An experiment on the impact of weather shocks and insurance on risky investment*

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Abstract

We conduct a framed field experiment in rural Ethiopia to test the seminal hypothesis that insurance provision induces farmers to take greater, yet profitable, risks. Farmers participated in a game in which they were asked to make a simple decision: whether or not to purchase fertilizer and if so, how many bags. The return to fertilizer was dependent on a stochastic weather draw made in each round of the game. In later rounds of the game a random selection of farmers made this decision in the presence of a stylized weather-index insurance contract. Insurance was found to have some positive effect on fertilizer purchases, particularly for risk averse individuals who understood the insurance contract well. Purchases were also found to depend on the realization of the weather in the previous round. We explore the mechanisms of this relationship and find that it is the result of both changes in wealth weather brings about, and changes in perceptions of the costs and benefits to fertilizer purchases.

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Many investment options available to individuals in the developing world have returns characterised by substantial uninsurable risk. Perhaps none more so than the decision made by farmers to invest in crop production that depends on the vagaries of weather. Markets for weather contingent securities to insure against this risk are limited and inaccessible to the majority of these farmers.

A rich theoretical literature considers how investment decisions of poor individuals are impacted by such uncertainty. Sandmo's seminal work proves that for a firm facing output price uncertainty an increase in the riskiness of the return to production activities or in the risk aversion of the firm will reduce the scale of production (Sandmo, 1971). This model has been adapted for rural households by Finkelshtain and Chalfant (1991), Fafchamps (1992), Barrett (1996), Kurosaki and Fafchamps (2002) and others. These papers similarly show that, absent the special case of output risk positively correlated with consumption prices, increases in output risk and the risk aversion of farmers reduce the scale of risky crop production. These models thus predict that reductions in risk, such as those that would result from a weather-index based insurance contract, will increase investments that are susceptible to weather risk.[1]

Empirically testing this prediction has proved somewhat difficult. There are few instances of exogenous variations in risk which have allowed the impact of reductions in risk—such as those that would result from the development of weather insurance markets—to be assessed. Studies on the supply response of insurance provision have mainly focused on traditional yield and revenue insurance (and mainly for the US, for example Horowitz and Lichtenberg, 1993; Ramaswami, 1993; Smith and Goodwin, 1996). However these insurance contracts differ significantly from the one considered in this paper in that they insure crop yields, which depended both on production investments and weather, and not returns to a given production investment. These traditional contracts are subject to considerable moral hazard which impacts the observed supply response. Furthermore, insurance in these studies was not an exogenous source of variation in risk, as farmers selected the amount of insurance coverage they would purchase. This made it difficult to separate the decision to purchase insurance from its impact on other production decisions, such as input purchases and the scale of operation.

Recently a number of experimental studies have been conducted in which weather-index based insurance has been randomly allocated, thereby allowing an empirical test of this hypothesis (Giné et al., 2008; Giné and Yang, 2007). However, there has not been sufficient take-up of insurance, neither in the number of people accessing insurance nor the level of insurance purchased, to allow for an assessment of its impact (Cole et al., 2009).

[1] The special case holds when the source of output risk faced by a household is price risk of a crop that the household both produces and purchases. Fafchamps (1992) characterizes this case of positively correlated output revenues and consumption prices thus: "growing a crop whose revenue is positively correlated with consumption prices is a form of insurance. Consequently, more risk-averse farmers will seek to insure themselves against consumption price risk by increasing the production of consumption crops." He notes that this is only the case if the consumption effects outweigh the direct effect on income that arises as a result of switching the portfolio of crops, and if the covariance between crop price uncertainty and revenue uncertainty is large and positive.

While small scale experiments (such as lab-like experiments in the field or what Harrison and List, 2004, call ”artefactual” or ”framed” field experiments) can be an interesting avenue to explore such impacts, it seems that such studies have been rather limited. Most experimental work of this type has focused on questions of demand and supply in laboratory settings. Recent work has explored willingness to partake in risk-sharing arrangements (Bone et al., 2004; Charness and Genicot, 2009); behaviour in experimental insurance markets (Camerer and Kunreuther, 1989) and willingness to pay for insurance, particularly, against low-probability losses (see, for example, Laury et al., 2009). The work that is closest to assessing the impact of insurance on investment behaviour is Carter (2008). He implements a framed field experiment with farmers in Peru to familiarize subjects with the concepts of basis risk and weather index based insurance. He then observes farmers decision to purchase insurance and choose to undertake a risky investment.

Insurance reduces an individual's exposure to risk thereby reducing the variance of output. However, just as changes in the underlying stochastic process alter behaviour, changes in an individual's perception of the degree of risk to which they are exposed can also result in behavioural adaptation. In the face of imperfect information about the stochastic process determining output, individuals form beliefs about expected return and risk. These beliefs are updated as a result of realizations of the stochastic process. Whilst some posit Bayesian updating of beliefs (for example Viscusi, 1985; Smith and Johnson, 1988; McCluskey and Rausser, 2001), there is a considerable and growing body of evidence that suggests individuals use heuristic tools in forming and updating beliefs (for example Kahneman and Tversky, 1973; Tversky and Kahneman, 1974; Grether, 1980; Mullainathan and Thaler, 2000; Vissing-Jorgensen, 2003). The use of these heuristic tools can result in individuals overweighing salient experiences—such as recent experiences or very good or bad experiences—in forming and updating beliefs.

As such, it is possible that realizations of an uncertain process, such as the weather, result in a contemporaneous impact on wealth and on perceptions. Whilst the importance of wealth and liquidity in undertaking investments in production is well documented (Dercon and Christiaensen, 2007), the role of previous shocks in impacting perceptions has been harder to identify. Surveys do not usually collect information on beliefs, so the identified relationship between previous shocks and future behaviour has been as a result of the changes in wealth it brings. Dercon and Christiaensen (2007) show this for the case of fertilizer purchases under weather risk (the case considered here). Using panel data they show that at lower levels of wealth farmers will purchase less fertilizer. This is because at lower levels of wealth farmers lack liquidity to purchase fertilizer, and lack the ability to manage, ex post, the consumption risk that fertilizer use engenders.

Wealth not only affects liquidity to make investments, it also affects an individual's aversion to risk. An individual's aversion to risk tends to fall as his or her wealth level rises (Arrow, 1971). Additionally in the presence of missing markets an individual's ability to insure consumption from one time period to the next increases with wealth, both as a result of greater asset holdings with which to self-insure (Lim and Townsend, 1998; Fafchamps et al., 1998), and as a result of better networks with which to share risk with other individuals (de Weerdt, 2001). In intertemporal models it is the curvature of the value function that determines a household's preference for risk, rather than the curvature of an individual's utility function. The more a household can disassociate consumption from income earned in one period through inter-temporal transfer of resources the flatter the value function becomes with respect to current income (Deaton, 1991). Thus Eswaran and Kotwal (1990) show that for a given degree of risk aversion, under-investment in risky production activities will be greater for households who are less able to insure consumption from uncertain returns. This relationship is born out empirically by Morduch (1991), Dercon (1996), and Hill (2009).

To explore some of these issues in a controlled environment we conducted a framed field experiment in rural Ethiopia to observe investment decisions under uncertainty with and without mandated insurance. Farmers were asked to make a simple decision: whether or not to purchase fertilizer and if so, how many bags. The return to fertilizer was dependent on a stochastic weather draw made in each round of the game. In later rounds of the game a random selection of farmers made this decision in the presence of a stylized weather-index insurance contract. Insurance was found to have some positive effect on fertilizer purchases. By examining the impact of weather-index insurance in this way a first assessment of the potential supply response of weather-index insurance can be garnered.

Purchases were also found to depend on the realization of the weather in the previous round. We explore the mechanisms which give rise to this relationship and find that it is the result of both changes in wealth weather brings about, and changes in an individual's perception of the costs and benefits to fertilizer purchases.

Our work is closest to Carter (2008) in that we implement a framed field experiment in rural Ethiopia that familiarizes subjects with the concepts of basis risk and weather index based insurance, and assesses the impact of insurance provision on investment in a risky prospect. The difference in our case is that insurance was exogenously mandated for a random selection of farmers.

In the next section we set out a model to formalize the intuition behind the hypothesis that providing insurance will increase investment in crop production. In Section 2 the experimental games are detailed and the survey site and implementation strategy are described. Section 3 discusses the empirical strategy, and Section 4 presents the empirical results. Section 5 concludes.

1 Model

To develop some intuition for our main hypothesis, we consider a simple single period model. The model presented and results derived are from Robles (2009). In this model a farmer has utility $U(.)$ over income earned from crop production, y. We assume that this utility function is twice continuously differentiable with positive first order derivative; i.e., the marginal utility of income is positive, $U' \equiv \frac{\partial U(.)}{\partial y} > 0$, and that the agent exhibits diminishing marginal utility of income, i.e., $U'' \equiv \frac{\partial^2 U(.)}{\partial y \partial y} < 0$.

The crop income received by the farmer in a given period is determined by the amount of fertilizer he decides to purchase and apply to his fields, and the realization of good or bad weather. Specifically crop income is $\theta g(f)$, where θ is a (continuous) random variable with support $\underline{\theta}, \overline{\theta}$ and $g(f)$ is a standard neoclassical production function with the properties $g' > 0$ and $g'' \leq 0$. Accordingly, the farmer solves the following problem:

$$\max_{f} \quad EU(y) \quad \text{s.t.}$$
$$y = (y_b - pf - c) + \theta g(f). \tag{1}$$

The first-order condition for this problem becomes:

$$E\left[U'(y(f^*))\frac{\partial y(f^*)}{\partial f}\right] = 0, \tag{2}$$

which can also be expressed as:

$$E\left[U'(y(f^*))(\theta g'(f^*) - p)\right] = 0. \tag{3}$$

In order to show the main result, we make use of the result in the following lemma, which is proved in the appendix.

Lemma 1 *Consider expression 3. There exists some* $\theta \in [\underline{\theta}, \overline{\theta}]$, θ^*, *such that* $\theta^* g'(f^*) - p = 0$ *and* $\theta^* < E(\theta)$

Proof See appendix.

Next, consider the case of net income under granted insurance, i.e, $\hat{y}$. Suppose farmers are granted a stochastic benefit b such that (1) $E(b) = 0$ (i.e., insurance is provided at actuarially fair price) and (2) $b = k(E(\theta) - \theta)$ (i.e., the benefit is perfectly and negatively correlated to the weather shock θ). Then, $\hat{y}$ is given by:

$$\hat{y} = (y_b - pf - c) + g(f)\theta + k(E(\theta) - \theta). \tag{4}$$

Farmers may revise their input decision in the presence of insurance. In such case, the optimal input level f^{**} satisfies the following first order condition:

$$\frac{\delta EU(f^{**})}{\delta f} \equiv E\left[U'(\hat{y}(f^{**}))\frac{\partial \hat{y}(f^{**})}{\partial f}\right] = 0 \tag{5}$$

Consider the particular case in which $k = g(f^*)$. Then, we can show that input choice increases with insurance. To show this, note that the function $\frac{\delta EU(f)}{\delta f}$ is decreasing in f as follows:

$$\frac{\delta^2 EU(f)}{\delta f^2} = E\left[U''(\hat{y}(f))\left[\frac{\partial \hat{y}(f)}{\partial f}\right]^2 + \frac{\partial U(\hat{y}(f))}{\partial \hat{y}}\frac{\partial^2 \hat{y}(f)}{\partial f^2}\right] \tag{6}$$

Now, consider each component that lies within the expectations operator. We have the following signs:

$$U''(\hat{y}(f)) < 0 \tag{7}$$

$$\left[\frac{\partial \hat{y}(f)}{\partial f}\right]^2 = \left[\theta g'(f) - p\right]^2 \geq 0 \tag{8}$$

$$\frac{\partial U(\hat{y}(f))}{\partial \hat{y}} > 0 \tag{9}$$

$$\frac{\partial^2 \hat{y}(f)}{\partial f^2} = \theta g''(f) < 0 \tag{10}$$

Accordingly, we have:

$$\frac{\delta^2 EU(f)}{\delta f^2} < 0 \tag{11}$$

Furthermore, $\frac{\delta EU(f)}{\delta f}$ evaluated at f^* can be shown to be positive since the expression for $\frac{\delta EU(f)}{\delta f}$ is:

$$\begin{aligned}\frac{\delta EU(f^*)}{\delta f} &= E\left[U'((y_b - pf^* - c) + \theta g(f^*) + g(f^*)(E(\theta) - \theta))(\theta g'(f^*) - p)\right] \\ &= U'((y_b - pf^* - c) + E(\theta)g(f^*))\left[E(\theta)g'(f^*) - p\right],\end{aligned}$$

which is strictly positive since $E(\theta)g'(f^*) - p > 0$ by lemma 1.

Since the function $\frac{\delta EU(f)}{\delta f}$ is decreasing in f, we can conclude that $f^* < f^{**}$. Therefore, the farmer would increase his choice of input (i.e., fertilizer) in the presence of insurance.

We note that within this simple one period model, wealth would impact a farmers choice only through its impact on the relative risk aversion of the individual (assuming relative risk aversion decreases with income, Arrow 1971). Positive weather shocks could impact fertilizer choices by increasing wealth, or by altering a farmer's belief about the nature of the distribution θ through some type of updating process (Bayesian or otherwise).

Next, we discuss the experimental design.

2 Experimental design

Unexpected events that cause ill health, a loss of assets, or a loss of income play a large role in determining the fortunes of households in Ethiopia. For example, Dercon et al. (2005) show that just under half of rural households in Ethiopia reported to have been affected by drought in a five year period from 1999 to 2004. The consumption levels of those reporting a serious drought were found to be 16 percent lower than those of the families not affected, and the impact of drought was found to have long-term welfare consequences: those who had suffered the most in the 1984-85 famine were still experiencing lower growth rates in consumption in the 1990s compared to those who had not faced serious problems in the famine. Research on the potential impact of shocks and insurance on production decisions is appropriate in this context of high dependence of welfare on uninsured weather risk

Danicho Mukhere kebele in Silte zone in southern Ethiopia was selected as the experimental site. The kebele is located by the main road linking Addis Ababa to Soddo (Wolayita), about half way between Butajira and Hosannah. There are around 2,000 households living in Danicho Mukhere, in a relatively dispersed fashion. The kebele is comprised of 8 villages, some in the lowlands by the road and others in the highlands. The lowland villages are close to a road and a trading post (one of the villages, Wonchele-Ashekokola encompasses this trading area) whilst those in the highland areas have to be reached by foot and face substantial market access constraints. Four of the eight villages in the kebele were purposively selected to ensure a variety of agro-climatic and market-access conditions were covered. The villages selected were: one village on the main road (Wonchele-Ashekokola), two villages in lowland area with slightly varying accessibility (Date Wazir and Mukhere), and one village in the highlands (Edo). Each of the four selected villages are indicated in figure 1. In this kebele there are a number of traditional insurance groups, called iddirs, that have been organically formed to insure households against the costs of funerals. However, at the time of the investigation, households had no means by which to insure the weather risk to which they were exposed.

In the following subsections we describe the design and implementation of the framed field experiment that was conducted.

2.1 The experimental games

We are mainly interested in the extent to which insurance provision affects ex ante risk-taking. Given our subject pool we constructed a simple game to elicit farmers' decision-making under varying degrees of risk. Our main aim was to create a game that farmers could relate to their day-to-day decision-making environment. So, we developed a framed game in which farmers had to make fertilizer purchase (i.e., input choice and investment) decisions. We refer to this as the investment in fertilizer game (IFG). One period of the IFG consisted of the following steps:

1. The farmer had an endowment e. In the first period the initial endowment was randomly assigned and in subsequent periods the endowment level evolved according to the farmer's choice and weather shocks. With probability π, the weather was good ($\theta = 1$) and with probability $1 - \pi$ the weather was bad ($\theta = 0$).

2. Prior to weather risk being resolved, the farmer had to make a production decision. In particular, he had to decide how many bags of fertilizer f to purchase. He could purchase zero, one or two bags of fertilizer at unit price p. All fertilizer purchased was automatically applied as input to the production process by the design of the experiment. So, the farmer's final income was affected by the return to fertilizer r in addition to income from production a. These returns to production were only effective in times of good weather. In the game $\theta g(f)$

was thus given by $(a+rf)\theta$. The farmer would reveal his preference by placing the amount of cash that corresponded to the value of the number of bags of fertilizer, fp, in a yellow envelope. This envelope was collected by the experimenter and handed to the experimenter assistant. The experimenter assistant recorded the farmer's choice and then replaced the amount of money in the yellow envelope with the corresponding number of vouchers that represented bags of fertilizer. The experimenter returned the yellow envelope to the farmer and the farmer would confirm the number of fertilizer vouchers that were in the yellow envelope.

3. At this stage, weather risk was resolved. The experimenter would call upon a farmer to draw the weather θ out of a bag. The probability of good or bad weather was represented by distinct color pen tops in a black opaque bag.

4. Once weather risk was resolved, the farmer would go to the experimenter assistant to settle his account according to his decision and the draw of the weather. Regardless of the weather, the farmer had to pay a fixed amount c to represent consumption. Furthermore, the farmer received a minimum income from production regardless of the weather,y_b. The farmer's final income under no insurance $\widetilde{y}$ was thus determined as posited in the model:

$$\widetilde{y} = (y_b - c - pf) + (a + rf)\theta, \tag{12}$$

5. All income earned up to a period was kept in a white envelope.

The above steps describe one period of the *baseline* IFG. The baseline IFG consisted of four such periods. To address the question of how insurance affects ex ante risk taking, we also conducted a *modified* IFG (MIFG). The MIFG was similar to the IFG, with the exception that the last two periods of the game were played in the presence of insurance. In other words, during the last two periods of the game, the farmer had to either purchase insurance at unit cost $\hat{c} > 0$ or was provided with a grant equal to $\hat{c}$ to purchase insurance at price $\hat{c}$. In either case, the farmer could only purchase one unit of insurance. Insurance was actuarially fair and paid $b > \hat{c}$ in times of bad weather. By inducing an insurance shock, we are able to characterize differences between farmers' decisions with and without insurance.

Procedurally, the last two periods of the MIFG differed from those in the IFG as follows. In the second step, the farmer also had to place an amount equivalent to the cost of one unit of insurance $\hat{c}$ into the yellow envelope. In the case of "out-of-pocket" insurance, this amount came from the white envelope which contained all income earned up to that stage. In the case of "granted" insurance, the experimenter provided the farmer with the amount $\hat{c}$, which had to be used to purchase insurance. In addition to any fertilizer vouchers, the experimenter assistant placed an insurance voucher in the yellow envelope. After weather risk was resolved, the farmer was paid according to his choice in the presence of insurance. Similarly to before, the farmer went to the experimenter assistant to settle his account. The farmer's final income under insurance $\hat{y}$ was thus determined as described before:

$$\hat{y} = (y_b - pf - c - \hat{c} + b) + (a + rf - b)\theta. \quad (13)$$

In addition to the IFG, all subjects participated in an insurance purchase game prior to the IFG. While the results of this prior game are not the focus of this paper, it served as important practice for farmers to gain a solid understanding of insurance concepts prior to making decisions in the presence of insurance or not.

The experimental games were parameterized as follows. Consumption c was always set at 8 Birr. The initial endowment e varied randomly from 2 Birr to 16 Birr. The probability of bad weather $1-\pi$ was varied from 1/3 to 1/4 to 1/5 between sessions, but held fixed within sessions. The return to fertilizer r was either 25% or 100% (this was held fixed within sessions). The additional income from production a and the minimum income from production were both set at 5 Birr.

2.2 Implementation

We conducted twelve sessions during the course of seven days. Of the twelve total sessions, six sessions were IFG and six were MIFG. Furthermore, six sessions offered 25% return on fertilizer and six sessions offered 100% return. Finally, the probability of bad weather $1-\pi$ was equal to 1/3 during one session, 1/4 during seven sessions and 1/5 during four sessions. The 1/3 session was significantly different from all other sessions, since it lead to very high realizations of bad weather, thus constraining individuals for several periods of decision making. Therefore, we exclude this session from our analysis.

Each experiment session consisted of registration, instruction, practice, decision making (i.e., the experimental game) and final payment in private. On average the experiments lasted 150 minutes and paid 27 birr. This compares to one and a half days of casual farm labour wage in this area.

The experiments were conducted in the library of the local school located at the center of Danicho Mukhere kebele. It was a large room with tables and chairs that we were able to space out. Additionally subjects were separated by dividers to provide more privacy to individuals when they were making decisions. A picture of one of our sessions during the instruction phase is indicated in figure 2.

Each of the four selected villages from Danicho Mukhere kebele have a large iddir containing all the households in the village as members, and many smaller iddirs which each contain 20-40 members. Given some of the other research questions considered as part of the broader research project were considering the provision of insurance through these traditional insurance groups, and given each household in the kebele is an active member of one of these groups it was decided to sample through these iddirs. Each large iddir from the four selected villages was automatically selected. To select the smaller iddirs we listed all the iddirs in the four villages. From this list of iddirs 20 were randomly sampled (5 from each zone). Leaders of these iddirs were contacted and asked to come and answer some questions on their iddir (the iddir survey) and to list all the members of the iddir.

Twelve individuals were randomly sampled from the iddir membership lists. We stratified by leader/non-leader to ensure that at least two leaders from each iddir participated. Additionally, we randomly selected ten individuals from each zone (from the lists for that zone) to participate as members of the large iddir. Two leaders of the large iddir were also selected to participate.

Although our target number of households was 240 (10 from each iddir), in total 288 people were sampled. We deliberately selected 12 people from each iddir in case some were not able to participate in the experiment (or arrived too late to participate), and in case some that had participated in the experiment were not able to undertake the survey. Of the 280 listed, 262 participated in the experimental sessions and 241 of these individuals also completed a household questionnaire, 94% of whom completed the survey subsequent to participation in the game.

Table 1 presents some descriptive statistics on the individuals that participated in the experiment and survey. The majority of participants (84%) were male and were engaged in farming as their main activity (91%). The majority of these farmers have very little education (the mean level of education is only 2.3 years).

Weather shocks are not unknown to these farmers. As Table 1 reports, nearly all farmers reported experiencing drought in the last 10 years. Subjective estimates of crop losses from the last occurrence of rain failure (reported as 2007 for most) suggest that the median farmer loses 75% of his crop when the rain fails (compared to a year in which rainfall is sufficient). Farmers view the probability of rainfall shortages in the coming season as quite high. Farmers perceptions of rainfall risk were elicited by asking them to place beans between two squares, rain failure and sufficient rain, in accordance with how likely they thought rain failure in the forthcoming season was (see Hill, 2009, for use of a similar method to elicit perceptions of price risk). On average, farmers thought rain would fail with a probability of 0.25.

In the presence of quite considerable rainfall risk, Table 1 indicates that farmers have very little means at their disposal to deal with weather shocks when they do arise. In the last occurrence of drought 25% of farmers experienced losses in productive assets and/or income, and 64% reduced consumption in addition to experiencing losses in productive assets and/or income. Further assessment of farmers' access to credit and participation in risk-sharing networks, shows that, in general, farmers borrow from those who live in the same village and neighborhood as themselves, households that are members of the same iddirs and labour sharing groups. These are households with whom they have very strong ties, households that they have given to and received help from in the past, but households that are exposed to almost identical weather risk. The contextualization of the experimental game as a situation of uninsured weather risk, was thus one that was very familiar and easily understood by these farmers.

In addition, the investment decision that farmers were asked to make was a familiar one. Fertilizer is the most commonly purchased input among these farmers: 50% had purchased fertilizer in the season prior to the experiment, and 63% had purchased fertilizer in the five years prior to the survey. In comparison, only 22% had purchased seeds in the season prior to participation and only 9% had hired labour and 15%, oxen.

3 Empirical strategy

As discussed in the previous section, insurance was provided to farmers by randomly selecting half of the sessions to be an "insurance" session. And likewise when insurance was provided, the selection of granted and actuarially fair insurance was also random. The allocation of good and bad weather was also randomly assigned as live weather draws were made by participants during the experimental sessions. In addition wealth and changes in wealth were varied across individuals within and between sessions by random allocation of initial wealth endowment and variations in return to fertilizer across sessions.

Randomization should result in no significant difference in the initial value of the outcome of interest or other covariates that may affect the outcome. In such cases a simple comparison of changes in fertilizer purchases before (rounds 1 and 2) and after (rounds 3 and 4) insurance should suffice. When repeated observations of individual behaviour are available, as in this case, the use of difference in difference estimators can provide a more robust estimator by additionally controlling for significant differences in the initial outcome of interest or covariates (Heckman and Robb, 1985) or any learning effects, earnings effects or fatigue that may occur as rounds progress (which would contaminate simple before and after estimates). Given the presence of multiple rounds of data before and after the provision of insurance, we can estimate a fixed effects regression of the changes in fertilizer purchases, $\triangle f_{it}$. Namely,

$$\triangle f_{it} = \beta_0 + \beta_{\triangle I} \cdot \triangle I_{it} + \triangle u_{it} \tag{14}$$

where I is a dummy taking the value of 1 when insurance is provided, and u_{it} is individual time specific errors.

However, as we discuss below, although there were few differences in individual characteristics across the sessions, the randomization of both weather and insurance across 44 rounds resulted in some important differences in round characteristics that need to be controlled for.

Table 1 presents summary statistics disaggregated by whether or not insurance was provided. There are no significant differences in both the mean and the median of these observable characteristics. The mean area of land owned does differ significantly between the treated and control groups, but not the median. Similarly although the mean yield loss from bad weather does not differ significantly across treatment and control sessions, the median does. This table suggests the randomization was successful in ensuring individuals with similar characteristics were in each session.

In Table 2 characteristics of the sessions are presented. As the weather was drawn randomly live during the session, each session varied in the amount and timing of bad weather. Given this process was random, for a large enough number of sessions, the amount and timing of bad weather should be orthogonal to the provision of insurance in a given session. In Table 2, however, we see that this was not the case for the experimental sessions we conducted. The history of weather draws was quite different between sessions in which insurance was offered and which it was not.

In sessions in which insurance was provided bad weather draws were less likely. There was a very large difference in the experience of weather in round 2 (the round before insurance was provided) between treatment and control sessions. Sessions with insurance universally experienced good weather in this round, while half of the sessions without insurance experienced bad weather. This resulted in large differences in the wealth levels of individuals in treatment and control sessions in rounds 3 and 4, the rounds in which insurance was provided. In these rounds individuals in treatment sessions were much wealthier even though wealth levels were not significantly different across insurance and no insurance sessions in rounds 1 and 2. It may also have given rise to individuals holding very different perceptions of the risks and benefits of fertilizer purchases as they went into the final rounds of the game. In round 3, only one session experienced bad weather, and this was a session in which insurance was offered.

In the analysis these differences in wealth and weather are controlled for by adding these covariates in the regression analysis, and by matching on these covariates.

In the fixed effects analysis, we thus estimate the following:

$$\triangle f_{it} = \beta_0 + \beta_{\triangle w} \cdot \triangle w_{it} + \beta_{\triangle w^2} \cdot \triangle w_{it}^2 + \beta_\theta \cdot \theta_{it} + \beta_{\triangle I} \cdot \triangle I_{it} + \triangle u_{it} \tag{15}$$

where w denotes wealth and θ is as previously defined (weather realization). The measure of weather (θ) included is the weather an individual experienced after the previous purchase of fertilizer, i.e. between time t and $t-1$. The use of multiple rounds of data allows for a more precise estimate of coefficients on w and θ. This in turn allows a more accurate estimate of the impact of providing insurance. Given the multiple rounds of observations it is important to difference the dummy variable that indicates the presence of insurance (Wooldridge, 2002). Also although w and θ are included as covariates the coefficients on these estimates are also of interest. In controlling for these covariates in the regression analysis we are able to both better explore the impact of insurance on fertilizer purchases, as well as the impact of changes in wealth and weather. In the estimation we also allow the impact of weather to vary depending on whether the individual experienced bad weather whilst having purchased fertilizer or not.

Nearest neighbor matching is also used to estimate the impact of providing insurance. This estimation method provides consistent estimates of the impact of insurance, but does not provide any information on the additional relationships of interest, the relationship between fertilizer purchases and weather and fertilizer purchases and wealth. There are a number of matching methods that can be used. We present results for nearest neighbor matching using the `nnmatch` estimator in Stata (Abadie et al., 2004). Matching can also be conducted using estimates of the propensity score with `pscore` in Stata (Becker and Ichino, 2002), however this requires correction of the standard errors (given the two stage estimation procedure) and bootstrapping has been shown inappropriate for this context (Abadie and Imbens, 2006). An additional advantage of using `nnmatch` is that it allows for exact matching on specific variables if required, something we make use of in the analysis.

However, there are two additional assumptions that must be met to consistently estimate of the impact of insurance on behaviour. First, there must be sufficient overlap in the covariate distributions, such that like individuals in each state can be compared (Imbens, 2004). Second, it must be the case that there is a common time effect across the two groups (Blundell and Costa-Dias, 2002). This requires that there is nothing in the initial characteristics or progression of sessions that could cause the outcome variable of interest to evolve differently.

Imbens (2004) notes that when there are cases of no-overlap that arise as a result of outliers in the control observations (as is the case in round 3, only the control observations had experienced good weather in the previous round), it can give rise to artificially precise estimates. When assessing result for round 3, we should be aware that the estimates of the coefficient on insurance may appear more significant than they should. In round 4, there is an outlier in the treatment observations as only some observations with insurance experienced bad weather in round 3. In this case inclusion of the outliers can result in biased estimates (Imbens, 2004). In the analysis of round 4 results we omit observations from the session in which bad weather occurred in round 3. In the fixed effects estimation all observations are used. The multiple observations for each individual allows an estimate of the behavioural response to good and bad weather both with and without insurance. With this more accurate estimate on the impact of weather on behaviour, the estimate of the impact of insurance also becomes more precise.

An additional difference in insurance and no-insurance sessions is the initial level of fertilizer purchases. Fertilizer purchases were much higher in rounds 1 and 2 of the sessions in which insurance was offered in rounds 3 and 4. The difference in initial fertilizer purchases could have two possible effects. It could indicate a preference for fertilizer purchases among those who received insurance, causing higher levels of fertilizer purchases observed among the insured to arise from this difference in initial preferences between groups. However, this would be controlled for by differencing as this nets out any time constant unobservable characteristics such as a preference for fertilizer.

More importantly, the difference in initial fertilizer purchases could also result in a violation of the second key assumption, the assumption of common time effects across each group. Fertilizer purchases were limited to a maximum of two bags per round in the experimental session. Those already purchasing two bags of fertilizer could thus not increase the number of bags they purchased even if their exposure to risk reduced, their wealth increased, or their perception of the net returns to fertilizer purchases improved. These individuals were already at a corner solution.[2] This in combination with the fact that wealth increased in each round (perhaps causing fertilizer purchases to increase for those who were not already purchasing two bags) may confound any effect insurance

[2]This is of course also true for those purchasing no bags of fertilizer, but in reality only 5% of individuals purchased no bags of fertilizer.

may have in encouraging farmers to purchase more fertilizer. This is the opposite effect to that observed in Eissa and Liebman (1996) in which the control group contained a much high proportion of labour market participation than the treatment group, causing economic growth to attribute a larger market participation impact to the treatment (Blundell and Costa-Dias, 2002). Matching on initial fertilizer purchases, and including a dummy for those already purchasing two bags of fertilizer in the regression analysis allows us to control for this effect. Matching has been shown to provide good estimates of the average treatment effect when, as in this case, data on the initial values of the outcome of interest can be used as part of the matching criteria (Heckman et al., 1997).

The following section presents the results.

4 Results

4.1 Main results

The empirical testing strategy rests on comparing the difference in fertilizer purchases in early and later rounds of the game between individuals that were offered insurance in later rounds and individuals that were not. We estimate the determinants of changes in fertilizer purchases across rounds and determine whether the provision of insurance had any impact on changing the amount of fertilizer bought.

Table 3 presents the unconditional estimations of the difference in fertilizer purchases for those with and without insurance. The table compares rounds 1 and 3, 2 and 3, 1 and 4 and 2 and 4. These unconditional results are mixed. The first two estimates are positive and significant. The second two are negative and significant. From these results it is difficult to interpret what the impact of insurance on fertilizer purchases really is. We also note that the R-squared of these regressions are very low, suggesting that the provision of insurance explains very little of the variation in changes in fertilizer purchases.

As the previous section highlighted, differences in initial insurance purchases and changes in wealth and weather across sessions and rounds also need to be controlled for. It is perhaps worth noting here that, in this experiment, changes in wealth do not depend solely on weather draws. Changes in wealth arise as a result of both participants' choices and weather draws. Additionally, given the return to fertilizer varied across sessions, identical choices and weather draws may yield different changes in wealth in different sessions.

In Table 4 we present estimates from a nearest neighbor matching estimation to control for some of these differences. Observations were matched on previous fertilizer purchases, level of wealth, change in wealth and experience of the weather. Exact matching was performed on the amount of fertilizer previously purchased so as to ensure constrained observations were not compared with unconstrained observations. In the latter two columns outliers in the treated pool (those for whom bad weather had occurred in the round 8) were omitted. Overall the estimates are similarly mixed, however the only significant estimate of impact is positive. This perhaps suggests some positive effect of insurance, but overall, conclusive results on the impact of insurance remain elusive.

Table 5 presents difference in difference estimates estimated using fixed effects. The dependent variable is the change in fertilizer purchases from round to round. The independent variables include variables expected to explain this variation in changes. The impact of insurance is estimated to have a weakly positive impact on fertilizer purchases. These estimates control for commensurate changes in wealth (allowing this to be non-linear), and weather, i.e. the presence of bad weather events, and also include a dummy that takes the value of 1 if a household was purchasing the maximum bags of fertilizer that could be purchased in the previous period (i.e. if the individual was already at a corner solution). We allow the weather to impact the purchases of fertilizer in two alternate ways. In column (1) we simply include the lagged value of weather in the previous period (i.e. the weather the household experienced between taking fertilizer purchase decisions). In column (2) we allow the households experience of weather between the periods to have a differential effect on households depending on whether the household had decided to purchase fertilizer or not.

In each case we find that wealth has a non-linear effect on the purchase of fertilizer. This relationship is graphed for the main range of values of $\triangle$ wealth in Figure 5 (using results from Table 5) alongside yhat. It suggests an increasing relationship between changes in wealth and changes in fertilizer purchases only for positive changes in wealth. Overall, the effect of wealth alone is small compare to the fitted values. Weather also has an impact on wealth, and indeed we find that experiencing good weather increases subsequent fertilizer purchases.

The fact weather dummies are so significant even when actual wealth changes are includes indicates good weather may not only impact fertilizer purchases as a result of its impact on wealth, but perhaps also as a result of its impact on beliefs on the costs and benefits of fertilizer purchases. This is tested further in column (2) by allowing weather to have a differential impact for those who bought insurance and those who did not. We see that those who observed good weather and had not bought fertilizer were more likely to increase fertilizer purchases even though their change in wealth was smaller than the change in wealth for the omitted category (those who experienced good weather and had bought fertilizer). Similarly the coefficient on "bad weather and no fertilizer" should have been negative. Weather failure had a very different impact for those who had bought fertilizer and those who had not. Those who bought fertilizer and experienced bad weather were likely to reduce their purchases of fertilizer, whilst those who observed bad weather without buying fertilizer increased their subsequent purchases of fertilizer. The presence of non-Bayesian updating could explain these differences. For example the observed pattern could be explained if individuals who saw good weather and had not bought fertilizer experienced regret that prompted them to increase purchases, and if those who saw bad weather but had not bought felt confidence to predict the weather and purchase in the subsequent round.

4.2 Further assessment of the impact of insurance

Although the significance of the impact of insurance on fertilizer purchases is not strongly significant, the magnitude of the effect is not small. Using the most favorable results from column (2), we see that insurance made the purchase of an additional bag of fertilizer 0.115 more likely. Taking the median expected return to fertilizer of 75%, this would imply that insurance provision would increase the average return realised by farmers by 8.625%. This is in addition to any welfare benefits that may result from insurance provision.

We explore further whether provision of insurance had a differential impact on behaviour for different types of people. In particular we examine whether insurance had a larger effect for those who better understood the contract, for those who were more risk averse, or for those who faced a relatively more risky investment prospect. We also determined whether farmers who were more favorable to fertilizer purchases in their farming decisions (measured by whether or not they had bought fertilizer in the 5 years prior to the survey) were more likely to increase fertilizer purchases in response to insurance provision in the game. Data collected in the household survey was used to provide a measure of understanding of the contract, and of risk aversion.[3] Information from the game was used to measure the coefficient of variation (C.V.) of return to fertilizer. In each case we split the sample in half according to measures of understanding, risk aversion CV of return and fertilizer preference, and compared the impact of insurance in each sub-sample. Results are presented in Table 6 and 7.

Understanding of the insurance contract was measured by assessing participant's understanding of a similar contract described in a survey conducted after the game. A weather insurance contract was described and questions on the contract asked. Participants with a higher and lower understanding of the contract were partitioned equally with an indicator dummy.[4] Interacting this measure of understanding with the provision of insurance, suggests that those more able to understand the contract were more likely to respond correctly.

Data on risk preferences were collected by offering a Binswanger style series of lotteries to the participants in the post-game survey and asking them to select the lottery they would prefer to play. Respondents were paid according to their choice and the lottery outcome. Participants that were more or less risk averse were equally partitioned. Insurance was found to have a larger and more significant effect for those who are more risk averse, as the theoretical model would predict.[5]

The impact of insurance was also assessed differentially for those who faced fertilizer returns with higher risk measured as the coefficient of variation of the return (C.V.). The results suggest that insurance was more effective in encouraging greater investment when the risk of the return to

[3]A measure of risk aversion can also be derived from choices made in the game, and choices in the game were correlated with the measure collected in the household survey.

[4]This meant that participants scoring 5 or more out of a possible 6 were recorded as having a high understanding and those whore corded 4 or lower were recorded as having a low understanding.

[5]This meant that participants with an constant partial risk aversion coefficient less than 0.47 were recorded as risk neutral and those with a partial risk aversion coefficient equal to or higher than this were recorded as risk averse.

the investment is not too high.

Finally the fertilizer supply response was compared for those who had reported using fertilizer in the 5 years prior to survey and those who had not. This was done because, despite the explicit parametrization of the return to fertilizer in the game, individuals entered the session with a different perception of the benefit to using fertilizer, and this perception is somewhat reflected in their fertilizer use decision. The much higher use of fertilizer observed in the highland villages is most likely because of the greater benefit to using it for the soil-crop combination in the highlands compared to the midlands. Indeed, we find that insurance had a stronger effect for those who had used fertilizer in the previous 5 years, those who most likely viewed the benefits to fertilizer as higher. This suggests that the way in which the experiment was framed was important in determining the behavioural effects observed.

Overall this disaggregation suggests that insurance has more impact for risk averse individuals when it is better understood, the risk of the investment is not too high.

5 Conclusion

In this paper we have assessed evidence in support of the hypothesis that insurance provision induces farmers to take greater, yet profitable, risks. Although a number of recent experimental studies have been conducted in which weather-index based insurance has been randomly allocated, thereby allowing an empirical test of this hypothesis (Giné et al., 2008; Giné and Yang, 2007).insufficinet take up of insurance has not allowed for an assessment of its impact (Cole et al., 2009). In this setting small scale framed field experiments may afford the means by which explore such an impact of insurance.

We conducted and analyzed results from a framed field experiment in rural Ethiopia in which farmers were asked to make a simple decision: whether or not to purchase fertilizer and if so, how many bags. Some evidence was found that insurance has a positive impact on fertilizer purchases. It is perhaps not surprising that stronger results were not present on average, in a short game. However, further disaggregation of the impact of insurance suggests that farmers that were more risk averse and that understood the contract better were more likely to increase fertilizer purchases in the presence of insurance.

Purchases were also found to depend on the realization of the weather in the previous round. This appears to be as a result of both the changes in wealth weather brings about, and another factor, perhaps changes in perceptions of the costs and benefits to fertilizer purchases.

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Lemma 2 *Consider expression 3. There exists some* $\theta \in [\underline{\theta}, \overline{\theta}]$, θ^*, *such that* $\theta^* g'(f^*) - p = 0$ *and* $\theta^* < E(\theta)$

Proof By assumption $U' > 0$. Thus, to satisfy the first order condition (3) it must the case that $\theta g'(f^*) - p < 0$ for some θ and $\theta f'(I^*) - p > 0$ for some other θ. Given $\theta g'(f^*) - p$ is monotonically increasing in θ there is a unique θ^* such that

1. $\theta^* g'(f^*) - p = 0$
2. $\theta g'(f^*) - p < 0$ if $\theta < \theta^*$, and
3. $\theta g'(f^*) - p > 0$ if $\theta > \theta^*$

Suppose $\theta^* \geq E(\theta)$. Then,

$$\begin{aligned} 0 &\geq (E(\theta) - \theta^*) g'(f^*) \\ &= \int_{\underline{\theta}}^{\overline{\theta}} (\theta - \theta^*) g'(f^*) dG(\theta) \\ &= \int_{\underline{\theta}}^{\theta^*} (\theta - \theta^*) g'(f^*) dG(\theta) + \int_{\theta^*}^{\overline{\theta}} (\theta - \theta^*) g'(f^*) dG(\theta). \end{aligned}$$

The first term in this last expression is a negative number, as it represents the area above a negative function in the interval $[\underline{\theta}, \theta^*]$. The second term is a positive number, as it represents the area below a positive function in the interval $[\theta^*, \overline{\theta}]$. As the overall expression is negative by supposition, the absolute value of the first term must be larger than the second term.

Given $U' > 0$, multiply both terms by $\frac{1}{U'((y_b - pf^* - c) + \theta^* g(f^*))}$ without changing signs of the inequalities to get:

$$\begin{aligned} 0 \geq & \int_{\underline{\theta}}^{\theta^*} \frac{1}{U'((y_b - pf^* - c) + \theta^* g(f^*))} (\theta - \theta^*) g'(f^*) dG(\theta) + \\ & \int_{\theta^*}^{\overline{\theta}} \frac{1}{U'((y_b - pf^* - c) + \theta^* g(f^*))} (\theta - \theta^*) g'(f^*) dG(\theta). \end{aligned}$$

Now, notice that

$$\int_{\underline{\theta}}^{\theta^*} \frac{U'((y_b - pf^* - c) + \theta g(f^*))}{U'((y_b - pf^* - c) + \theta^* g(f^*))} (\theta - \theta^*) g'(f^*) dG(\theta) < \int_{\underline{\theta}}^{\theta^*} (\theta - \theta^*) g'(f^*) dG(\theta) \quad (16)$$

and

$$\int_{\theta^*}^{\overline{\theta}} \frac{U'((y_b - pf^* - c) + \theta g(f^*))}{U'((y_b - pf^* - c) + \theta^* g(f^*))} (\theta - \theta^*) g'(f^*) dG(\theta) < \int_{\theta^*}^{\overline{\theta}} (\theta - \theta^*) g'(f^*) dG(\theta). \quad (17)$$

Hence,

$$
\begin{aligned}
0 &> \int_{\underline{\theta}}^{\theta^*} \frac{U'((y_b - pf^* - c) + \theta g(f^*))}{U'((y_b - pf^* - c) + \theta^* g(f^*))}(\theta - \theta^*)g'(f^*)dG(\theta) + \\
&\quad \int_{\theta^*}^{\overline{\theta}} \frac{U'((y_b - pf^* - c) + \theta g(f^*))}{U'((y_b - pf^* - c) + \theta^* g(f^*))}(\theta - \theta^*)g'(f^*)dG(\theta) \\
&= \int_{\underline{\theta}}^{\overline{\theta}} \frac{U'((y_b - pf^* - c) + \theta g(f^*))}{U'((y_b - pf^* - c) + \theta^* g(f^*))}(\theta - \theta^*)g'(f^*)dG(\theta) \\
&= \frac{E\left[U'((y_b - pf^* - c) + \theta g(f^*))(\theta g'(f^*) - \theta^* g'(f^*) + \theta^* g'(f^*) - p)\right]}{U'((y_b - pf^* - c) + \theta^* g(f^*))} \\
&= \frac{E\left[U'(y(f^*))(\theta g'(f^*) - p)\right]}{U'((y_b - pf^* - c) + \theta^* g(f^*))}.
\end{aligned}
$$

Since $\frac{1}{U'((y_b - pf^* - c) + \theta^* g(f^*))} > 0$ we have:

$$
0 > E\left[U'(y(f^*))(\theta g'(f^*) - p)\right],
$$

which contradicts first-order condition (3). Therefore, it must be the case that $\theta^* < E(\theta)$.

Q.E.D.

Table 1: Descriptive statistics

	Statistic	All farmers	Insurance sessions	No insurance sessions	T-test of difference+
Socioeconomic Characteristics					
Gender (1=Male)	Prop.	0.84	0.81	0.87	-1.04
Age (years)	Mean	45	45	45	-0.13
	Median	45	42	45	0.18
Years of Schooling	Mean	2.3	2.3	2.3	0.06
	Median	1	1	0	0.01
Farming as main activity	Prop.	0.91	0.90	0.92	-0.69
Housework as main activity	Prop.	0.06	0.07	0.05	0.07
Area of land owned (hectares)	Mean	0.61	0.55	0.66	-2.19**
	Median	0.50	0.50	0.50	1.26
Experience of weather risk					
Experienced drought in last 10 years	Prop.				
Prop. of crop lost last rain failure	Mean	0.76	0.78	0.75	1.36
	Median	0.75	0.81	0.75	3.06*
Perceived prob of rain failing	Mean	0.27	0.27	0.27	-0.02
	Median	0.25	0.25	0.25	0.00
Impact of drought on household welfare					
Lost productive assets/income	Prop.	0.25	0.24	0.26	
Reduced consumption	Prop.	0.11	0.07	0.15	
Both red. cons. and lost assets/inc.	Prop.	0.64	0.69	0.59	
Input use					
Used fertilizer last season	Prop.	0.50	0.50	0.50	-0.06
Bought seeds last season	Prop.	0.22	0.23	0.21	0.39
Hired farm labour last season	Prop.	0.09	0.09	0.08	0.23
Hired oxen last season	Prop.	0.15	0.18	0.12	1.24
Used fertilizer in last five years	Prop.	0.63	0.62	0.64	-0.28

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

+ The continuity corrected Pearson $\chi^2(1)$ statistic is reported for tests of equality between medians

Table 2: Session characteristics

	Round	All sessions	Insurance sessions	No insurance sessions	T-test of difference
Proportion of bad weather draws		0.22	0.21	0.23	-1.66*
Endowed wealth		7.5	7.7	7.4	0.60
Wealth (Birr on hand)	1	11.3	11.8	10.9	1.33
	2	12.9	12.4	12.5	0.94
	3	14.0	16.2	12.0	3.83***
	4	16.2	17.9	14.9	2.42**
Change in wealth (Birr)	1 & 2	1.6	1.5	1.7	-0.29
	2 & 3	1.0	2.9	-0.6	9.68***
	3 & 4	2.3	1.6	2.9	-6.49**
Good Weather occurred	1	0.81	0.80	0.82	-0.28
	2	0.72	1	0.48	11.12***
	3	0.91	0.81	1	-5.64***
	4	1	1	1	–
Fertilizer purchased (bags)	1	1.55	1.71	1.42	4.03***
	2	1.63	1.79	1.50	4.13***
	3	1.55	1.79	1.34	5.46***
	4	1.71	1.79	1.65	2.17**

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

Table 3: Basic difference in differences

Difference in bags of fertilizer purchased in rounds...	(1) 1 and 3	(2) 2 and 3	(3) 1 and 4	(4) 2 and 4
Insurance	0.154*	0.157**	-0.152*	-0.149**
	(0.0826)	(0.0733)	(0.0843)	(0.0641)
Constant	-0.0746	-0.157**	0.231***	0.149***
	(0.0692)	(0.0643)	(0.0580)	(0.0535)
Observations	248	248	248	248
Adjusted R^2	0.009	0.013	0.009	0.016

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

Robust standard errors in parentheses

Table 4: Matching estimates of impact of insurance

Difference in bags of fertilizer purchased in rounds...	(1) 1 and 3	(2) 2 and 3	(3) 1 and 4	(4) 2 and 4
Nearest neighbor matching	0.273**	-0.061	-0.059	-0.027
	(0.113)	(0.074)	(0.077)	(0.061)

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

Table 5: Difference in difference regression estimates

	(1)	(2)
△ insurance	0.0897	0.115*
	(0.0688)	(0.0601)
△ wealth	-0.192***	-0.0181
	(0.0379)	(0.0308)
Square of △ wealth	0.0161*	0.0350***
	(0.00826)	(0.00688)
Good weather	1.858***	
	(0.260)	
Good weather and no fertilizer		1.272***
		(0.143)
Bad weather and no fertilizer		0.445*
		(0.266)
Bad weather and fertilizer		-0.568***
		(0.215)
Dummy for max fertilizer	-1.435***	-1.375***
	(0.0901)	(0.0769)
Constant	-0.453**	0.565***
	(0.180)	(0.141)
Observations	744	744
Number of id	248	248
Adjusted R^2	0.3151	0.3601

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

Standard errors in parentheses. Round dummies were included but are not shown.

Table 6: Differential insurance effects: risk aversion and understanding

	(1)	(2)	(3)	(4)
△ I * high understand	0.104	0.124**		
	(0.0711)	(0.0622)		
△ I * low understand	0.0363	0.0800		
	(0.0942)	(0.0747)		
△ I * risk neutral			0.0830	0.114
			(0.0877)	(0.0728)
△ I * risk averse			0.128*	0.125**
			(0.0672)	(0.0571)
△ wealth	-0.192***	-0.0183	-0.191***	-0.0186
	(0.0380)	(0.0308)	(0.0379)	(0.0307)
Square of △ wealth	0.0160*	0.0350***	0.0163**	0.0351***
	(0.00826)	(0.00688)	(0.00825)	(0.00687)
Good weather	1.858***		1.851***	
	(0.261)		(0.260)	
Good weather and no fertilizer		1.272***		1.269***
		(0.143)		(0.143)
Bad weather and fertilizer		-0.569***		-0.576***
		(0.215)		(0.214)
Bad weather and no fertilizer		0.444*		0.440*
		(0.266)		(0.264)
Dummy for max fertilizer	-1.435***	-1.375***	-1.438***	-1.374***
	(0.0901)	(0.0769)	(0.0895)	(0.0764)
Constant	-0.452**	0.566***	-0.449**	0.566***
	(0.180)	(0.141)	(0.178)	(0.141)
Observations	744	744	744	744
Number of id	248	248	248	248
Adjusted R^2	0.627	0.734	0.627	0.734

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

Robust standard errors in parentheses

Table 7: Differential insurance effects: risk and perceived return of investment

	(1)	(2)	(3)	(4)
△ I * low C.V.	0.0894	0.174***		
	(0.0780)	(0.0665)		
△ I * high C.V.	0.0901	0.0516		
	(0.0798)	(0.0699)		
△ I * has bought fertilizer			0.128*	0.125**
			(0.0659)	(0.0559)
△ I * has not bought fertilizer			0.0890	0.116
			(0.0869)	(0.0728)
△ wealth	-0.192***	-0.00785	-0.192***	-0.0188
	(0.0394)	(0.0329)	(0.0379)	(0.0308)
Square of △ wealth	0.0161*	0.0371***	0.0160*	0.0350***
	(0.00865)	(0.00729)	(0.00827)	(0.00691)
Good weather	1.858***		1.854***	
	(0.262)		(0.259)	
Good weather and no fertilizer		1.286***		1.269***
		(0.144)		(0.143)
Bad weather and fertilizer		-0.536**		-0.577***
		(0.220)		(0.214)
Bad weather and no fertilizer		0.467*		0.439*
		(0.266)		(0.265)
Dummy for max fertilizer	-1.435***	-1.378***	-1.435***	-1.373***
	(0.0903)	(0.0770)	(0.0897)	(0.0767)
Constant	-0.453**	0.519***	-0.449**	0.567***
	(0.180)	(0.151)	(0.178)	(0.141)
Observations	744	744	744	744
Adjusted R^2	0.626	0.735	0.627	0.734
Number of id	248	248	248	248

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

Robust standard errors in parentheses

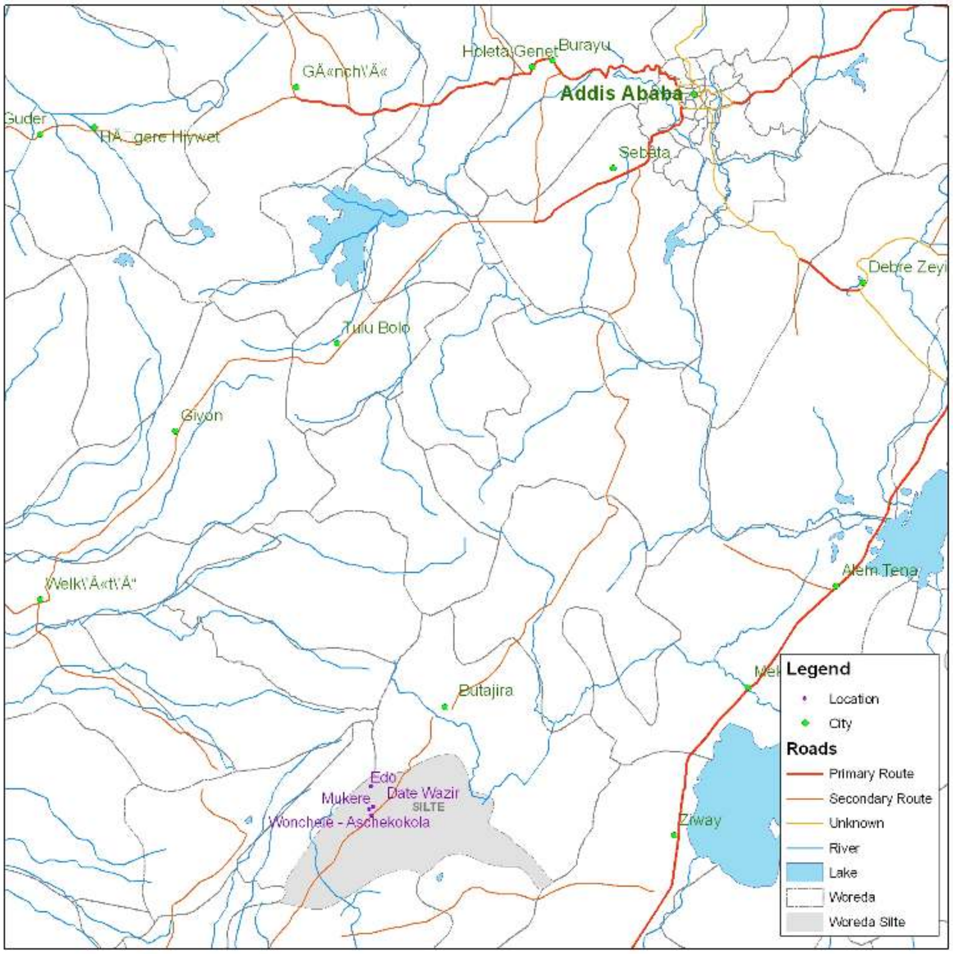

Figure 1: Map of Silte woreda containing treatment villages

Figure 2: Experiment session

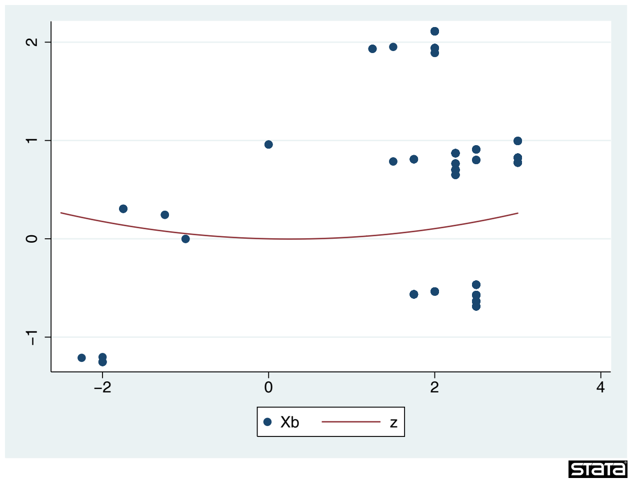

Figure 3: Graph of relationship between $\triangle wealth$ and predicted values of $\triangle f$