Ex-ante Impacts of Agricultural Insurance:

Evidence from a Field Experiment in Mali

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Abstract

Anticipating a negative income shock, uninsured households may refrain from undertaking profitable, but risky activities. This ex-ante risk coping strategy can be costly in terms of forgone income. Therefore, insuring households so that they are objectively (and subjectively) less exposed to risk can prevent them from adopting welfare decreasing behaviors. To test this hypothesis, we randomly offered a microinsurance contract to a group of cotton cooperatives in Mali. Using instrumental variables techniques, we find that being insured and feeling insured had a significant impact on households' cotton production decisions. The intervention had impacts primarily on the extensive margin by increasing the area devoted to cotton, the total input expenditures, and the amount of loans.

1 Introduction

Uninsured risk remains a serious impediment to poverty reduction in developing countries. It disproportionally affects the poorest within a population, potentially impeding their ability to benefit from growth. When facing a negative income shock, uninsured poor households tend to protect their assets at the cost of reduced consumption. Even the anticipation of a negative shock causes uninsured households to refrain from undertaking profitable, but risky activities. They instead invest in traditional technologies that have a low rate of return, which makes them even poorer.

Microinsurance has been promoted as a tool to improve households' resilience to shocks, by mitigating the pernicious ex-post and ex-ante effects of uninsured risk. Despite the rapid spread of microinsurance pilots around developing countries, there is little empirical evidence on their effectiveness as a tool to reduce poverty. The goal of this paper is to remedy this gap in the literature by evaluating the efficacy of a microinsurance intervention that targeted cotton farmers in Mali. The focus of the study is to analyze the ex-ante impacts of insurance by looking at the agricultural production decisions.

We designed the pilot project on which we base the analysis around cotton cooperatives since the cotton industry in Mali takes place in cooperatives. The research strategy we adopted was a randomized intervention that involved 87 cooperatives. We allocated two thirds (59) of the cooperatives into treatment group and we maintained one third (28) of the cooperatives as a control group. The treatment cooperatives were then offered the option of purchasing a microinsurance contract. To increase the likelihood of substantial take-up, we adopted an encouragement design: treatment cooperatives randomly received randomly distributed discounts that reduced the price to 50%, 75%, or 100% of the actuarially fair premium.

The microinsurance contract is an index insurance contract. Unlike conventional indemnity insurance in which payouts are based on individual outcomes, index insurance insures an objectively measured index, designed to be highly correlated but not identical to individual outcomes (for example rainfall insurance or area-yield insurance).

In the first year of the program, 16 out of the 59 treatment cooperatives (30%) agreed to purchase the index insurance contract. This uptake rate is well above up-take rates in some other pilot projects. Using methods that account for the endogenous decision of being insured and feeling insured, we find that being insured and feeling insured had a significant impact on households' ex-ante behaviors at the extensive margin. The intervention had impacts primarily on the extensive margin by increasing the area devoted to cotton, the total input expenditures, and the amount of loans. Our findings are robust to other specifications. The remainder of the paper is structured as follows. In Section 2, we present a literature review of the studies of the impact of insurance. We then present the context of the intervention in Section 3. In Section 4 we describe the sample. In Section 5 we present our main findings. We conclude with policy implications.

2 Impact of microinsurance on risk coping and risk mitigation mechanisms

To set the stage for the impact of insurance on welfare, let us examine household behavior in the absence of insurance. The literature has established two main channels through which uninsured risk affects a poor household. The first channel takes place after the shock occurs (ex post), and consists in two complementary smoothing mechanisms. Consumption smoothing consists in liquidating the household's assets such as livestock to maintain a critical level of consumption. It is the most common type of coping strategy among the rural poor. It leads to a suboptimal accumulation of capital, and therefore a lower level of long-term income. Asset smoothing, which complements consumption smoothing, consists in destabilizing the households' consumption to protect their assets (Hoddinott 2006, Carter et al. 2007, Carter and Lybbert 2012,Kazianga and Udry 2006Jalan and Ravallion 1997Townsend 1994). Not only does this type of behavior have immediate short term impact on households 'nutritional status, but it can also lead to potentially irreversible losses in child health, nutrition and education [Carter et al., 2007]).

The second channel through which uninsured risk affects households' well-being occurs before the realization of the shock or ex ante. For an agricultural household, this channel takes place primarily through their production decisions. Anticipating a negative income shock, a household chooses to adopt a risk averse production behavior by investing in lower risk and lower return production method, instead of profitable but riskier alternatives [Rosenzweig and Binswanger, 1993]; [Carter et al., 2007]).

Empirical studies of the impact of microinsurance[1] on household production decisions in developing countries are scarce, mainly because of a low level of uptake of these products. Earlier studies have reported liquidity constraints [Cole et al., 2013a, Giné and Yang, 2009], lack of trust poor understanding ([Cai et al., 2009, Dercon et al., 2011, Cole et al., 2013a] as a possible explanation for the low uptake problem of microinsurance. More recent literature used insights from behavioral economics such as ambiguity aversion [Bryan, 2010], compound risk aversion ([Elabed and Carter, 2014]), and prospect theory considerations ([Petraud, 2014] to shed light on the problem of low insurance demand.

In theory, by protecting households against shocks and therefore reducing income variability, microinsurance allows households to avoid the costly asset smoothing and consumption smoothing behaviors. To date, only Janzen and Carter [2013] study the ex post impact of micro insurance on households' welfare. Their study is based on a drought induced insurance intervention in Kenya. Using households' reported risk coping strategies they find that insured farmers were less likely to smooth their consumption and their assets.

The main finding of the ex-ante impacts of microinsurance is that it induces farmers to take more profitable but riskier activities. When studying agricultural decisions in Ghana, Karlan et al. [2012] show that uninsured risk is the binding constraint to farmer's investment decisions. They randomly distributed cash grants, the possibility of purchasing insurance, or both. They showed that insuring against the main production risk enables farmers to spend more resources on their farm. Cole et al. [2013b] randomly distributed insurance contracts to a sample of Indian farmers. They find that farmers intensify the production of their main cash crop, which is risky relative to other land and labor uses. They do so by allocating more fertilizers, seeds and land to that crop. Mobarak and Rosenzweig [2012] randomly offer households the opportunity to purchase a rainfall insurance contract. They find that insured households are more likely to plan a variety of rice that has a significantly higher yield but is less drought tolerant. Cai et al. [2009] randomly distributed the opportunity to purchase an insurance contract to Chinese farmers in Southwestern China. They find that increased insurance adoption leads to an increase in sows. Cai [2012] uses a natural experiment and a household level panel data set in rural china to study the impact of government weather insurance program. She finds that insurance results in a significant increase in the production area of the insurance crop, a decrease in the production diversification. [Vargas Hill and Viceisza, 2010] designed framed field experiment in rural Ethiopia. In the games, farmers were asked to decide between whether to purchase a fertilizer and if so how many bags. Fertilizers represent the high risk high return activity in those experiments. Introducing a hypothetical insurance contract induces farmers to take more risk by purchasing more fertilizers than their non-insured counterparts.

[1] Cole et al. [2012] and [De Bock and Darwin Ugarte, 2013] do a systematic review of the effectiveness of index insurance in developing countries.

3 Context and evaluation

3.1 Background on cotton production in Mali

Cotton is the main cash crop in Mali. It participates by up to 1% of the country's GDP and 15% of export revenues (African outlook 2013). Moreover, it plays a crucial role in rural development: between 10 and 13 million Malians depend directly on the cotton sector for their livelihood (IFDC2013). Most of the production takes place in Southern Mali in the regions of Sikasso, Bougouni, Fana, Sikasso and Kita.

Cotton is an annual crop, and grown on an average of 2 ha in rotation with other staple and cash crops such as maize. Its planting season coincides with the rainy season, which starts in late May or early June. The harvest takes place during the months of December and January. Since cotton constitutes one of the main sources of cash for Malian households, it is an important input into households' food security. In addition, the cotton crop functions as collateral to get input loans for the staple crops such as maze. Cotton producers are eligible for fertilizer loans from the national agricultural bank, with the obligation to repay at harvest time. In a setting where individual credit is nonexistent, this is a very important attribute.

The cotton sector in Mali is characterized by four main features. First, it is characterized by a high degree of vertical integration. The CMDT, the company Malienne des Textiles, is a national company that controls the cotton sector in Mali. Upstream, it acts as a monopsony by providing farmers with inputs and technical assistance. Downstream, it acts as a monopoly by purchasing all the cotton harvest from the farmers. In addition, CMDT divided the cotton growing area in several Secteurs (there is a total of 5 Secteurs in South of Mali). Each sector is divided into Zones de Production Agricole (ZPA), and each ZPA is in turn divided into cooperatives comprised of 25-30 farmers each.

The second feature of the cotton sector in Mali is that production takes place in cooperatives. An individual farmer has no access to credit to finance cotton production inputs. This is due to the usual problem of moral hazard that guarantee the failure of individual microcredit in rural areas of the developing world. To solve the problem of lack of access to credit, cotton production in Mali takes place in cooperatives. In a given village there are from 1 to 2 cooperatives with an average of 20 farmers. The main role of a cooperative is to give its members an access to input loans, mainly seeds, urea and the complexe cotton – the main fertilizer used in cotton.[2] The Banque National de Developpement Agricole (BNDA) is the primary source of input loans for the cotton sector. It passes loans to the CMDT, which on-lends the funds to individual village cooperatives. Every cooperative has a bank account at the BNDA.

The third feature is that the input loan comes with a binding joint liability clause. If at least one producer is unable to pay back his loan, all the other members of the cooperative have to pay back the difference.

[2] At the beginning of the growing season, each member of the cooperative lists his needs in terms of production inputs. The secretary of the cooperative gathers the list from all the members and gets an input loan in kind from the BNDA. Then the cooperative distributes the inputs in kind among its members. After the harvest, The CMDT sends trucks to the villages and publicly weighs the cotton production, then transport it to its processing facilities. Then, the amount of the loan is deducted from the CMDT payment to pay back the loans. Then it distributes the profits to the village cooperatives, which are responsible for distributing the profit among their members.

Therefore, productive cotton farmers bear the burden of less productive farmers, which creates tensions within the cooperatives. There is evidence that joint liability is enforced in the area. Members who were not able to pay back their loans are forced to sell their productive assets.

The final characteristic of the cotton sector in Mali is that farmers do not face a price risk since the CMDT announces the price long before the onset of the growing season. However, they face a substantial production risk. Since cotton is entirely rain fed in the study area, its production is vulnerable to weather shocks. The household survey we conducted highlights the extreme poverty and vulnerability of these farmers to adverse shocks: more than three quarters of the households reported that they suffered financially because of a drought during the year preceding the survey (i.e. in 2011). The average reported cost of this drought is equal to almost 348,000 CFCA (approximately 696 USD), which represents half of the financial costs of the shocks experienced by the households in 2011.

Households unable to pay back their input loans suffer a loss of their productive assets and go through costly risk coping mechanisms. While insurance is a potential solution to the effects of these adverse shocks, it is widely absent in Mali. In this context, the Index Insurance Innovation Initiative launched in 2010 a pilot in the sector of Bougouni, in Southern Mali.

3.2 Design of the cotton insurance contract

The study area consists of the Secteurs of Dogo and Bougouni located within the region of Bougouni. There are a total of 270 cooperatives in these two Secteurs. Since the cotton industry in Mali is controlled by a monopsony/monopoly, and the production takes place in cooperatives, we decided to make the cotton cooperative as the insured unit.

The contract we designed is an area-yield index insurance contract. Unlike traditional insurance that pays individual farmers based on the losses they experience in their fields, a conventional index insurance pays based on an index that is designed to be highly correlated but not identical to farmer's losses. A conventional area yield index insurance contract pays a cooperative if the average yield in an aggregate area falls below a predetermined historical level. The contract is a double-trigger lump sum indemnity contract. Compared to conventional single trigger contract, this contract has the advantage of reducing uninsured basis risk faced by cooperatives. The first trigger is the cooperative average yield, and it varies between 264 and 913 kg/ha. The second trigger is the ZPA yield and is equal to 900 kg/ha. We adjusted the level of the first trigger to keep the price of the insurance contract constant across cooperatives. Payoff occurs only if both the cooperative yield and the ZPA yield are below their triggers. Thus a cooperative with a yield of 740kg/ha would receive a payoff if the ZPA yield is 780kg/ha, but not if the ZPA yield is 1000kg/ha.

The triggers were set based on an estimation of the statistical distribution of the yield data at both levels. The CMDT provided cotton yield data at the ZPA level for all the ZPAs of Bougouni Region for 7 years (from 2001/2002 to 2007/2008). In addition, we obtained cooperative level yields for nearly all the cooperatives in the Secteurs of Dogo and Bougouni for the last 5 or 6 years. The probability of getting a payment is set at 7%, and the insurance payment is equal to a lump sum of 95000 CFA/ha (or about 190 $US per hectare). It corresponds approximately to the amount of the loan taken by the farmers at the beginning of the growing season from the BNDA.

The upside of these contracts is that they reduce the basis risk for the cooperative while avoiding the moral hazard that would occur if payments were made only based on cooperative level yields. Under this dual trigger contract, insured cooperatives have no perverse incentives to reduce their yields, since payoffs are made only if the greater area of the ZPA has a low average yield. For more details about this contract see [Elabed et al., 2013].

Since the insured unit is the cotton cooperative, cooperative members decide to purchase the contract thanks to an internal decision making process. The decision has to be made before the beginning of the growing season, i.e. before the end of May. If the cooperative decides to buy the insurance contract, then the CMDT signs a formal insurance agreement with the insurance company, naming the covered cooperative and the appropriate number of hectares insured. The CMDT pays the insurance company directly and then deduct the premium charges from the cooperatives using the same mechanism it uses to recover loan repayment (that is, loan and insurance charges are to be deducted from the value of cotton sales which are made directly to the CMDT).

3.3 Experimental Design

The reinsurance company priced microinsurance contracts for 87 cotton cooperatives from the initial number of 270 cooperatives for which we intended to price a contract. We randomly allocated two thirds (59) of the cooperatives into treatment group and we maintained one third (28) of the cooperatives as a control group. We then offered the treatment cooperatives the option of purchasing the insurance contract. The contracts are identical from an actuarial point of view. They have the same probability of payment, and differ in terms of the triggers set at the cooperative and ZPA level. The actuarially fair premium of the insurance contract is equal to 7,125 CFA (15 USD). The insurance company charged a 50% mark-up, which results in a premium of 10,716 FCFA/ha (22 USD).

To increase the likelihood of substantial take-up, we adopted an encouragement design: treatment cooperatives received randomly distributed discounts that reduced the price to 50%, 75%, or 100% of the actuarially fair premium. Overall there are three categories of prices, implying three levels of subsidies. The first category corresponds to a price of 7125 FCFA (15 USD), the actuarilly fair price, which implies a subsidy of 3591 FCFA/ha (7 USD). The second category corresponds to a price of 5344 FCFA/ha (11 USD), which represents 75% of the actuarially fair price. The third price is 3563 FCFA/ha (7 USD), which is 50% of the actuarially fair premium.

The implementation of the randomization consisted of three steps. We organized a workshop in Bamako to train a group of local extension agents about the insurance contract and the implementation of the randomization. During the months of April and May 2011, these agents organized group trainings with the

Table 1: Test of Audit-based Reclassification of Treatment Status

	Treated Cooperatives (Original Classification)		*Control Cooperatives (Original Classification)*
	Not Reclassified	Reclassified	
Percent Farmers Saying Offered Insurance	82%[1]	23%	25%[2]
Percent Farmers Saying Insured	30%[1]	8%	9%[2]

[1] Means of not-reclassified and reclassified are different at the x% significance level

[2] Cannot reject the hypothesis that means of reclassified and original Control are the same

secretaries of the cooperatives from the treatment groups to inform them about the intervention. The idea was that the secretary would then train the members of his cooperative about the insurance contract. In the final stage of the implementation process, the extension agents were supposed to visit each cooperative from the treatment group to hold a general meeting with all its members. The outcome of the meeting would be a decision of the farmers of whether they want to subscribe to the insurance contract or not.

We administered a follow-up survey in December 2011 and January 2012, after the harvest. We sampled the households to survey in one wave in 2011/2012. There was no baseline survey but we relied on recall data over a short period of time. To draw the sample, groups of enumerators were assigned a certain number of cooperatives in the study area. Then, each group coordinator asked the chief of the cooperative to list the names of the cooperative members. Using a randomization table, the survey coordinator identified 12 household heads to survey. The final sample frame consisted of 312 household members from the control group, and 669 households from the treatment group.

The questionnaire included demographic, wealth, production and food consumption modules. There was also a module about insurance purchases. In every household, we surveyed the household head, the woman in charge of preparing the meals (the food queen), and the woman who has the youngest children in the household. We also measured the heights and weights of children aged from 6 months to 5 years.

To make sure that the implementation of the intervention complies with the procedure we established, we included an audit question in the impact survey. Specifically, we asked the surveyed cooperative member whether he knew that his cooperative had access to an insurance contract or not. Surprisingly, 9 cooperatives out of the 59 initially allocated to the treatment group have a high percentage of negative answers. We further investigated this issue by talking to the extension agents who implemented the intervention. We found out at that at least 3 cooperatives were not offered the possibility of purchasing the insurance contract. The reason behind this imperfect implementation is primarily the deadline we imposed on the collection of the insurance subscriptions by the extension agents. In fact, since we are also interested in studying the ex-ante decisions of farmers, we imposed the deadline of May 31st to guarantee that farmers made their insurance purchase decisions before starting to make their planting decisions. To account for the high level of negative answers within the 9 cooperatives, we decided to reclassify them in the control group. The rest of the paper carries the analysis using this audit-based reclassification, our preferred classification, and the original classification.

4 Sample and balance tests

In what follows, the "treatment group" refers to members of cooperatives that were offered an insurance contract, and "control group" refers to members of cooperatives that were not offered the insurance contract.

Panel A of Table 2 provides the descriptive statistics of the households belonging to the control group. The average household head is approximately 56 years old, and has limited formal education (less than one year of schooling). Moreover, 60% of the surveyed farmers are Bambara, while only 30% are Peuhl. Most of the farmers are non-immigrants (80%) and more than half of them are related to the village chief. The respondents have a relatively long experience farming (19 years on average) and being a cooperative member (9 years on average). The total area in cotton per household is around 2 ha, with a yield of 1,070 kg/ha. The total area allocated to the other crops (corn, millet, mill, sorghum and rice) is around 4 ha per household. Overall, the study sample is made by really poor small scale cotton farmers.

Randomization of treatment should ensure that treatment and control groups have similar baseline characteristics on average. To check this, table 2 presents means of several key demographic and production characteristics for the treatment and control group, relying on their recalled baseline levels of characteristics, and using both the original and the preferred classifications, as well as the significance level of the F-test that the difference in means is statistically different from zero.

Overall, the randomization achieved balance, i.e. the difference in means is not statistically different from zero, across nearly all the variable presented (cotton area, cotton harvest, maize, sorghum, and mill areas, household head's age, education, number of years of membership in the cooperative, whether the household head has a function in the cooperative, whether the house is in stones, whether the house has a private well). The only exception is that cotton yields among treatment groups are about 140 kg/ha lower than in the control group, and this difference is statistically significant at the 1% level. As cotton yield does not reflect only ex-ante decisions, it is also subject to factors such as droughts that occur after the farmer makes his cotton production decisions, finding a difference in this variable between the treatment and control groups is not problematic.

	N	Preferred classification (4) Control	(5) Treatment
Pre-intervention outcomes			
Cotton area 2010 (hectares)	586	2.19	2.44
		[1.33]	[1.77]
Cotton harvest 2010 (kg)	584	2316.6	2291.2
		[1741.3]	[1939.4]
Cotton yield 2010 (kg/ha)	584	1053.1	914.6***
		[422.9]	[342.7]
Area in foodgrains (hectares)			
Household characteristics			
Household head age	962	54.9	55.1
		[14.23]	[14.19]
Household head years of schooling		0.87	0.76
		[2.05]	[1.53]
Household head is ethnically Bambara	981	0.61	0.65
		[0.49]	[0.48]
Membership in cooperative (years)	970	8.09	8.70
		[4.71]	[6.23]
Cooperative leader	981	0.25	0.22
		[0.43]	[0.41]
Stone house	970	0.17	0.14
		[0.38]	[0.34]
Private well	970	0.29	0.35
		[0.45]	[0.48]
Post intervention outcomes			
Cotton Area Cultivated (hectares)	954	2.53	2.92*
		[1.68]	[2.15]
Amount Borrowed ('000 CFA)	966	301.740	339.998
		[237.712]	[285.427]
Expenditures on cotton seed & fertilizer			
Cotton Harvest (kg)	941	2567.7	2761.7
		[2015.6]	[2247.8]
Area in Foodgrains (hectares)			

Table 2: Balance

5 Impact of insurance on production decisions

This section investigates the impact of insurance on cotton production decisions: area in cotton, and expenditures on seeds and fertilizers. In addition to recall data covering the year before the insurance program, the analysis here relies on one round of data collected after the offer of the insurance program. We start by describing the uptake of insurance. Then we present the empirical strategy and the results.

5.1 Descriptive results

In the first year of the program, 14 out of the 50 treatment cooperatives (28%) agreed to purchase the index insurance contract. This corresponds to 164 households out of the 571 households in the treatment group. The demand does not have the expected downward sloping shape, for both the original and preferred classifications. This is shown in Figure 1, which uses the random variation in the premiums used as an encouragement design to examine the fraction of cooperatives purchasing insurance as a function of the price of insurance. The demand slightly dropped when the price went from 100% of the fair premium to 75% of the fair premium. Then it slightly increased when the price went down to 50% of the fair premium. This result is puzzling and could be explained by the imperfect implementation of the encouragement design in the field. Therefore, the following analysis will not study the implications of the encouragement design.

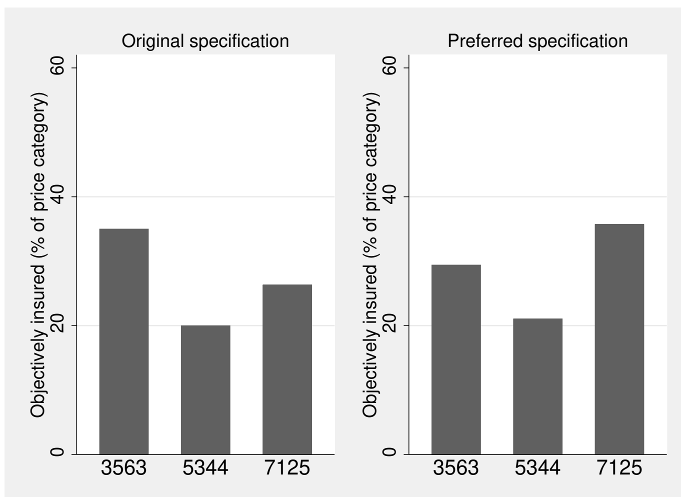

Figure 1: Insurance Take up by Price per ha (CFA)

5.2 Empirical strategy

Believing insured versus being insured:

Our main hypothesis is that if a farmer perceives a risk reduction thanks to an insurance contract, then he will free the resources allocated as a coping mechanism against negative income shocks. At the extensive margin, he may allocate a larger share of his land to cotton production. Insuring the farmer would then increase the overall farm revenue, protecting him from costly consumption and asset smoothing strategies. If, however, he does not perceive a risk reduction, then he will not change his investment behavior.

Several factors could prevent the farmer from perceiving a risk reduction. In the context of this study, the difference between the randomization unit (cooperative), which is also the decision making unit, and the study unit (the individual) could create a situation in which a cooperative member is objectively insured, meaning that his cooperative purchased the insurance contract, but he does not know that he is insured. This situation could occur when the cooperative member is not present during the meeting to decide whether or not to buy insurance, which is very likely since the rule for a cooperative to make a decision is that at least the third of the members are present.

Given the above discussion, the following section will rely on two measures of risk reduction. The first one is the objective risk reduction measured by whether or not the cooperative purchased insurance. The other is the subjective risk reduction measured by whether or not the individual farmer believes that his cooperative purchased the insurance.

We are interested in studying the impact of “believe insured” and “purchased insurance” on different *ex-ante* production outcomes such as loans obtained from the CMDT to finance cotton production, expenditure on seeds and fertilizers, and area allocated to cotton. We use the following specification:

$$Y_{ic} \quad = \quad \alpha + \beta I_{ic} + \gamma X_{ic} + \epsilon_{ic} \tag{1}$$

where I_{ic} is either the variable “believe insured” and “purchased insurance” for individual i in cooperative c. “Believe insured” is equal to one if the household member thinks his cooperative bought the insurance contract. The second variable, “purchased insurance” is equal to one if the cooperative bought the insurance contract. X_{ic} is a vector of household-level characteristics and ε_{ic} is an error term. Treatment assignment at the cooperative level creates spatial correlation among farmers within the same cooperative. Therefore, the reported standard errors are clustered at the cooperative level. The number of clusters being larger than 5, the significance tests based on the clustered errors are not likely to over reject the null hypothesis (Cameron et al. 2008).

The coefficient β on the insurance dummy variable is the impact of believing insured (purchased insurance) on the ex-ante production decision, and answers the question “By how much does a farmer who believes that he is insured (is insured) increases his area in cotton?”. “believe insured” and “purchased insurance” are endogenous variables. Therefore, we use an instrumental variable approach relying on (1) the randomization status, and (2) the insurance penalty mark-up explained below.

The reinsurance penalty mark-up

The penalty mark-up is a penalty imposed by the reinsurance company on cotton cooperatives that suffered from data problems. The penalty translates to an overestimated variance of the probability distribution of cotton yield, which leads to an additional mark-up on the insurance contract price. For instance, a cooperative for which we have cotton yields data for the past 5 years has a less favorable contract than its counterpart for which we have more data, despite being located in a very similar agro climatic zone.

To measure the reinsurance penalty markup, we have first estimated an ideal probability distribution of the cotton yields. To do so, we pooled the historical yield data generated by cooperatives located at the same agroclimatic zones and within a distance of 20 to 30 km from each other. Pooling the yields data allows us to improve the precision of the estimation of the cotton yield distributions. Then, based on our estimated probability distribution function, we calculated an ideal cooperative level trigger that determines the insurance payment. The reinsurance penalty markup is the difference between our calculated trigger, and the trigger calculated by the insurance company:

$$Z_{ic} \quad = \quad (Calculatedtrigger - actualtrigger) * 1000$$

We argue that the reinsurance penalty markup is a valid instrument for the endogenous variables “being insured” and “believing insured”. First, it is random. In most of the cases, the cooperative secretary keeps track of the yield data. However, if he suffers an idiosyncratic shock such as a disease or death, he tends to not handover the information to his successor. This random absence of data causes the insurance company to perceive this cooperative as riskier than its counterpart that had a more complete production times series. Second, it is expected to be highly correlated with the endogenous variables that we are studying. A cooperative that suffered a penalty markup because of random data problems would be less likely to uptake insurance compared to its counterpart that was not penalized. Third, this instrument is not correlated with the error term of the second stage regression and could not be included as an explanatory variable in the second stage regression. This exclusion restriction is justified by the fact that the penalty markup would affect the outcomes of interest only indirectly by increasing the likelihood of “purchased insurance” and “believe insured”.

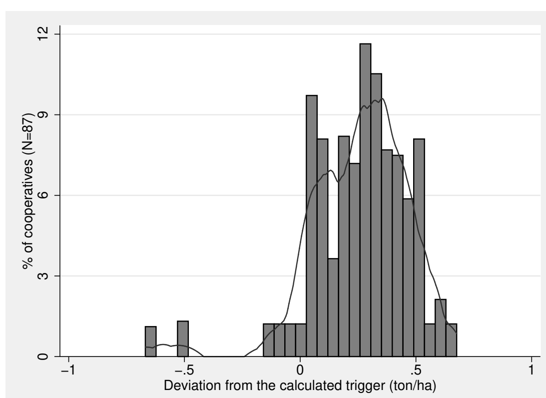

Figure 2: Distribution of the reinsurance penalty markup

Figure 2 above plots the histogram of the reinsurance penalty mark-up in in the studied sample in tons per hectare. More than 96% of the cooperatives in the study area were assigned a trigger below our calculations.

The median difference is 255 kg/ha, and the standard deviation is 218 kg/ha.

Two-stage least square strategy

The first stage regression is:

$$I_{ic} = \alpha + \delta_1 T_{ic} + \delta_2 Z_c + \gamma X_{ic} + \varepsilon_{ic} \quad (2)$$

where T_{ic} is the treatment status of individual i in cooperative c and Z_c is the insurance penalty. Due to the exogenous nature of T_{ic} and Z_c, controlling for baseline variables should have only a marginal effect on the coefficients δ_1 and δ_2, but has the advantage of absorbing residual variation and reducing the size of standard errors.

We then estimate the impact of insurance on Y_{ic} with the following second stage regression:

$$Y_{ic} = \alpha + \beta \hat{I_{ic}} + \gamma X_{ic} + \epsilon_{ic} \quad (3)$$

where $\hat{I_{ic}}$ is the predicted value of the "insured" variable using the first stage regression 2.

5.3 Results

First stage results

	Coop Purchased Insurance	Individual Believes Insured
Treated	0.241***	0.234***
	(0.071)	(0.063)
Penalty	-0.441**	-0.149
	(0.193)	(0.165)
Constant	0.106	-0.100
	(0.143)	(0.096)
N	897	888
r2_a	0.187	0.108
F stat	10.11	7.13

Table 3: Uptake

Table3 presents estimates of the first stage equation 2 using both the original and preferred classifications for the variables "purchased insurance" and "believe insured", and omitting the coefficients associated with the control variables. Columns (1) and (2) show that being assigned to the treatment group leads to a 26.2% and 24.1% uptake rate using the original and preferred classifications, respectively. These treatment effects are also statistically significant at the 1% level.

As predicted, we find that the level of the reinsurance penalty markup strongly discourages the uptake of insurance: an increase in the reinsurance penalty by 100 kg leads to a decrease in the likelihood of taking up insurance by 40% using the original classification, and 44% using the preferred classification.

Being part of a cooperative that was offered an insurance contract leads to a 19.6% and 23.4% increase in the likelihood that a farmer believes he is insured using the original and preferred classifications, respectively. These coefficients are significant at the 1% level. The reinsurance markup also negatively affects "Believe insured", but the coefficient is not statistically significant at the 5% level for neither classification.

The last row of table3 presents the F-statistic from F-tests of the joint significance of the two instruments. The instruments are strong for "Purchased insurance" (F-test more than 10), but they are somewhat weak for "Believe insured" suggesting that the instrumental variable estimates may be biased in the same direction as OLS estimates and may not be consistent. Therefore, we will interpret the local average treatment effects of "Believe insured" cautiously.

Local average treatment effects

As predicted, we find that the offer of insurance, and the feeling of being insured encourage investments in cotton production, by increasing the amount of input loans, the area grown in cotton, and the expenditure on fertilizers and seeds. The results are displayed in 4.

Cotton farmers who are part of cooperatives that purchased the area-yield index insurance contract significantly increased their area in cotton compared to their counterparts who were not insured. Column (9) of table 4 shows that insurance led a 1.3 ha increase in the area in cotton, which represents a 55% increase from the baseline value of the treatment group, using the preferred classification.

Purchasing insurance also led to an increase in the expenditures on seed and fertilizers, and loans, which is consistent with the observed increase in cotton area. Expenditure on seed significantly increased by about 13,047 CFA, and expenditure on fertilizers increased by 85,726 CFA, which represent respectively 103% and 68% more than the corresponding expenditures among the control group. Although non-significant, the size of loans is 34% higher than the comparison group.

The IV estimates of the impacts of "believe insured" on the various cotton production decisions are qualitatively similar to those of "being insured." Farmers who believed that they were insured increased the area in cotton by 1.56 ha, which represents a 64% increase from the baseline area in cotton. They increased the amount of loans by 138,000 CFA, which is equal to 46% of the loans among the control group. They also increased their expenditure on seeds by 18,000 CFA (142% of the expenditure on seeds among the control group), and their expenditures on fertilizers by 103,990 CFA (82% of the expenditures on loans among the control group).

Purchased insured:					
	Loans (kCFA)	Area (ha)	Grain Area (ha)	Inputs (kCFA)	Harvest (kg)
Insured	102.875	1.339**	0.639	97.847***	944.8
	(65.251)	(0.612)	(0.645)	(36.449)	(585.4)
Constant	74.002	0.148	1.379***	18.737	33.1
	(66.104)	(0.442)	(0.660)	(26.057)	(644.9)
N	894	883	897	878	871
R2 (adj)	0.123	0.100	0.243	0.046	0.157
Believe is insured:					
	Loans (kCFA)	Area (ha)	Grain Area (ha)	Inputs (kCFA)	Harvest (kg)
Individual believes insured	138.944	1.569*	1.096	121.010**	837.7
	(89.144)	(0.852)	(0.908)	(52.570)	(775.325)
Constant	90.367	0.367	1.522**	35.294	178.6
	(65.346)	(0.456)	0.646	(26.680)	(672.7)
N	885	875	888	870	863
R2 (adj)	0.111	0.066	0.236	-0.042	0.164

Table 4: Impact of being insured and believe insured

6 Robustness checks

This section explores other potential specifications to measure the impact of insurance. As shown below, we find overall similar results if we control for baseline cotton area, or if we use only the treatment status as an instrument for the endogenous variables “believe insured” and “purchased insurance”.

6.1 Original Classification

blah, blah ... .

	(1)	(2)	(3)	(4)
	Purchased insurance Original		Believe insured Original	
Treated	0.262***		0.196***	
	(0.061)		(0.062)	
Penalty	-0.397**		-0.120	
	(0.175)		(0.168)	
Constant	0.028		-0.149	
	(0.139)		(0.104)	
N	897		888	
r2_a	0.191		0.079	
F stat	12.99		5.31	

Table 5: First Stage with Original Classification

Coop purchased insured:					
	Loans (kCFA)	Area (ha)	Area in Foodgrains (ha)	Inputs (kCFA)	Harvest (kg)
Insured	55.259	1.069*	0.589	80.713**	786.2
	(61.540)	(0.618)	(0.621)	(36.426)	(569.6)
Constant	75.854	0.159	1.381**	19.523	37.11
	(66.882)	(0.433)	(0.657)	(25.310)	(650.5)
N	894	883	897	878	871
R2 (adj)	0.151	0.131	0.244	0.086	0.169
Individual believes is insured:					
	Loans (kCFA)	Area (ha)	Area in Foodgrains (ha)	Inputs (kCFA)	Harvest (kg)
Individual believes insured	83.715	1.550	1.162	125.010**	877.7
	(97.581)	(1.007)	(1.120)	62.901	(931.8)
Constant	85.095	0.365	1.528**	35.649	182.5
	(65.219)	(0.455)	(0.646)	26.772	(673.1)
N	885	875	888	870	863
R2 (adj)	0.146	0.069	0.234	-0.056	0.161

Table 6: Impact Results with Original Classification

6.2 Controlling for cotton area at baseline

Given that the area in cotton after purchasing insurance might be heavily determined by its past levels, a valid concern is that not including it in the regressions might lead to omitted variable bias. Therefore, including the lagged cotton area value should absorb most of the variance of the coefficient of interest and is likely to make the effect of "purchase insurance" and "believe insurance" less significant– with smaller point estimate and larger standard errors. Column (4) of Table 7 confirms this hypothesis. The coefficient on lagged cotton area is large (1.006 and 1.008) and strongly significant. An insured farmer increased his area in cotton by 0.772 ha (42% less than the estimates in the specification that does not control for baseline cotton area). Farmers who believed that they were insured increased their area in cotton by 0.727 ha (54% less than the estimates in the original specification).

The remaining columns of the first panel of Table 7 show that the magnitudes of the impacts of "purchased insurance" on the expenditure on seed are comparable to the one obtained without controlling for the lagged area in cotton, and the levels of significance are the same. The impact on the expenditure on fertilizers is however lower and significant only at the 5% level (compared to 1% level when controlling for baseline cotton area). Impacts on loans and harvest remain insignificant, but decrease in magnitude.

The second panel of 7shows that controlling for the lagged cotton area leads to a comparable magnitude of the impact of "believe insured" on the expenditure on seeds. The impact on the expenditure on fertilizers is however much lower and significant only at the 5% level (compared to 1% level when not controlling for baseline cotton area). Impacts on loans and harvest remain insignificant, but decrease in magnitude.

	Loans	Area	Area in Foodgrains	Inputs	Harvest
	(kCFA)	(ha)	(ha)	(kCFA)	(kg)
Purchased insurance					
Insured	23.998	0.77	0.82	69.208**	194.82
	(72.159)	(0.54)	(0.82)	(31.120)	(624.133)
Cotton area 2010(ha)	103.621***	1.01***	0.75***	53.299***	923.12***
	(9.342)	(0.08)	(0.11)	(4.831)	(57.26)
Constant	195.935**	0.42	1.79	34.795	573.03
	(96.768)	(0.71)	(1.33)	(48.771.)	(766.59)
N	542	545	545	543	539
R2 (adj)	0.466	0.650	0.411	0.544	0.556
Believe insured					
Believe insured	53.451	0.73	1.37	69.132**	-291.75
	(81.038)	(0.562)	(0.96)	(34.100)	(671.00)
Cotton area 2010(ha)	104.404***	1.01***	0.77***	53.390***	914.53***
	(9.413)	(0.08)	(0.11)	(4.991)	(58.35)
Constant	202.171**	0.62	2.01	52.822	658.22
	(96.342)	(0.67)	(1.32)	(45.421)	(755.73)
N	536	539	539	537	533
R2 (adj)	0.464	0.650	0.396	0.529	0.558

Table 7: Robustness checks rec

In sum, controlling for the lagged cotton area decreases the magnitude and significance of the observed impacts. However, this result might be caused by the small size of the sample on which we adjust for lagged cotton area (by controlling for lagged cotton area, we are restricting the research sample to only the 587 farmers who reported their areas in cotton).

Descriptive statistics by whether or not a farmer recalled the area in cotton at baseline

For the variables maize area, sorghum area. mill area, age of household head and years of membership in cooperative, and whether or not has a function at the cooperative (presented in Table 8), the difference in means is statistically different from zero. Cooperative members who recalled the area in cotton in 2010 tend to allocate more land to staple food, be older, more senior in their cooperatives, and tend to hold a position at their cooperatives.

	Recalled 2010	Did not recall 2010
	(1)	(2)
Maize area 2010 (ha)	2.15	1.46**
	[2.06]	[4.75]
Rice area 2010 (ha)	0.21	0.20
	[0.63]	[0.65]
Sorghum area 2010 (ha)	1.13	1.60***
	[1.66]	[1.90]
Fonio area 2010 (ha)	0.04	0.04
	[0.28]	[0.19]
Mil area 2010 (ha)	0.33	0.68***
	[0.98]	[1.39]
Millet area 2010 (ha)	0.04	0.05
	[0.30]	[0.33]
Age household head (years)	56.28	53.24***
	[13.80]	[14.62]
Education household head	0.76	0.88
	[1.59]	[2.02]
Household head is Bambara	0.65	0.60
	[0.48]	[0.49]
Membership in cooperative (years)	8.85	7.83**
	[5.56]	[5.72]
Has a function at the coop.	0.26	0.19**
	[0.44]	[0.39]
House in stones	0.16	0.14
	[0.37]	[0.35]
Private well	0.30	0.36
	[0.46]	[0.48]
Observations	587	397

Table 8: Baseline characteristics, by whether or not they recalled the area in cotton in 2010

Using treatment status only as instrument

While it is plausible that the reinsurance penalty markup is exogenous, it must satisfy the exclusion restriction: the penalty should affect farmers' production only through the uptake of insurance. We perform a robustness check by dropping the penalty markup from the set of instruments and using only the treatment status. The impact results shown in Table 9 remain qualitatively the same using both classifications, but are less precise for the area in cotton.

	Original					Reclassified				
	(1) Loans (kCFA)	(1) Area (ha)	(1) Area in Foodgrains (ha)	(1) Inputs (kCFA)	(1) Harvest (kg)	(1) Loans (kCFA)	(1) Area (ha)	(1) Area in Foodgrains (ha)	(1) Inputs (kCFA)	(1) Harvest (kg)
Purchased insurance										
Insured	44.554	0.86	0.92	73.580*	253.89	120.668	1.25	1.08	99.691*	411.61
	(71.632)	(0.66)	(0.83)	(37.892)	(669.25)	(96.700)	(0.84)	(0.90)	(51.084)	(73.523)
Constant	76.271	0.17	1.37**	19.850	50.50	73.310	0.15	1.36**	18.652	46.536
	(67.513)	(0.43)	(0.68)	(25039.985)	(677.58)	(66.402)	(0.44)	(0.69)	(26.090)	(669.641)
N	894	883	897	878	871	894	883	897	878	871
R2 (adj)	0.156	0.151	0.235	0.100	0.197	0.109	0.111	0.229	0.041	0.190
Believe insured										
Sub.Insurance	71.389	1.29	1.26	111.540*	500.94	133.801	1.36	1.17	109.942**	526.77
	(102.742)	(0.99)	(1.21)	(61.057)	(938.70)	(97.808)	(0.87)	(0.95)	(52.875)	(781.21)
Constant	83.919	0.34	1.54**	34.453	145.47	89.876	0.35	1.53**	34.311	148.01
	(65.054)	(0.45)	(0.65)	(26.374)	(673.14)	(65.288)	(0.450)	(0.65)	(26.400)	(673.16)
N	885	875	888	870	863	885	875	888	870	863
R2 (adj)	0.152	0.105	0.229	-0.011	0.187	0.115	0.096	0.233	-0.006	0.186

Table 9: Using treatment only as an instrument

7 Conclusion

In the absence of formal insurance markets, poor rural households in developing countries may rely on costly risk-management mechanisms, including income smoothing strategies that entail avoiding riskier technologies with higher expected returns. In this paper we report results from a randomized field experiment that evaluates the effectiveness of microinsurance on agricultural production decisions among cotton farmers in Mali.

In the first year of the program about 30% of the cooperatives agreed to purchase the index insurance contract. This uptake rate is well above up-take rates in some other pilot projects. The impact results imply that the intervention had impacts primarily on the extensive margin by increasing the area devoted to cotton, increasing the total input expenditures, and increasing the amount of loans.

The results have important policy implications. Policy makers showed interest in scaling up micorinsurance pilots to target a larger sample of vulnerable households in the developing countries. However, the evidence on the effectiveness of microinsurance interventions is scarce. The results of this paper show that an innovative microinsurance contract can overcome the negative ex-ante impacts of uninsured risk by boosting investment in risky but profitable activities.

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A Appendix

A.1 Reduced form estimation and results using the preferred reclassification and the original classification (ITT)

We first estimate the overall average effect of being assigned to the treatment on a given outcome by ordinary least squares with clustering at the cooperative level. We use the following specification [3]:

$$Y_{ic} = \alpha + \beta^{ITT} T_c + \varepsilon_{ic} \tag{5}$$

Denote Y_{ij} the outcome of interest measured for individual i in cooperative c. T_c is cooperative c's treatment status, and is equal to 1 if cooperative c belongs to the treatment group. The average effect of being assigned to a treatment cooperative versus a control cooperative is captured by the parameter β. Since the treatment $T = 1$ was randomly assigned, we should expect $E(\varepsilon_{ic}|T) = 0$ and the ordinary least square estimate of β is unbiased. Standard errors are clustered at the cooperative level.

[3] We have also estimated the average effect of being assigned to the treatment on the area in cotton by estimating the following equation, using a fixed effect model:

$$Y_{ict} = \theta_{ic} + \beta T_c + \varepsilon_{ict} \tag{4}$$

where t is the year and θ_{ic} is the individual time invariant fixed effect. Using the original treatment assignment, the reduced form results imply an 0.08 ha increase in the area of land devoted to cotton compared to the baseline level. This number increases to 0.18 ha when we consider the audit-based treatment status. However, the point estimates are not precisely estimated because the sample size is reduced: only 40% of the respondents were able to remember their 2010 cotton production decisions.

	(1) Area (ha) (ha)	(2) Harvest (kg)	(3) Loans (kCFA)	(4) Seed (kCFA)	(5) Fertilizer (kCFA)	(6) Seed per ha (kCFA/ha)	(7) Fertilizer per ha (kCFA/ha)	(8) Area of other crops (ha)	(9) Land owned (ha)
Panel A. No control variables									
Audit based treatment	0.39**	191	37.883*	4.633***	21.372**	0.945***	-1.422	-0.12	2.39**
	(0.18)	(202.956)	(22.603)	(1.423)	(9.492)	(0.354)	(2.394)	(0.32)	(1.16)
Constant	2.53***	2,570***	302.114***	12.704***	127.165***	5.254***	54.006***	4.027***	11.96***
	(0.11)	(138.353)	(13.451)	(0.871)	(6.020)	(0.226)	(2.181)	(0.279)	(0.73)
N	954	941	966	951	950	951	952	969	969
R2 (adj) Panel A	0.009	0.001	0.004	0.025	0.009	0.020	-0.001	-0.001	0.008
Panel B. Control variables									
Audit based treatment	0.34**	114	34.384*	4.304***	18.969**	0.963***	-1.665	-0.09	1.98**
	(0.17)	(186)	(19.280)	(1.238)	(8.944)	(0.345)	(2.525)	(0.28)	(0.972)
Constant	0.24	164	90.593	3.391	24.646	6.787***	59.210***	3.93*	-6.47**
	(0.42)	(688)	(67.193)	(3.505)	(22.773)	(0.844)	(6.088)	(1.98)	(2.71)
N	938	925.	949	935	934	935	936	952	952
R2 (adj) Panel B	0.20	0.201	0.170	0.137	0.172	0.053	0.000	0.091	0.181

Notes: Controls include age, education, ethnic group and agricultural experience of the household head, household assets, agricultural assets, house quality, source of water and source of electricity.
****Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.*

Table 10: ITT results with audit-based reclassification

	(1) Area (ha) (ha)	(2) Harvest (kg)	(3) Loans (kCFA)	(4) Seed (kCFA)	(5) Fertilizer (kCFA)	(6) Seed per ha (kCFA/ha)	(7) Fertilizer per ha (kCFA/ha)	(8) Area of other crops (ha)	(9) Land owned (ha)
Panel A. No control variables									
Treated	0.21	74.84	3.677	2.952*	18.027*	0.729*	-0.332	-0.25	2.20*
	(0.18)	(212.96)	(22.221)	(1.490)	(9.358)	(0.369)	(2.852)	(0.37)	(1.15)
Constant	2.61***	2,630.09***	321.571***	13.375***	127.273***	5.304***	53.412***	4.12***	11.85***
	(0.13)	(167.51)	(15.117)	(1.088)	(6.585)	(0.277)	(2.681)	(0.34)	(0.83)
N	954	941	966	951	950	951	952	969	969
r2_a	0.002	-0.001	-0.001	0.009	0.005	0.010	-0.001	-0.000	0.006
Panel B. Control variables									
Treated	0.25	69.84	14.229	3.093**	20.017**	729.248**	-0.557	-0.22	2.18**
	(0.17)	(195.62)	(19.743)	(1.265)	(8.598)	(359.765)	(2.873)	(0.37)	(0.98)
Constant	0.20	158.12	91.448	2.893	19.669	6.660***	59.126***	4.00*	-7.03**
	(0.43)	(699.78)	(69.554)	(3.605)	(22.852)	(0.858)	(6.596)	(2.05)	(2.82)
N	938	925	949	935	934	935	936	952	952
r2_a	0.200	0.201	0.167	0.125	0.172	0.042	0.000	0.091	0.182

Notes: Controls include age, education, ethnic group and agricultural experience of the household head, household assets, agricultural assets, house quality, source of water and source of electricity.
****Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.*

Table 11: ITT results with original classification

Panel A of Table 7 provides evidence on the average treatment impact of insurance on cotton production decisions using equation 5. The adjusted R-squared is provided at the bottom of the table. The regressions do not include co-variates. The estimation results are consistent with the hypothesis that the intervention had impacts on both the extensive margin and the intensive margin. Column (1) shows that compared to households from the control group, households from treated cooperatives significantly increased the area in cotton by 15%. In addition, the total expenditure on seeds per household significantly increased to 4,572 CFA from a baseline value of 12,766 CFA, which represents a 35% increase. The amount of fertilizers used and agricultural loans did also increase but the point estimates are not significantly different from zero.

At the intensive margin, households from the treated cooperatives used seeds more intensively than their counterparts in the control group. In fact, the intervention resulted in 14% increase in the expenditure on seeds per hectare per household. The amount of fertilizer per ha decreased but the point estimates are not significantly different from zero.