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How Does Risk Management Influence Production Decisions? Evidence from a Field Experiment

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Evidence from a Field Experiment[*]

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Weather is a key source of income risk, particularly in emerging market economies. This paper uses a randomized controlled trial involving a sample of Indian farmers to study how an innovative rainfall insurance product affects production decisions. We find that insurance provision induces farmers to shift production towards higher-return but higher-risk cash crops, particularly among educated farmers. Our results support the view that financial innovation can mitigate the real effects of uninsured production risk. Addressing the puzzle of low adoption, we show payouts improve trust in the product, and that farmers shield payouts from claims by relatives.

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1. Introduction

Small entrepreneurial firms around the world are exposed to a wide range of income risks, including recessions, demand shifts, technology shocks, weather, and natural disasters. Reflecting these risks, around one-third of US business establishments fail within two years (Puri and Zarutskie, 2012). Risks associated with entrepreneurship may be even greater in volatile emerging market economies. For a risk-averse individual, these uninsured risks can be a significant disincentive to engage in entrepreneurial activity (Moskowitz and Vissing-Jorgensen, 2002; Banerjee and Newman, 1993).

This paper studies a financial innovation designed to mitigate income risk among small Indian agricultural producers. Our sample of farmers is located in a semi-arid region in which variation in monsoon rainfall is the dominant source of production and income risk. In this context, we study the effects on behavior of a rainfall index insurance policy, which partially insures against a poor monsoon by providing a payout contingent on low measured local rainfall.

Our goal is to estimate the effects of the rainfall insurance on real production and investment decisions by farmers. Given that the decision to purchase insurance is typically endogenous, we use a randomized controlled trial (RCT) approach to elicit the causal effect of insurance coverage on behavior. At the start of the monsoon, a randomly selected subset of farmers (the "treatment group") is provided with 10 rainfall insurance policies with a combined market value of approximately 1,000 Indian rupees (equivalent to ca. $20 US at the time of our study). This represents a significant amount of coverage for our sample; the maximum insurance payout of 10,000 rupees (Rs.) is equivalent to about 90% of median household savings. We then study how this insurance provision influences subsequent production decisions such as crop choice and usage of agricultural inputs, compared to a control group promised a *fixed* payment equal to the estimated actuarial value of the insurance.

We find that, while insurance provision has little effect on total agricultural investments, it significantly shifts the *composition* of investments towards riskier production activities. In particular, treated households increase production of the main cash crops grown in our study areas, castor and groundnut. These crops produce higher expected returns, but are also more sensitive to deficient rainfall. We find that insured farmers are more likely to plant these two cash crops, sow more land with them and devote a larger amount of agricultural inputs to them relative to uninsured farmers. Quantitatively, the fraction of farmers planting cash crops is 6 percentage points higher for the treatment group (p=0.041), a 12 percent increase relative to the control group, about half of whom plant cash crops in the year of our study. The evidence suggests the impact of insurance is primarily on the extensive margin: it has large effects on the decision to sow cash crops, but little effect among the subset of farmers with the highest cash crop investments.

We then test whether the treatment effect varies by household characteristics. We find that the effects of insurance on behavior are concentrated among educated farmers, measured either by years of schooling or an indicator variable for whether the farmer is literate. Among literate farmers, assignment to the insurance treatment group increases the likelihood of investing in cash crops by 15 percentage points; in contrast, for illiterate farmers, the treatment effect is close to zero. This result is consistent with the view that new financial products predominantly assist more-advantaged households with low costs of accessing the financial system or higher financial literacy.

Using data on the timing of agricultural decisions, we find that the effects of insurance provision on production decisions occur ex ante, prior to the end of the insurance coverage period, when the insurance payout and monsoon rainfall are still uncertain. We also conducted a second follow-up survey in the following year, after insurance payouts were disbursed, to study how insurance payouts were ultimately spent by farmers. While the statistical power of this analysis is relatively low, our results suggest that payouts were mainly saved for the next monsoon or used to pay down expensive sources of credit.

A. Related literature

Although insurance is a key function of the global financial system, we have only a partial understanding of how insurance provision causally influences real economic behavior and risk-taking. This study is among the first in a small body of recent research which uses an RCT approach to study the causal relationship between insurance and agricultural decisions.

Karlan et al. (forthcoming) randomly allocate cash grants and discounted insurance offered by an NGO, or both, to farmers in Ghana, finding that cash grants do not affect investment, but that insurance does. Mobarak and Rosenzweig (2012) conduct a randomized evaluation which uses subsidies to induce households to purchase insurance against late monsoon arrival: while their main interest is the interaction between insurance demand and informal risk-sharing, they also find evidence that insured households plant riskier varieties of rice, although planting may happen after knowledge of the payout. In a related study, Cai et al. (forthcoming) finds evidence from China that hog insurance increases investment in hogs.[1]

Several features distinguish our paper from this complementary literature. First, our design allows us to study how insurance affects the timing of decisions, and to distinguish clearly between ex ante effects of insurance (effects on behavior during the insurance coverage period), and ex post effects due to the receipt of insurance payouts or the anticipation of future payouts. Second, we study a relatively mature, commercially available insurance policy, one that many farmers have purchased at least once over the previous five years. It is less likely in this setting that changes in behavior are due to the novelty of the product. Third, we find large differences in the treatment effect of insurance by educational attainment, although not along other household characteristics. Finally, we present the first (and to our knowledge, only) systematic evidence on how insurance payouts are used. Taken together, the nascent literature demonstrates in a variety of institutional and economic settings that access to insurance leads to an increase in risky production activities.

Our analysis is relevant to the vast literature on risk, growth, and technology adoption in emerging market economies (e.g., Acemoglu and Zilibotti, 1997; King and Levine, 1993; Banerjee and Newman, 1993; Rosenzweig and Binswanger, 1993). While technological improvements from the "Green Revolution" such as high-yield crops and chemical fertilizer has dramatically increased global agricultural productivity, traditional practices still prevail in many areas (Duflo, Kremer and Robinson, 2008; Hazell, 2009; Foster and Rosenzweig, 2010). Our evidence suggests that limited insurance against production risk is one reason

[1] Emerick et al. (2014) study the introduction of a drought-resistant rice variety that both reduces the yield variability induced by weather and increases average yields. They also find that the rice variety leads to increases in land cultivated, investment in fertilizer and the use of a more labor intensive planting method.

why firms limit investments that produce high expected returns but involve risk. Correspondingly, financial innovation that "completes" missing markets, like the insurance policy we study, may boost risk-taking and technology adoption. This channel may account for part of the link between finance and growth identified in prior research (Levine, 2005; Beck, Levine and Loayza, 2000).[2]

A related literature explores the link between finance and entrepreneurial activity in developed economies, although research to date generally focuses on credit constraints (e.g., Black and Strahan, 2002; Hurst and Lusardi, 2004). Most closely related, Fan and White (2003) find evidence of greater business ownership associated with the option to declare bankruptcy, a procedure that allows entrepreneurs to shield future income and some assets from creditors, limiting the downside risk of entrepreneurial activity. Insurance and investment risk tolerance has also been studied in the context of large, sophisticated corporations (e.g., Campello et al., 2011; Pérez-Gonzáles and Yun, 2013).

Finally, recent household finance research has emphasized two major pitfalls that prevent customers from taking full advantage of financial innovations: predatory behavior and mistakes due to low financial literacy (Agarwal et al., 2009, Campbell, 2006). Our finding that changes in behavior are concentrated among educated farmers may be indicative of a lack of trust in the product, or understanding of it, among less-educated farmers.

2. Background and experimental design

Consumption risk-sharing, though surprisingly effective in mitigating nonsystematic income shocks (Cochrane, 1991; Townsend, 1994), has been found to be incomplete, particularly for spatially correlated shocks such as weather. Droughts, for example, have significant negative effects on economic well-being and health for rural households in India and other emerging market economies, suggesting that the risk of drought is underinsured (e.g. Burgess et al.,

[2] Our analysis is also related to research studying the effects of climate change on agricultural productivity. Guiteras (2009) estimates that predicted climate change from 2010-2039 will reduce crop yields by 4.5-9 percent. While rainfall insurance cannot of course affect the climate, it may enable farmers to continue producing risky crops in the face of greater climate variability, mitigating the real impact of climate change.

2013; Maccini and Yang, 2009; Jayachandran, 2006; Rose, 1999; see Cole et al., 2013, for further references).

When it is not possible to insure consumption against income risks such as drought, individuals may reduce uninsured income risk by smoothing their income ex ante, selecting production and investment activities that generate a less volatile income stream at the cost of lower average income (Morduch, 1995; Gollier and Pratt, 1996; Walker and Ryan, 1990). Corporate finance research makes an analogous prediction for firms: in the presence of financial constraints, a firm facing nondiversifiable risks will invest less in additional risky projects, particularly when the project return is positively correlated with the prior existing risk exposure (Froot and Stein, 1998).

Income smoothing tactics for farmers include intercropping by drought tolerance, spatial separation of plots, shifts in the timing and staggering of planting, moisture conservation measures such as bunds, furrows and irrigation, and income diversification between agricultural and non-agricultural sources. Several papers find suggestive evidence of costly income smoothing by agricultural firms in developing countries (e.g., Rosenzweig and Stark, 1989; Morduch, 1995; Dercon, 1998; Dercon and Christiaensen, 2011).[3]

The key hypothesis tested in this paper is that the provision of insurance against rainfall risk will induce households to allocate more resources to higher-risk, higher-yield investment and production activities. To fix ideas, we illustrate this hypothesis using a simple theoretical model of insurance and production in which households choose between two production methods: one safe, the other higher-yielding but risky (Appendix A). Insurance against production risk induces risk-averse farmers to allocate more resources to the high-yield production method. While our model uses a simple CARA-normal setup that yields a closed-form solution, this basic prediction will apply to nearly any model with risk-averse agents, incomplete markets and production risk.

[3] Rosenzweig and Stark find that farmers with more volatile profits are more likely to have a household member engaged in steady wage employment. Morduch suggests that households close to a subsistence level of consumption devote a larger share of land to safer crop varieties. Dercon finds Tanzanian farmers with a large stock of liquid assets engage in higher risk agricultural activities. Dercon and Christiaensen find that fertilizer purchases are lower among poorer Ethiopian households, in part due to their lesser ability to smooth adverse shocks ex post. Rosenzweig and Binswanger (1993) estimate that a one standard deviation increase in the variability of monsoon onset would, through reduced risk-taking, reduce agricultural profits by 15 percent for the median household.

We test the above theoretical prediction in a setting where firms face a dominant, exogenous source of production risk: variation in local monsoon rainfall. Rainfall is cited as the most important source of risk by 89% of farmers in our study areas. Although these local rainfall shocks are approximately uncorrelated with aggregate asset returns, farmers in our sample have a large, non-diversified exposure to local weather risk. Recognizing the importance of rainfall risk, Indian insurers have recently developed innovative retail index insurance products designed to pay out when realized monsoon rainfall is poor. We study a particular policy developed by the private Indian insurer ICICI Lombard. Our analysis builds on a series of experiments and surveys that we have conducted since 2004 in Andhra Pradesh, India (Cole et al., 2013; Giné, Townsend and Vickery, 2008). This previous work has focused on studying the determinants of rainfall insurance demand, rather than the impact of insurance on behavior.[4]

A. Crop choice and risk-taking

The model in Appendix A considers the tradeoff between high-risk, high-yield and low-risk, low-yield production activities. The analog in our empirical analysis is the allocation of agricultural inputs across crop types. During the main cropping season (June to November) in our study areas, farmers grow a variety of cash and subsistence crops that vary by sensitivity to low rainfall. The primary cash crops grown in the study areas are castor and groundnut, two rain-fed oilseeds, as well as paddy, which is almost exclusively irrigated and thus less subject to rainfall risk (84% of paddy plots in our empirical sample are irrigated). The main subsistence crops grown in the area are sorghum and legumes (red gram, Pigeon pea and to a lesser extent green gram).

Cultivation costs for the main cash crops exceed those of subsistence crops and range between Rs. 5,000 and Rs. 9,000 per hectare ($94 to $168 US), if the recommended amounts of organic and inorganic fertilizer are applied.[5] Based on the local District Handbook of

[4] Although some of our earlier research also adopts a field experimental approach (Giné and Yang, 2009 and Cole et al. 2013), uptake has been too limited to allow an assessment of the impact of insurance on real decisions. Two related laboratory experiments conducted by Lybbert et al. (2010) and Hill and Viceisza (2012) suggest that, over time, subjects learn about insurance and change behavior accordingly.

[5] Input recommendations (used to calculate 2009 production costs per hectare for castor, groundnut, sorghum, and red and green grams) come from the University of Agricultural Sciences in Bangalore (UAS, 1999).

Statistics, average yields for castor are 600 Kg per hectare if fertilizer is used, which would generate Rs. 10,896 in revenue at 2009 prices. Groundnut yields are 540 Kg per hectare with fertilizer, corresponding to Rs. 11,702. Sorghum yields with fertilizer are 700 Kg per hectare or Rs. 4,788 and red gram yields are 300 Kg or Rs. 5,791. Thus, expected profits for castor and groundnut are indeed higher at Rs. 2,771 and Rs. 2,951 compared to sorghum (negative Rs. 212) and red gram (Rs. 141).

In terms of water requirements, researchers at the Central Research Institute for Dryland Agriculture (CRIDA) estimate that castor grown in Mahbubnagar under rain-fed conditions requires 625 mm of accumulated rainfall over the season if sown around the normal planting date while groundnut in Anantapur requires 533 mm. Red gram requires a similar amount of accumulated rainfall, 523 mm, but in contrast, sorghum only requires 376 mm and green gram 278 mm.[6]

To summarize, castor and groundnut are more profitable on average than other crops grown in our study areas, but have higher water requirements and therefore are more sensitive to drought.

B. Product description

The rainfall insurance policies offered in this study are an example of “index insurance,” that is, a contract whose payouts are linked to a publicly observable index like rainfall, temperature or a commodity price. Unlike traditional insurance products, index insurance is not generally subject to moral hazard or adverse selection problems, because payouts are linked to an exogenous, publicly observable variable, in this case, rainfall measured at a local rain gauge. Index insurance also involves lower administrative costs because no claims verification process is required. However, rainfall insurance only covers rainfall-related losses and may entail significant basis risk, especially if the household is located too far from the relevant weather reference station.[7]

[6] Based on personal communication from Dr. Bodapati Rao and Dr. Vijay Kumar, Principal Scientists at CRIDA.

[7] In our study, villages are generally located within 10km of the reference weather station. Given the relatively flat terrain one may think that basis risk is likely to be relatively low, at least for our sample. However, Section 5 reports evidence consistent with basis risk.

Information frictions and high transaction costs have limited the commercial success of agricultural insurance. Insurance companies have initiated a number of index insurance pilots in recent years in the hope of developing a financially sustainable product that farmers will buy (World Bank, 2005; Skees, 2008). Today, rainfall insurance is one of the core product offerings of Indian agricultural insurance providers with over 10 million farmers covered by index policies. Clarke et al. (2012) and Giné et al. (2012) provide non-technical overviews of this market and further institutional details.

The policies we study are designed and underwritten by ICICI Lombard, a large Indian insurance firm. Payoffs are calculated based on measured rainfall at a nearby government rainfall station or an automated rain gauge operated by a private third-party vendor. ICICI Lombard policies divide the monsoon season into three contiguous phases of 35-45 days each, corresponding to sowing, flowering, and harvest. The study offered only Phase I policies, which cover the first and most critical period of the season.

Each insurance contract specifies a threshold amount of rainfall, designed to approximate the minimum required for successful crop growth. The start date of the policy is defined as the first date at which cumulative rainfall since June 1 is at least 50 mm (or defaults to July 1 if June rainfall is below 50mm). Payouts are then determined based on cumulative rainfall during the 35 days following the start date. The policy pays out if cumulative rainfall during this coverage period is below a threshold known as the "strike." Payouts are linear in the rainfall deficit relative to the exit, or are equal to a fixed maximum amount of Rs. 1000 per policy if rainfall is below a second, lower threshold call the "exit."

Since payouts are linked to rainfall levels determined by a nearby gauge, treated farmers received policies linked to one of five weather stations, depending on their village. Because the 2009 monsoon turned out to be significantly below average, three of these five policies provided positive payouts *ex post*, with one policy paying out the maximum payout of Rs. 1,000 per policy, corresponding to a total payout of Rs. 10,000 for each treated farmer.

C. The insurance experiment

Our sample consists of 1,479 farmers drawn from 45 villages in one drought-prone district of Telangana (Mahbubnagar) and another in Andhra Pradesh (Anantapur).[8] Two-thirds of the sample participated in previous research we conducted on rainfall insurance; these were originally selected via a stratified random sample of land-owning farmers in 37 study villages in 2004 (see Giné et al., 2008, for details). To improve statistical power for this study, an additional 500 households were drawn from these 37 villages as well as 8 nearby villages.

Figure 1 presents the timeline of events. Each farmer received a home visit from a member of a trained team of enumerators from the agricultural research organization ICRISAT between June 4 and July 13, 2009, coinciding with the onset of the 2009 monsoon season.[9] During the visit, the enumerator first conducted a short baseline survey, collecting demographic information and data on practices by the farmer during the previous monsoon. They then explained the recommended fertilizer dosages for castor and groundnut, the two main rain-fed cash crops in the area, as well as the concept of insurance, and gave specific details about the policies offered by ICICI Lombard.

[Insert Figure 1 here]

The farmer then received a scratch card (similar to the format of a scratch-off lottery ticket sold in the United States), revealing treatment assignment. The key treatment for the purposes of this paper is the assignment of the household to either an insurance group or a control group. Farmers in the insurance treatment group received a certificate for 10 Phase-I weather insurance policies, similar to those sold in the region in previous years. "Control" farmers received a post-dated check of Rs. 200 (our estimate of the expected payouts of these

[8] At the time of the study, the newly formed state of Telangana was still part of Andhra Pradesh.

[9] Although the distribution of all insurance policies was planned to be completed prior to the occur before the start of the insurance coverage period, delays in the shipping of policy certificates from ICICI headquarters in Mumbai resulted in a significant minority (40 percent) of the initial visits occurring on or after the policy activation date. In these cases, however, distribution occurred close to the start of the activation period, within five days on average. For the sample as a whole, only six percent of farmers had started to plant by the time the initial household visit and insurance assignment occurred. The small amount of prior monsoon investments occurred prior to the distribution of insurance may if anything mean that our results are slightly attenuated relative to the case where insurance policies were distributed earlier (since earlier distribution would have given farmers more time to adjust behavior in in response to the knowledge of insurance coverage).

10 policies) that could be cashed at the local BASIX branch. This compensation was offered to ensure that differences in behavior between the insurance and control group would be due to the state-contingent nature of the insurance, rather than any wealth effects arising from the expected value of the insurance. The date when the check could be cashed coincided with the expected timing of insurance payouts.

A second independent treatment also provided via the scratch card, involved coupons for discounts on locally appropriate inorganic fertilizer (DAP in Anantapur, NP fertilizer in Mahbubnagar). Unfortunately the implementation of this treatment was largely unsuccessful because the incentives were too small.[10] For that reason, we do not study it here, although our analysis controls for the household's fertilizer discount treatment status in our analysis.[11]

Treatments were assigned randomly and independently across households. The use of scratch cards ensured that neither the respondent nor the enumerator had prior information about the household's treatment status. Farmers also had the option to purchase additional insurance policies from the local vendor, BASIX, although few did so in practice.

In October and November 2009, after the growing season, the ICRISAT team revisited each household, and conducted the first of two follow-up surveys. In addition to demographic data, the survey collected information on livestock, financial assets (including savings, loans, and insurance), agricultural investments and production decisions during the monsoon, as well as attitudes towards and expectations of weather and insurance payout, and risk-coping behavior. Although payouts had not been made by the time of the first follow-up survey, because of the poor monsoon in 2009, 93% of the farmers in the treated group expected to receive a payout. Roughly the same percentage expected final crop yields to be below average.

Payouts to the insurance and control group were made in December 2009 and January 2010. This timing is well after one might have expected, given that policies indicate a

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[10] The number of coupons (or bags) with a subsidy was calibrated to fertilizer usage reported in a survey conducted in 2006. According to that survey, 70 percent of farmers in Mahbubnagar but only 34.4 percent in Anantapur had used fertilizer and those that did would purchase at most two bags. However, follow-up data collected in November 2009 revealed much higher fertilizer usage (see Section 4.F for details).

[11] Our results are almost identical whether or not we control for fertilizer treatment status; this is unsurprising given that the fertilizer treatment is statistically independent of our main insurance treatment, by design.

settlement date of "thirty days after the data release by data provider and verified by Insurer." However, the timing was relatively consistent with previous years. The long timeframe reflected both slow release of rainfall data and slow processing by ICICI Lombard.

Between April and July 2010 the team of enumerators revisited all farmers to conduct the second follow-up survey.[12] The goal of this final round of data collection was to measure how payouts were used. The survey collected more detailed information on landholdings, livestock, financial assets, agricultural investments and production decisions during the Rabi (winter season), household consumption as well as attitudes towards the insurance product, the use of payout funds (if any), transfers to and from other households and other risk-coping behavior. Although our main focus is to measure the ex ante effects of insurance on behavior before the resolution of uncertainty and receipt of payouts, we study these ex post effects of insurance in Section 5.

Figure 2 plots total cumulative rainfall (blue line) and cumulative "index" rainfall (measured from the policy start date), for each of the five policies. The gold horizontal lines represent the strike (top) and exit (bottom) levels of rainfall for the rainfall station. For example, in Naryanpet, rainfall was very low in June, never reaching the trigger amount of 50 mm. Thus, the policy started automatically on July 1. Cumulative rainfall then quickly crossed the exit (5mm) level, but only reached 16 mm during the coverage period, well below the strike of 50mm. Each policy therefore triggered a payout of Rs. 10 x (50-16), or Rs. 340, or Rs. 3,400 per treated farmer, since each treated farmer received ten policies. Farmers in Anantapur received per-policy payouts of (30-10) x 10 = Rs. 200 (i.e. Rs. 2,000 in total). In Hindupur, no rainfall fell in the month of July, triggering the 'exit'; consequently, farmers received a payout of Rs. 1,000 per policy, or Rs. 10,000 in total. As we describe below, many of these payouts were quite large (Rs. 10,000 is approximately $200, an amount 50% greater than the average household's financial assets).

[Insert Figure 2 here]

[12] There is a small amount of attrition between the first and second follow-up surveys -- out of 1,479 farmers that completed the first two surveys, only 1,459 completed the second follow-up survey.

3. Summary Statistics

Table 1 presents baseline summary statistics about household characteristics, savings, credit, insurance knowledge and other variables. These statistics are drawn from the initial baseline survey whenever possible. Since logistical constraints limited the length of the initial baseline survey, however, a subset of the variables were collected using recall questions in the first follow up survey conducted just after the monsoon. Respondents in the follow up survey were asked to report information about fixed characteristics (e.g., years of schooling) and to provide recall data on the value of livestock and other assets as of June 2009.

[Insert Table 1 here]

Panel A presents demographic data. The average household has 5.35 members with a 50-year old household head. Household heads are usually (91%) male, and on average have obtained 3.75 years of schooling, with over half (54%) self-reporting being "unschooled." Literacy is low, with only 44 percent and 41 percent of heads self-reporting being able to read and write, respectively. These statistics are similar to those reported in our previous work (e.g., see statistics in Cole et al. 2013, which are based on a 2006 survey instrument).

Given that insurance provision was randomized, we should not observe systematic differences in characteristics between the treatment and control groups. This hypothesis is tested in Online Appendix Table OA1, for demographic characteristics (Panel A), financial assets and credit (Panel B), livestock and other assets including land (Panel C), and agricultural investments during the previous monsoon in 2008 (Panel D). Validating the randomization, we find a statistically significant difference between the two groups for only one out of 53 variables (the use of non-traditional savings). Furthermore, an F-test of the null hypothesis that all average characteristics are the same for the treatment and control groups cannot be rejected (P-value = 0.79).

Table 2 presents summary statistics for agricultural investment decisions during the 2009 monsoon, based on the first follow up survey conducted in late 2009. We collected information on planting decisions and usage of different agricultural inputs, including seeds, fertilizer, manure, pesticide, irrigation and hired labor. For five inputs, we also separately measure the value of the input used *only* for the production of castor and for groundnut, as well as the area of land sown under castor and groundnut.

A very high share (93%) of farmers planted some crop, and roughly half (48%) planted cash crops (castor or groundnut). Fewer farmers planted cash crops in 2009 than 2008, reflecting the poor 2009 monsoon. Also reflecting the poor monsoon, 18% of farmers abandoned their crop during the 2009 monsoon season.

[Insert Table 2 here]

Table 3 summarizes contract details and realized payouts for the five insurance policies (recall that farmers were given policies linked to different rainfall stations depending on the location of the farmer's village). Three of the five insurance contracts realized a positive payout, and the 242 treated farmers with insurance indexed to Hindpur station rainfall received the maximum payout of Rs. 1,000 per policy (Rs. 10,000 in total). We use variation in payouts across rainfall stations to distinguish between ex ante and ex post effects of insurance provision (see section 4), and to track how insurance payouts were ultimately used by farmers (see section 5).

[Insert Table 3 here]

4. Estimation results

A. Baseline estimates

Table 4 presents the estimated average treatment effects of insurance provision on farmers' agricultural decisions, based on the investment variables summarized in Table 2. We analyze four outcome variables: (i) a dummy equal to one if any agricultural inputs were used during the monsoon, (ii) the area of land sown, (iii) the market value of agricultural inputs used, and (iv) the value of agricultural inputs purchased. For the first three outcome variables, we separately study inputs used for the production of castor and groundnut.[13] These cash crop estimates are presented separately in the table.

[Insert Table 4 here]

In Panel A, each outcome variable is regressed on a dummy for whether the household received the insurance treatment (the key variable of interest), a set of village dummies, and a dummy for each fertilizer treatment. A tobit estimator is used when the dependent variable is continuous, while a probit is used for the "any inputs used" dummy. To conserve space, only results for the key coefficient on the insurance treatment dummy are presented.

Studying total investments (the first column of results), we find a positive, although statistically insignificant, effect of the insurance treatment on the quantity of inputs used or the area of land cultivated. However, when the analysis is restricted to castor and groundnut investments, the treatment effects become much larger, and are also statistically significant at the 5% level or lower in each specification. Quantitatively, assignment to the insurance treatment group increases the probability of planting cash crops by 6 percentage points (or 12 percent). Ln(1+land planted for cash crops) increases by 0.163, equivalent to a 27 percent increase in land sown for a farmer who would have planted 2 acres of cash crops in the absence of the treatment.[14]

To summarize, we find significant substitution effects towards cash crop investments, although no significant effect on *total* agricultural expenditures. This latter result could be consistent with the presence of fixed short-run production factors (e.g. a given amount of land, which cannot be easily adjusted in the short run), or the presence of financial constraints. It may also simply reflect our limited statistical power.

Specifications in Panel B of Table 4 are otherwise identical, but include measures of household socioeconomic status as additional controls, as a robustness check. Adding the

[13] We did not collect this information for the "market value of inputs purchased" variable.

[14] If the farmer originally planned to sow two acres of cash crops, our point estimate implies that the new quantity of land planted for cash crops will be exp((ln(1+2)+0.163)-1) = 2.53 acres, a 26.5% increase. Recall that about half the farmers in our sample plant no cash crops during the 2009 monsoon. A small minority planted no crops at all. This is due to the poor realized quality of the 2009 monsoon.

controls has little effect on our estimates, consistent with the random assignment of farmers to the treatment and control groups. Table OA2 of the Online Appendix also reports regression results for cash crop expenditures split up by input type (seeds, fertilizer, etc.).

Table 4 reports average treatment effects – Figure 3 instead plots the cumulative distribution function of investment in cash crops by insurance treatment status. This plot suggests that the effect of the insurance treatment is quite non-linear. Insurance causes a sizeable number of farmers to switch on the extensive margin from not growing cash crops into growing cash crops, consistent with the probit regression estimates. But for farmers in the top part of the distribution of cash crop investments, insurance provision has little or no effect on cash crop inputs used. In other words, the effect of insurance is primarily on the extensive rather than the intensive margin.

[Insert Figure 3 here]

Figure 3 also illustrates that there is a discrete jump in the level of cash crop investment once the farmer decides to invest a positive amount. This points to the presence of scale economies; farmers do not sow a given crop below a minimum scale. Around this decision threshold, the provision of insurance against income risk makes farmers more willing to invest a positive amount in castor and/or groundnut. According to our data, the minimum area cultivated under cash crops is 0.5 acres, accounting for 10 percent of average landholdings. For farmers planting cash crops, the median area under cash crops cultivation is 3 acres (70 percent of landholdings).

B. Heterogeneous treatment effects

In Table 5, we test for heterogeneity in the treatment effect by measures of household wealth, education and expectations. We estimate regressions of the form:

outcome = *f*(a + b. insurance + c. characteristic + d. insurance x characteristic + … + e)

where “insurance” is the dummy for insurance treatment status, and “characteristic” is the source of heterogeneity of interest (e.g. wealth, education etc.). Our primary interest is the coefficient *d* on the interaction term. As in Table 4, we consider three outcome variables, a dummy for whether the farmer plants cash crops, the value of their investment in cash crops, and the area of land planted with cash crops.

[Insert Table 5 here]

We first study how the insurance treatment effect varies with two wealth measures: acres of land owned, and a wealth index derived as the first principal component of asset holdings (see Appendix B for details of how this variable and selected other variables used in this study are constructed). These wealth variables are included as interaction characteristics one at a time. It is unclear theoretically what effect is expected; on one hand, wealthier households may have better ex post consumption insurance (as in Mobarak and Rosenzweig, 2012), making them less likely to respond to rainfall insurance. On the other hand, wealthy farmers may be able to more easily adjust agricultural practices in response to a shift in the risk-return frontier introduced by insurance (e.g., because they are less financially constrained). Empirically we find mixed and weak results – the treatment effect is increasing in landholdings but decreasing in the wealth index; neither relationship is statistically significant. The direct effect of wealth using either variable is highly positive and statistically significant, as expected; that is, wealthy farmers are much more likely to invest in cash crops.

Next, we consider heterogeneity by two measures of educational attainment: log years of education, and a dummy for whether the household head is literate. Strikingly, we find large, positive, statistically significant interaction effects for both measures, implying that the treatment effect of insurance provision on production behavior is concentrated amongst educated households. This heterogeneity by educational attainment is economically important as well as statistically significant. For literate farmers, assignment to the insurance treatment group increases the likelihood of investing in cash crops by 15 percentage points; for illiterate farmers, the treatment effect is close to zero and statistically insignificant.

Next, we use ex post realized payouts as the interaction variable. This provides a test of whether farmers' investment responses might reflect their expectation of receiving a high payout in the future (e.g. because of early information that the monsoon is likely to be poor). This interaction variable is quantitatively small and statistically insignificant, implying that the investment response is not driven by this anticipation effect.

Finally, we consider two specific measures of the farmer's knowledge of insurance (measured at baseline) as the interaction variables. Neither of these variables is statistically significant. Interestingly, it appears to be the farmer's overall education level, not their specific knowledge of the insurance policy at baseline, that matters for the strength of the treatment effect. A possible interpretation of this finding is that a well-educated farmer, even if unfamiliar with a specific financial product, will be able to learn about the product as needed once they receive it, or will be able to more easily think through how access to the product should influence other decisions. In unreported regressions, we also found no evidence of significant heterogeneity in the treatment affect associated with the farmer's measured expectations about the dispersion of yields, or exogenous variation in their past experience with insurance.[15]

Summing up, the main source of heterogeneity that we are able to identify given the power of our statistical tests, is farmer education. This finding, if applicable more generally, has interesting implications for the distributional effects of financial innovation. Specifically, innovation may increase income inequality by educational attainment, at least during a transition period of financial deepening.[16] As a caveat on this interpretation, we note that while our insurance treatment is randomly assigned, education of course is not. Thus, our results could reflect omitted variables which are correlated with educational attainment but not with wealth.

C. Timing

Figure 4 presents evidence on how the insurance treatment affects the *timing* of cash crop investments. This figure is constructed by estimating regressions similar to Table 4 tracing out how the insurance treatment affects the probability of planting cash crops along the growing season. Specifically, each point on the graph represents the marginal effect from a probit regression where the dependent variable is equal to 1 if the farmer had planted cash

[15] These regression results are available upon request. Our tests of past experience with insurance use as instruments the marketing treatments applied in our prior research (see Cole et al., 2013). These randomly assigned treatments affect the probability that famers purchased insurance in 2006. We do not find any significant interaction effects based on this variation in past experience, however.

[16] See Townsend and Ueda (2006) for a model-based quantitative evaluation of the relationship between economic growth, financial deepening and inequality in an emerging markets context (the Thailand economy between 1976 and 1996).

crops by date *t*. The explanatory variables are the insurance treatment dummy and the other controls from Panel A of Table 4. Vertical lines indicate the time period at which insurance distribution commenced, and the latest time period in which rainfall was used to calculate the index.

[Insert Figure 4 here]

As expected, the insurance treatment effect is extremely close to zero at the point the insurance policies are randomly allocated across farmers. The cumulative treatment effect by date then rises sharply, becoming statistically significant prior to the average end of the realized insurance coverage period (this end point varies by policy). It then flattens out, and ultimately converges to the point estimate from the average treatment effect regression from Table 4.

The estimates summarized in this figure imply that the effect of the insurance treatment on behavior occurs before the end of the insurance coverage period, and several months before the insurance payout is received. Consistent with this finding, our analysis of heterogeneity in treatment effects described earlier (and shown in Table 5) uncovers no evidence of heterogeneity in the treatment effect by ex post realized payouts.

Given these results, our interpretation is that farmers viewed insurance as an incentive to take riskier production decisions during the monsoon season, in the knowledge that they would be partially hedged in the event of a poor monsoon. This is the mechanism highlighted in the theoretical model presented in Appendix A.

D. Qualitative self-reported changes in behavior

Complementing this statistical analysis, the first follow-up survey conducted after the 2009 monsoon simply asked farmers in the insurance treatment group to report whether and how the provision of insurance affected their investment behavior. We asked farmers whether the knowledge of being insured led to an increase, decrease or no change in the amount of fertilizer, seeds and other inputs they used, and whether it influenced decisions about planting, replanting and/or abandoning crops. Survey responses are presented in Table 6.

[Insert Table 6 here]

A significant fraction of respondents report not changing their behavior, between 36-52% depending on the question. However, among those that did change behavior, most reported increasing investments in agricultural inputs, rather than reducing them. This was true for five out of six agricultural inputs; for example, 50% reported using more fertilizer, while only 14% reported using less fertilizer. The exception was bullock labor (23% more, 29% less). Farmers also report that awareness of being insured also influenced them towards planting earlier (26%, versus only 5% planting later), and against abandoning crops.

Although we view this evidence as suggestive only, given the qualitative nature of the questions posed to farmers, the direction of these responses appears consistent with our overall finding of a relationship between insurance and investment in risky agricultural activities.

F. Additional robustness checks

Two additional sets of robustness checks are reported in the Online Appendix. First, to test for the potential influence of outliers, we re-estimated our main results after winsorizing the top and bottom 2% of all continuous variables. Second, we find similar results if we estimate linear probability models instead of using tobit and probit estimators. See tables OA3 and OA4 of the Online Appendix for these results.

5. How were insurance payouts spent?

During the 2009 experiment, India experienced a drought during the normal planting period followed by heavy rains during crop growth and harvest. Nationally, accumulated rainfall during the monsoon months was 79% of normal, defined as a 50-year average by the Indian Meteorological Department. Rainfall during the critical early planting period was very low in the two districts where the experiment was conducted (65.1% of normal in Mahbubnagar in June; and 16.8% for Anantapur in June). Although total rainfall recovered (rainfall for the entire growing season was 77.6% of normal in Mahbubnagar, and 117.6% in Anantapur, due to high rainfall in August), this low early rainfall affected yields of the main cash crops, especially groundnut in Anantapur. According to district-level data from the Ministry of

Agriculture, groundnut yields in Anantapur were only 42% of the 10 year average, while castor yields in Mahbubnagar were 95% of the 10 year average.[17] Reflecting this low rainfall during the coverage period, most (but not all) insured farmers received cash payouts, ranging from Rs. 2100 (ca. $42) to Rs. 10,000 (ca. $200), as indicated in Table 3. Table 7 and 8 present data on how farmers spent the payouts once they were received.

A. Self-reported uses of insurance payouts

Panel A of Table 7 presents results of the second follow-up survey (conducted in 2010), in which farmers who were treated and received an insurance payout were simply asked to report how the cash payout was allocated among different uses such as saving, immediate consumption, gifts, and so on.

[Insert Table 7 here]

Forty-five percent reported purchasing at least some inputs for Rabi, which is the winter growing season following the summer season covered by the insurance policies. Since little or no rain falls during the winter, only farmers with access to a well can plant. In the data, about half of the farmers own a well, implying that nearly all farmers with well access report using part of the payout funds to purchase inputs for the winter season. Purchases of goods and services, mainly for immediate consumption, accounted for 39% of funds received, with 84% of farmers reporting using at least some funds for immediate consumption. Thirty-six percent of funds received were saved or used to pay down debt, while about one-tenth was given away.

These responses, taken at face value, represent a rejection of either a full risk-sharing benchmark or a permanent income hypothesis benchmark, since more than two-fifths of funds received were used for immediate consumption or for physical agricultural investments. The survey responses are however consistent with empirical evidence from emerging and developed countries that individuals consume or invest a significant fraction of cash windfalls (e.g., Aaronson, Agarwal and French, 2012; de Mel, McKenzie and Woodruff, 2008; Souleles, 1999).

[17] Data from the Directorate of Economics and Statistics of the Ministry of Agriculture can be accessed at http://eands.dacnet.nic.in/.

Panel B of Table 7 summarizes what information other parties (e.g., family, friends) had about the insurance coverage of treated farmers, the size of the payout, and the extent to which payouts were shared within and outside the immediate household. This information is important because farmers in our study areas engage in significant informal risk-sharing, which may crowd out formal insurance; social pressure to provide assistance to families, neighbors, or friends could reduce the incentive to purchase insurance in the first place, or to change investment decisions once insured.

Our main empirical estimates show that insurance coverage *does* change production decisions, implying that insurance payouts are not entirely socialized. Panel B confirms this result. While family and/or friends of treated farmers who received a payout often knew that the farmer had insurance and had received a payout, the sharing of insurance payouts was much less common. The payout was shared within the immediate household in about half of cases (48%), but with extended family in only 8% of cases, and with friends or others in only 1% of cases. This low rate of sharing outside the household occurs despite the fact that in 72% of cases, the extended family knew that a payout had been received, while friends were aware about half the time.

B. Regression analysis

Next we conduct regression analysis of the effect of insurance payouts on savings and debt, real outcomes such as agricultural investments, consumption and migration, as well as attitudes towards the insurance product. These outcome variables were also collected in the second follow up survey conducted in 2010. Summary statistics for each outcome variable are reported in table OA5 of the Online Appendix.

We estimate regressions of the form:

outcome = *f*(a + b. insurance + c. (insurance x payout amount) + controls + e),

where "insurance" is a dummy for whether the individual was assigned to the insurance treatment group, and "payout amount" is a continuous variable, bounded between zero and one, indicating what fraction of the maximum possible payout was received (i.e., equal to 0 for weather stations for which the contract did not pay out, and equal to1 for the contract in which the total payout was Rs. 10,000). We include village dummies and the fertilizer treatment dummy as controls, as in our earlier analysis. We therefore do not separately control for payout amount, which varies only by village as it is thus absorbed by the village dummies.

Interpreting the evidence on the ex post effects of payouts requires a more nuanced view than our earlier ex ante evidence for at least two reasons. First, ex post effects measured in coefficients b and c in the above equation reflect both differential ex ante behavior (e.g., greater investment in cash crops) and ex post outcomes (weather realization and insurance payouts). Conceptually, the effects are different from the effects of an unexpected "cash drop" received after the harvest. Our experiment cannot identify what the effect of a post-harvest "cash drop" after harvest would be. Second, and more importantly, we observe only a single year's realization of rainfall. We do not know how well the insurance performed with respect to basis risk: e.g., were payouts particularly well suited to local loss conditions, or were payouts not well matched to local loss? This limits the value of this ex post analysis.

Results are presented in Table 8. We first examine how product experience affects attitudes towards insurance, measured by asking farmers to react to interviewer questions on a 1-10 Likert scale (1=strongly disagree; 10=strongly agree). The first column of Panel A shows that treated farmers report 0.371 higher trust in the insurance company on this ten-point scale, compared to an average response of 5.33. This effect on trust was larger for farmers who received payouts, though not statistically significantly so.

[Insert Table 8 here]

When asked about perceptions of basis risk in column 2—perhaps the most significant drawback of index insurance—insured farmers receiving no payout feel no differently than the control group, but farmers that did receive a payout are statistically significantly more likely to agree that the product pays out in times of drought. The coefficient of 0.395 indicates that those receiving a Rs. 10,000 payout agreed with the statement by 0.395 points more on the 1-10 Likert scale, relative to insured farmers that received zero payout. The mean reported response value is only 3.69, suggesting that the sample as a whole does view basis risk as a significant drawback of the insurance product.

Turning to financial outcomes, we find that treated farmers report higher levels of financial savings ex post (column 3). While the individual coefficients are not significant, a test of the hypothesis b + c = 0 can be rejected at the 5 percent level. Quantitatively, farmers who received the maximum insurance payout of Rs. 10,000 report higher savings of Rs. 1,561 in 2010 compared to untreated farmers.

While we do not find any evidence that the treatment affected total indebtedness, we do find that it affected the probability that households hold expensive debt, defined as debt from money lenders, microfinance institutions (MFIs) and other sources (column 5). These three sources charge an average interest rate of 31%, compared to debt from family, typically given at zero interest rate, or debt from commercial banks at 15%. Treated households that did not receive a payout report being 28.1 percentage points more likely to hold expensive debt than the control group. In contrast, treated households that received the maximum payout were 15.7 percentage points *less* likely to hold expensive debt than the control group (0.281 -0.438 = -0.157). These results appear consistent with the existence of basis risk. Insurance recipients that did not receive a payout needed to resort to expensive sources of credit to invest or smooth consumption, because of riskier decisions taken during the monsoon combined with the poor realized quality of the monsoon. But treated farmers in areas where the insurance policy did pay out were able to use payouts to reduce their reliance on expensive forms of indebtedness. We note that the amount of expensive debt is not particularly large: mean expensive debt is Rs. 1482 (USD 32.15) at the time of the survey.

Regressions in Panel B study whether insurance cash payouts affected ex post real decisions and investments in the period *after* payouts were received. Such effects would be expected if farmers were financially constrained. Overall, we find little statistically significant evidence of such real ex post effects, although our statistical power is relatively low given the magnitude of the standard errors. Column 1 finds no effect of payouts on the area planted during the Rabi winter growing season. As noted, only farmers with a well can cultivate during Rabi; well owners tend to be wealthier and may be less financially constrained. Similar to our results for expensive debt, we find a positive effect of assignment to the insurance treatment group on the labor supply of children (two hours more per week relative to a mean of 12.4 hours), although this increase is not present for farmers receiving large payouts.[18] Insurance treatment status has no effect on the probability a household engages in the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), a ubiquitous work program for the poor, or on the probability that a household reports earning income from migration. We also find no effects on the change in value of livestock and durable goods, though the standard errors are quite large.[19]

The final column of Panel B reports estimates of the effect of payouts on self-reported consumption (measured per day). As in the other columns, we find no statistically significant effect of assignment to the treatment group on daily consumption. However, for farmers receiving the maximum payout, the combined effect of being treated and receiving the maximum payout is actually negative and statistically significant at the five percent level. We are unsure how to interpret this result. Insurance payouts were received at least several months before the second follow up survey was conducted, thus we would not expect to identify any immediate consumption induced by the receipt of payouts. However it is harder to understand why consumption would actually be *lower* for farmers that received payouts, relative to control farmers in the same village that were not treated with insurance. Although we lack a clear explanation, one possibility is the presence of fixed costs or lumpy investments that can make consumption nonlinear in liquid assets (e.g., Townsend and Ueda, 2006).

6. Conclusions

We find that the provision of insurance against an important source of risk influences production decisions by a sample of Indian farmers. In particular, it causes substitution in agricultural investments towards higher-return but rainfall sensitive cash crops. This shift in behavior is concentrated on the extensive margin, and among more-educated farmers.

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[18] For a farmer receiving the maximum payout of Rs. 10,000, the net effect on child labor is 2.028 – 2.665 = -0.637 hours, not statistically different from the control group.

[19] We focus here on change, rather than levels, because we have pre-period data, and because there may be significant individual-level variation in how respondents report the estimated value of these goods.

Our findings, as well as results from other recent research, suggest that insurance arrangements that “fill in” missing markets have significant effects on entrepreneurial production and risk-taking, consistent with models from producer theory and corporate finance. Consequently, financial innovations that improve risk diversification, such as the insurance policy studied here, may play a significant role in boosting growth and real incomes in emerging market economies.

From a broader international perspective, insurance arrangements facing would-be entrepreneurs vary widely across countries and over time. Examples include health insurance systems, unemployment insurance, bankruptcy law, and social security. Empirical analysis of the effect of insurance systems on entrepreneurial activity and risk-taking seems to be a promising area for future academic research.

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Appendix A: Model of insurance and production decisions

This Appendix presents a simple illustrative model of a farmer's entrepreneurial decisions to highlight the interaction between insurance access and production behavior. The key result illustrated by the model is that for a risk-averse farmer, investment in risky production activities is increasing in access to insurance against production risk. Although we assume a very simple setting to highlight the basic intuition, this result extends to a much more general class of models, as discussed in the main text.

A. Basic setup and timing

Consider a one-period model of a farmer with initial wealth W_0 and constant absolute risk aversion (CARA) utility. The farmer has access to a risky production activity or project (e.g. sowing cash crops, or applying fertilizer), and decides at the start of the period what fraction of their wealth (α) to devote to this risky activity. The remainder of their wealth is invested in a safe activity, which for simplicity is assumed to produce a real return of zero. The net return on investment (per rupee invested) is given by $\bar{R}$ + e, where $\bar{R}$ is the expected return and e is a zero-mean normally distributed error term: e ~ N(0, σ^2_e).

The farmer can partially hedge the production risk associated with the risky activity by purchasing insurance. We denote the amount spent on insurance premia by φ. The insurance payout is negatively correlated with the return on investment, but not perfectly (i.e. there is some basis risk). Net of the initial premium, the net payout on the insurance (per rupee of premium) is given by: -e + u - μ, where u ~ N(0, σ^2_u). The higher is σ^2_u, the greater the basis risk. We generally assume that $\mu > 0$, which means that the expected insurance payout net of the premium is negative (i.e. the insurance is not actuarially fair).[20]

Summary of timing: At the start of the period the farmer chooses how much to invest (α) and how much insurance to purchase (φ). At the end of the period, the return on the risky production activity and the insurance payout are realized. The farmer then consumes their initial wealth W_0 plus their net income from the investment and from insurance.

[20] This could be because of imperfect competition amongst insurers, administrative costs of providing the insurance, or a compensation for the risk borne by the insurer.

We assume there is an interior solution (i.e. the fraction of their wealth invested in the risky project, inclusive of any insurance purchased, is between zero and one), and that μ is large enough so that insurance demand is positive in equilibrium.

B. Optimal investment in the presence of insurance

The farmer's objective is to maximize expected end-of period utility $E[u(W_1)]$. End of period wealth (W_1) is given by the law of motion:

$$\begin{aligned}\text{End of period wealth } (W_1) &= \text{initial wealth } (W_0) + \text{investment return } (Y) + \text{insurance payout}(IP) \\ &= W_0 + \alpha(\overline{R} + e) + \varphi(-e + u - \mu)\end{aligned}$$

Given our exponential-normal setup, and denoting the farmer's coefficient of absolute risk aversion by γ, the farmer's problem can be written as:

$$\max_{\alpha, \varphi} E[u(W_1)] = \max_{\alpha, \varphi} \{E(W_1) - ½\gamma \operatorname{var}(W_1)\} \qquad [A.1]$$

where:

$E(W_1) = W_0 + \alpha \bar{R} - \varphi\mu$

$\operatorname{var}(W_1) = (\alpha - \varphi)^2\sigma^2_e + \varphi^2\sigma^2_u$

Taking first order conditions of [A.1] with respect to α and φ, and solving the resulting simultaneous equations, the optimal investment level is given by the following expression:

$$\alpha^* = \frac{1}{\gamma}\left[\frac{\bar{R} - \mu}{\sigma^2{}_u} + \frac{\bar{R}}{\sigma^2{}_e}\right] \qquad [A.2]$$

An alternative and similar expression can be derived if we assume that the level of insurance φ is assigned exogenously to the household, rather than being a decision variable. (This is the setting that corresponds most exactly to the design of our field experiment). In this case, optimal investment is given by the simpler expression:

$$\alpha^* = \frac{1}{\gamma}\frac{\bar{R}}{\sigma_e^2} + \varphi$$

C. Comparative statics

Inspecting expression [A.2] yields the following comparative statics results for the farmer's equilibrium level of investment in the risky production activity:

Proposition: The farmer's equilibrium investment in the risky activity (α^*) is:

A. *decreasing in the expected per-unit net cost of insurance (μ).*

B. *decreasing in the basis risk of the insurance (σ^2_u)*

C. *decreasing in the variance of investment returns (σ^2_e)*

D. *decreasing in risk aversion (γ)*

E. *increasing in the expected return on investment ($\bar{R}$)*

<u>Proof</u>: By taking first derivatives of [A.2] with respect to each parameter.

The same comparative statics results apply to the alternative expression for optimal investment assuming that insurance is assigned exogenously. The only difference is that part A of the Proposition instead states that investment in the risky production activity (α^*) is increasing in the exogenously determined level of insurance, φ, rather than being decreasing in the cost of insurance.

The key result of this Proposition is that an improvement in access to insurance – either an increase in the amount of exogenously provided insurance, a reduction in the cost of the insurance, or an improvement in the quality of the insurance while keeping the cost fixed – increases investment in the risky activity.

The simple intuition for these results is that the farmer's optimal level of investment trades off the high expected return of the investment against its risk. Improving access to insurance against production risk allows the farmer to reduce the background risk associated with any given investment level (i.e. to shift this risk-return frontier outwards), allowing the farmer to invest more in equilibrium. Given these results, it is also straightforward to verify that the farmer's expected income and expected utility are decreasing in the expected per-unit net cost of insurance (μ), and the basis risk of the insurance (σ^2_u), so that improving access to insurance increases expected income and welfare.

Note that since we assume exponential utility, there are no wealth effects in the model presented here. In reality, provision of insurance may affect behavior both through its risk-management benefits and because it increases household wealth. To control for this, in our field work we compare two groups, one of which receives insurance for free, the other of which is promised the actuarial value of the insurance for free. In other words we effectively hold fixed the wealth of the household between the treatment and control groups.

Appendix B: Selected variable definitions

Variable	Descriptive information
Children: Mean Hours Worked Per Week	Mean number of hours worked by each household member between ages 6 and 20. Households that did not report any members between ages 6 and 20 are omitted from the table 8 regression.
Durable Goods	Includes value of tractors, animal-pulled equipment, electric motor/oil engine/pipeline, sprinkler set/drip equipment set, hand tools, thresher, insecticide pump, manuals, sprayer & dusters, processing units, ox/bullocks cart, furniture, refrigerator, bicycle, motorcycle, sewing machine, electrical goods, telephone/cell phone, others
Expensive Debt	Amount of credit from a microfinance institution (MFI), moneylender or other sources (other than credit from banks or from family or friends).
Insurance Knowledge Index	Individuals are asked to calculate, given a set of assumptions, whether they would get an insurance payout and how large would that payout be. One point is assigned to each 'good' response to five questions. The insurance knowledge Index is the sum of this score [0-5]
Liquid Savings	Amount of savings at the bank, Post Office and cash at home.
Livestock	Buffalos, cows, young calves/young stock, oxen/bullocks, goats and sheep
St. dev. of expected yield (kg/acre) of cash crops without fertilizer	Each respondent reports the expected minimum, maximum, mean and intermediate values (25th and 75th percentile) cash crop yield, given a set of assumptions about rainfall. The variable reports the computed standard deviation of expected yield computed from these estimates.
Total Daily Consumption	Total daily consumption, measured by summing consumption of different items measured over different time intervals between one day and three months (normalized to a per-day basis in each case).
Wealth index: PCA	First component of a principal components analysis (PCA). Variables includes a dummy if the household owns a specific type of livestock, the log of the total value of livestock, a dummy if the household has any type of credit, a dummy if the household has any type of savings, the log of total amount of savings and credit, the house type, the number of rooms in the house, the total area of agricultural land, the log of the house value, the log of the land value, and the log of the value of other assets.

Figure 1: Timeline

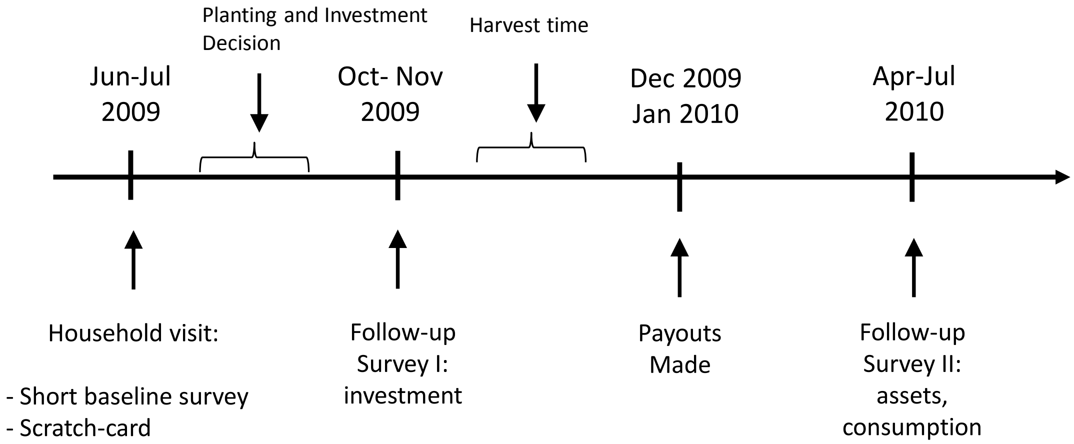

Figure 2: Cumulative Rainfall during Kharif 2009, for Phase 1 Policies

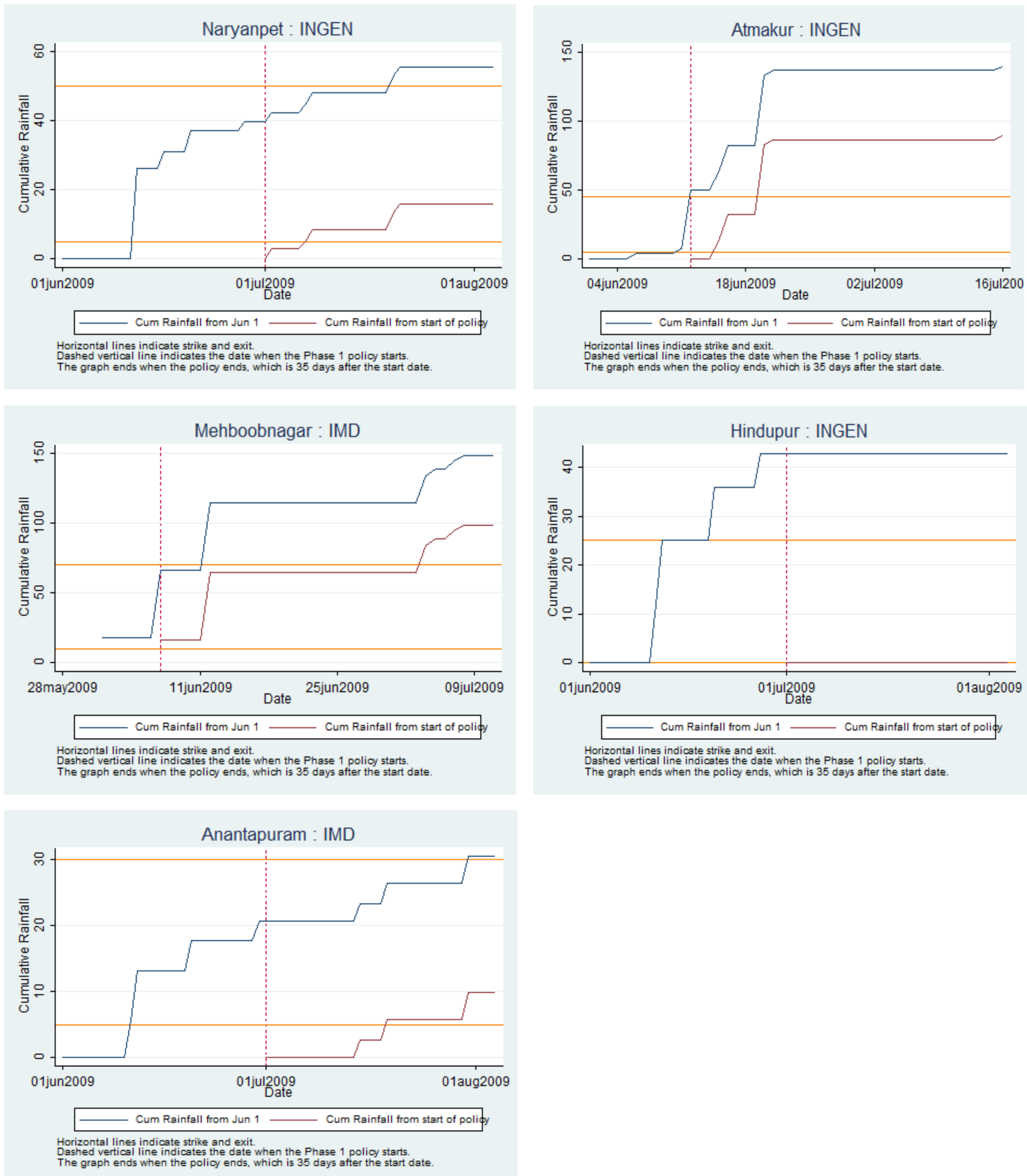

Figure 3: Cumulative density, log investment in cash crops

Y axis plots the natural log of 1 + the amount invested in cash crops (in Rs.) for the treatment and control groups, both sorted in increasing order of cash crop investment.

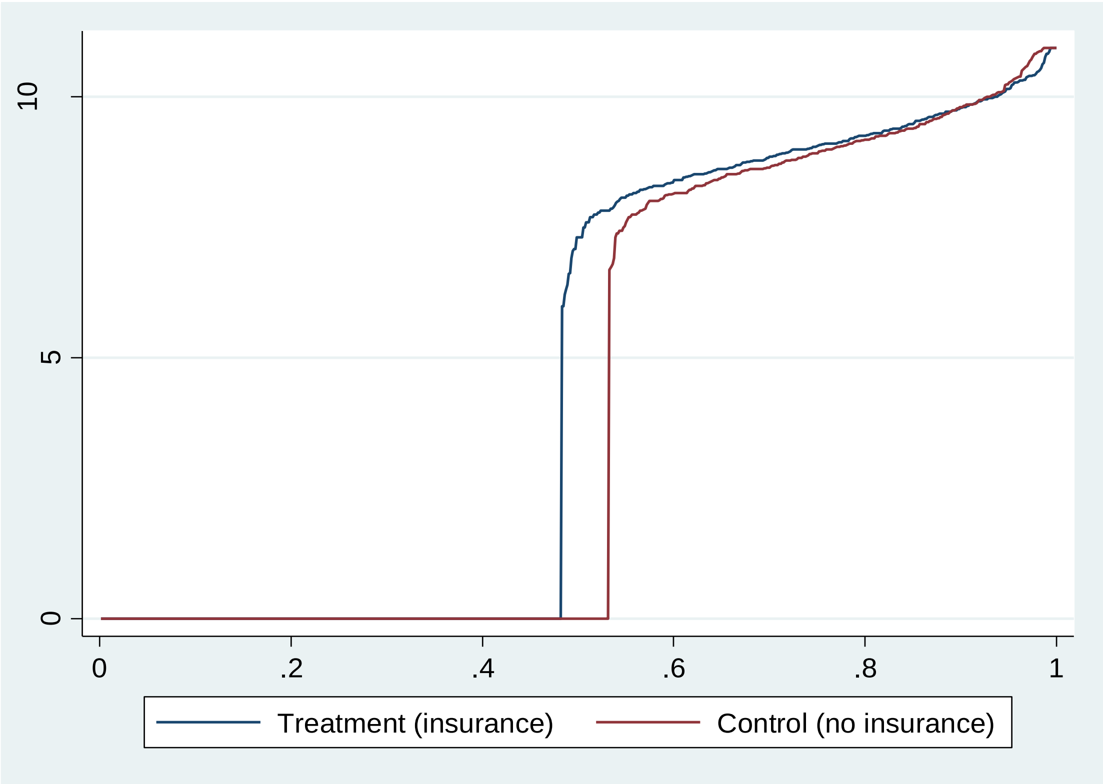

Figure 4: Effect of insurance treatment status on timing of cash crop investments

The x-axis of the figure plots the passage of time in 2009. The y-axis plots the effect of insurance treatment status on the probability of having planted cash crops by the date in question. The two red vertical lines indicate the period during which the insurance policies were distributed to treated farmers. The dashed black line indicates the end of the coverage period for any of the insurance policies.

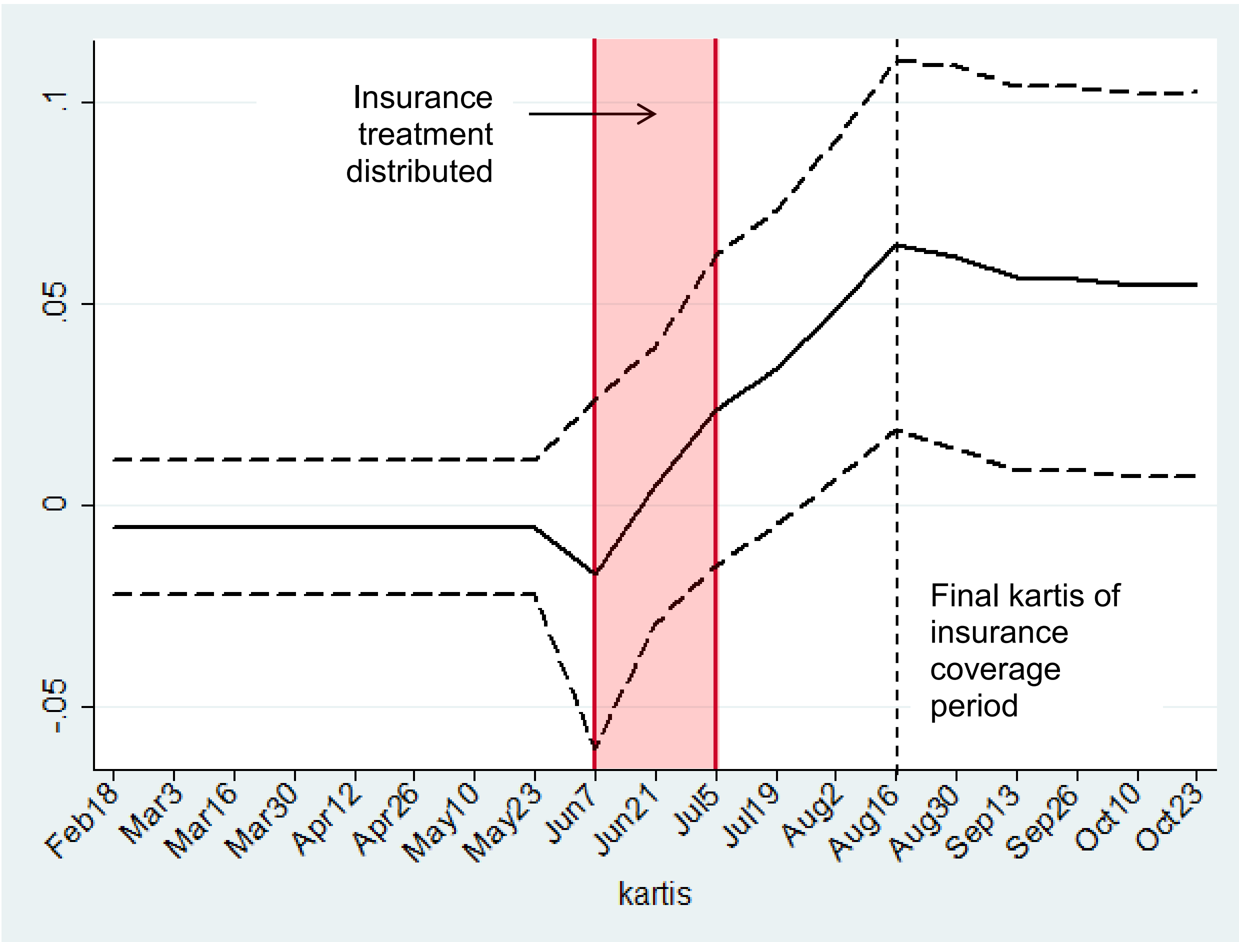

Table 1: Household Summary Statistics

Variable	N	Mean	SD	p10	p50	p90
A. Demographic Characteristics						
Household size	1,479	5.35	2.28	3	5	8
Number of children 6 years old or younger	1,479	0.20	0.54	0	0	1
Number of children 18 years old or younger	1,479	1.70	1.51	0	2	4
Age of household head (Years)	1,479	49.60	12.40	35	50	65
Highest level of schooling completed by HH (Years)	1,479	3.75	4.76	0	0	11
Household head is unschooled (1 = "Yes")	1,479	0.54	0.50			
Household head able to read (1 = "Yes")	1,479	0.44	0.50			
B. Livestock (as of June 2009)						
No. of large animals owned, i.e. buffalos, cows and oxen	1,479	2.25	3.01	0	2	6
No. small animals owned, i.e. goats, sheep, chicken, pigs	1,479	5.23	22.22	0	0	10
Total market value of livestock owned (Rs.)	1,479	34,263	58,623	0	20,000	80,000
C. Savings and Credit						
Total amount of savings, all sources (Rs.)	1,479	21,353	29,472	0	11,000	56,980
Amount of savings with bank or post office (Rs.)	1,479	1,575	5,640	0	0	4,000
Amount of savings in cash at home (Rs.)	1,479	1,715	3,228	0	600	5,000
Amount of savings in jewelry (Rs.)	1,479	13,335	20,589	0	5,000	32,000
Amount of savings with SHG or other group (Rs.)	1,479	2,152	4,910	0	720	5,000
Amount of other savings (Rs.)	1,479	2,576	11,427	0	0	3,600
Total amount of credit owed, all sources (Rs.)	1,479	41,644	50,498	8,000	29,000	87,000
Amount of credit from bank (Rs.)	1,479	20,414	31,823	0	15,000	45,000
Amount of credit from family and friends (Rs.)	1,479	6,406	19,505	0	0	20,000
Amount of credit from MFIs (Rs.)	1,479	692	3,684	0	0	0
Amount of credit from moneylenders (Rs.)	1,479	12,747	30,840	0	0	35,000
Amount of credit from other sources of credit (Rs.)	1,479	1,386	5,079	0	0	5,000
D. Other Assets						
House type: strong structure (1 = "Yes")	1,479	0.54	0.50			
House type: semi-strong structure (1 = "Yes")	1,479	0.33	0.47			
House type: weak structure (1 = "Yes")	1,479	0.13	0.33			
Number of rooms in the house	1,479	2.63	1.34	1	2	4
Estimated value of the house if owned (Rs.)	1,479	117,221	165,962	25,000	70,000	220,000
Total area of agricultural land (Acres)	1,479	5.37	5.47	2	4	10
Estimated value of agricultural land (Rs.)	1,479	508,519	1,463,349	70,000	240,000	980,000
Est. value of non-agricultural land and other assets (Rs.)	1,479	8,642	49,500	0	0	20,000
E. Other Variables of Interest:						
Wealth Index (PCA)	1,479	0	1.7	-2.1	0.03	2.07
St. dev. of expected cash crop yield (kg/acre)	1,479	46.22	38.05	14.14	35.36	88.25
Insurance knowledge at the baseline (0-5)	1,479	1.73	2.12	0	0	5
Household head has heard of rainfall insurance (1 = "Yes")	1,479	0.42	0.49			

Notes: This table reports the summary statistics for the sample, which includes the 1479 individuals that participated in both the baseline and follow-up surveys. The variables reported in Section C and E were collected during the baseline survey conducted between April and June 2009. Variables in Section A, B and D were collected during the follow up survey in November 2009, but respondents were asked to report answers as of June 2009. See Appendix Table A2 for variable definitions.

Table 2: Investment in Kharif 2009

	All Crops						Cash Crops					
	Amount >0	Mean	SD	p10	p50	p90	Amount >0	Mean	SD	p10	p50	p90
Land use:												
Total cultivated land (Acres)	0.93	4.00	3.59	1.00	3.00	8.00	0.48	1.92	2.98	0.0	0.0	5.0
In which Kartis did farmer plant?		15.68	2.78	13.00	16.00	18.00		15.26	2.29	13.0	15.0	18.0
Did farmer replant crop this Kharif? (1="Yes")							0.05					
Did farmer abandon crop this Kharif? (1="Yes")							0.18					
Total amount spent on inputs (Rs.):												
Hybrid seeds	0.63	1,774	3,679	0	750	4,000						
Improved seeds	0.59	3,871	6,112	0	1,500	11,000						
Manure	0.74	3,237	4,261	0	2,000	8,000						
Pesticide	0.64	1,438	2,656	0	600	4,000						
Irrigation	0.26	1,039	2,822	0	0	3,550						
Hiring tractors or other implements	0.91	3,541	3,482	600	3,000	7,000						
Manual labor	0.95	3,069	3,432	500	2,000	6,000						
Bullock labor	0.68	1,299	1,933	0	1,000	3,000						
Total amount spent, all inputs	0.98	22,424	19,935	6,300	16,600	44,500						
Market value used on inputs for all crops (Rs.):												
Hybrid seeds	0.63	1,852	3,961	0	800	4,450	0.17	476	2,480	0	0	1,200
Improved seeds	0.56	3,779	6,012	0	1,200	11,000	0.31	2,402	5,537	0	0	8,000
Fertilizer	0.93	3,208	3,873	500	2,000	7,000	0.45	1,098	1,973	0	0	3,000
Manure	0.73	3,182	4,213	0	2,000	8,000	0.35	1,360	3,112	0	0	4,500
Pesticide	0.64	1,447	2,659	0	600	4,000	0.30	544	1,823	0	0	1,500
Irrigation	0.25	1,025	2,779	0	0	3,550						
Hiring tractors or other implements	0.91	3,545	3,552	500	3,000	7,000						
Manual labor	0.94	3,044	3,453	500	2,000	6,000						
Bullock labor	0.68	1,295	1,943	0	1,000	3,000						
Total market value used, inputs 1-5	0.96	13,467	13,758	2,600	9,500	28,700	0.49	6,123	11,096	0	0	17,800
Total market value used, all inputs	0.97	22,377	20,206	5,550	16,700	45,000						

Notes: Data were collected during the follow up survey conducted in October and November 2009. The sample includes the 1479 individuals that participated in both the baseline and follow-up surveys. All reported monetary values are in Rupees. At the time of this survey, the average exchange rate between US Dollars and Indian Rupees was Rs. 47 per dollar. The statistics report the mean of an indicator variable for whether the quantity listed is greater than zero, and the mean, standard deviation and percentiles of the values.

Table 3. Policy Details

Reference Station	Start Date	End Date	Strike (mm)	Exit (mm)	Per mm (Rs.)	Maximum Payout	Realized Payout per policy (Rs.)	Number of Treatment Farmers
Atmakur	June 12	July 16	45	5	10	1000	0	38
Narayanpet	July 1	August 4	50	5	10	1000	341.5	170
Mahbubnagar	June 6	July 10	70	10	10	1000	0	112
Hindupur	July 1	August 4	25	0	10	1000	1000	242
Anantapur	July 1	August 4	30	5	10	1000	210	175

Notes: This table reports insurance policy details and payouts. The "Strike" level is the rainfall threshold below which the policy pays a certain amount per mm of shortfall below the threshold. This amount is reported in the "Per mm" column. The "Exit" level is the rainfall threshold below which the policies pays the "Maximum Payout". The payout per policy reports the payout received by farmers in 2009. Each farmer in the treatment group received 10 insurance polices.

Table 4. Effects of insurance on agricultural investments

Crop types:	All crop types		Cash crops only		
	Insurance dummy (marginal effect)	pseudo-R^2	Insurance dummy (marginal effect)	pseudo-R^2	Estimator
A. Without household covariates					
Any ag. inputs used (1 = Yes)	0.016	0.074	0.060**	0.213	probit
	(0.012)		(0.029)		
ln(1+total cultivated land, acres)	0.029	0.05	0.163**	0.155	tobit
	(0.034)		(0.070)		
ln(1+market value of ag. inputs used, Rs.)	0.082	0.032	0.800**	0.092	
	(0.087)		(0.387)		
ln(1+total amount spent on ag. inputs, Rs.)	0.05	0.032			tobit
	(0.079)				
B. With household covariates					
Any ag. inputs used (1 = Yes)	0.013	0.133	0.065**	0.222	probit
	(0.010)		(0.030)		
ln(1+total cultivated land, acres)	0.041	0.133	0.176***	0.170	tobit
	(0.031)		(0.067)		
ln(1+market value of ag. inputs used, Rs.)	0.112	0.062	0.862**	0.096	tobit
	(0.083)		(0.383)		
ln(1+total amount spent on ag. inputs, Rs.)	0.079	0.065			
	(0.074)				
N	1479		1479		
Village dummies	yes		yes		

Notes: Data were collected during the baseline and follow up surveys conducted in 2009. The sample includes the 1479 individuals that participated in both the baseline and follow-up surveys. Symbols *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variables are: a dummy variable equal to one if the household used any agricultural inputs, the log of (1+ the amount of land under cultivation), the log of (1+ the value of inputs used), and the log (1+ the market value of inputs purchased). The column to the left reports regression results for all crop types, while the column to the right reports regression results for cash crops only. Cash crops are defined as castor in Mahbubnagar and groundnut in Anantapur. The top panel reports results for the main specification, while the panel at the bottom includes household covariates as a robustness check. Household covariates include the age of the household head, the log of the highest level of schooling completed by household head and the wealth index. The regressions include indicator variables for each village.

Table 5. Heterogeneous Effects of Insurance

Dependent variable:	Dummy: Cash crop investments > 0			ln(1+investment in cash crops, Rs.)			ln(1+land cultivated for cash crops)		
	Treatment (1=yes)	Household covariate:	**Treatment x covariate**	Treatment (1=yes)	Household covariate:	**Treatment x covariate**	Treatment (1=yes)	Household covariate:	**Treatment x covariate**
Interaction variable is:									
Wealth measures									
Wealth index: principal component	0.062**	0.041***	**-0.012**	0.180***		**-0.035**	0.871**	0.641***	**-0.220**
	(0.029)	(0.013)	**(0.018)**	(0.068)	(0.030)	**(0.042)**	(0.388)	(0.168)	**(0.235)**
ln(1+total area of ag. Land, acres)	0.026	0.165***	**0.018**	0.118		**0.013**	0.636	2.615***	**0.052**
	(0.096)	(0.038)	**(0.055)**	(0.212)	(0.084)	**(0.119)**	(1.241)	(0.475)	**(0.666)**
Education measures									
Household head can read (1 = yes)	-0.001	-0.019	**0.147****	-0.042	-0.077	**0.469*****	-0.048	-0.155	**1.959****
	(0.039)	(0.043)	**(0.059)**	(0.093)	(0.102)	**(0.141)**	(0.523)	(0.575)	**(0.779)**
ln(1+years of education)	-0.007	-0.013	**0.073*****	-0.053	-0.04	**0.218*****	-0.128	-0.140	**0.948*****
	(0.039)	(0.019)	**(0.027)**	(0.094)	(0.046)	**(0.063)**	(0.529)	(0.259)	**(0.348)**
Ex-post insurance payouts									
Payout (Rs.)	0.033	na	**0.000**	0.076	na	**0.000**	0.333	na	**0.001**
	(0.045)	na	(0.000)	(0.098)	na	(0.000)	(0.544)	na	(0.001)
Knowledge of Insurance									
Insurance Knowledge Index	0.067*	-0.065**	**0.022**	0.150*	-0.129**	**0.034**	0.792	-0.921**	**0.244**
	(0.039)	(0.026)	**(0.034)**	(0.088)	(0.065)	**(0.089)**	(0.482)	(0.380)	**(0.504)**
Household head has heard of rainfall insurance (1=Yes)		0.292***	**-0.104**		0.537*	**-0.105**		4.182**	**-1.003**
		(0.110)	**(0.143)**		(0.292)	**(0.377)**		(1.702)	**(2.137)**
Estimator		Probit			Tobit			Tobit	

Notes: Data was collected during the baseline and follow up surveys conducted in 2009. The sample includes the 1479 individuals that participated in both the baseline and follow-up surveys. The sample is equal to 1405 for probit regression, and 1479 for the tobit regressions. Symbols *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The table reports marginal effects for the treatment dummy, for the coefficient for the main interaction term, and for the interaction between the treatment dummy and the main effect. Each specification includes a different main effect and interaction term, reported in the first column to the left. The specification that includes the insurance knowledge index additionally includes a dummy variable equal to one if the respondent has never heard of rainfall insurance, and its interaction term. Cash crops are defined as castor in Mahbubnagar and groundnut in Anantapur. The regressions include an indicator variable for each village.

Table 6: Self-Reported Effects of Rainfall Insurance on Agricultural Investments

Variable	N	More	No Change	Less
Effect of rainfall insurance on:				
The amount used of:				
Fertilizer	743	50%	36%	14%
Seeds	743	41%	43%	16%
Pesticides	743	32%	41%	27%
Bullock labor	743	23%	48%	29%
Hired labor	743	35%	42%	23%
Funds borrowed to finance agricultural inputs	743	26%	52%	22%
The timing of initial planting				
No change	743	69%		
Later	743	5%		
The decision of whether to abandon crops				
Against	743	26%		
No change	743	67%		
Towards	743	7%		

Notes: This table reports self-reported investment decisions among farmers in the treatment group with data from the first follow-up survey conducted in November 2009.

Table 7: Who Knew About the Payouts, and How Were They Spent?

Panel A. Self-Reported Use of Insurance Payout

Responses to "What have you done with this money you have received?"	% of Payout Received	% Farmers Reporting > 0	N
Invested in agricultural activities for the Rabi	16.43	44.61	529
Bought goods and services to be used straight away	26.93	83.64	538
Bought goods that will last a longer time	12.04	59.40	532
Paid off debts	12.44	53.53	538
Saved for 2010 Kharif	20.41	70.76	537
Saved for later in the future	2.66	20.93	516
Gave to family and friends	10.36	3.75	520

Panel B: Knowledge About Insurance Status

	Household	Family	Friends	Others
Knew you had insurance	0.99	0.88	0.66	0.26
Knew you received a payout	0.99	0.72	0.49	0.21
Knew the size of your payout	0.93	0.51	0.31	0.09
Asked for money because of payout	0.70	0.19	0.03	0.01
Received money because of payout	0.48	0.08	0.01	0.01

Notes: Data were collected during the second follow up survey conducted in 2010. The sample includes the 535 treated farmers that participated in both the baseline, first and second follow-up surveys and received a positive rainfall insurance payout.

Table 8. Ex-Post Effects of Insurance Payouts

Panel A: Effect of Treatment and Payouts on Attitudes Towards Insurance and Financial Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)
	ICICI Lombard is trustworthy (1-10)	BASIS Risk Product Pays Out During Drought (1-10)	Savings in Bank or Cash (Winsorized)	Total Outstanding Debt (Winsorized)	Dummy: Any Expensive Debt	Sum of Expensive Debt (Winsorized)
Insurance Treatment (yes = 1)	0.371**	-0.00423	192.3	111.2	0.281***	582.2*
	(0.162)	(0.0487)	(866.9)	(376.2)	(0.100)	(345.6)
Insurance Treatment x Payout (fraction of max)	0.141	0.395***	1368.8	-0.566	-0.438***	-791.1
	(0.214)	(0.0906)	(1252.6)	(704.7)	(0.164)	(679.4)
N	1445	1459	1459	1459	1459	1459
Mean of dep var (full sample)	5.33	3.69	4917.8	3708.46	0.59	1482.21
P-value of Test: Max Payout = Control	0.000	0.000	0.048	0.833	0.173	0.683
Estimator	Tobit	Tobit	Tobit	Tobit	Probit	Tobit

Panel B: Effects of Inusrance (Ex-Post) on Real Outcomes

	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Log (Acres Planted in Rabi)	Children Mean Hours Worked per Week	Dummy: HH Has NREGA Earnings	Dummy: HH Earned Income from Migration	Change in Value of Livestock (Winsorized)	Change in Value of Durable Goods (Winsorized)	Total Daily Consumption (Winsorized)
Insurance Treatment (yes = 1)	-0.0265	2.028*	-0.114	-0.115	2214.4	594.7	-4.251
	(0.0787)	(1.166)	(0.109)	(0.148)	(2288.0)	(3567.1)	(7.871)
Insurance Treatment x Payout (fraction of max)	0.0396	-2.665	0.0906	-0.00844	-4217.7	-1704.4	-10.97
	(0.138)	(1.770)	(0.186)	(0.235)	(3292.4)	(6566.0)	(9.399)
N	1459	1081	1336	1270	1459	1459	1459
Mean of dep var (full sample)	0.429	12.440	0.704	0.128	4989.0	1267.2	207.6
P-value of Test: Max Payout = Control	0.897	0.601	0.857	0.406	0.350	0.814	0.011
Estimator	Tobit	Tobit	Probit	Probit	Tobit	Tobit	Tobit

Notes: Data were collected during the second follow up survey in 2010. The sample includes the 1459 individuals that participated in the baseline survey and first and second follow-up surveys. Children hours worked per week is for children ages 6-20 (380 households have no children). In specifications 9 and 10, the dependent variable is zero for all observations in several villages, so that the observations are dropped from the probit regression. The table reports marginal effects for the treatment dummy and for the interaction between the treatment dummy and amount paid out. Symbols *, **, *** denote significance at the 10, 5 and 1 percent level, respectively.

Online Appendix for

How Does Risk Management Influence Production Decisions?

Evidence from a Field Experiment

Table OA1: Test of Balance

Variable	N	Treatment Mean	Control Mean	Difference	Robust p-value	Significance Level
A. Demographic Characteristics						
Household size	1,479	5.32	5.38	-0.06	0.60	
Number of children 6 years old or younger	1,479	0.19	0.20	-0.01	0.72	
Number of children 18 years old or younger	1,479	1.67	1.72	-0.05	0.49	
Age of household head (Years)	1,470	49.82	49.37	0.45	0.49	
Highest level of schooling completed by household head (Years)	1,479	3.62	3.77	-0.15	0.54	
Household head is unschooled (1 = "Yes")	1,479	0.56	0.54	0.02	0.32	
Household head able to read (1 = "Yes")	1,479	0.42	0.44	-0.02	0.37	
Household head able to write (1 = "Yes")	1,479	0.38	0.41	-0.03	0.25	
B. Savings and Credit						
Total amount of savings, all sources (Rs.)	1,479	22,093	20,607	1,486	0.33	
Amount of savings with bank or post office (Rs.)	1,479	1,735	1,413	322.08	0.27	
Amount of savings in cash at home (Rs.)	1,479	1,832	1,597	235.10	0.16	
Amount of savings in jewelry (Rs.)	1,479	13,275	13,396	-121.77	0.91	
Amount of savings with SHG or other group (Rs.)	1,479	2,186	2,117	68.39	0.79	
Amount of other savings (Rs.)	1,479	3,065	2,083	982.04	0.10	*
Total amount of credit owed, all sources (Rs.)	1,479	41,320	41,972	-652.13	0.80	
Amount of credit from bank (Rs.)	1,479	21,168	19,652	1,516	0.36	
Amount of credit from family and friends (Rs.)	1,479	6,810	5,998	812.19	0.42	
Amount of credit from MFIs (Rs.)	1,479	557.87	827.45	-269.58	0.16	
Amount of credit from moneylenders (Rs.)	1,479	11,505	14,000	-2,496	0.12	
Amount of credit from other sources of credit (Rs.)	1,479	1,279	1,494	-215.29	0.42	
C. Livestock and other Assets (as of June 2009)						
Number of large animals owned, i.e. buffalos, cows and oxen	1,479	2.22	2.29	-0.07	0.64	
Number of small animals owned, i.e. goats, sheep, chicken, pigs	1,479	4.70	5.77	-1.07	0.36	
Total market value of livestock owned (Rs.)	1,479	31,922	36,626	-4,704	0.12	
House type: strong structure (1 = "Yes")	1,479	0.54	0.55	-0.01	0.65	
House type: semi-strong structure (1 = "Yes")	1,479	0.33	0.32	0.01	0.67	
House type: weak structure (1 = "Yes")	1,479	0.13	0.12	0.01	0.81	
Number or rooms in the house	1,479	2.62	2.65	-0.03	0.72	
Estimated value of the house if owned (Rs.)	1,479	116,938	117,346	-407.42	0.96	

(cont. following page)

Table OA1: Test of Balance (Continued)

Variable	N	Treatment Mean	Control Mean	Difference	Robust p-value	Sig. Level
C. Livestock and other Assets (as of June 2009) contd.						
Total area of agricultural land (Acres)	1,479	5.44	5.29	0.15	0.59	
Estimated value of agricultural land (Rs.)	1,479	558,434	457,887	100,547	0.19	
Estimated value of non-agricultural land and other houses (Rs.)	1,479	6,677	10,615	-3,938	0.13	
D. Agricultural Investments						
Total cultivated land (Acres) - all crops during Kharif'08	1,479	4.38	4.24	0.14	0.50	
Total cultivated land (Acres) - cash crops during Kharif'08	1,479	3.48	3.32	0.16	0.27	
Any land planted - cash crops during Kharif'08 (1 = Yes)	1,479	0.92	0.92	0.00	0.66	
Total amount spent on inputs - all crops during Kharif'08	1,479	20,036	20,115	-78.51	0.94	
Amount spent on hybrid seeds - all crops during Kharif'08	1,479	853.28	844.28	9.00	0.94	
Amount spent on improved seeds - all crops during Kharif'08	1,479	4,374	4,356	18.58	0.96	
Amount spent on fertilizer - all crops during Kharif'08	1,479	3,287	3,267	20.47	0.92	
Amount spent on manure - all crops during Kharif'08	1,479	2,073	2,339	-266.07	0.10	
Amount spent on irrigation - all crops during Kharif'08	1,479	119.64	181.66	-62.02	0.18	
Amount spent on hiring tractor/other impl - all crops during Kharif'08	1,479	2,723	2,635	88.07	0.64	
Amount spent on manual labor - all crops during Kharif'08	1,479	5,028	4,896	132.35	0.63	
Amount spent on bullock labor - all crops during Kharif'08	1,479	1,578	1,597	-18.90	0.88	
Total amount spent on inputs - cash crops during Kharif'08	1,479	15,868	15,923	-54.52	0.94	
Amount spent on hybrid seeds - cash crops during Kharif'08	1,479	454.99	427.08	27.91	0.61	
Amount spent on improved seeds - cash crops during Kharif'08	1,479	4,012	3,969	42.30	0.89	
Amount spent on fertilizer - cash crops during Kharif'08	1,479	2,284	2,302	-17.67	0.88	
Amount spent on manure - cash crops during Kharif'08	1,479	1,754	1,928	-174.63	0.24	
Amount spent on irrigation - cash crops during Kharif'08	1,479	22.53	40.23	-17.70	0.29	
Amount spent on hiring tractor/other impl - cash crops during Kharif'08	1,479	2,083	1,960	123.08	0.28	
Amount spent on manual labor - cash crops during Kharif'08	1,479	3,866	3,884	-18.55	0.93	
Amount spent on bullock labor - cash crops during Kharif'08	1,479	1,392	1,412	-19.27	0.86	

Notes: The table reports a randomization test run on the baseline sample, where each variable is tested for treatment assignment OLS estimation, robust standard errors. Symbols *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. An F-test confirms that the variables are jointly insignificant: the F-statistic is 0.83, and the corresponding p-values is 0.7896.

Table OA2. Cash crop treatment effects disaggregated by investment type

Dependent variable:	Dummy: Investment > 0		ln(1+investment, Rs.)	
	Insurance dummy (marginal effect)	pseudo-R^2	Insurance dummy (marginal effect)	pseudo-R^2
Agricultural input used (Rs.):				
Hybrid seeds	0.024	0.202	0.712	0.144
	(0.024)		(0.706)	
Improved seeds	0.025	0.316	0.383	0.17
	(0.029)		(0.474)	
Fertilizer	0.045	0.214	0.569	0.086
	(0.029)		(0.360)	
Manure	0.020	0.203	0.362	0.093
	(0.027)		(0.469)	
Pesticide	0.054**	0.254	0.932**	0.134
	(0.026)		(0.447)	
N	1479		1479	
Village dummies	yes		yes	
Estimator	Probit		Tobit	

Notes: Data was collected during the baseline and follow up surveys conducted in 2009. The sample includes the 1479 individuals that participated in both the baseline and follow-up surveys. Symbols *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. Dependent variables are listed in the first column to the left. Cash crops are defined as castor in Mahbubnagar and groundnut in Anantapur. The regressions include village indicator variables.

Table OA3. Treatment Effects, Winsorized Two Percent

Crop types:	All crop types		Cash crops only		
	Insurance dummy (marginal effect)	pseudo-R^2	Insurance dummy (marginal effect)	pseudo-R^2	Estimator
A. Without household covariates					
Any ag. inputs used (1 = Yes)	0.016	0.074	0.060**	0.213	probit
	(0.012)		(0.029)		
ln(1+total cultivated land, acres)	0.030	0.050	0.162**	0.156	tobit
	(0.034)		(0.068)		
ln(1+market value of ag. inputs used, Rs.)	0.088	0.032	0.808**	0.092	tobit
	(0.087)		(0.387)		
ln(1+total amount spent on ag. inputs, Rs.)	(0.078)	0.031			tobit
	(0.078)				
B. With household covariates					
Any ag. inputs used (1 = Yes)	0.013	0.074	0.065**	0.213	probit
	(0.010)		(0.030)		
ln(1+total cultivated land, acres)	0.042	0.050	0.175***	0.156	tobit
	(0.031)		(0.066)		
ln(1+market value of ag. inputs used, Rs.)	0.118	0.032	0.869**	0.092	tobit
	(0.083)		(0.383)		
ln(1+total amount spent on ag. inputs, Rs.)	0.085	0.031			
	(0.074)				
N	1479		1479		
Village dummies	yes		yes		

Notes: Data were collected during the baseline and follow up surveys conducted in 2009. The sample includes the 1479 individuals that participated in both the baseline and follow-up surveys. Symbols *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variables are: a dummy variable equal to one if the household used any agricultural inputs, the log of (1+ the amount of land under cultivation), the log of (1+ the value of inputs used), and the log (1+ the market value of inputs purchased). The column to the left reports regression results for all crop types, while the column to the right reports regression results for cash crops only. Cash crops are defined as castor in Mahbubnagar and groundnut in Anantapur. The top panel reports results for the main specification, while the panel at the bottom includes household covariates as a robustness check. Household covariates included in this specification are the age of the household head, the log of the highest level of schooling completed by household head and the wealth index. The regressions include indicator variables for each village.

Table OA4. Treatment Effects with Linear Probability Model

Crop types:	All crop types		Cash crops only		
	Insurance dummy (marginal effect)	pseudo-R^2	Insurance dummy (marginal effect)	pseudo-R^2	Estimator
A. Without household covariates					
Any ag. inputs used (1 = Yes)	0.012		0.045**		OLS
	(0.010)		(0.022)		
ln(1+total cultivated land, acres)	0.029		0.080**		OLS
	(0.033)		(0.035)		
ln(1+market value of ag. inputs used, Rs.)	0.079		0.380*		OLS
	(0.086)		(0.195)		
ln(1+total amount spent on ag. inputs, Rs.)	0.049				OLS
	(0.078)				
B. With household covariates					
Any ag. inputs used (1 = Yes)	0.013		0.048**		OLS
	(0.010)		(0.022)		
ln(1+total cultivated land, acres)	0.040		0.088***		OLS
	(0.030)		(0.034)		
ln(1+market value of ag. inputs used, Rs.)	0.109		0.411**		OLS
	(0.082)		(0.193)		
ln(1+total amount spent on ag. inputs, Rs.)	0.078				
	(0.074)				
N	1479		1479		
Village dummies	yes		yes		

Notes: Data were collected during the baseline and follow up surveys conducted in 2009. The sample includes the 1479 individuals that participated in both the baseline and follow-up surveys. Symbols *, **, *** denote significance at the 10, 5 and 1 percent level, respectively. The dependent variables are: a dummy variable equal to one if the household used any agricultural inputs, the log of (1+ the amount of land under cultivation), the log of (1+ the value of inputs used), and the log (1+ the market value of inputs purchased). The column to the left reports regression results for all crop types, while the column to the right reports regression results for cash crops only. Cash crops are defined as castor in Mahbubnagar and groundnut in Anantapur. The top panel reports results for the main specification, while the panel at the bottom includes household covariates as a robustness check. Household covariates included in this specification are the age of the household head, the log of the highest level of schooling completed by household head and the wealth index. The regressions include indicator variables for each village.

Table OA5: Summary Statistics for 2010 Followup Survey

Variable	N	Mean	SD	p10	p50	p90
A: Effect of Treatment and Payouts on Attitudes Towards Insurance and Financial Outcomes						
How Trustworthy: ICICI Lombard (1-10)	1,445	5.33	2.09	3	5	8
BASIS Risk Product Pays Out During Drought (1-10)	1,459	3.69	0.71	3	4	5
Savings in Bank or Cash (Winsorized)	1,459	4,917.80	9,821.34	0	2,000	12,000
Total Outstanding Debt (Winsorized)	1,459	3,708.46	5,403.92	30	100	10,080
Dummy: Any Expensive Debt	1,459	0.59	0.49			
Sum of Expensive Debt (Winsorized)	1,459	1,482.21	3,344.98	0	20	10,000
B: Effects of Inusrance (Ex-Post) on Real Outcomes						
Log (Acres Planted in Rabi)	1,459	0.43	0.56	0	0	1
Children Mean Hours Worked per Week	1,081	12.44	11.31	0	11	28
Dummy: HH Has NREGA Earnings	1,459	0.68	0.47			
Dummy: HH Earned Income from Migration	1,459	0.11	0.32			
Change in Value of Livestock Excluding Chickens and Other Animals (Winsorized)	1,459	4,989.00	11,670.37	0	0	19,000
Change in Value of Durable Goods (Winsorized)	1,459	1,267.24	6,151.43	0	0	0
Total Daily Consumption (Winsorized)	1,459	207.57	107.32	122	183	302

Notes: This table reports the summary statistics for the sample, which includes the 1459 individuals that participated in the 2010 followup survey. See Appendix Table A2 for variables' definitions.