The Impact of Index Insurance on Risk Taking Under Individual and Joint Liability Loan Contracts

Abstract

Index insurance backed contingent credit offers considerable advantages over standalone insurance policies in improving farmers' access to agricultural credit. However, research on demand for such products and their impact on profitable investment decisions has been limited and has yielded conflicting results to date. In this article, we investigate the impact of insurance-backed contingent credit on demand for credit and investment decisions using a framed field experiment conducted in rural Tanzania. We find that insurance-backed contingent credit increases demand for credit as well as increases high-return investments significantly. Furthermore, we demonstrate that these effects hold under both individual and joint liability loan contracts and increase in borrowers' degree of risk aversion.

Microfinance has spread rapidly in developing countries over the past several decades in the hope that access to credit will spur widespread economic development (Morduch 1999). However, access to microfinance in the agricultural sector remains low (Perron 2016), and even existing programs have failed to produce growth in microenterprise profitability (Karlan and Zinman 2010; Banerjee et al. 2013). Evidence has shown that the large amount of risk in agriculture may be driving the poor performance of microfinance in rural areas. Systemic risk that characterizes agricultural production hinders credit demand due to fear of lost collateral and other default penalties (Boucher et. al 2008), hinders supply by threatening widespread defaults in bank loan portfolios (Miranda and Farrin 2012), and incentivizes low-risk low-return investment strategies (Cole, Gine, and Vickery 2014; Clarke and Dercon 2009; McIntosh, Villaran and Wydick 2011; Zimmerman and Carter 2003). To address these challenges, index insurance has been proposed as a cost-effective means to manage systemic risk and reduce default rates (Giné 2009, Miranda and Gonzalez-Vega 2010, Miranda and Farrin 2012). While theoretical research has suggested that index insurance may be effective both at increasing credit access and agricultural investments, empirical evidence has been mixed (Farrin and Miranda 2015; Miranda and Gonzalez-Vega 2010; Giné and Yang 2009; Mishra et al. 2017; Gallenstein et al. 2017).

In this article, we investigate the impact of an index insurance backed contingent loan (hereafter just contingent credit)[1] on credit demand and risk-taking. In particular, we first develop a theoretical model of risk-taking in the context of both individual and joint liability agricultural loans both with and without contingent credit. We then test the model's predictions by conducting a framed field experiment among Tanzanian smallholder farmers. We find that index insurance unambiguously increases risk-taking and borrowing under both contract structures, and that the effect is statistically the same under both contracts. Furthermore, we find evidence that both the borrowing effect and the risk-taking effect are stronger for more risk-averse individuals, and the risk-taking effect is stronger when there are greater default penalties.

Recent theoretical research has suggested that contingent credit may be effective both at increasing credit access and agricultural investments. In terms of credit market access, Miranda and Gonzalez-Vega (2010) demonstrate that contingent credit, by managing the risk of systemic defaults within a bank's portfolio and avoiding strategic defaults, can significantly improve a bank's portfolio performance and increase supply of agricultural credit. This result is supported by Carter et al. (2016) who show that by intentionally linking insurance payouts to loan repayment will increase supply and demand for agricultural credit. In terms of high-return investments, Farrin and Miranda (2015) demonstrate that contingent credit improves adoption of high-return technologies relative to uninsured loans or loans that mandate borrowers to purchase standalone insurance contracts.

Despite the robust theoretical predications regarding the benefits of contingent credit, empirical work on the impact of contingent credit is smaller and somewhat conflicting. Giné and Yang (2009) find that contingent credit loans coupled with input bundles experience lower take up rates than conventional uninsured loans in Malawi. In Ghana, Karlan et al. (2011) find no impact of a contingent credit loan on credit demand or on high-return investments while Gallenstein et al. (2017) find demand for contingent credit loans to be lower than demand for uninsured loans. Furthermore, Mishra et al. (2017) demonstrate that contingent credit can improve credit demand for farmers with high trust in their banking institutions and significantly increase supply of credit by improving loan approval rates.

These somewhat sparse and conflicting results leave many unanswered questions. First, the impact of contingent credit on agricultural credit demand remains unclear and more work is necessary to understand the conditions under which contingent credit will improve credit demand. Second, the majority of research on contingent credit focuses on the borrowing decision or has modeled the investment decision as synonymous with the borrowing decision (Carter, Cheng, and Sarris 2016; Gine and Yang 2009) leaving the impact of contingent credit on the loan capital investment decision under explored. However, farmers may choose to borrow yet still invest loan capital into a low-return risk-reducing diversified cropping system (Dercon and Christiaensen 2011; Larson and Plessmann 2009). Therefore, separately investigating the impact of contingent credit on loan capital investment decisions will be essential to identify the impact of contingent credit on agricultural development. Lastly, the theoretical research has focused exclusively on insurance under individual liability contracts while joint liability is the most common contract structure in the empirical literature.

In light of this, this article makes two contributions to the literature. First, we provide experimental evidence of a positive effect of contingent credit on both credit demand and risk-taking among smallholder farmers in a drought-prone area. Second, to our knowledge, this is the first article that both theoretically and experimentally studies contingent credit under joint liability lending.

The rest of the article is organized as follows. In the second section, we develop a theoretical model of loan demand and risk-taking with and without insurance and derive a set of testable hypotheses. Then we provide a detailed description of our experimental design, followed by a description of the data. Subsequently we discuss our empirical strategy and the results. In the final section we provide some concluding thoughts and policy recommendations.

Theoretical Model

Consider a representative smallholder farmer who starts the farming season with wealth W and has access to an agricultural loan with repayment amount $R = (1 + r)$ where $r \in [0,1]$ is the interest rate[2,3]. In the case of default, the farmer faces a default penalty D, understood as consisting of collateral, social penalties, and present value of lost future loan access[4]. Should the farmer choose to not borrow, she resorts to self-financing a riskless low-return crop production technology which yields ω with certainty. Should she choose to borrow, she can then choose to invest in a range of activities that vary in risk level $\tau \in [0,1]$. An investment yields $Y(\tau)$ with probability $P^S(\tau)$ and 0 with probability $P^F(\tau) = 1 - P^S(\tau)$. To establish the fundamental risk-return tradeoff in investment decisions (Heady 1952) we assume $\frac{\partial P^S(\tau)}{\partial \tau} < 0$ and $\frac{\partial Y(\tau)}{\partial \tau} > 0$. We abstract away from other morally hazardous behavior such as strategic default and credit diversion by assuming that the loan is always repaid when sufficient yields are realized and all of the loan capital is invested.

We will consider an insured agricultural loan and an uninsured loan. For the insured loan, we assume it takes the form of contingent credit, in which the bank purchases an insurance policy that covers the loan repayment amount in full and passes the cost of the premium on to the farmer as a higher loan repayment amount. The loan repayment amount then becomes $RI = (1 + r)(1 + \pi\beta)$ where π is the actuarially fair insurance premium and β is a loading factor[5]. As an index policy, payouts are made based on an index $i \in \{l, h\}$ that is imperfectly correlated with farmer losses, i.e. it contains basis risk. The insurance is triggered when $i = l$ with probability $(1 - q)$, (where $q \in [0,1]$ is the probability that the index is not triggered) at which point the loan is repaid in full. The payout structure for individual and joint liability loans can be found in table 1.

We will also consider joint liability contracts in addition to individual liability. Under joint liability, we assume there are two identical farmers, each borrowing the same loan amount and who are jointly liable for the loan repayment. Under this arrangement, a successful farmer must repay on behalf of an unsuccessful partner when able. Following previous models of joint liability, we assume farmers lose social collateral, i.e. social standing with other group members, $\sigma(R)$, when they require assistance from their partner (Besley and Coate 1995; Flatnes and Carter 2017). We assume that the lost social collateral is a linear and increasing function of the repayment amount, $\sigma(R) = \sigma R$. Under joint liability, there are eight possible consumption outcomes with eight corresponding outcome probabilities, with the payout structure presented in table 1.

The farmer's preferences are captured by a utility function of consumption $U(C)$ where $U^{'}(C) > 0$ and $U^{''}(C) < 0$. The expected utility functions for individual liability and joint liability with and without insurance are summarized as follows:

$$EU(C_{IL,U}|r) = P^S U(W + Y(\tau) - R) + (1 - P^S)U(W - D) \quad [1]$$

$$EU(C_{IL,I}|r) = P_h^S U(W + Y(\tau) - RI) + P_l^S U(W + Y(\tau)) + P_h^F U(W - D) + P_l^F U(W) \quad [2]$$

$$EU(C_{JL,U}|r) = P^{SS} U(W + Y(\tau) - R) + P^{SF} U(W + Y(\tau) - 2R) + P^{FS} U(W - \sigma R) + P^{FF} U(W - D) \quad [3]$$

$$EU(C_{JL,I}|r) = P_h^{SS} U(W + Y(\tau) - RI) + P_h^{SF} U(W + Y(\tau) - 2RI) + P_h^{FS} U(W - \sigma RI) + P_h^{FS} U(W - D) + P_l^S U(W + Y(\tau)) + P_l^F U(W) \quad [4]$$

We further specify functional forms for the yield and probability functions. We assume that yields have a fixed-return component and a term that changes in risk-taking. Successful yields are $Y(\tau) = A + B\tau$ where we assume $A > 2RI$ [Assumption 1] to ensure sufficient income to repay the insured loan under joint liability and $B > A + D(1 - q) - R - RIq$ [Assumption 2][6] to ensure non-negative risk-taking. The probabilities are functions of risk-taking and the index trigger probability and the two outcomes are correlated (as in Giné and Yang (2009)): $P_h^S = (1-\tau)q + \varepsilon$; $P_l^S = (1-\tau)(1-q) - \varepsilon$; $P_h^F = tq - \varepsilon$; $P_l^F = (1-q)\tau + \varepsilon$. Following the definition of correlation, $\varepsilon = \rho\sqrt{\tau(1-\tau)q(1-q)}$ where ρ is the correlation coefficient[7]. To derive analytical solutions, we make the following simplifying assumptions, which we will relax later when simulating the model: (1) risk neutrality, $U(C) = C$, (2) no initial wealth, $W = 0$, (3) yields and the index probabilities are independent of loss probabilities: $\rho = 0$.

Borrowing

We first consider the naïve case of the impact of contingent credit on borrowing while holding τ constant. We define the impact of contingent credit on demand for credit as $\Delta_{IL}^b = \left[EU\left(C_{IL,I}\right) - U(\omega)\right] - \left[EU\left(C_{IL,U}\right) - U(\omega)\right]$ for individual liability and $\Delta_{JL}^b = \left[EU\left(C_{JL,I}\right) - U(\omega)\right] - \left[EU\left(C_{JL,U}\right) - U(\omega)\right]$ for joint liability where positive values indicate an increase in the demand for credit. Substituting in equations 1 and 2 for individual liability and 3 and 4 for joint liability we find the following expressions:

$$\Delta_{IL}^b = P^S(R - RIq) + (1 - P^S)(1-q)D \qquad [5]$$

$$\Delta_{JL}^b = P^S[2 + \sigma - P^S(1+\sigma)](R - RIq) + \left(1 - 2P^S + P^{S^2}\right)(1-q)D \qquad [6]$$

Using these expressions, we derive our first proposition.

Proposition 1. For a risk-neutral farmer with constant risk-taking and an actuarially fair insurance premium, contingent credit increases borrowing

a. *for individual liability when* $D > \frac{RP^S(R-1)}{(1-P^S)[1-R(1-q)]} > R$ *and*

b. *for individual liability when* $D > \frac{RP^S[2+\sigma-P^S(1+\sigma)](R-1)}{\left(1-2P^S+P^{S^2}\right)[1-R(1-q)]} > R$.

The proof for Proposition 1 can be found in the appendix.

Intuitively, Proposition 1 states that when the benefit of insurance (i.e. protection against default penalties) outweighs the costs (i.e. the premium), borrowing will increase with contingent credit. However, because the insurance premium is priced to cover the full loan amount, the default penalties must strictly exceed that of the loan repayment amount at actuarially fair insurance rates to achieve an increase in borrowing.

Risk-Taking

Now, we turn to assess the impact of contingent credit on risk-taking, allowing the farmer to choose the risk level of her investment. She chooses $\tau^*_{k,j} = argmax_\tau \, EU(C_{k,j}|r)$ where $k = \{IL, JL\}$ indicating the liability structure and $j = \{U, I\}$ indicating the presence of insurance.

For individual liability, she chooses optimal risk-taking by maximizing equation 1 which yields $\tau^*_{IL,U} = \frac{B-A+R-D}{2B}$. It can be easily shown that exogenously increasing the default penalty unambiguously decreases risk-taking while exogenously increasing the loan repayment amount unambiguously increases risk-taking. These findings are consistent with the roles that collateral and interest rates play in credit markets (Ghatak and Guinnane 1999; Stiglitz and Weiss 1981) in that increased interest rates induce moral hazard and collateral reduces moral hazard. With insurance, she chooses optimal risk-taking by maximizing equation 2 which yields $\tau^*_{IL,I} = \frac{B-A+q(RI-D)}{2B}$. We define the impact of contingent credit on risk-taking as $\Delta^\tau_{IL} = \tau^*_{IL,I} - \tau^*_{IL,U}$. Simplifying, we find $\Delta^\tau_{IL} = \frac{q(RI-D)+D-R}{2B}$. Using Δ^τ_{IL}, we define our second proposition.

Proposition 2: For a risk-neutral farmer facing a contingent-credit loan with an insurance premium greater than or equal to actuarially fair,

a. contingent credit will unambiguously increase risk-taking relative to an uninsured loan, and

b. the impact of contingent credit is unambiguously increasing in default penalties.

The proof for Proposition 2 can be found in the appendix.

Intuitively, Proposition 2 predicts that the introduction of contingent credit will increase risk-taking for two reasons. First, by reducing the probability of suffering default penalties, farmers are willing to take higher-risk investments. Second, the insurance premium increases the loan repayment amount, which reduces utility in the success state, thereby incentivizing greater risk-taking. As default penalties increase, risk-taking under the uninsured loan will decrease faster than under contingent credit due to the higher probability of facing default penalties under the uninsured loan. Therefore, increasing default penalties increases the impact of insurance.

For joint liability, the borrower chooses optimal risk-taking without insurance by maximizing equation 3 and optimal risk-taking with insurance by maximizing equation 4, solving for the Nash equilibrium assuming identical borrowers. This yields $\tau^*_{JL,U} = \frac{B-A+R(1-\sigma)}{2B-R(1+\sigma)+X}$ without insurance and $\tau^*_{JL,I} = \frac{B-A+RIq(1-\sigma)}{2B-RIq(1+\sigma)+Xq}$ with insurance. We define the impact of contingent credit on risk-taking as $\Delta^\tau_{JL} = \tau^*_{JL,I} - \tau^*_{JL,U}$. We thus define our final proposition.

Proposition 3: For a risk-neutral farmer facing a contingent-credit loan with an insurance premium greater than or equal to actuarially fair,

a. *contingent credit will unambiguously increase risk-taking relative to an uninsured loan, and*
b. *default penalties have an ambiguous effect on the impact of contingent credit, and*
c. *social collateral has an ambiguous effect on the impact of contingent credit.*

The proof for Proposition 3 can be found in the appendix.

Intuitively, Proposition 3 predicts that introducing contingent credit into joint liability will also increase risk-taking unambiguously. This is for similar reasons as under individual liability. However, with joint liability, farmers also face social collateral penalties and make strategic risk-taking decisions considering their partner's risk-taking. The impact of default penalties may be ambiguous due to strategic decision making. In isolation, default penalties reduce risk-taking, however, behaving strategically, a farmer's risk-taking will increase in response to a reduction in her partner's risk-taking (free-riding), which in turn increases risk-taking. The impact of social collateral is ambiguous due to competing interactions with the insurance premium. The introduction of contingent credit reduces the probability of facing social collateral losses, which will increase the impact of insurance. However, the insurance premium will increase the loan repayment amount, which then increases the magnitude of the social collateral penalty when it occurs, thereby decreasing the impact of insurance. These competing effects result in ambiguous influences of default penalty and social collateral on risk-taking under individual liability.

Simulation

Since the model cannot be solved analytically under the assumption of risk aversion and $\rho > 0$, we instead solve the model numerically. We assume a constant relative risk aversion utility function, $U(C) = \frac{1}{1-\alpha} C^{1-\alpha}$, allow for wealth $W > 0$, and correlation between the index and success $\rho > 0$. Intuitively, we expect the impact of contingent credit to increase in risk aversion, because a negative shock has a higher utility cost for a risk averse agent. In the case of contingent credit, because the cost of insurance is only passed onto the borrower when they repay, the contingent credit contract makes the borrower's failure-state payout greater than or equal to the failure-state payout under the uninsured loan[8]. This improvement in the failure-state will incentivize risk averse borrowers to increase risk-taking.

In figure 1, we present simulation results for the impact of contingent credit on risk-taking[9]. We find that under both individual liability (Panel A) and joint liability (Panel B), the impact of contingent credit is positive. We also find that the impact of contingent credit is increasing in risk aversion and default penalties for each liability structure. For joint liability, we also consider variation in social collateral. Panel B.2 displays results for variation in social collateral where we confirm that the impact of contingent credit is ambiguously varying in social collateral. Lastly, we note that the impact of insurance on risk-taking is greater for individual liability than for joint liability. This is likely the result of the two technologies functioning as substitutes.

We also investigate the impact of contingent credit on borrowing while allowing for endogenous risk-taking. More formally, we define $\Delta_k^b(\tau_{k,I}^*, \tau_{k,U}^*) = \left[EU\left(C_{k,U}(\tau_{k,I}^*)\right) - U(\omega)\right] - \left[EU\left(C_{k,U}(\tau_j^*)\right) - U(\omega)\right]$ and plot $\Delta_k^b(\tau_{k,I}^*, \tau_{k,U}^*)$ across values of risk aversion and default penalties in Figure 2 ($k \in \{IL, JL\}$). We find that contingent credit has an ambiguous impact on borrowing that is negative for low levels of default penalties and risk aversion. The effect of risk aversion and default penalties on the impact of contingent credit is ambiguous for individual liability.

Model Results and Predictions

Based on the theoretical propositions and simulation results, we summarize our predications as follows:

Prediction 1: The impact of contingent credit on borrowing will be

a. *positive given sufficiently high default penalties and*
b. *ambiguous in risk aversion.*

Prediction 2: The impact of contingent credit on risk-taking under individual liability will be

a. *unambiguously positive,*
b. *increasing in risk aversion, and*
c. *increasing in default penalties.*

Prediction 3: The impact of contingent credit on risk-taking under joint liability will be

a. *unambiguously positive,*
b. *increasing in risk aversion,*
c. *increasing in default penalties, and*
d. *ambiguous in social collateral.*
e. *Furthermore, the impact of contingent credit will be smaller for joint liability than for individual liability.*

Experimental Design

To test our theoretical predictions, we conducted a framed field experiment with 407 smallholder farmers in rural Tanzania[10]. The experiment closely resembles the theoretical model introduced above. Participants first faced a borrowing decision followed by a binary risk-taking decision for those that chose to borrow, and these decisions were calibrated to capture the fundamental tradeoff between risk and expected return. To capture default penalties, we include dynamic incentives, i.e. we bar defaulters from borrowing in subsequent rounds. Finally, we included multiple games that varied the presence of joint liability, and insurance to capture the impact of contingent credit on both individual and joint liability.

General Experiment Setup

Participants were told that they had access to one acre of high-quality land and were pre-approved for an agricultural loan. If they chose to borrow, they would receive a 50,000 TZS[11,12] loan (equivalent to roughly $23), enough to buy all necessary inputs for one acre of sunflower cultivation. If they chose not to borrow, they would use traditional sorghum seeds, known for low yields but low yield variability, which we assumed to produce an income of 100,000 TZS with certainty. Those choosing to borrow then faced a discrete investment decision between a (1) high-risk high-return investment i.e. cultivating with a high yielding variety seed, and a (2) low-risk low-return investment, i.e. cultivating with a drought and pest-resistant seed. Crop yields were determined stochastically using draws of colored balls from two bags. The first bag was an idiosyncratic shock bag framed as a crop disease and contained seven green balls representing good idiosyncratic outcomes, one yellow ball representing poor idiosyncratic outcomes, and two red balls indicating very poor idiosyncratic outcomes. The second bag was a systemic shock bag framed as rainfall that contained seven blue balls indicating good rains and three black balls indicating drought. Table 2 displays the basic payout structure for the general experiment setup without insurance. The table illustrates the yield and income outcomes as well as the probabilities of each outcome, the loan repayment amounts, net payoffs, and the instances of default.

Experimental Treatments

The experiment included six treatments that introduced variations in the liability and insurance structures of the loan contract and a framed risk preference game. Each treatment was proceeded by two practice rounds to familiarize the participants to the general experiment setup and the unique characteristics of the treatment. Table 3 summarizes the treatments.

Treatment 1 is an individual liability loan with dynamic incentives. It follows the general experiment setup described above and serves as the control case for the analysis. We present the payout structure in table 3. Participants played Treatment 1 (as well as 2-6) for five rounds, and defaulters were barred from borrowing in subsequent rounds of the treatment[13].

Treatments 2 and 3 added an insurance component to the agricultural loan at two different coverage levels, which we will call insurance and over-insurance, respectively. For Treatment 2, in the case of a drought, the insurance policy repaid the loan. For Treatment 3, in the case of a drought, the insurance policy repaid the loan plus providing supplemental income to the participant. The price of the insurance was added to the repayment amount, increasing it to 90,000 TZS for Treatment 2 and 120,000 TZS for Treatment 3[14]. The insurance included basis risk in that it paid out based on the systemic shock and not based on losses. Therefore, there were instances of losses for which there was no payout (downside basis risk) and one instance of a payout when there were no losses (upside basis risk). The upside basis risk event occurred 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 reduced the expected income for both the safe and risky project choices. Tables demonstrating the payout structures for Treatments 3 and 4 can be found in the appendix.

Treatment 4 was a joint liability loan that followed the same procedure as Treatment 2 with the addition of shared responsibility for repaying the group loan. We simulated joint liability by requiring successful borrowers to repay the loans of unsuccessful borrowers and used the performance of the group as a whole to determine the repayment status of each group member.

Treatment 5 and 6 were identical to Treatment 4 with the addition of index insurance and over-insurance respectively.

In addition to the treatments, we also utilized a framed risk preference game to determine the constant relative risk aversion (CRRA) parameters for the participants in the sample. This game is similar to Treatment 1 and excluded joint liability, insurance, and dynamic incentives. It therefore constituted a choice between a certain outcome (not borrowing) and two lotteries that differed in risk and expected payouts. The implied CRRA parameter ranges for each decision can be found in Table 4[15]. The participants played the game for three rounds to avoid first-round bias.

After the completion of all the treatments, the participants received a cash payment based on the total income from a randomly selected round from a randomly selected treatment to ensure incentive compatibility. We set the minimum incentive payment at 1,000 TZS (roughly $0.50) and the maximum at 16,000 TZS (roughly $7.40) with an average around 5,000 TZS (roughly $2.30).

Data

The data for the empirical analysis were generated through conducting the above framed field experiment and a survey on a sample population of smallholder farmers in Tanzania. Below we discuss this sample of farmers and present some descriptive statistics for that population.

Experimental Sample

We identified a sample of roughly 600 small-scale farmers from roughly 57 borrowing groups through cooperation of Vision Fund Tanzania, a microfinance NGO. We chose a sample of farmers from the drought-prone Dodoma region in central Tanzania to maximize familiarity with drought and identify effects of insurance with a population exposed to regular systemic weather shocks. The sample included the vast majority of Vision Fund Tanzania agricultural credit clients in the region. We chose to hold experimental sessions with one borrowing group at a time to ensure that we capture any social capital that 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. The final experimental sample included 407 farmers from 41 farmer groups.

Descriptive Statistics

At the end of each experimental session, we conducted an individual survey to elicit individual-level and household-level characteristics. The survey included questions on basic individual and household characteristics, loan history, and a social networks survey. We present descriptive statistics in table 5. 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. We find that the average person in our sample is roughly 40 years old and has 6.4 years of schooling. The majority of the sample participants are household heads and 47% of them are women. They have relatively large land holdings relative to smallholder farmers in that area, with an average of 13.4 acres of land owned. The majority has income sources other than farming, although people 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; however, 59% of the sample expressed a preference for individual liability loans.

We used the framed risk preference game to elicit participants' constant relative risk aversion coefficient based on the cutoff ranges found in table 4 and found a population mean CRRA coefficient of 0.57, which corresponds to moderate risk aversion[16].

To create a measure of social collateral, we conducted a social network survey. We took pictures of each participant and uploaded these pictures into our computer-based survey. During the survey, the enumerators asked six questions in which the respondents would indicate the other members of the group (by pointing to their picture on the screen) for whom the question applied[17]. The questions can be found in the appendix. We used these questions to create a social capital index based on the proportion group for which the questions applied. The average social capital index is 0.16.

Results

Here we present and discuss the empirical results of our framed field experiment. We begin with simple mean comparisons to gain a general understanding of our results. We then present our econometric strategy and results.

Characterizing Borrowing and Risk-Taking 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 with mean t-test comparisons to elicit the statistical impacts of insurance. We present the results in table 6. Here, Treatment 1 serves as the control for Treatments 2 and 3, while Treatment 4 serves as the control for Treatments 5 and 6. Panel A reports the results for borrowing and Panel B for risk-taking decisions. Insurance and over-insurance both increase borrowing and are significant for individual and joint liability. For risk-taking, 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. From this initial look at the data, there appear to be robust impacts of contingent credit both on credit demand and risk-taking.

Econometric Strategy

In this section, we econometrically estimate the impacts of the treatments on borrowing and risk-taking. To analyze the borrowing decision, we use a linear probability individual fixed-effects model of the binary borrowing decision variable regressed on the treatments and a vector of control variables as follows:

$$B_{i,t} = \theta_0 + \theta_1 II_t + \theta_2 OI_t + \theta_3 JL_t + \theta_4 JL_t * II_t + \theta_5 JL_t * OI_t + \mathrm{I}_i + \epsilon_{i,t} \qquad [7]$$

Where $B_{i,t} \in \{0,1\}$ is the borrowing decision (1 indicating borrowing), for individual i under treatment t. JL_t is a dummy variable indicating the presence of joint liability, II_t is a dummy variable indicating the presence of index insurance backed contingent credit, OI_t is a dummy variable indicating the presence of over-insurance backed contingent credit, and I_i is an individual fixed effect. We will consider models both with and without the over-insurance variables included.

To analyze the risk-taking decision, we again use an individual fixed-effects model as with the borrowing decision model from equation 7.

$$R_{i,t} = \beta_0 + \beta_1 II_t + \beta_2 OI_t + \beta_3 JL_t + \beta_4 JL_t * II_t + \beta_5 JL_t * OI_t + \mathrm{I} + \epsilon_{i,t} \qquad [8]$$

Where $R_{i,t} \in \{0,1\}$ is the risk-taking decision (1 indicating risky investment). This specification may have two sources of bias. The first is a selection bias as we only observe the risk-taking decision for those choosing to borrow. The selection bias arises from a correlation between the error terms for the borrowing and the risk-taking models which occurs if there are omitted variables that impact both borrowing and risk-taking. We control for this bias through the use of the individual fixed-effects model which will control for all individual characteristics, observed and unobserved, that may explain both the borrowing and risk-taking decisions[18]. The second bias arises from the fact that we do not observe the risk-taking decision after a participant defaults on her loan and those choosing the higher risk investment will default more frequently than those choosing the safer investment. This will result in a sample of data weighted in favor of the safe project choice. We address this problem by restricting the regression model to include only the first (out of five) rounds. This solution eliminates the differential weighting in favor of those choosing the safe investment and maximizes the amount of dynamic incentives that we leverage as a default penalty.

Borrowing Decision

In table 7, we present the results for the borrowing decision. Model 1 shows the results of estimating the individual fixed-effects model without differentiating between the two coverage levels. We find an 11% significant increase in borrowing in the presence of index insurance. Joint liability has a significant negative impact on borrowing of 6.7%. The interaction of joint liability and index insurance is negative although statistically insignificant. Moving to Model 2 with over-insurance, we again find a positive and significant impact of insurance on borrowing of roughly 9% but no significant additional impact of the higher coverage. The impact of joint liability is identical to Model 1. As in Model 1, there is no significant interaction effect of insurance and joint liability.

Taken together, these results suggest a positive impact of contingent credit on borrowing under both individual and joint liability. In Prediction 1*,* we stated that contingent credit will increase borrowing when default penalties are sufficiently high. Given large default penalties induced by the dynamic incentives, our results are consistent with this prediction.

We also find a robust negative impact of joint liability on borrowing, which is consistent with other recent research (Giné and Karlan 2014). Joint liability may reduce borrowing due to the threat of lost social collateral as a result of being unable to repay, resentment or disutility associated with needing to help others repay (anecdotally reported by participants in our sample), or a general dislike of joint liability stemming from personal experiences with joint liability through Vision Fund Tanzania.

Risk-Taking Decision

In table 8, we present the individual fixed-effects model results for the impact of insurance on risk-taking. In Model 1, we find a positive impact of insurance on risk-taking of roughly 33% and in Model 2, we find a positive impact of 28%. There is no additional impact of over-insurance on risk-taking in Model 2. We fail to find a significant impact of joint liability or a significant interaction between insurance and joint liability in either model.

These results suggest a strong positive impact of insurance on risk-taking. In Prediction 2a, we predicted insurance to increase risk-taking unambiguously when the premium is greater than or equal to actuarially fair. These conditions hold in our experiment and we confirm these results here, finding a robust positive impact of insurance on risk-taking. We fail to find evidence of an impact of joint liability or a statistically significant interaction effect, and therefore we fail to provide evidence for Prediction 3e.

Heterogeneous Treatment Effects

To attempt to disentangle the mechanisms identified in the theoretical model, we now turn to investigating heterogeneous treatment effects. Our theoretical model suggests that the impact of index insurance on risk-taking will depend on the default penalty, risk aversion, and social collateral under joint liability. We address each in turn.

In table 9, we report the fixed-effects model results for variation across risk aversion. Our theoretical model suggests that risk aversion will have an ambiguous effect on the impact of contingent credit on borrowing yet the impact of contingent credit on risk-taking will increase in risk aversion. To test this, we interact the contingent-credit treatment with our estimated CRRA risk aversion parameter value and report results for this interaction for both borrowing and risk-taking. For borrowing, we find no impact of contingent credit for risk neutral individuals yet a significant and positive impact as risk aversion increases. Contingent credit may increase borrowing for the more risk-averse farmers because these farmers are more likely to be risk rationed from the credit market in the absence of insurance. By reducing the likelihood of default and thereby reducing the likelihood of incurring default penalties, the insurance induces more risk averse farmers to enter the credit market. Furthermore, the insurance also increases risk-taking to a greater extent for the more risk averse, therefore providing these risk-averse farmers with a greater expected income after choosing to borrow.

For risk-taking, we find that at risk neutrality, insurance increases risk-taking by 15% and that a marginal increase in the CRRA parameter value increases risk-taking by 35%, consistent with Prediction 2b. Intuitively, this result may be due to the effect of the contingent credit on the failure state. Under contingent credit, the farmer is better off when failing than under an uninsured loan because either their loan is repaid or they face the same default penalty as under the uninsured loan. Therefore, more risk averse farmers who choose low risk without insurance to avoid the project failure state will be incentivized to take greater risk under contingent credit.

Next, we test for the impact of insurance across default penalty levels. Prediction 2c states that insurance will have a larger impact when default penalties are high. To test this, we look at variations in risk-taking decisions across rounds. Because there are a fixed number of rounds, participants know that there is a reduction in the cost of default because there are fewer future rounds in which to access the loan. Therefore, we would predict two changes across rounds. First, risk-taking should increase during later rounds as the dynamic incentive diminishes. Second, the impact of insurance should decline as the dynamic incentive diminishes. In table 10, we present results from a linear probability model of risk-taking on the treatments, round dummies, and the interaction between the round dummies and insurance[19]. If our prediction holds, the interaction terms between insurance and rounds will be negative, indicating a smaller impact of insurance when the dynamic incentive penalty declines. We find that risk-taking increases in round 5, which confirms that farmers do respond to changes in the dynamic incentive. We also confirm the results from our theoretical model, as we find that insurance has a significantly smaller impact on risk-taking during rounds 4 and 5. This finding holds for both individual and joint liability, confirming Predictions 2c and 3c.

Lastly, we look at variation in the impact of insurance across social collateral. Our theoretical model predicts an ambiguous effect of social collateral on the impact of contingent credit. In table 11, we present results from a fixed-effects regression model restricted to only joint liability treatments and including an interaction between the insurance treatment and social collateral. We find no significant change in risk-taking across social collateral levels, which is consistent with an ambiguous effect.

Repayment

Although the primary outcomes of interest in this experiment are borrowing and risk-taking, in this last section we will go beyond the model predications and investigate the impact of contingent credit on loan repayment rates. We are particularly interested in how contingent credit impacts repayment rates when considering both the mechanistic effect (increased loan repayment due to the insurance payout) and the behavioral effect (decreased loan repayment due to higher risk-taking). To disentangle these effects, we simulate the loan repayment rate for insured and uninsured individual and joint liability loans both with and without the behavioral effect on risk-taking. To capture the behavioral effects, we used predicted risk-taking levels from a probit model of risk-taking on the treatment variables and risk aversion[20]. In figure 3, we present our simulation results. Panel A shows the repayment rates for individual liability lending plotted against risk aversion. The graph includes repayment rates for the uninsured loan and contingent credit with and without the behavioral effect. Panel B shows the same results for joint liability. For individual liability, contingent credit 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 in the absence of insurance which reduces repayment rates and results in a larger impact. Factoring in the behavioral effect, we find that insurance still increases repayment yet to a lower extent for the least risk averse, due to the increased level of risk-taking. For joint liability, the contingent credit also increases repayment for the least risk averse yet actually reduces repayment for the most risk averse. This counter-intuitive result is due to the premium affecting repayment rates in the good systemic states. In good rainfall seasons, the price of the premium makes repayment more difficult when multiple members experience idiosyncratic shocks. Under the unique parameters of this experiment, when two out of three group members experienced an idiosyncratic shock, the third member could repay the group's loan only if they had taken the risky project. 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.

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 impact of index insurance on risk-taking under both individual and joint liability. Particularly, we are interested in their effects on borrowing and risk-taking, where risk-taking improves expected returns. To study these effects, we developed a theoretical model, derived predictions, and tested them using a framed field experiment in rural Tanzania. We generated several important and policy-relevant results.

First, index insurance backed contingent credit significantly improved borrowing in our experiments, which is a surprising result in light of the extant literature. However, our work in this article is consistent with other framed field experimental results that find robust demand for index insurance including the work of Norton et al. (2015). The divergence between lab-in-the-field results and RCTs may be due to differences in comprehension, product clarity, and institutional trust issues not present in the former but present in the latter. If true, in order to realize experimentally observed demand in real decision making, improvements in insurance product clarity and trust in relevant institutions is necessary; a conclusion noted elsewhere in the literature (Mishra et al. 2017; Clarke and Dercon 2009).

Second, index insurance backed contingent credit significantly increased risk-taking. Policy makers and development practitioners are primarily interested in microfinance contracts that will promote economic growth and poverty reduction and are therefore interested in how to promote profitable risk-taking. Our results suggest that index insurance is a promising tool to achieve this in the rural context when default penalties are sufficiently high. Furthermore, index insurance appears to be equally as effective when bundled with joint liability loan contracts as individual liability contracts. Our results suggest that in contexts in which collateral is minimal and dynamic incentives penalties are poorly enforced, index insurance will have a smaller impact. Therefore, reliable enforcement of contract terms will be necessary to ensure this effect.

Third, we found no significant interaction effect between insurance and joint liability on risk-taking or borrowing but a possible negative interaction for loan repayment. Furthermore, we found limited impacts of joint liability on risk-taking and a significant negative effect of joint liability on borrowing. These findings may be relevant for the growing debate over the relative benefits of individual and joint liability. First, we confirm previous findings that joint liability reduces demand for credit and demonstrate that index insurance does little to change this effect. As a consequence, individual-liability loans with insurance have an advantage over joint-liability loans with insurance in regards to farmer demand. Second, regarding promotion of profitable risk-taking, adding index insurance to individual liability may be just as effective as adding it to joint liability loans. Third, our results for loan repayment show that when the premium is sufficiently high to push groups into default in good systemic outcome years, insurance can reduce repayment rates under joint liability. These results suggest that when choosing between individual and joint liability insured loans, MFI's should carefully assess the impact of the insurance premium on the ability of joint liability group members to repay each other's loans in the absence of an insurance payout. Taken together, the introduction of index insurance backed contingent credit may favor the transition to individual-liability loan contracts already underway among many leading MFI's. The insurance has a strong positive impact on profitable risk-taking and repayment while not introducing a reduction in demand for credit. Favoring individual liability will be particularly pronounced in cases where the premium could push groups into default in good systemic years. Recent results from the Philippines show that individual liability achieves a comparable repayment rate as joint liability but with higher demand (Giné and Karlan 2014). In this context, the introduction of index insurance would do little to the demand difference but may have a larger positive impact on repayment rates under individual liability, making insurance more beneficial for individual liability contracts.

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Footnotes

1- Under a contingent credit contract, the bank, rather than the borrower, is the insurance policy holder. The insurance premium is added to the interest rate of the loan, and any insurance payouts are credited towards borrowers’ outstanding loan amount.

2- We assume that the interest rate is fixed, regardless of the contract structure or collateral requirement. We do this for two reasons. First, microfinance institutions in rural areas of developing countries often set fixed interest rates within a region to avoid confusion and accusations of unfairness by clients. Second, this matches well with our experimental design in which we assume interest rates are fixed in each treatment. In reality, a microfinance bank operating in a competitive market would vary the interest rate across contract structures to reflect differences in the probability of default. We present simulation results with endogenous interest rate in appendix. We find limited qualitative differences in these results relative to the exogenous interest rate. See the appendix for further discussion.

3- Loan principal normalized to 1.

4- For simplicity the default penalty is assumed to be fixed. However, in reality, the default penalty may vary due to a number of factors including the collateral requirement, discount factors, social norms, etc.

5- Actuarially fair premium π solves $\pi = (1+r)(1-q)(1+\pi)$. Solving for π, we find $\pi = \frac{(1+r)(1-q)}{1-(1+r)(1-q)}$.

6- We derive Assumption 2 from the optimal risk-taking level for the uninsured individual liability loan ($\tau^{*}_{IL,U}$) and the contingent credit individual liability loan ($\tau^{*}_{IL,I}$) found below. We simultaneously solve $\tau^{8}_{IL,U}$ and $\tau^{8}_{IL,I}$ for the value of B that ensures non-negative risk-taking and find $B > A + D(1-q) - R - RIq$ is a necessary and sufficient condition.

7- For joint liability: $P_h^{SS} = (1-\tau 1)(1-\tau 2)q + \varepsilon 1 + \varepsilon 2$; $P_h^{SF} = (1-\tau 1)t2q + \varepsilon 1 - \varepsilon 2$; $P_h^{FS} = \tau 1(1-\tau 2)q - \varepsilon 1 + \varepsilon 2$; $P_h^{FF} = \tau 1\tau 2q - \varepsilon 1 - \varepsilon 2$; $P_l^{SS} = (1-\tau 1)(1-\tau 2)(1-q) - \varepsilon 1 - \varepsilon 2$; $P_l^{SF} = \tau 2(1-\tau 1)(1-q) - \varepsilon 1 + \varepsilon 2$;$P_l^{FS} = \tau 1(1-\tau 2)(1-q) + \varepsilon 1 - \varepsilon 2$; $P_l^{FF} = \tau 1\tau 2(1-q) + \varepsilon 1 + \varepsilon 2$. Where $\varepsilon 1 = \rho\sqrt{\tau 1(1-\tau 1)q(1-q)}$ and $\varepsilon 2 = \rho\sqrt{\tau 2(1-\tau 2)q(1-q)}$ which are the correlations between farmer 1's probability of success and good rainfall and farmer 2's probability of success and good rainfall, respectively.

8- Under individual liability, the farmer fails with probability τ and experiences the default penalty $-D$. Under contingent credit, the farmer faced the default penalty only when she fails and the insurance does not pay, i.e. when there is a downside basis risk event, τq. Therefore, the farmer is strictly better off in the failure state under contingent credit $\tau q(-D) > \tau(-D)$.

9- The simulation assumes the following parameter values: $X = 8, \rho = 0.7, q = 0.7, A = 2, B = 8, r = 0.2, \beta = 1, D = 2, \sigma = 0.1$

10- Our methodology closely follows the experimental design of two recent articles that investigate the impacts of joint liability on risk-taking and effort levels in developing countries (Flatnes and Carter 2017; Giné, Jakiela, Karlan and Morduch 2010). Our primary contribution to the experimental design is the addition of index insurance backed contingent credit to individual and joint liability contracts while adopting the borrowing decision from Flatnes and Carter (2017) and a risk-taking decision similar to Giné et al. (2010).

11- $1 was roughly equivalent to 2,170 TZS at the time of the experiment.

12- 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.

13- The default penalty from dynamic incentives can be calculated as the discounted expected return from subsequent rounds of borrowing less the non-borrowing return. In round 1, the penalty of defaulting for a risk neutral borrower will be $DP = \sum_{i=1}^{4} P_j^i * (E[Payout_j] -$

$Payout_{not\ borrow}$), where P is the probability of repayment, $j \in \{safe, risky\}$, and we assume a discount factor of 1 given that rounds are only minutes apart. This dynamic incentive default penalty exceeds the loan repayment amount (for a safe investment strategy, the default penalty in round 1 is 153,000 TZS which is larger than the loan repayment amount).

14- In each case, the loan repayment amount consisted of the principal, interest, and the premium with a load. We first calculated the actuarially fair insurance policy based on the payouts and drought probabilities, then we rounded this value up to include the actuarially fair premium plus a load at an easily comprehendible round number.

15- The framed risk preference game was chosen over an unframed version used in Holt and Laury (2002) because recent literature has demonstrated that risk aversion measures typically vary between domains (Hanoch et al. 2006; Dohmen et al. 2012).

16- To specifically define each person's CRRA coefficient using their responses to the risk preference 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.

17- For example: "Please indicate who is a family member or close relative."

18- Two alternative approaches could be used in this case. First, a heckprobit model which uses a two-step regression model that explicitly controls for the selection decision. Second, we could use a semiparametric sample selection model. We also used both of these methods and a discussion of the approaches and findings can be found in the appendix. Using these approaches, we found similar results as the fixed effects model and only limited evidence for statistically significant sample selection. We therefore chose to present the fixed effects model here and present estimates from all three models in the appendix to demonstrate robustness.

19- We run this regression on a sample of only borrowers that borrow in all 5 seasons. We restrict the sample to control for the bias that arises from riskier farmers being more likely to drop out of the sample due to default. This would make insurance have a positive impact on risk-taking under future seasons simply because risky borrowers default less often under insurance and survive to later rounds. By restricting the sample to only those who survive to the last season, we are able to look at how behavior changes across seasons among this specific sub sample. Therefore, these results cannot be said to hold for the full sample.

20- We use a probit model rather than the LPM employed during the main analysis so that we may generate predicted values bounded between 0 and 1. The LPM and Probit models generate very similar qualitative results.

Appendix

Theoretical Model Proofs

Proposition 1 Proof

We begin with $\Delta_{IL}^{b} = \left[EU\left(C_{IL,I}\right) - U(\omega)\right] - \left[EU\left(C_{IL,U}\right) - U(\omega)\right]$. Substituting in the functional forms for the utility functions and assuming risk neutrality, constant risk-taking, and no correlation between the index and losses, we have:

$\Delta_{IL}^{b} = P^{S}q(Y - RI) + P^{S}(1 - q)(Y) + (1 - P^{S})q(-D) - \omega - P^{S}(Y - R) - (1 - P^{S})(-D) + \omega.$

$\Delta_{IL}^{b} = P^{S}(R - RIq) + (1 - P^{S})(1 - q)D.$

We then set $\Delta_{B}^{I} > 0$ and solve for the conditions under which this inequality holds. Assuming an actuarially fair insurance premium ($\beta = 1$) and solving for default penalty we find $D > \frac{RP^{S}(R-1)}{(1-P^{S})[1-R(1-q)]}$. Setting the $RHS > R$ and simplifying we find that the RHS is greater than R when $1 < R(1 - q + P^{S}q)$ which is true given $r \geq 0$ and $q \leq 1$. A similar procedure demonstrates *Proposition 1.b* for joint liability.

Proposition 2 Proof

By setting $\Delta_{IL}^{\tau} > 0$ and simplifying we find $\Delta_{IL}^{\tau} = \frac{q(RI-D)+D-R}{2B} > 0$. Assuming actuarially fair premium ($\beta = 1$) and solving for default penalty we find $D > \frac{R(1-R)}{1-R(1-q)}$. The RHS is negative given $r \geq 0$ and assuming $q > r$ (Assumption 3). Therefore, for $\forall\ X > 0$ and $\beta \geq 1$, $\Delta_{IL}^{\tau} > 0$.

Taking the derivative of Δ_{IL}^{τ} with respect to the default penalty we find $\frac{\partial \Delta_{IL}^{\tau}}{\partial D} = \frac{1-q}{2B} > 0$, which demonstrates that the impact of insurance on risk-taking increases in default penalties.

Proposition 3 Proof

First we set $\Delta_{JL}^{\tau} = \frac{[B-A+RIq(1-\sigma)][2B-R(1+\sigma)+X)]-[B-A+R(1-\sigma)][2B-RIq(1+\sigma)+Xq]}{[2B-RIq(1+\sigma)+Xq][2B-R(1+\sigma)+X)]} > 0$. Acknowledging that the denominator is unambiguously positive when $B > A > 2RI$ (Assumptions 1 and 2), identifying the conditions under which the numerator is positive is sufficient to establish when contingent credit will increase risk-taking. Simplifying the numerator and setting it greater than 0 we find $D(1-q)(B-A) + [RIq - R]\Omega > 0$, where $\Omega = (1+\sigma)(B-A) + (1-\sigma)(2B)$. Assuming an actuarially fair premium ($\beta = 1$) and solving for default penalty we find $D > \frac{R\Omega(1-R)}{(B-A)\left(1-R(1-q)\right)-R(1-R)(1-\sigma)q}$. The RHS is negative given $r \geq 0$ and assuming $q > r$ (Assumption 3). Therefore, for $\forall\ X > 0$ and $\beta \geq 1$, $\Delta_{JL}^{\tau} > 0$.

Taking the derivative of Δ_{JL}^{τ} with respect to the default penalty we find $\frac{\partial \Delta_{JL}^{\tau}}{\partial D} = \frac{-q[B-A+RIq(1-\sigma)}{[2B+Dq-RIq(1+\sigma)]^2} + \frac{[B-A+R(1-\sigma)}{[2B+D-R(1+\sigma)]^2} \approx 0$, thus the effect of default penalties on the impact of contingent credit on risk-taking under joint liability is ambiguous. Taking the derivative of Δ_{JL}^{τ} with respect to social collateral we find $\frac{\partial \Delta_{JL}^{\tau}}{\partial \sigma} = \frac{RIq[RIq-B-A-Dq]}{[2B+Dq-RIq(1+\sigma)]^2} + \frac{R[B+A+D-R(1-\sigma)}{[2B+D-R(1+\sigma)]^2} \approx 0$, thus the effect of social collateral on the impact of contingent credit on risk-taking under joint liability is also ambiguous.

Endogenous Interest Rate

Our theoretical model and simulation both assume constant interest rate. However, a bank operating in a competitive market will adjust their interest rate in response both to changes in risk-taking by the borrowers and the presence of the insurance. Therefore, the impact of contingent credit cannot be fully accounted for without allowing the interest rate to adjust to changes in the the loan contract and the borrowers behavior. Here we will set up and simulate our results with an endogenized interest rate, taking into account the bank's response to insurance and borrower behavior. We assume that the bank internalizes the borrowers' risk-taking decision yet the borrower is a price taker and therefore does not internalize the bank's profit maximization process. Therefore, we solve the bank's zero profit function for interest rate $r^*_{k,j} = argmax[\Pi_{k,j}(\tau)]$. Then we substitute into the optimal risk-taking decisions and solve for $\tau^{**}_{k,j}$, the optimal risk-taking with endogenized interest rate. The bank's zero profit functions are as follows:

$$\Pi_{IL,U}(\tau) = (1-\tau)r - \phi \quad \text{[A1]}$$

$$\Pi_{IL,I}(\tau) = [(1-\tau)q + e]r + [(1-\tau)(1-q) - e]r + [\tau(1-q) + e]r - \phi \quad \text{[A2]}$$

$$\Pi_{JL,U}(\tau_1,\tau_2) = (1-\tau_1)(1-\tau_2)r + \tau_1(1-\tau_2)r + \tau_2(1-\tau_1)r - \phi \quad \text{[A3]}$$

$$\Pi_{JL,I}(\tau_1,\tau_2) = [(1-\tau_1)(1-\tau_2)q + e_1 + e_2]r + [\tau_1(1-\tau_2)q - e_1 + e_2]r + [\tau_2(1-\tau_1)q + e_1 - e_2]r + (1-q)r - \phi \quad \text{[A4]}$$

Solving the zero profit functions for $r^*_{k,j}$ we find: $r^*_{IL,U} = \frac{\phi}{1-\tau}$, $r^*_{IL,I} = \frac{\phi}{e+1-\tau q}$, $r^*_{JL,U} = \frac{\phi}{1-\tau_1\tau_2}$, $r^*_{JL,I} = \frac{\phi}{e_1+e_2+1-\tau_1\tau_2 q}$. Substituting these endogenized interest rate functions into the optimal risk-taking functions we have:

Optimal risk-taking with endogenized interest rate $\tau^{**}_{IL,U}$ solves: $\tau = \frac{B-A+(1+\frac{\phi}{1-\tau})-D}{2B}$.

$\tau^{**}_{IL,I}$ solves: $\tau = \frac{B-A+q((1+\frac{\phi}{e+1-\tau q})(1+\theta(r^*_{IL,I}(\tau))-D)}{2B}$.

$\tau^{**}_{JL,U}$ solves: $\tau = \frac{B-A+(1+\frac{\phi}{1-\tau_1\tau_2})(1-\sigma)}{2B-(1+\frac{\phi}{1-\tau_1\tau_2})(1+\sigma)+X}$

$\tau^{**}_{JL,I}$ solves: $\tau = \frac{B-A+(1+\frac{\phi}{e_1+e_2+1-\tau_1\tau_2 q})(1+\theta(r^*_{JL,I}(\tau))q(1-\sigma)}{2B-(1+\frac{\phi}{e_1+e_2+1-\tau_1\tau_2 q})(1+\theta(r^*_{JL,I}(\tau))q(1+\sigma)+Xq}$

We then calculate the impact of contingent credit on risk-taking as

$$\Delta_k^{\tau} = \tau_{k,I}^{**} - \tau_{k,U}^{**},$$

and the impact of contingent credit on borrowing as

$$\Delta_k^{b}\left(\tau_{k,I}^{**}, \tau_{k,U}^{**}\right) = \left[EU\left(C_{k,I}(\tau_{k,I}^{**})\right) - U(\omega)\right] - \left[EU\left(C_{k,U}\left(\tau_{k,U}^{**}\right)\right) - U(\omega)\right].$$

Below, in figure A.1, we present side by side simulation results for exogenous and endogenous interest rate for the impact of contingent credit on risk-taking. In Figure A.2 we do the same for borrowing.

Comparing results for exogenous and endogenous interest rate reveal qualitatively similar results. There is, however, one notable difference. With the endogenous interest rate, the impact of contingent credit on risk-taking is no longer unambiguous, and becomes negative for low levels of default penalties and risk aversion. Intuitively we may understand why by considering the derivative of Δ_{IL}^{τ} with respect to the interest rate, $\frac{\partial \Delta_{IL}^{\tau}}{\partial r} = \frac{1}{2B} > 0$ ($\frac{\partial \Delta_{JL}^{\tau}}{\partial r} > 0$, as well). In a competitive market, the bank will set the interest rate considering the impact of insurance on repayment. Contingent credit will have higher repayment mechanically (by repaying the loan under a triggering event) and reduced repayment behaviorally (by increasing risk-taking). If the mechanical effect dominates the behavioral effect, repayment will increase resulting in a reduction in the interest rate faced by the borrowers. Under a reduced interest rate, borrowers have less incentive to take on additional risk thus making it possible for contingent credit to reduce risk-taking.

Selection Model Robustness Check

In this section, we present two modeling frameworks to control for sample selection. We will then present some summary results from each approach and show that our results are fairly robust across models and that we fail to find evidence of statistically significant selection bias.

Probit Model with Sample Selection

To analyze the risk-taking decision, we use a probit model with sample selection (also known as a Heckprobit model) following Van de Ven and Van Pragg (1981). We use the Heckprobit model to correct for potential sample selection bias arising from the risk-taking data being truncated by the decision to borrow. The Heckprobit model controls for the selection process through jointly modeling the outcome of interest and the selection process.

The true model of the outcome of interest is the latent, continuous, risk-taking variable:

$$RISK_{i,t,r}^{*} = \beta_0 + \beta_1 II_t + \beta_2 OI_t + \beta_3 JL_t + \beta_4 JL_t * II_t + \beta_5 JL_t * OI_t + \beta_6 GSC_{i,t} + \beta_7 RA_i + \beta_8 X_i + \Gamma + R_t + \epsilon_{i,t,r} \quad \text{[A.5]}$$

$$= \boldsymbol{X_{i,t,r}B} + \epsilon_{i,t,r}$$

Where r indicates round, $GSC_{i,t}$ is the experimentally assigned group level social capital index, and $RISK_{i,t,r}^{*}$ is the risk level. We only observe the binary risk-taking decision from the experimental game, which is modeled as a probit model: $RISK_{i,t,r} = \mathrm{I}(RISK_{i,t,r}^{*} > 0)$ where $RISK_{i,t,r}$ is the binary risk level ($RISK_{i,t,r} \in \{0,1\}$). However, due to the truncation, the binary decision is only observed for those choosing to borrow. We specify this selection equation as a probit model of the borrowing function:

$$B_{itr} = I(\theta_0 + \theta_1 II_t + \theta_2 OI_t + \theta_3 JL_t + \theta_4 JL_t * II_t + \theta_5 JL_t * OI_t + \theta_6 SSC_{i,t} + \theta_7 RA_i + \theta_8 X_i + \theta_9 EX_i + \Gamma + u_{i,t,r} > 0) \quad \text{[A.6]}$$

$$= I(\boldsymbol{Z_{i,t,r}}\boldsymbol{\Theta} + u_{i,t,r} > 0)$$

Where EX_i is an exclusion restriction which we discuss below. Assuming $\epsilon_{i,t,r} \sim N(0,1)$, $u_{i,t,r} \sim N(0,1)$, and $corr(\epsilon_{i,t,r}, u_{i,t,r}) = \rho$, we estimate the coefficients using maximum likelihood with the log-likelihood function:

$$lnL = \sum_{\substack{i,t,r\epsilon S \\ RIsk_{i,t,r} \neq 0}} \ln(\Phi_2(\boldsymbol{X_{i,t,r}B}, \boldsymbol{Z_{i,t,r}\Theta}, \rho)) + \sum_{\substack{i,t,r\epsilon S \\ Risk_{i,t,r}=0}} \ln(\Phi_2(-\boldsymbol{X_{i,t,r}B}, \boldsymbol{Z_{i,t,r}\Theta}, -\rho))$$

$$+ \sum_{i,t,r \notin S} \ln(1 - \Phi(\boldsymbol{Z_{i,t,r}\Theta}))$$

Where S is the set of observations for which $Risk_{i,t,r}$ is observed, Φ_2 is the cumulative bivariate normal distribution and Φ is the standard cumulative normal distribution.

Semi Parametric Sample Selection Model

An alternative to the Heckprobit model is a semiparametric sample selection model. In this model we avoid distributional assumptions over the error terms and avoid heteroscedasticity bias as in the probit model. To analyze the risk-taking decision, we estimate a truncated sample selection model semi parametrically to identify coefficients A in the model

$$R_{i,t,r} = B_{i,t,r} * [X_{i,t,r}\text{A} + \epsilon_{i,t,r}]. \qquad \text{[A.7]}$$

Where $R_{i,t,r}$, risk-taking, for individual i in treatment t and round r is a function of regressors $X_{i,t,r}$, error term $\epsilon_{i,t,r}$, and the indicator variable $B_{i,t,r}$ that determines the truncation based on the decision to borrow. The borrowing decision is modeled as a standard binary response model,

$$B_{i,t,r} = 1(W_{i,t,r}\Theta + v_{i,t,r} > 0) \qquad \text{[A.8]}$$

where $W_{i,t,r}$ are regressors and $v_{i,t,r}$ is the error term.

Due to the selection process, there is a dependence between error terms ϵ and v that will introduce bias in the coeffeicient estimates of equation [A.7]. We can restate equation [A.7] as:

$$R_{i,t,r} = X_{i,t,r}\mathrm{A} + \boldsymbol{\lambda}\big(\boldsymbol{W_{i,t,r}\Theta}\big) + u_{i,t,r} \qquad \text{[A.9]}$$

where

$$\boldsymbol{\lambda}(\boldsymbol{W_{i,t,r}\Theta}) = E[\epsilon_{i,t,r}|u_{i,t,r} > -\boldsymbol{W_{i,t,r}}\Theta].$$

We follow Klein and Spady (1993) and use quasi maximum likelihood to estimate $\widehat{\boldsymbol{\Theta}}$ non parametrically and then incorporate a polynomial approximation of $\gamma(Z_{i,t,r}\Theta)$ to control for sample selection.

$$\boldsymbol{\lambda}(\boldsymbol{W_{i,t,r}\Theta}) \cong \sum_{l=0}^{L} \boldsymbol{\gamma_l}(\boldsymbol{W_{i,t,r}\Theta})^{l}$$

Therefore, we model the risk-taking decision as a partially linear model with a function $\gamma(\boldsymbol{W_{i,t,r}\Theta})$ denoting the bias due to sample selection. Our final model is as follows:

$$R_{i,t,r} = \alpha_1 II_t + \alpha_2 JL_t + \alpha_3 JL_t * II_t + X_{i,t,r}A + \textstyle\sum_{l=0}^{L} \gamma_l\big(Z_{i,t,r}\Theta\big)^{l} + u_{i,t,r} \qquad \text{[A.7]}$$

Where JL_t is a dummy variable indicating the presence of joint liability, I_t is a dummy variable indicating the presence of index insurance, and $JL_t * I_t$ is an interaction term between joint liability and index insurance.

Both modeling framworks require the selection model to include a valid exclusion that impacts the selection decision but does not directly impact the second stage outcome, and therefore correlated with the error term. As the exclusion restriction, we use a carefully designed survey question called the “borrowing game” to elicit participants’ propensity to borrow. Based on pre-testing and informal conversations, many participants thought that since they were actual borrowers, they should borrow in the game; a behavior we are calling a latent propensity to borrow. To capture this phenomenon, we designed a survey question meant to elicit the propensity to borrow while avoiding all other borrowing-related concerns including complexity or risk. The question provided a very simple framed agricultural loan borrowing decision in which the participant is presented with a scenario and given the choice of whether to borrow or not. In this question design, unlike in the experiment, the decision to borrow involved no risk, and both choices resulted in the same payout at the end, leaving no real difference between borrowing and not borrowing. The question is available in the last section of the appendix. This propensity to borrow based on real experience cannot be translated into the risk-taking decision because the risk-taking decision was framed in terms to two seed types not currently available for farmers. Therefore, this exclusion restriction based on experience based propensity to borrow should be uncorrelated with the outcome variable, which is confirmed through regression of the outcome variable on the borrowing game (results available upon request).

Summary Results

Appendix table 3 present results from our results section side by side with estimates from the heckprobit model and the semi parametric sample selection model. We find that our estimations are robust across models, especially in terms of the trends. We also find no evidence of sample selection, therefore justifying the use of the individual fixed effects models in the body of this article.

Select Survey Questions

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.)

Appendix table 4 is an English language version of the table of payoffs shows to participants.

Social Network Questions

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

Figures and Tables

Table 1: Theoretical Model Payout Structures under Analytical Assumptions

The first row in each panel gives the outcome probability where superscript S indicates a successful project and F indicates a failed project. The subscript indicates the index value where l denotes a state in which there is a trigger. For joint liability the first superscript denotes the outcome of the farmer's own project and the second superscript denotes the outcome of the partner's project. The second row in each panel presents the consumption in each state for an uninsured loan, where wealth is suppressed for clarity. The third row in each panel presents consumption in each state for a contingent credit loan.

A. Individual Liability

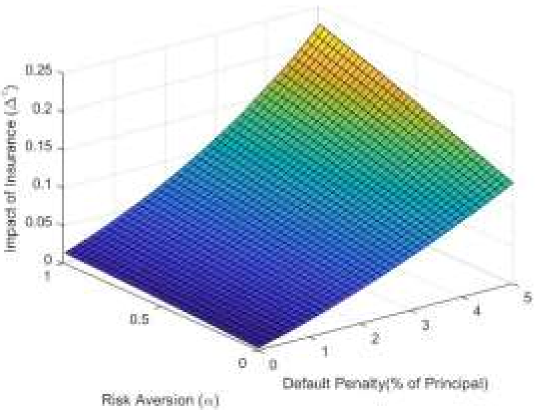
Probability	P_h^S	P_l^S	P_h^F	P_l^F
Without Insurance	$Y(\tau) - R$	$Y(\tau) - R$	$-D$	$-D$
With Insurance	$Y(\tau) - RI$	$Y(\tau)$	$-D$	0

B. Joint Liability

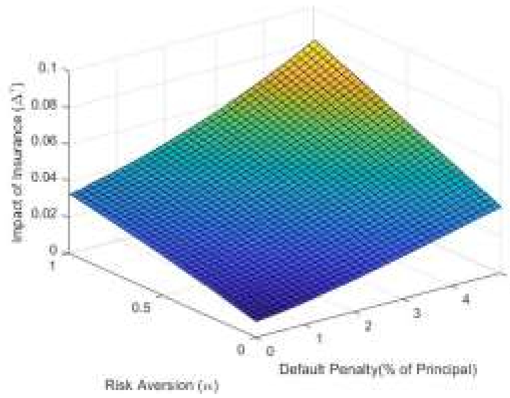
Probability	P_h^{SS}	P_h^{SF}	P_h^{FS}	P_h^{FF}	P_l^{SS}	P_l^{SF}	P_l^{FS}	P_l^{FF}
Without Insurance	$Y(\tau) - R$	$Y(\tau) - 2R$	$-\sigma R$	$-D$	$Y(\tau) - R$	$Y(\tau) - 2R$	$-\sigma R$	$-D$
With Insurance	$Y(\tau) - R\mathrm{I}$	$Y(\tau) - 2RI$	$-\sigma RI$	$-D$	$Y(\tau)$	$Y(\tau)$	0	0

Figure 1: Impact of contingent credit on risk-taking

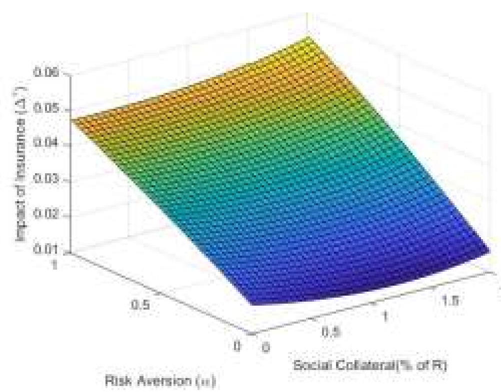
A. Individual Liability



B.1 Joint Liability



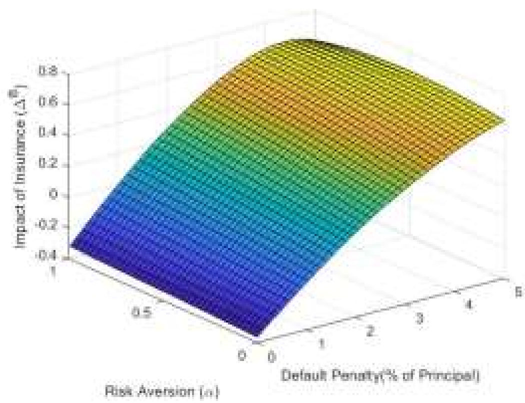
B.2 Joint Liability



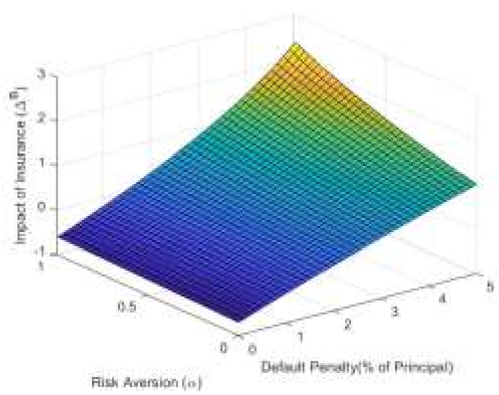
Panel A presents the impact of contingent credit on risk-taking vs risk aversion (x-axis) and default penalty (y-axis) for individual liability. Panel B.1 presents the impact of contingent credit on risk-taking vs risk aversion (x-axis) and default penalty (y-axis) for joint liability. Panel B.2 presents the impact of contingent credit on risk-taking vs risk aversion (x-axis) and social collateral (y-axis) for joint liability.

Figure 2: Impact of insurance on borrowing

A. Individual Liability



B. Joint Liability



Panel A presents the impact of contingent credit on borrowing vs risk aversion (x-axis) and default penalty (y-axis) for individual liability. Panel B presents the impact of contingent credit on borrowing vs risk aversion (x-axis) and default penalty (y-axis) for joint liability. The impact on borrowing is determined by calculating the certainty equivalent with insurance and without insurance. Therefore, the impact is measured in certainty equivalent consumption units.

Table 2: Payout Structure Without Insurance

The payout structure for the experimental design. Participants had a borrowing decision and risk-taking decision if they chose to borrow. This table presents the payouts under each decision as well as the probabilities for each outcome.

Decision	Systemic Outcome	Idiosyncratic Outcome	Compound Probability	Repayment Amount	Crop Payoff	Net Payoff
Not Borrowing	N/A	N/A	100%	N/A	100,000	100,000
Safe	Good Rains	Good	49.00%	60,000	300,000	240,000
		Poor	7.00%		250,000	190,000
		Very Poor	14.00%		0	0, Default
	Drought	Good	21.00%		250,000	190,000
		Poor	3.00%		0	0, Default
		Very Poor	6.00%		0	0, Default
Risky	Good Rains	Good	49.0%	60,000	600,000	540,000
		Poor	7.0%		0	0, Default
		Very Poor	14.00%		0	0, Default
	Drought	Good	21.0%		0	0, Default
		Poor	3.0%		0	0, Default
		Very Poor	6.00%		0	0, Default

Table 3: Treatment Description

Table 3 demonstrates the correspondence between treatment name and treatment characteristic.

	Individual Liability	Joint Liability
No Insurance	Treatment 1	Treatment 4
Insurance	Treatment 2	Treatment 5
Over-insurance	Treatment 3	Treatment 6

Table 4: Frame Risk Preference Game

Table 4 presents the expected payout and the implied CRRA parameter range for each decision under the general experiment setup.

	Expected Payout	CRRA Range
Not Borrow	100,000	$[0.67 , \infty]$
Safe	170,800	[0.49 , 0.67]
Risky	264,600	$[-\infty , 0.49]$

Table 5: Descriptive Statistics

Table 5 presents descriptive statistics for the sample population.

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	5.4	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
Social Capital Index	395	0.16	0.01

Table 6: Borrowing and Risky Project Choice Averages

Table 6 presents treatment effects of contingent credit by demonstrating mean differences between insurance treatments and non-insurance treatments for the borrowing (Panel A) and risk-taking (Panel B) decisions. The second column presents the treatment without insurance, the third column presents the treatment with insurance and the fourth column presents the difference with significance.

Comparison			Difference
A. Borrowing Decision			
Impact of CC in Individual Liability	Treatment 1 0.74	Treatment 2 0.81	0.07*
Impact of CC (with over insurance) in Individual Liability	Treatment 1 0.74	Treatment 3 0.89	0.15***
Impact of CC in Joint Liability	Treatment 4 0.67	Treatment 5 0.75	0.08*
Impact of CC (with over insurance) in Joint Liability	Treatment 4 0.67	Treatment 6 0.77	0.09**
B. Risk Taking Decision			
Impact of CC in Individual Liability	Treatment 1 0.17	Treatment 2 0.45	0.28***
Impact of CC (with over insurance) in Individual Liability	Treatment 1 0.17	Treatment 2 0.55	0.37***
Impact of CC in Joint Liability	Treatment 4 0.19	Treatment 5 0.51	0.31***
Impact of CC (with over insurance) in Joint Liability	Treatment 4 0.19	Treatment 6 0.61	0.42***

Note: p<0.1 *,p<0.05 **, p<0.01 ***; CC= contingent credit

Table 7: Borrowing Decision

Table 7 presents treatment effects on the borrowing decision.

Variables	Model 1 Combined Insurance	Model 2 Disaggregated Insurance
Insurance	0.11***	0.085**
Over-insurance		0.051
Joint Liability	-0.067**	-0.067**
Joint Liability + Insurance	-0.025	0.004
Joint Liability + Over-insurance		-0.05
Individual Fixed Effects	YES	YES
N	1,614	1,614

Notes: p<0.1 *, p<0.05 **, p<0.01 ***; Clustered robust standard errors at individual level

Table 8: Risky Project Choice

Table 8 presents results for the impact of treatments on risk-taking.

Variables	Model 1 Combined Insurance	Model 2 Disaggregated Insurance
Insurance	0.33***	0.28***
Over-insurance		0.08
Joint Liability(JL)	0.02	0.02
JL*Insurance	0.03	0.03
JL*Over-insurance		0.002
Individual Fixed Effects	YES	YES
N	1,223	1,223

Note: p<0.1 *, p<0.05 **, p<0.01 ***; Clustered robust standard errors at individual level

Table 9: Heterogeneous Treatment Effects by Risk Aversion

Table 9 presents results for treatments interacted with risk aversion to identify the heterogeneous treatment effect across risk aversion level.

	Borrowing	Risk Taking
Insurance	-0.09	0.15*
Insurance*CRRA Parameter	0.36**	0.35***
Individual Fixed Effects	YES	YES
N	1,614	1,223

Notes: p<0.1 *, p<0.05 **, p<0.01 ***; Clustered robust standard errors at individual level. Impacts of Joint Liability, insurance-joint liability interaction, or their interactions with risk aversion are not reported but were included in the models. There were no statistically significant results for interactions between insurance and joint liability.

Table 10: Heterogeneous Treatment Effects by Round

Table 10 regresses the risk-taking decision on the treatment variables, round dummies, and interactions between the treatment and round dummies. The models are restricted to data from individuals that successfully borrowed for all 5 rounds.

Risk Taking	Full Sample	Individual Liability	Joint Liability
Index Insurance	0.46***	0.46***	0.37***
Joint Liability	0.14***		
Joint Liability*Insurance	-0.09**		
Round 2	0.003	0.009	0.0
Round 3	0.009	0.0	0.01
Round 4	0.022	0.02	0.02
Round 5	0.059***	0.05**	0.06***
Insurance*Round 2	-0.019	-0.02	-0.019
Insurance*Round 3	-0.031	-0.04	-0.024
Insurance*Round 4	-0.048**	-0.06*	-0.04
Insurance*Round 5	-0.074***	-0.09***	-0.06*
Group Fixed Effects	YES	YES	YES
Controls	YES	YES	YES
N	3,875	1,430	2,445

Notes: p<0.1 *, p<0.05 **, p<0.01 ***; Clustered robust standard errors at individual level.

Table 11: Social Collateral

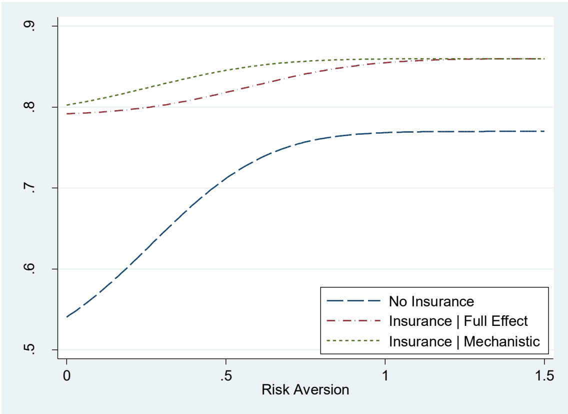
Table 11 presents the treatment effect of insurance interacted with the social collateral index. The model uses data exclusively from the joint liability treatments.

Risk Taking	
Insurance	0.36***
Insurance*Social Collateral	-0.21
Individual Fixed Effects	YES
N	573

Notes: p<0.1 *, p<0.05 **, p<0.01 ***; clustered robust standard errors at individual level

Figure 3: Simulation of repayment rates

A. Individual Liability



B. Joint Liability

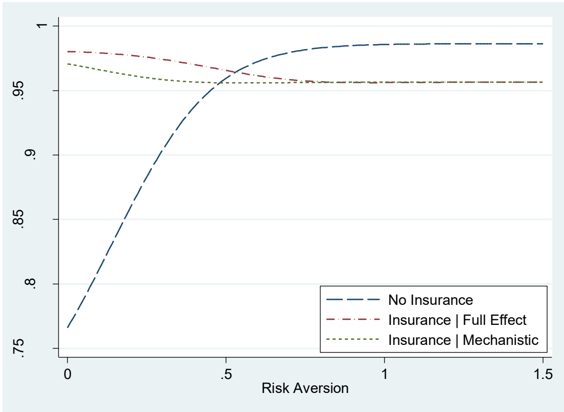


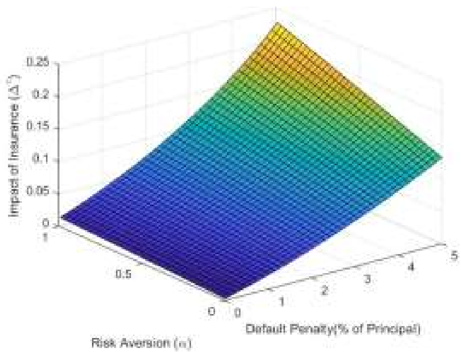
Figure 3 demonstrates simulated repayment rates for treatments with and without insurance for individual liability (Panel A) and joint liability (Panel B). "Full effect" refers to the repayment rate that considers both mechanistic and behavioral impacts of insurance. "Mechanistic" refers to the repayment rate when only considering the mechanistic impact of insurance.

Appendix Figures and Tables

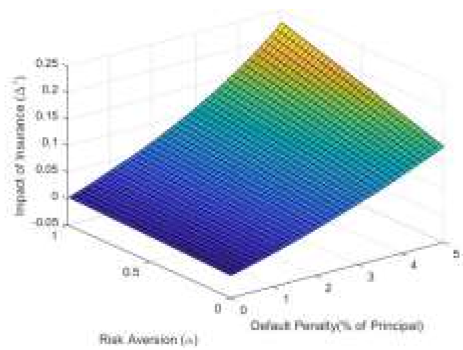
Figure A.1: Impact of contingent credit on risk-taking

Exogenous Interest Rate — Endogenous Interest Rate

A. Individual Liability

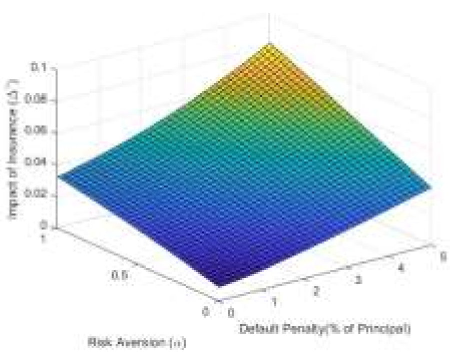


A.1

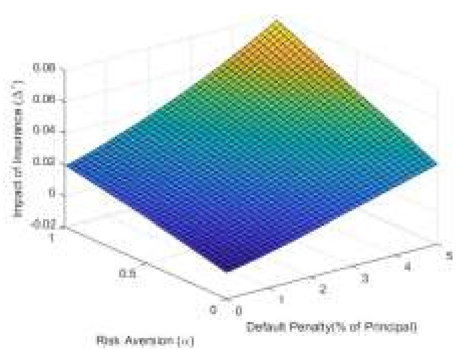


A.2

B. Joint Liability



B.1



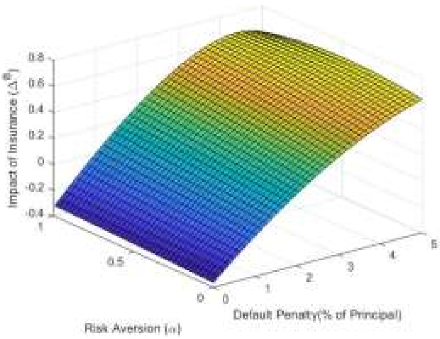
B.2

Panel A presents the impact of contingent credit on risk-taking vs risk aversion (x-axis) and default penalty (y-axis) for individual liability. A.1 shows results for exogenous interest rate and A.2 for endogenous interest rate. Panel B presents the impact of contingent credit on risk-taking vs risk aversion (x-axis) and default penalty (y-axis) for joint liability. B.1 shows results for exogenous interest rate and B.2 for endogenous interest rate.

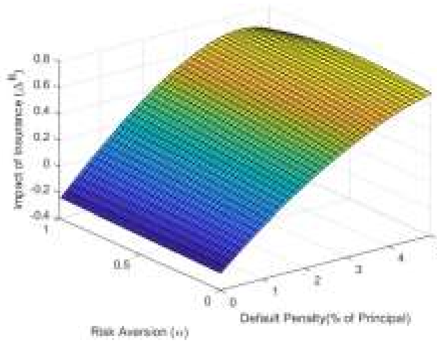
Figure A.2: Impact of contingent credit on borrowing

Exogenous Interest Rate Endogenous Interest Rate

A. Individual Liability

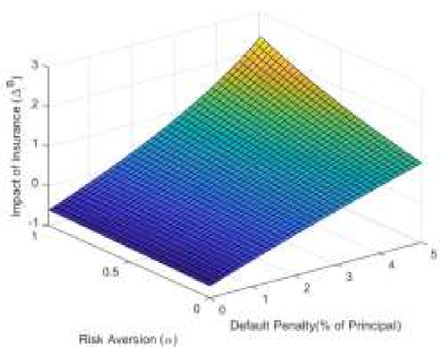


A.1

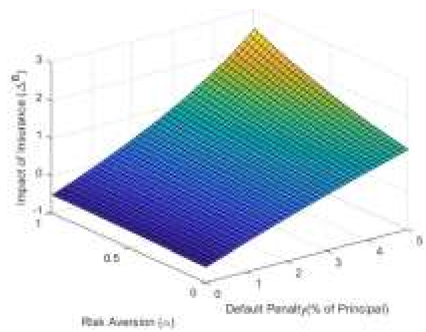


A.2

B. Joint Liability



B.1



B.2

Panel A presents the impact of contingent credit on borrowing vs risk aversion (x-axis) and default penalty (y-axis) for individual liability. A.1 shows results for exogenous interest rate and A.2 for endogenous interest rate. Panel B presents the impact of contingent credit on borrowing vs risk aversion (x-axis) and default penalty (y-axis) for joint liability. B.1 shows results for exogenous interest rate and B.2 for endogenous interest rate.

Appendix Table 1: Payout Structure | Insurance

The payout structure for the experimental design with insurance. Participants had a borrowing decision and risk-taking decision if they chose to borrow. This table presents the payouts under each decision as well as the probabilities for each outcome.

Decision	Systemic Outcome	Idiosyncratic Outcome	Net Probability	Repayment Amount	Crop Payoff	Net Payoff
Not Borrowing	N/A	N/A	100%	N/A	100,000	100,000
Safe	Good Rains	Good	49.00%	90,000	300,000	210,000
		Poor	7.00%		250,000	160,000
		Very Poor	14.00%		0	0, Default
	Drought	Good	21.00%		250,000	250,000
		Poor	3.00%		0	0
		Very Poor	6.00%		0	0
Risky	Good Rains	Good	49.0%	90,000	600,000	510,000
		Poor	7.0%		0	0, Default
		Very Poor	14.00%		0	0, Default
	Drought	Good	21.0%		0	0
		Poor	3.0%		0	0
		Very Poor	6.00%		0	0

Appendix Table 2: Payout Structure | Over-insurance

The payout structure for the experimental design with over-insurance. Participants had a borrowing decision and risk-taking decision if they chose to borrow. This table presents the payouts under each decision as well as the probabilities for each outcome.

Decision	Systemic Outcome	Idiosyncratic Outcome	Net Probability	Repayment Amount	Crop Payoff	Net Payoff
Not Borrowing	N/A	N/A	100%	N/A	100,000	100,000
Safe	Good Rains	Good	49.00%	120,000	300,000	180,000
		Poor	7.00%		250,000	130,000
		Very Poor	14.00%		0	0, Default
	Drought	Good	21.00%		250,000	300,000
		Poor	3.00%		0	50,000
		Very Poor	6.00%		0	50,000
Risky	Good Rains	Good	49.0%	120,000	600,000	480,000
		Poor	7.0%		0	0, Default
		Very Poor	14.00%		0	0, Default
	Drought	Good	21.0%		0	50,000
		Poor	3.0%		0	50,000
		Very Poor	6.00%		0	50,000

Appendix Table 3: Risk Taking Decision – Model Robustness Checks – Continued

Appendix table 3 present results for the fixed effects model side by side with the heckprobit model and the semi-parametric sample selection model to demonstrate the robustness of the results using sample selection models. FE refers to individual fixed effects model, Heckprob refers to the heckprobit model, and Semi refers to the semiparametric model. A significant athrho suggests that there is sample selection. The Joint F-Stat is used to test the joint significance of the polynomial terms in the semi parametric sample selection model.

		Treatment			Heterogeneous Effects – Risk Aversion	
Risk Taking	FE	Heckprob	Semi	FE	Heckprob	Semi
Insurance (I)	0.33***	0.28***	0.32***	0.15*	0.07	0.20**
Joint Liability (JL)	0.02	0.09**	0.02	-0.24***	-0.25***	-0.4***
JLI	0.03	-0.03	0.02	0.13	0.1	0.02
CRRA					-1.04***	-0.9***
I*CRRA				0.35**	0.6***	0.25*
JL*CRRA				0.5***	0.76***	0.53***
JLI*CRRA				-0.21	-0.4*	-0.05
athro		-1.06*			-0.5	
Joint F-Stat			1.60			1.77
Individual Controls	NO	YES	NO	NO	YES	NO
Group Fixed Effects	NO	NO	NO	NO	YES	NO
Individual Fixed Effects	YES	NO	NO	YES	NO	NO
N	1223	1556	1218	1223	1556	1218

Notes: p<0.1 *, p<0.05 **, p<0.01 ***; clustered robust standard errors at individual level for the individual fixed effects model.

Appendix Table 4: Borrowing Game Payout Structure

Appendix table 4 provides the payout structure for the borrowing game used to elicit propensity to borrow. The game is designed to provide participants with a risk free decision to borrow or not borrow in which each decision results in the same outcome.

	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