1***	-0.1**		
/athrho			-0.23	-0.24		
Group Fixed Effects	YES	YES	YES	YES	NO	NO
Round Fixed Effects	YES	YES	YES	YES	NO	NO
N	3507	3507	5015	4761	3669	3669

p<0.1 *,p<0.05 **, p<0.01 ***

Notes: Clustered robust standard errors at individual level

Table 9: Heterogeneous Treatment Effects Across Risk Aversion -- Individual Fixed Effects Model

	A. Risk Taking		B. Borrowing	
Variables	Model 1 Low Risk Aversion	Model 2 High Risk Aversion	Model 1 Low Risk Aversion	Model 2 High Risk Aversion
Index Insurance	0.22***	0.35***	0.045	0.15***
Joint Liability	-0.11**	0.11***	-0.13***	-0.035
Joint Liability + Insurance	0.13**	-0.04	0.12**	-0.09**
Group Fixed Effects	YES	YES	YES	YES
Round Fixed Effects	NO	NO	NO	NO
Controls	YES	YES	YES	YES
N	1386	2283	538	1020

p<0.1 *,p<0.05 **, p<0.01 ***

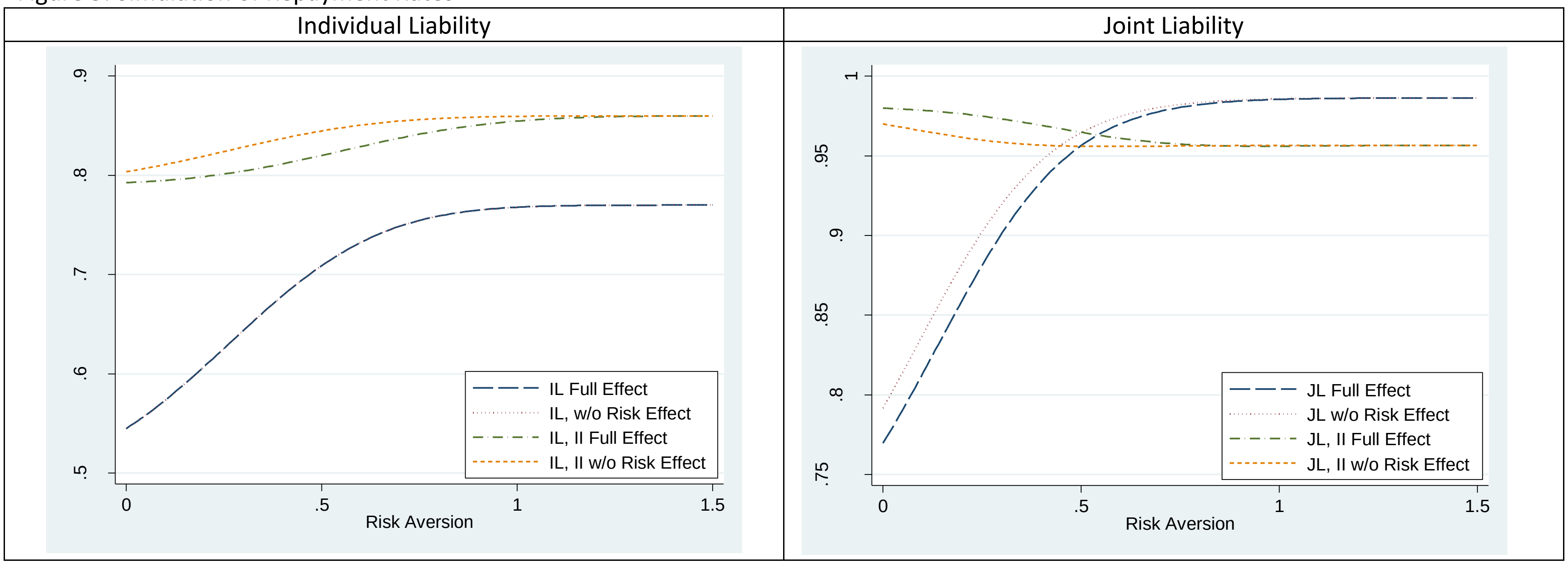
Notes: Clustered robust standard errors at individual level

Table 10: Heckman Sample Selection -- Default and Total Income – Marginal Effects				
	A. Default		B. Total Income	
Variables	Model 1 OLS	Model 2 OLS	Model 3 OLS	Model 4 OLS
Index Insurance	-0.096***	-0.081***	46361***	37337***
Index Insurance + Income Coverage	-	-0.027	-	17289
Joint Liability	-0.19***	-0.19***	15884***	15883***
Joint Liability + Insurance	0.085**	0.067***	-15668**	3324
Joint Liability + Insurance + Income Coverage	-	0.035	-	-36391***
Group Fixed Effects	YES	YES	YES	YES
Round Fixed Effects	YES	YES	YES	YES
N	3157	3157	7790	7790

p<0.1 *,p<0.05 **, p<0.01 ***

Notes: Clustered robust standard errors at individual level

Figure 5: Simulation of Repayment Rates



Appendix

Borrowing Game Question:

Imagine you have one acre to cultivate and you can either take a loan or not. If you take the loan you will receive 50,000 TZS to purchase newer seeds and you will make 150,000 TZS from your farming. However you have to repay 100,000 at the end of the season. In this case you end up with 50,000 TZS. If you do not take a loan, you can use old seeds and make 50,000 from your farming but dont have to repay any loan. In this case you end up with 50,000 TZS. Would you choose to borrow or not borrow? (the question was followed by this table in Kiswahili clearly representing the terms of the decision. The enumerators led the participants through this table while asking the question.)

	Amount Borrowed	Crop Income	Loan Repayment Amount	Final Income
Borrow	50,000 TZS	150,000 TZS	100,000 TZS	50,000 TZS
Not Borrow	0 TZS	50,000 TZS	0 TZS	50,000 TZS

Social Network Questions:

Relationships

1. Please indicate those who are your family members or close relatives
2. Please indicate those who are you would consider a close friend

Trust

3. Please indicate those who you would feel comfortable leaving your child with
4. Please indicate those who you would lend 10,000 TSH (if you had the money available).

Shame

5. If you could not repay your loan, who of these people would you feel ashamed if they found out
6. If you could not repay your loan, for who would you feel bad if they had to repay your loan