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Credit, insurance and farmers' liability: evidence from a lab in the field experiment with coffee farmers in Costa Rica*

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Abstract:

This paper examines the effect of farmers' liability on demand for credit with and without insurance. We test predictions of a theoretical model in a lab in the field experiment with coffee farmers in Costa Rica. Farmers choose how much to invest in six different settings, described on the one hand by whether the loan is insured or not, and on the other by their liability. Our results show that the uptake of loans bundled with insurance is significantly higher than the uptake of loans without insurance, when farmers are liable for sure, and when there is uncertainty about their liability. In the case of limited liability, the uptake of credit is high irrespective of whether the loans are insured or not. Our results suggest that in order to increase the uptake of insurance as a strategy to increase private investment and reduce the vulnerability of farmers to shocks, it is important that farmers are liable with at least some probability.

Keywords: credit, insurance, liability, agriculture

1. Introduction

To cope with losses from extreme hydro-meteorological events, governments typically implement disaster relief programs and offer debt relief to affected parties (The World Bank, 2007). For example, agricultural banks in developing countries frequently cooperate with poor agricultural borrowers after they experience a significant loss, restructuring their loans, and sometimes outright canceling outstanding debts (Carter et al., 2007). However, governments in general and in developing countries in particular have a limited capacity to help. Moreover, in the context of climate change, debt relief practices are becoming less viable because the risk is systemic and losses can easily surpass most governments' debt relief budgets. An example of systemic risk is exposure to increasingly frequent floods and droughts, as predicted under climate change scenarios for Central America[1]. Insurance is potentially an alternative, but in developing countries insurance markets are thin (Carter et al., 2014).

Rural households in developing countries face a number of credit constraints and market imperfections that shape investment decisions (Karlan et al., 2014). In the absence of insurance markets, "risk rationing", as explained by Boucher et al. (2008), suggests that the borrower voluntarily withdraws from taking a loan, due to the risk of losing collateral (Giné and Yang, 2009). Traditional formal insurance instruments can be used to manage risks, but such insurance services are basically non-existent in rural areas of developing countries (Carter et al., 2014). This lack of insurance markets might aggravate the effect of risk rationing on credit uptake (Boucher et al., 2008; Giné and Yang, 2009). The combination of credit and crop insurance, therefore, could be applied as a mechanism to improve credit markets and encourage investment in the agricultural sector (Carter et al., 2014), but has received only limited attention in empirical research to date (Marr et al. 2016).

A number of previous studies have focused on the combined effects of credit and insurance on investment, and the effects of insurance on credit demand and vice versa.[2] The evidence is mixed. When combining credit and insurance, some studies find credit with insurance increases investment (i.e., fertilizer purchase) (Hill and Viceisza, 2012), while others find that mandatory insurance actually reduces the demand for credit (Giné and Yang, 2009) or has no effect on investment and adoption of new technologies (Brick and Visser, 2014). Finally,

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[1] Systemic and highly covariate weather risks can be insured with the appropriate reinsurance. See Carter (2013) for a review on insurance partnerships for agricultural insurance markets.

[2] See Marr et al. (2016) for a review of the most recent literature on index insurance and bundling insurance with credit.

Karlan et al. (2014) state that crop insurance alone increases farm investment, but when insurance is bundled with credit, it does not necessarily increase investment. Giné and Yang (2009) suggest that the uptake of insured credit is low due to farmers' limited liability, which provides a sort of implicit insurance.

Although in theory, limited liability plays an important role in the links between credit and insurance, empirical evidence on how farmers' individual liability affects the uptake of insured credit is scarce. Some studies focus on joint liability and credit, showing that joint liability promotes screening, monitoring, enforcement of repayment (Ghatak and Guinnane 1999; Chowdhury 2005)[3], reduces moral hazard among borrowers (Flatnes and Carter 2015), and increases risk-taking, especially for risk-averse borrowers (Giné et al., 2010)

Our objective is to examine the effect of farmers' liability on the uptake of credit with and without mandatory insurance, using a lab-in-the-field experiment. We believe this is the first empirical study to address this question. The definition of limited liability we use is the one implied by the work of Giné and Yang (2009), namely that repayment of debt in case of a bad outcome (harvest) is limited to the value of production.

We follow the theoretical model of Giné and Yang (2009), and conduct an experiment with coffee farmers in Costa Rica. Each farmer chooses how much to borrow in order to invest in his or her farm. Credit is offered either with or without mandatory insurance with a premium cost, under three different liability scenarios. Farmers are faced with limited liability (through the guarantee of public debt relief in case of bad weather), full liability, or a 50% chance of full liability. A laboratory approach allows us to isolate the impact of limited liability on the demand for loans with and without mandatory insurance.[4] To abstract from other factors that are likely determinants of insurance uptake, our design involves an actuarially fairly priced insurance, with payout triggered by weather realization and without any basis risk. While we focus exclusively on the demand for credit with or without insurance, we do recognize that supply side considerations also play a key role in ultimately determining the market equilibrium. However, our experiment is designed so that the lender always recovers the loan and would be indifferent between providing credit with or without insurance.

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[3] Joint liability is when borrowers receive individual loans but form a group in which all members are mutually responsible for the total repayment to the lender (Flatnes and Carter, 2015).

[4] In the experiment, limited liability results from a government debt relief program provided with certainty, with uncertainty or not at all. We do recognize that government debt relief programs are determined by many factors, including their potential high cost, so that a complete elimination of farmers' liability is an extreme case. It is used here merely for experimental design purposes.

Our results show that uptake of insured credit is significantly higher than uptake of uninsured credit when farmers are fully liable, but also when there is a 50% probability of full liability. Insurance has no effect on credit demand if farmers have limited liability. That is, we find no evidence that mandatory insurance reduces credit demand in case of limited liability, but we do see a positive effect on the demand for insured credit when farmers are liable, even if only in probabilistic terms.

Authorities may fear that when farmers are fully liable for their debt, they face unacceptably high vulnerability to shocks. Our results show that, in order to generate an increased uptake of insured credit, governments would not need to abandon programs that generate limited liability altogether. Introducing uncertainty on the likelihood of debt relief is enough to increase demand for insured credit, thereby reducing the vulnerability of farmers to shocks. Moreover, providing limited liability only in probabilistic terms should ease the burden on authorities in case of a systemic shock to farmers.

The rest of this paper is organized as follows. The second section describes the literature on credit constraints, credit combined with insurance, and the role of limited liability; the third section presents a model on credit, investment and insurance, and develops our hypotheses; section four describes our experimental design and implementation procedures; section five presents the results; and the last section concludes the paper.

2. Literature review

In this section, we briefly review the relevant literature on credit market imperfections. We then discuss previous evidence on bundling credit with mandatory insurance and the effects on farm investment. Finally, we reflect on the role of limited liability.

In the absence of insurance markets, "risk rationing", as explained by Boucher et al. (2008), suggests that the borrower voluntarily withdraws from taking a loan, due to the risk of losing collateral (Giné and Yang, 2009). Traditional formal insurance instruments can be used to manage risks, but such insurance services are basically non-existent in rural areas of developing countries (Carter et al., 2014). This lack of insurance markets might aggravate the effect of risk rationing on credit uptake (Boucher et al., 2008; Giné and Yang, 2009). Hence, the combination of credit and crop insurance could be applied as a mechanism to improve credit markets and encourage investment in the agricultural sector (Carter et al., 2014).

Some studies focus on bundling credit with mandatory insurance and the effects on risk rationing and farm investment. Regarding risk rationing, Cheng (2014) studies the effects of index insurance on risk rationed households in China. In his experiment, providing insurance to risk rationed farmers induced more than half of the farmers to apply for credit, with approximately two-thirds using the loan for productive investment rather than for consumption. Regarding farm investment, Carter, Cheng and Sarris (2016) formally model and analyze the conditions under which index-based crop insurance can be most effective. They show that insurance will have no impact on investment and technology adoption when risk is low and the loan is covered by limited liability contracts. Under low collateral requirements, bundling credit and insurance will foremost benefit the lenders by bringing stability to the loan portfolio. In high collateral situations, even stand-alone index insurance can considerably increase investment in new technologies when the risk is covered by a well-designed index contract (Carter et al., 2016).

In an experimental study on the importance of capital constraints and uninsured risk, Karlan et al. (2014) examine if financial market imperfections discourage investment by smallholder farmers. They conduct a randomized controlled trial with cash grants, rainfall insurance grants, and rainfall insurance sales in northern Ghana. They find strong responses of agricultural investment to the rainfall insurance grant, but relatively small effects of the cash grants. Hence, uninsured risk limits farmer investment, while farmers with insurance grants manage to find resources to increase investment on their farms. This clearly suggests that agricultural credit market policy alone is not sufficient to increase investment in the agricultural sector.

Brick and Visser (2014) use a lab in the field experiment in South Africa to examine whether the provision of index insurance induces farmers to opt for riskier activities. They find that providing a loan with insurance does not increase investment in new technologies. Furthermore, risk-averse farmers are more likely to opt for traditional seeds than for high-yield seeds, regardless of the presence of insurance. Their experimental design reflects the reality of an index insurance product that minimizes the risk of rainfall variability, but the design does not account for other risk factors (i.e., basis risk) that might have affected their results given the high degree of risk aversion in their sample.

Giné and Yang (2009) conduct a field experiment in Malawi to examine whether production risk suppresses the demand for credit. They offer credit to purchase high-yielding seeds to a control group of farmers and credit bundled with index insurance (at actuarially fair price) to a

treatment group. Their results show that take-up is lower when credit is bundled with insurance. They argue, and show theoretically, that limited liability provides enough implicit insurance, so farmers will prefer loans without mandatory insurance, which are less costly.

To summarize, existing experimental and theoretical evidence is mixed. On the one hand, providing crop insurance increases farm investments (Hill and Viceisza, 2012; Karlan et al. 2014; Elabed and Carter 2014). On the other hand, when credit and insurance are combined, investment does not necessarily increase (Karlan et al. 2014; Brick and Visser 2015) and may even decline (Giné and Yang, 2009).

We now turn to a more extensive review of the role of limited liability. When production is low, farmers may be forced to default to maintain a subsistence level of consumption (Miranda and Gonzalez-Vega, 2011). Default can occur involuntarily when associated with shocks or other risks that make borrowers unable to repay, but can be voluntary when lack of contract enforcement incentivizes borrowers to default even when they have the means to repay their loans (Ghosh et al., 2000). When contracts are subject to limited liability, borrowers are not forced to repay the bank if returns on investment are less than loan repayment obligations (Ghosh et al., 2000).

Agricultural banks and governments in developing countries often cooperate with poor agricultural borrowers to deal with losses from extreme events, by restructuring loans and through debt relief programs (Carter et al., 2007). This affects farmers' liability, even though governmental assistance is not guaranteed (Carter et al., 2007; Miranda and Gonzalez-Vega, 2011). After the strong effects of "El Niño" 1998 in Peru, for example, a government decree forced lenders to reschedule, meaning that farmers in default could repay later. Lenders believed these public sector interventions damaged the credit culture that had been formed in previous years (Trivelli et al., 2006). In Costa Rica, the government applied debt relief six times between 2004 and 2012, to assist borrowers who had received credit from development banks and were struggling to repay their loans (Gutierrez-Vargas, 2015).

Empirical evidence on the effect of farmers' liability on uptake of credit combined with insurance is scarce. There is some evidence that farmers' perception of the availability of disaster relief is associated with less participation in insurance programs. A study by van Asseldonk et al., (2002) explores the role of producers' beliefs in disaster relief in the Netherlands. Farmers' willingness to pay to participate in a hypothetical insurance program is negatively and significantly associated with their belief that disaster relief will be available in

the future. In addition, a recent study by Deryugina and Kirwan (2016) asks whether the Samaritan's dilemma exists in U.S. agriculture.[5] They instrument for disaster payments using political variation across counties and then estimate how expectations of receiving these payments affect farmers' decisions. They find that bailout expectations reduce crop insurance coverage by reducing expenditures on premiums and inducing farmers to choose less generous insurance plans. At the same time, farmers also reduce farm labor and fertilizer use.

Giné and Yang (2009) explicitly focus on the bundling of credit and insurance and refer to the existence of limited liability as a possible explanation for lower credit demand when credit is bundled with insurance. They show theoretically that a loan contract with limited liability provides enough implicit insurance, and therefore credit demand is predicted to decline with mandatory insurance that increases the price of credit. The next section presents their theory in more detail.

3. Theoretical model

This section describes the theoretical model for credit demand and insurance, building on the model developed by Giné and Yang (2009). We start with the general model setup and then illustrate the simple case of loans without insurance, followed by the case of loans with mandatory insurance. Finally, we introduce differences in farmers' liability and discuss the hypotheses.

3.1. General model setup

To analyze farmers' demand for credit, we consider a risk-averse farmer who is offered credit under two types of contract (with and without mandatory weather insurance) and three types of liability (limited liability, uncertainty about liability, or full liability). Farmers use the credit to invest in their agricultural production. Farm output depends on the level of investment, the return on investment, and the state of the weather. We define p and $(1-p)$ as the probability of good (bad) weather. Following Giné and Yang (2009), we assume perfect correlation of investment returns and state of the weather, so that investment returns depend solely on the realization of the weather with a probability $p = \frac{1}{2}$.

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[5] First described by Buchanan (1975), the Samaritan's dilemma explains how individuals who expect to be bailed out in times of crisis (e.g., natural disasters and financial crises) take on additional risk in response (Deryugina and Kirwan, 2016).

Without investment, farmers can realize a base output level Y_B in case of bad weather or $Y_B + a$ in case of good weather, while investment will increase output to the level Y_H in case of good weather and reduce output to the level Y_L in case of bad weather.[6] We assume that expected output with investment is higher than expected output without investment, so that

$$p\,(Y_B + a)\, +\, (1 - p)Y_B < p\,Y_H + (1 - p)Y_L.^{7}$$

Output with investment, Y_H or Y_L, depends on the amount invested, which is equal to the loan size C. In case the weather is good, investment gives the farmer a positive return r, so that $Y_H = Y_B + a + rC$. In case of bad weather, the return is negative r, so that $Y_L = Y_B - rC$.

To invest, the farmer needs to borrow from a bank. We define i as the interest rate, W as the value of famers' assets required as collateral for a loan of any given size, and R as the repayment of the loan, consisting of the amount borrowed and the interest due. We assume that the value of the collateral is enough to cover the repayment of the loan: $W > (1 + i)C = R$, and that output in the low state is not sufficient to repay the bank $(Y_L < R)$. The lender can always seize up to the full value of farm output Y_L or Y_H in order to secure repayment of the loan, but only seizes other assets W with a probability ϕ. The three scenarios we analyze are limited liability $(\phi = 0)$, uncertain liability $(\phi = ½)$, and full liability $(\phi = 1)$.

3.2. Credit without insurance

First, consider the case when credit is offered without insurance and farmers decide whether to borrow and invest amount C. When the farmer chooses not to invest, expected utility is defined as

$$U_B = \frac{1}{2}u(Y_B + a + W)\, +\, \frac{1}{2}u(Y_B + W) \tag{1}$$

When the farmer chooses to invest, output can be high or low, depending on the weather. Consumption in the high output state is $c_H = Y_H - R + W$. In the low output state, consumption depends on whether the bank seizes (part of) the collateral to recover repayment,

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[6] We give farmers the example of investing in new coffee trees (see Annex 2), when indeed a bad weather shock can lead to negative returns on investment.

[7] In the original model by Giné and Yang (2009), the base output level is not affected by the weather, so that $Y_B < p\,Y_H + (1 - p)Y_L$.

which it does with probability ϕ. Hence, expected utility with investment in the case of credit without insurance is given by:

$$U_U = \frac{1}{2}u(Y_H - R + W) + \frac{1}{2}[\phi\, u(Y_L - R + W) + (1 - \phi)u(W)] \qquad (2)$$

3.3. Credit with mandatory insurance

Second, consider the case when credit is offered only in combination with weather insurance provided by the bank. The insurance premium π is set at an actuarially fair price (following Giné and Yang, 2009), so that, in order to invest level C, farmers need to borrow an amount $C + \pi$. The total repayment to the bank for a loan with insurance is therefore $R^I = (1 + i)(C + \pi)$. In states of bad weather, the insurance pays out the total amount R^I. Given the actuarially fairly priced insurance, the premium can be written as a function of repayment without insurance (as in Giné and Yang, 2009), which gives $R^I = \frac{R}{p} = 2R$ (see Annex 4). Hence, expected utility of investment when credit is combined with insurance is:

$$U_I = \frac{1}{2}u(Y_H - 2R + W) + \frac{1}{2}\,u(Y_L + W) \qquad (3)$$

3.4. Differences in farmers' liability

We evaluate three different liability scenarios: limited liability ($\phi = 0$), uncertain liability ($\phi = \frac{1}{2}$), and full liability ($\phi = 1$). In general, credit demand with actuarially fairly priced insurance depends on the level of output in case of bad weather, Y_L, and on farmers' risk aversion. In the next section, we use a constant relative risk aversion utility function (CRRA)[8] and show the predictions of the theoretical model under the distinct features of our experimental design.

Intuitively, when farmers have limited liability and income in the low state is lower than repayment with insurance $Y_L < R$, loans without insurance should provide sufficient implicit insurance. Thus, demand for uninsured credit should be higher than demand for insured credit. When farmers are uncertain about their liability or are fully liable for sure, low values

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[8] Constant relative risk aversion utility function: $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$; $0 < \sigma < 1$, where $\sigma = 0$ indicates risk neutrality and $\sigma > 0$ indicates risk aversion.

of Y_L and a contract without insurance still provide implicit insurance and thus higher expected utility for uninsured loans. However, when Y_L increases, farmers' default costs also increase and expected utility is higher for loans with insurance (Giné and Yang, 2009, p4).

4. Experimental design and implementation

To test our hypotheses in a controlled environment, we implemented a lab in the field experiment with coffee farmers in Costa Rica. The experiment is set up as a within-subject design in which each farmer faces six different treatments, three times each. In each round, the farmer chooses how much to borrow for investment in her farm, while facing ex-ante uncertainty about the weather, which can be good or bad. In the treatments, credit is offered either with or without mandatory insurance, and with farmers having limited liability ($\phi = 0$), uncertainty about their liability ($\phi = \frac{1}{2}$), or full liability ($\phi = 1$). We explain to the farmers that their liability is the result of whether or not there will be debt relief by the government in case of bad weather.[9] Each treatment is presented as a one-period decision-making game, independent from the other treatments.

The experimental design is developed in line with the previous model, in which good and bad weather occur with equal probability ($p = \frac{1}{2}$). We determined our experimental parameters with a CRRA risk aversion parameter (σ) of $\frac{1}{2}$ in mind but assess the model's predictions across all levels of risk aversion. Base output (without any investment) is $Y_B = 2$ in case of bad weather, while good weather will result in additional output over base output equal to $a = 1$ (Hill and Viceisza, 2012). Farmers can choose to invest zero, one or two units of capital C. If the weather is good, investment gives the farmer a positive return over the capital *(r = 5)*: $Y_H = Y_B + a + 5C$. In case of bad weather, the return is negative *(r = -1)* and*: $Y_L = Y_B - C$.*

In each of the 18 rounds (six treatments appearing three times each), farmers are given an endowment (W = 3) that can serve as collateral. This endowment is sufficient to guarantee the maximum uninsured repayment amount (W > R), with the interest rate fixed at *i =0.10* throughout the experiment. Farmers are told that their asset endowment can be seen as farmland, housing, or other properties that the lender can take in case of default. Farmers' consumption will depend on the amount invested C, the weather draw, and whether or not

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[9] We do recognize that government bailouts of this sort are determined by many factors, and indeed the assumption of a certain bailout is just a feature of our experiment.

their collateral is seized by the bank. One unit of income or consumption in the experiment is set equal to 1,000 Costa Rican Colones (CRC).[10]

Figure 1 shows expected utility without credit (zero investment) and with maximum investment ($C=2$), with or without insurance, for different risk aversion parameter values and while holding the expected returns constant. As Figure 1 shows, for low levels of risk aversion, the expected utility associated with maximum investment is always higher than the expected utility without investment, whether or not credit comes with insurance. Yet when comparing insured and uninsured credit, it is clear that farmers' liability and risk aversion determine which type of credit is preferred.

In case of limited liability, uninsured credit provides higher expected utility than insured credit. With uncertain liability, insured credit provides higher expected utility for relatively risk-averse farmers. Finally, with full liability, insured credit is always the best option regardless of the risk aversion parameter.

Farmers in our experiment choose their level of credit under each type of loan (insured or uninsured) and liability scenario, rather than choosing between an insured and uninsured loan. Hence, our theoretical model predicts that, when farmers have limited liability, credit demand should be higher if credit is not bundled with insurance than if credit is bundled with insurance, unless farmers are very risk-averse in which case the difference becomes small. When farmers are uncertain about their liability and have relatively low risk aversion, credit demand should also be higher if credit is not bundled with insurance. With uncertain liability and high levels of risk aversion, credit demand should be higher if credit is bundled with insurance. When farmers are fully liable, credit demand should be higher if credit is bundled with insurance[11].

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[10] 1000 CRC equals approximately two US dollars.

[11] The choice of credit and the amount of credit is affected by individual risk preferences. However, the experiment itself was not designed to elicit the risk preferences of the participants. We did collect self-reported willingness to take financial risk in the 2014 survey (which is described below). These data indicate that farmers in the experiment are on average slightly risk-averse: the measure ranges from 0 (not at all willing to take risk) to 10 (very willing to take risks) and the sample mean equals 4.84.

Figure 1. Expected CRRA utility varying the risk aversion parameter
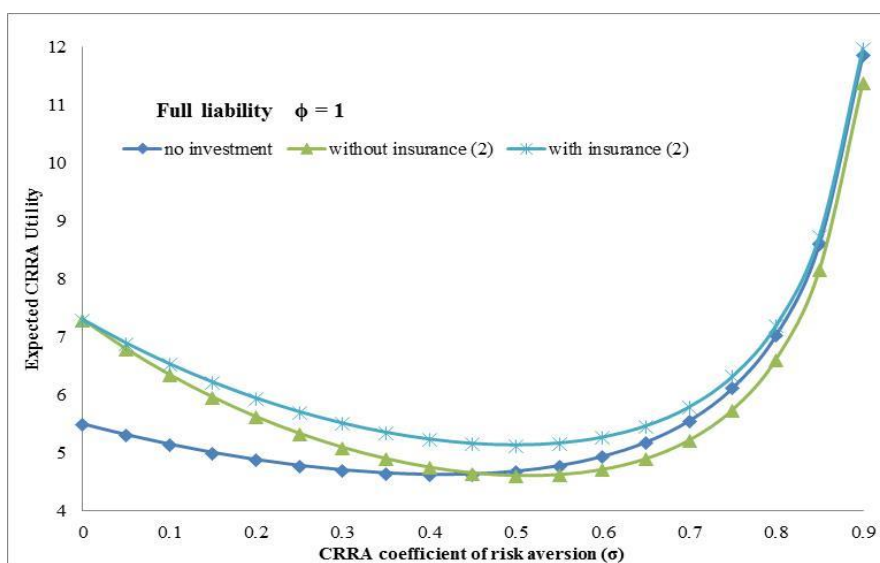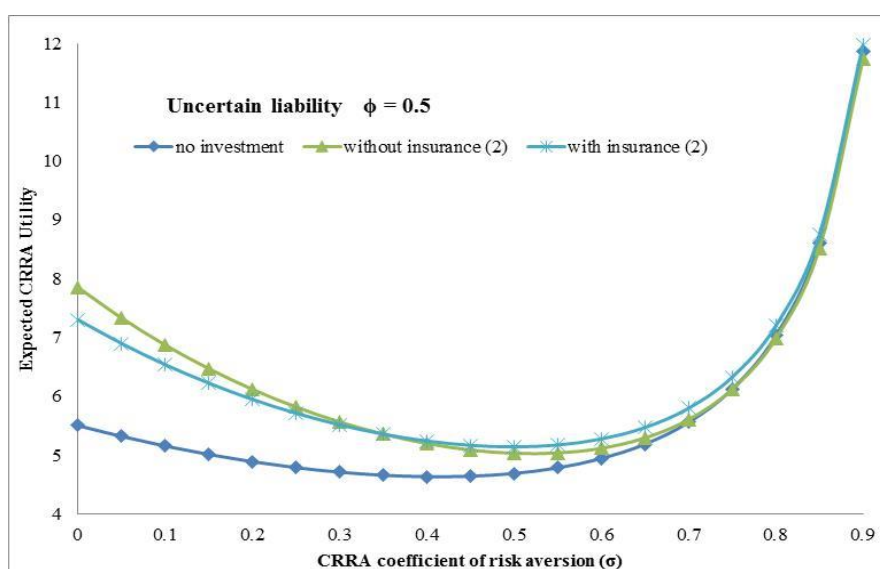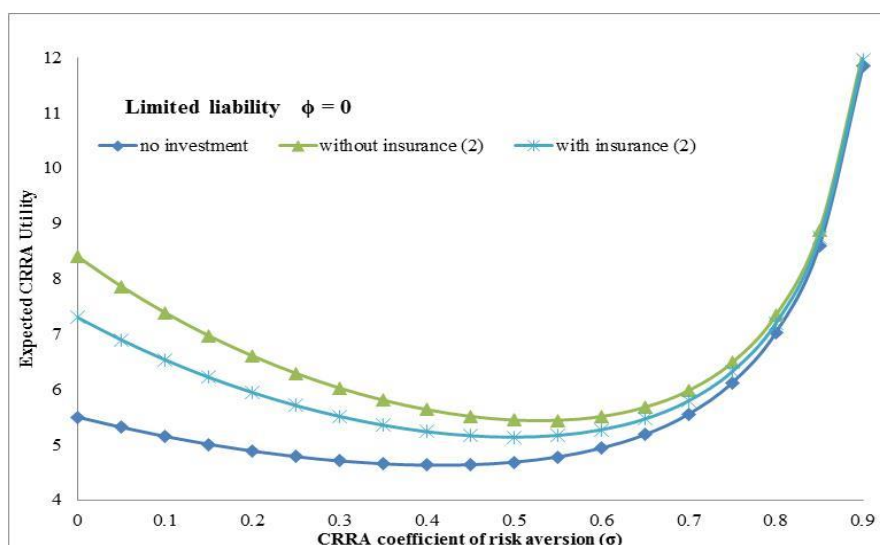
Each of the six treatments was repeated three times. We explain that the 18 rounds are independent from each other, and that one round will be randomly selected for payment at the end of the experiment. The draw of the round for payment and the weather draw were determined in private for each farmer. Selection of the payment round was done by taking one chip out of a bag with 18 chips numbered 1-18, while the weather draw was determined with the toss of a coin. Final payment consisted of a show-up fee of 2000 CRC plus the level of consumption the farmer reached in the selected round, for an average earning of 8179 CRC.[12] Detailed instructions are included in the complete experimental protocol in Annex 2.

Farmers invited to participate in the experiment were selected from two coffee regions, Brunca and Tarrazú, using stratified random sampling according to the density of coffee plots. Regions were selected to capture the variation in altitude and effects of a coffee rust epidemic in 2012-13[13]; all farmers were surveyed in 2014 as part of a different study (Naranjo et al., 2018). We contacted all surveyed farmers and conducted thirteen experimental sessions at local primary schools during the second and third week of October 2015.[14] Sessions took approximately two hours and were organized one per day during the afternoon, with on average 10 farmers per session, who were assigned randomly to individual desks around the classroom. The order of treatments was selected randomly in the first two sessions, and then these two orders were repeated in subsequent sessions, alternating between the first and second order.

The empirical research was set in Costa Rican coffee farming areas. We focus on the coffee sector, because, although coffee is no longer the main agricultural export of the country, it remains a leading agricultural commodity. According to the Costa Rican Coffee Institute (ICAFE), there are around 41,300 coffee growers (11,180 less than in 2008), producing over 2 million coffee bean *fanegas*[15] annually (ICAFE, 2018). Furthermore, the coffee sector is mostly composed of small-scale growers (90%), who produce less than 100 coffee *fanegas*

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[12] Through the different rounds farmers could earn a minimum of 2800 CRC to a maximum of 15800 CRC depending on their choices, with an average 8179 CRC across rounds. In 2014, the minimum wage for an unqualified agricultural laborer was 8.944,51 CRC per day (MTSS, 2014). An average payment of 8179 CRC provides "incentive compatible earnings" for the farmers for sessions that lasted approximately two hours.

[13] The coffee rust is a leaf disease caused by the fungus: *Hemileia vastatrix*. Factors contributing to the disease becoming epidemic include climatic factors, like the increased temperature and humidity, which modifies the life cycle of the fungus causing it to expand rapidly; and economic factors such as low coffee prices and high input costs, which lead producers to reduce investment in preventive adaptation practices (Avelino et al., 2015).

[14] Farmers were offered two possible dates to attend a workshop session at two nearby villages.

[15] A *fanega* is a standard unit of volume to measure coffee in Central America, of approximately 250 kg.

per year (ICAFE, 2018) and are a target population for financial instruments to reduce the consequences of weather related events.

In total, 134 (46% of the 2014 survey participants) farmers participated in the experiment, two of which had incomplete responses for the experiment and are excluded from the analyses. The experiment participants are a self-selected subsample from the 2014 survey sample. Since the latter sample was a random sample representative of coffee farmers in the two regions, we compare characteristics of the survey and experimental participants in Table 1. Differences in means (t-test) show no differences between the two groups for most of the variables, except that farmers participating in the experimental sessions have on average a smaller total area planted with coffee, and are less likely to be from Brunca region.

The bottom row of Table 1 reports the results of the F-test that all characteristics are jointly insignificant in predicting partcipation in the experiment. The p-value is 0.0036, indicating that these characteristics do jointly predict participation in the experiment, and hence the sample may not be representative of coffee farmers in the two regions. As we discuss in the next section, however, our treatment effect estimates do not vary with farmers' coffee area.

Table 1. Variables and sample means for survey and experimental sample

	Survey 2014		Experiment 2015		t-test	
	Mean	*sd*	*Mean*	*sd*	*Difference*	*p-value*
Age (years)	51.76	13.62	51.52	13.04	0.25	0.828
Women	0.10	0.30	0.11	0.31	-0.01	0.783
Education (years)	5.79	2.61	5.79	2.78	0.00	0.993
Region (% from Brunca)	0.47	0.50	0.39	0.49	0.08*	0.053
% income from coffee	56.94	36.23	57.83	35.63	-0.89	0.780
Total coffee area (ha)	3.48	4.61	2.53	2.45	0.96***	0.000
Affected by leaf rust	0.81	0.39	0.81	0.39	0.00	0.975
Observations	294		132			
F-test of joint insignificance in predicting participation in the experiment						F = 2.92 (p-value 0.004)

Source: (Naranjo et al., 2018). Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

As Table 1 shows, roughly 58% of income from participating farmers is earned through coffee production. Other sources of income they report include cultivation of other crops.

labor at other farms, animal husbandry, construction work, and other services like repairing cars and taxi driving.

Farmers taking part in the lab-in-the-field experiment, report having some experience with credit in the past (66%) but only few have knowledge about the existence of crop insurance (16%). Private banking institutions, in association with the National Insurance Institute, have now started introducing credit bundled with insurance via cooperatives organizations. Nonetheless, these are still pilot initiatives and were not in place during the time of our experiment.

5. Empirical strategy and results

To analyze the effect of farmers' liability on demand for credit with and without insurance, we first present some descriptive analyses of the average amount borrowed across the three rounds within each treatment. Figure 2 presents the distribution of farmers' credit demand across the six experimental treatments.

Credit demand varies considerably across treatments. Farmers are more likely to demand the highest level of credit (2000 CRC) when governmental debt relief ensures limited liability for the two types of loans, with insurance (52%) and without insurance (58%). Comparing Figures 2a and 2b, there appears to be little impact of mandatory insurance on farmers' credit demand when farmers are not liable, in line with theoretical predictions at high levels of risk aversion (see Figure 1). Compared to the limited liability scenario, credit demand is lower when farmers are uncertain about their liability and especially when they are fully liable. Comparing Figures 2c and 2d, as well as Figures 2e and 2f, we see that, with uncertain or full liability, mandatory insurance increases demand for credit. Again, this is in line with predictions from the model, and suggests the farmers in our sample have intermediate to high levels of risk aversion.
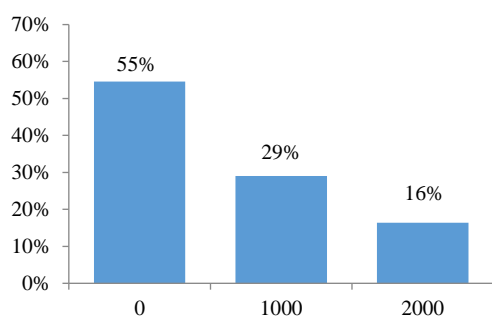
Figure 2. Credit demand by treatment

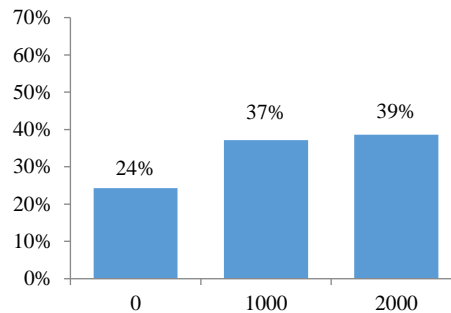2a. Loan **without** insurance and limited liability
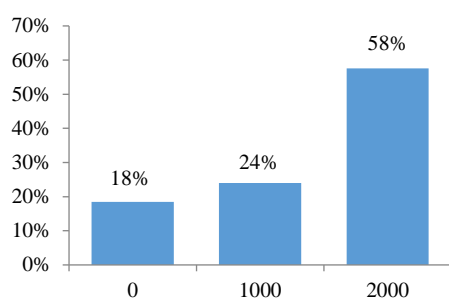
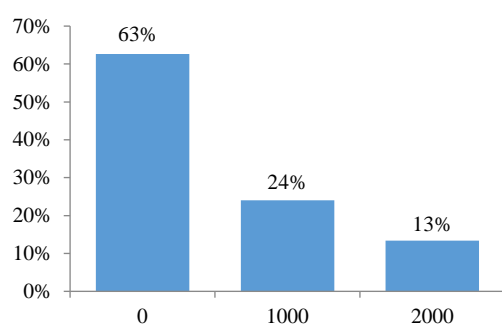2b. Loan **with** insurance and limited liability
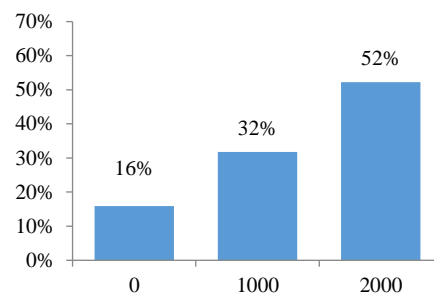
2c. Loan **without** insurance and uncertain liability

2d. Loan **with** insurance and uncertain liability

2e. Loan **without** insurance and full liability

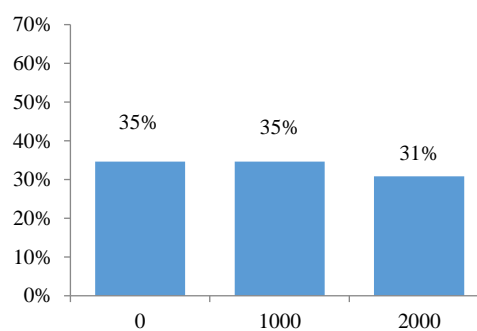2f. Loan **with** insurance and full liability

16

Table 2 and Figure 3 explore differences in means between treatments using a paired t-test. Comparing means across the rows of Table 2 again shows that liability decreases total credit demand. We also confirm that uptake of loans with insurance is significantly higher than without insurance when farmers are liable or when there is uncertainty about their liability. We find no significant differences between demand for loans with and without insurance in case of limited liability.

Table 2. Paired t-test for differences in credit demand means across treatments

	Without insurance		With insurance		t-test		N
	Mean	*Std. Error*	*Mean*	*Std. Error*	*Difference*	*p-value*	
Limited liability	1.39	0.053	1.36	0.052	-0.03	0.593	132
Uncertainty	0.62	0.050	1.14	0.052	0.53***	0.000	132
Full liability	0.51	0.051	0.96	0.053	0.45***	0.000	132

Note: *** p<0.01, ** p<0.05, * p<0.1

Figure 3. Differences in credit demand across treatments

17
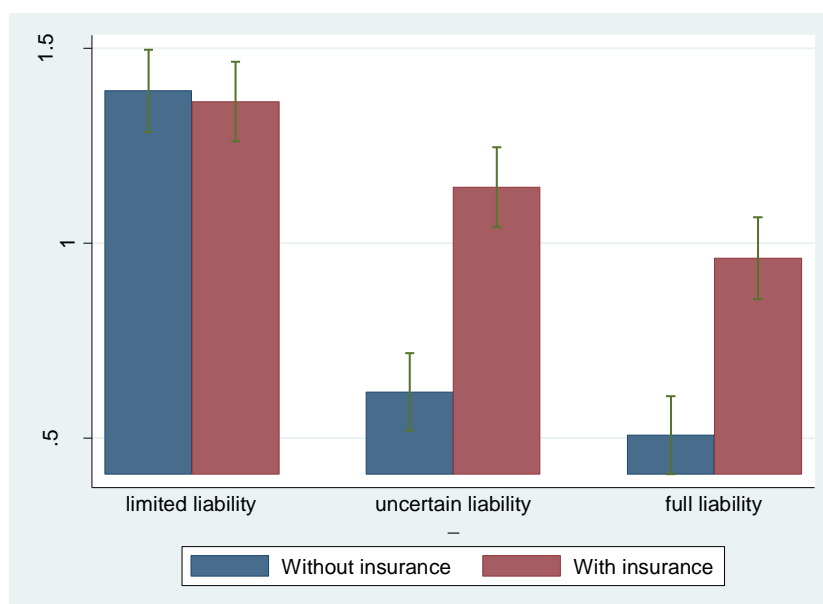
To formally analyze the effect of mandatory insurance and liability, we estimate the following equation:

$$Y_{itjk} = \alpha + \beta_1 Insurance_j + \beta_2\ Uncertain\_liability_k$$
$$+ \beta_3\ Full\_liability_k + \beta_4\ Insurance_j \times Uncertain\_liability_k$$
$$+ \beta_5\ Insurance_j \times Full\_liability_k + \gamma_i + \varepsilon_{itjk} \qquad (4)$$

Our dependent variable Y_{itjk} is the amount borrowed by farmer i in round t, with insurance treatment j and liability treatment k; γ_i are farmer fixed effects; and ε_{itjk} is the error term. The treatment with no insurance and limited liability is taken as the reference. Standard errors are clustered at the farmer level.

In Table 3, the first column shows that the introduction of mandatory insurance has no significant effect on credit demand when liability is limited. This result differs from Giné and Yang (2009) where take-up was significantly lower among farmers offered insurance with the loan in the presence of limited liability. Hence, we do not find evidence for their prediction that insurance reduces credit demand in case of limited liability.

On the other hand, the coefficients on the interaction terms show that, when there is uncertainty about liability or full liability, the effect of mandatory insurance is positive and highly significant. Moreover, the effect is large: insurance increases credit demand by around 0.5 (or 500 CRC), which is more than one-third of the sample average (1.38), and close to one standard deviation (0.60).

We perform a number of robustness checks. First, we have a total of six treatments that appeared during three different moments in time. To ensure results are not driven by the order in which the treatments were presented during the sessions, we introduce 18 dummy variables in the regression analysis, capturing the time period within the session (Table 3, column 2). Second, we cluster the standard errors at the session level (13 clusters) using the wild bootstrap method (Cameron et al., 2008). These results are reported in the third column of Table 3. In all estimations, we find very similar results.[16]

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[16] In addition, since farmers are restricted in their choice of investment level, we estimate our model using a Tobit specification (accounting for the upper limit of 2 units of credit) as well as an ordered logit specification. While coefficient sizes are larger, as expected, the results are qualitatively the same and our conclusions are not affected. Results are available from the authors.

Table 3. Impact of insurance and liability on credit demand

Dependent variable: *amount borrowed*			
	(1)	(2)	(3)
Insurance	-0.03	-0.09	-0.09
	[0.05]	[0.08]	[0.12]
Uncertain liability	-0.77***	-0.86***	-0.86***
	[0.06]	[0.10]	[0.28]
Full liability	-0.88***	-0.90***	-0.90***
	[0.06]	[0.07]	[0.29]
Insurance * Uncertain liability	0.55***	0.58***	0.58***
	[0.06]	[0.16]	[0.20]
Insurance * Full liability	0.48***	0.53***	0.53***
	[0.06]	[0.08]	[0.00]
Order dummies	No	Yes	Yes
Wild bootstrap[a]	No	No	Yes
Mean dependent variable	1.38	1.38	1.38
Observations	2,376	2,376	2,376
R-squared within subjects	0.227	0.234	0.171
Number of subjects	132	132	132

Note: Standard errors clustered by respondent are shown in in brackets, *** p<0.01, ** p<0.05, * p<0.1.
[a] Standard errors clustered at session level (13 sessions), using wild bootstrap with 1000 replications following Cameron et al. (2008).

Finally, we verify whether treatment effects depend on farmers' total area planted with coffee. Recall from Table 1 that coffee area is significantly smaller for farmers in the experiment sample, compared to the random sample of farmers that were invited to participate. Results in Table 4 show there are no differences by farmers' total coffee area.

We also analyze heterogeneous effects across other social and financial characteristics of the farmers. These include farmers' age, gender, years of schooling, percentage of income coming from coffee harvest, having been affected by other shocks in the past (including their experience with the recent coffee leaf rust epidemic in 2012-13)[17], and survey estimates of

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[17] In our experiment, we cannot test this hypothesis directly since there was not feedback implemented (Hill and Viceisza, 2012). Each round was an independent decision from previous rounds, and only one was selected for payment.

impatience and willingness to take risk regarding their financial decisions. However, we do not find significant heterogeneity with any of these variables.

Table 4. Heterogeneous effects for coffee area

	Amount borrowed
Insurance	-0.12
	[0.09]
Uncertain liability	-0.80***
	[0.11]
Full liability	-0.81***
	[0.09]
Insurance*Uncertain liability	0.55***
	[0.17]
Insurance*Full liability	0.52***
	[0.10]
Coffee area*Insurance	0.01
	[0.02]
Coffee area*Uncertain liability	-0.02
	[0.02]
Coffee area*Full liability	-0.04*
	[0.02]
Coffee area*Insurance*Uncertain liability	0.01
	[0.02]
Coffee area*Insurance*Full liability	0.01
	[0.02]
Constant	1.46***
	[0.07]
Order dummies	Y
Mean dependent variable	1.38
Observations	2,376
R-squared with-in subjects	0.238
Number of subjects	132

Note: Standard errors clustered by respondent are shown in in brackets, *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Our lab in the field experiment design was relatively simple and easy to understand for farmers, compared to previous field experiments evaluating existing insurance programs (which typically carry basis risk and involve trust concerns due to lack of information). This may explain why we find no differences based on education, income, and previous experience with shocks. Another explanation could be that our experimental sample and the farmers' population in our study regions in general is very homogeneous in terms of socioeconomic

characteristics, and hence we may not have sufficient variability in the data to detect heterogeneous effects.

6. Conclusions and discussion

In this paper, we examine the effect of farmers' liability on the uptake of credit with and without mandatory insurance, using a lab-in-the-field experiment. We follow the theoretical model of Giné and Yang (2009) and conduct an experiment with coffee farmers in Costa Rica. Using their conceptual model, we explore the effect of limited liability on demand for credit with and without mandatory insurance. We focus exclusively on the demand side, abstracting from supply side considerations.

Our results show that the uptake of loans bundled with insurance is significantly higher than uptake of loans without insurance, both when farmers are fully liable for their debt, and also when there is uncertainty about their liability. Under limited liability, the uptake of credit is high irrespective of whether the loans are insured or not. This last result differs from Giné and Yang (2009) where take-up was significantly lower among farmers offered insurance with the loan in the presence of limited liability. A possible explanation is that by design, in our experiment there was never a binary choice between loans with and without insurance. Farmers were offered one option at a time, and then decided on the level of investment. In the presence of limited liability, acquiring debt is very attractive, and the salience of costly insurance is not the decisive factor.

Our results suggest that in order to increase the uptake of insurance as a strategy to increase private investment and reduce the vulnerability of farmers to shocks, it is important that farmers are liable with at least some probability. Governments in developing countries have accustomed farmers to enjoy limited liability for their loans, when in reality there is always uncertainty about the level of government resources. We show that clearly and credibly communicating this level of uncertainty can result in increased uptake of insured credit and hence in farmers being better covered against risk.

In terms of policy design, our results show that government programs limiting farmers' liability do not have to be abandoned altogether in order to generate an increase in the uptake of insured credit. Because of public pressure and a concern for the well-being of farmers in rural areas, authorities could be reluctant to let farmers be exposed to full liability with a

private lender, in cases in which the loss is not due to inadequate management, but because their trade was unsuccessful due to extreme hydro-meteorological events or pests. According to our results, introducing uncertainty about farmer's exposure to liability (i.e. providing debt relief only in probabilistic terms) is enough to increase insured investment, thereby reducing the vulnerability of farmers to shocks. Accordingly, such uncertain debt relief should ease the burden on the authorities should there be a systemic shock to farmers.

An important question we do not address in this study is how to design insurance products. In theory, well-designed insurance can incentivize investment in new technologies by small-scale farmers, but the impact of the insurance depends strongly on the collateral requirements by the lender (Carter et al., 2016). Lenders in developing countries are diverse, from private companies to state support entities and from informal to formal lenders, with different characteristics and requirements that shape the environment for the sustainability of credit and insurance instruments. More research needs to be done on the supply side, taking into account the lender's standpoint and other conditions under which financial instruments like weather index insurance are likely to be effective.

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Annex 1. General Experimental Instructions

I. Welcome procedures

1. *Meet people at the door; request ID.*
2. *Match ID with survey ID.*
3. *Write the ID survey number in the decision sheet booklet.*
4. *Give them the closed decision sheet booklet. Stress that they can't open the booklet until indicated by the coordinator.*
5. *Invite them to sit, assigning them randomly across the room.*

II. General instructions for farmers and experimenters

[START POWERPOINT PRESENTATION]

☼ **[Slide 1]** *Good afternoon. Today you will participate in a decision-making workshop. You are invited as a follow-up to a survey conducted last year. The exercises are based on real-life decisions that will allow us to learn from your experience, according to the decisions made during the workshop. The workshop will last about two hours, and we need to stay together until the end. At the end of the workshop, you will be compensated with real money, the amount of which will depend on the decisions made and on chance. You will receive a minimum payment of 2,000 colones, plus the result of your decisions in the workshop exercises.*

We are going to read the instructions together. First the general instructions and then gradually through the decision game rounds. Listen carefully to the instructions for each choice. Look carefully at the possible payments and the probabilities associated with each choice before making a decision. Remember that your final earnings will depend on the decisions you make and on chance.

*If you have any questions, please raise your hand, and one of my colleagues or I will come to help you! Please do not hesitate to ask a question if you do not understand. There are no right or wrong answers. Your decisions are personal and depend on your own preferences. Your decisions are also anonymous. This means the decisions can only be yours and your choices will remain private. So, please remain quiet and do not share your decisions or talk to the person sitting next to you. **This is very important!***

[GO THROUGH INSTRUCTIONS WITHOUT INVITING QUESTIONS. AVOID PUBLIC QUESTIONS]

☼ **[Slide 2] <u>To borrow or not to borrow money from the bank</u>**

You choices today consist of deciding whether or not to take a loan to invest in your farm. If you decide to invest, just like any loan contract, you must have illiquid assets as a guarantee

in case you cannot pay the loan. These assets can be your own farmland, house or other properties that are taken by the lender if you can´t pay back what you borrowed.

*Since we cannot quantify what you possess, today you all have the same value of wealth as a guarantee, equal to **3,000 colones,** before you make your decision.*

☼ **[Slide 3]** <u>**You pay an interest rate**</u>

You decide how much to borrow. You can borrow nothing, 1,000, 2,000 or 3,000 colones. The decision is yours. Remember there are no right or wrong answers.

Like any credit, you must pay an interest rate to the Bank. *The interest rate is **10%** of the amount you decide to borrow. This means that, according to the table below, if you decide to invest and borrow **1,000 colones** from the bank, you have to pay back **1,100 colones**. If you invest and borrow **2,000 colones**, you have to pay back **2,200 colones**. If you decide **not to borrow**, then you pay nothing back to the bank. **Do you have any questions?***

You invest and borrow	You pay back to the bank
₡0	₡0
₡1,000	₡1,100
₡2,000	₡2,200

☼ **[Slide 4]** <u>**Your investment is risky and depends on the weather**</u>

Note that the result depends on the weather. For example, consider renewing your farm with a new variety of coffee. If things go well and the weather conditions are favorable, you get a profit. However, if things go wrong and there is a lack of rain or a hurricane to damage your new coffee plantation, then you will have a much lower output than if you had not invested.

The probability of a good or bad result is 50/50. That is, after deciding how much to borrow to invest, you have to throw a coin. If the coin marks "Crown," that means there will be good weather and if the coin marks "Shield," that means there will be bad weather. If you choose not to invest, you will have an output of 3,000 colones if there is good weather and production of 2,000 colones if weather conditions are not favorable and affect the harvest.

*On the other hand, if you decide to borrow and invest, there is a chance that things will go well and that you will earn more money, or that things will go badly and you will be worse off than without investing. If you borrow and invest 1,000 colones and there is good weather, you might get 8,000 colones and if bad weather 1,000 colones. If you borrow and invest 2,000 colones and there is good weather, you might get 13,000 colones, and if bad weather zero colones. **Do you have any questions?***

You invest and borrow	Good weather	Bad weather
₡0	₡3,000	₡2,000
₡1,000	₡8,000	₡1,000
₡2,000	₡13,000	₡0

Do you have any questions? [WAIT AND EXPLAIN AGAIN IF NECESSARY]

☼ **[Slide 4] <u>Production + Capital – Payment to the bank</u>**

After the good or bad weather determines the outcome of your investment, you will still have to pay the Bank according to your loan. Remember that everyone has the same initial capital as collateral, which is equal to ₡ 3,000. Therefore, your final output is production + capital – what you have to pay the bank.

You invest and borrow	Good weather	Bad weather
₡0	₡3,000 + ₡3,000 – ₡0 = **₡6,000**	₡2,000 + 3,000 – ₡0 = **₡5,000**
₡1.000	₡8,000 + ₡3,000 – 1,100 = **₡9,900**	₡1,000 + ₡3,000 – 1,100 = **₡2,900**
₡2.000	₡13,000 + ₡3,000 – 2,200 = **₡13,800**	₡0 +₡3,000 – 2,200 = **₡800**

Any questions? [WAIT AND EXPLAIN AGAIN IF NECESSARY]

☼ **[Slide 5] <u>Weather insurance</u>**

*Pay attention to the instructions. Sometimes the loan offered is bundled with insurance. This means that, when you take the loan, it includes **mandatory insurance**. The benefits from the insurance are that it takes care of repaying the bank when bad weather events occur, securing your assets. However, the insurance is costly. Therefore, when the weather is good, there is a cost reflected by the amount to repay to the bank.*

You invest and borrow	You pay back the bank with NO insurance	You pay back to the bank with insurance
₡0	₡0	₡0
₡1.000	₡1,100	₡2,200
₡2.000	₡2,200	₡4,400

Do you have any questions? [WAIT AND EXPLAIN AGAIN IF NECESSARY]

☼ [Slide 6] Government help in case of bad weather

*Sometimes when a bad weather event occurs and affects an entire sector, for example, coffee production, the government takes action to relieve the consequences of the shock. In the past, the government has applied debt forgiveness on credit loans when farmers affected by shocks can´t pay back the banks. Please pay attention to the instructions, since in some rounds the government will apply debt forgiveness when bad weather events occur and sometimes it might help according to a probability. **Do you have any questions?***

[WAIT AND EXPLAIN AGAIN IF NECESSARY]

Debt forgiveness when bad weather events occur	

	• No help ➜ You have to pay the bank
	• Debt forgiveness ➜ You don't have to pay the bank
	• Depends on a probability ➜
	  - You have to pay the bank
	  - You don't have to pay the bank

☼ [Slide 7] Payment procedure

*You will take **18 decision tasks.** After you have taken all the decisions, one of your decisions will be drawn for real payment. This means the amounts indicated in the decision problem will be paid out for real.*

*At the end of this workshop, one of the **18 decision tasks** will be drawn at random by each of you, by taking one chip out of this bag with equal probability for each decision task to be extracted for payment. You can check that in the bag there will be precisely **18 numbered chips,** one for each decision previously taken. Then, you will draw a coin to pay you according to the good weather or bad weather. **Do you have any questions?***

[WAIT AND EXPLAIN AGAIN IF NECESSARY]

EXAMPLE

✓ Credit <u>does not require insurance</u>

✓ The <u>government cannot help</u> and the Bank will seize your properties if no payment

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POSSIBLE RESULTS

Amount borrowed	Good weather	Bad weather	Mark your answer
₡ 0	₡ 6,000	₡ 5,000	
₡ 1,000	₡ 9,900	₡ 2,900	
₡ 2,000	₡ 13,800	₡ 800	

Annex 4: Case of loan bundled with insurance

To analyze the case of loans with mandatory insurance, we need to define the joint probabilities of income and weather. Using the definition of correlation between income and weather $\varepsilon = \rho \sqrt{p(1-p)q(1-q)}$, the joint probabilities can be rewritten as (Giné and Yang, 2009, p.3):

$$Pr(Y_H, h) = pq + \varepsilon \qquad\qquad Pr(Y_L, h) = (1\text{-}p)q - \varepsilon$$

$$Pr(Y_H, l) = p(1\text{-}q) - \varepsilon \qquad\qquad Pr(Y_L, l) = (1\text{-}p)(1\text{-}q) + \varepsilon$$
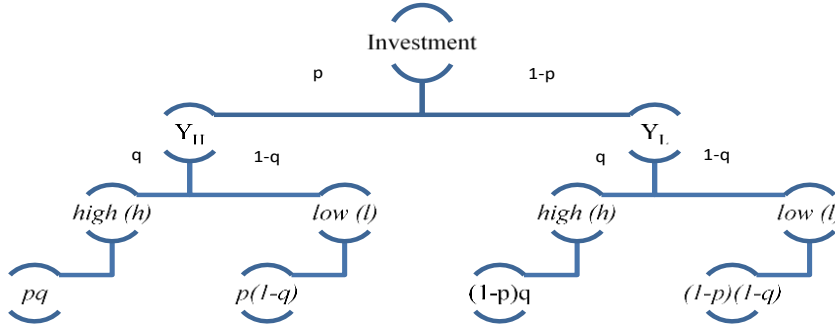
Following Giné and Yang (2009), the insurance always pays in states of bad weather, both the loan $(1+i)C$ and the insurance premium π. The farmer repayment to the bank is: $R^I = (1+i)(C+\pi)$ for a loan with mandatory insurance and the priced fair premium for the insurance is: $(1+i)\pi = (1-q)R^I$ and simplifies to $\pi = \frac{(1-q)C}{q}$ as follows:

$$\pi = \frac{(1-q)R^I}{(1+i)} \quad = \quad \frac{(1-q)(1+i)(C+\pi)}{(1+i)} \quad = \quad (1-q)(C+\pi) \quad = \quad C - qC + \pi - q\pi$$

$$\pi - \pi + q\pi = C - qC \quad \rightarrow \quad \pi = \frac{(1-q)C}{q}$$

Then, the amount to repay the bank with mandatory insurance writes as a function of the loan without insurance $R^I = \frac{R}{q}$.

$$R^I = (1+i)(C+\pi) \quad = \quad (1+i)(C + \frac{(1-q)C}{q}) \quad = \quad (1+i)\frac{C}{q} \quad = \quad (1+i)C \quad = \frac{R}{q}$$

We assume p = q = ½ and rewrite the joint probabilities. Then $\varepsilon = \rho \sqrt{p(1-p)q(1-q)} = \frac{\rho}{4}$ and the joint probabilities are:

$$Pr(Y_H, h) = pq + \varepsilon = \frac{(1+\rho)}{4} \qquad\qquad Pr(Y_L, h) = (1\text{-}p)q - \varepsilon = \frac{(1-\rho)}{4}$$

$$Pr(Y_H, l) = p(1\text{-}q) - \varepsilon = \frac{(1-\rho)}{4} \qquad\qquad Pr(Y_L, l) = (1\text{-}p)(1\text{-}q) + \varepsilon = \frac{(1+\rho)}{4}$$

Finally, the repayment of the loan with insurance becomes R= $\frac{R}{q} = 2R$