Patterns of Rainfall Insurance Participation in Rural India

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Abstract:

This paper describes the contract design and institutional features of an innovative rainfall insurance policy offered to smallholder farmers in rural India, and presents preliminary evidence on the determinants of insurance participation. Insurance takeup is found to be decreasing in basis risk between insurance payouts and income fluctuations, increasing in household wealth and decreasing in the extent to which credit constraints bind. These results match with predictions of a simple neoclassical model appended with borrowing constraints. Other patterns are less consistent with the 'benchmark' model. Namely, participation in village networks and measures of familiarity with the insurance vendor are strongly correlated with insurance takeup decisions, and risk averse households are found to be less, not more, likely to purchase insurance. We suggest that these results reflect household uncertainty about the product itself, given their limited experience with it.

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1. Introduction

Insurance markets are growing rapidly in the developing world. As part of this growth, innovative new products allow individual smallholder farmers to hedge against agricultural risks, such as drought, disease and commodity price fluctuations. For example, a recent World Bank volume (World Bank, 2005a) discusses ten case studies in countries as diverse as Nicaragua, the Ukraine, Malawi and India. Each is a study of 'index insurance', an insurance product whose payouts are linked to a publicly observable index such as rainfall recorded on a local rain gauge. Advocates argue that index insurance is transparent, inexpensive to administer, enables quick payouts, and minimizes moral hazard and adverse selection problems associated with other risk-coping mechanisms and insurance programs.

These financial innovations hold significant promise for rural households. Shocks to agricultural income, such as a drought-induced harvest failure, generate movements in consumption for households who are not perfectly insured, and at the extreme, may lead to famine or death. Available evidence suggests households in developing countries are partially although not fully insured against income shocks (eg. Townsend 1994, Morduch 1995, Lim and Townsend 1998). Moreover, weather events tend to affect all households in a local geographic area, making other risk-sharing mechanisms like inter-household transfers and local credit and asset markets less effective at ameliorating the impact of the shock. Other evidence suggests that households engage in costly ex ante risk-mitigation strategies to reduce fluctuations in agricultural income. Morduch (1995) summarizes a range of evidence of this kind of household 'income smoothing'; for example, Indian farmers near subsistence level spatially diversify their plots, and devote a larger share of land to lower-yielding, traditional varieties of rice and castor. These activities reduce the variability of agricultural revenues, but at the expense of lower average income.

This paper studies a particular rainfall insurance product offered in recent years to smallholder farmers in the Andhra Pradesh region of southern India. The product provides a payout based on rainfall during three separate phases of the Kharif, or monsoon season, and is inexpensive enough to be accessible to farmers of modest income (one policy covering all three phases of the Kharif costs around Rs. 150-250, equivalent to $3-5US). The product is sold to farmers by BASIX, a microfinance institution, and rainfall risk is underwritten by the insurance firm ICICI Lombard and their reinsurers.

A basic research question for the study of micro-insurance markets is estimating the cross-sectional determinants of household insurance takeup, and identifying the impediments to trade that prevent remaining households from participating. After describing the insurance product, we present empirical evidence on the determinants of insurance participation, based on a household survey implemented by ICRISAT and the World Bank in late 2004. We first evaluate takeup patterns against a simple neoclassical benchmark, which predicts that insurance participation is increasing in risk aversion and the variance of risk, and decreasing in basis risk between insurance payouts and the risk to be insured. We find some evidence consistent with the basis risk prediction; namely households who historically plant a high share of castor and groundnut, the two crops for which contracts are designed, are more likely to purchase insurance. Takeup rates are also higher amongst wealthy households, and lower amongst households identified as credit constrained. These findings are consistent with an extension of the 'benchmark' model to include borrowing constraints.

Other evidence is more difficult to reconcile with the benchmark model. First, amongst the quantitatively most significant determinants of insurance takeup are variables measuring the household's degree of familiarity with the insurance vendor, such as whether the household is an existing BASIX customer. Participation is also higher amongst households that are members of the town Gran Panchayat (local council), and those that are connected to other village networks, especially when a larger number of other members or the household's primary network also buy insurance. Second, risk-averse households are somewhat *less* likely to take up rainfall insurance, not more likely as the neoclassical framework would suggest. This result is concentrated amongst households who are unfamiliar with the vendor, BASIX, or do not use other types of insurance.

We interpret these finding to suggest that many households are uncertain about the insurance product itself, leading risk-averse households, households with higher costs of evaluating new technologies, and households who are less familiar or place less trust in the insurance provider, to eschew purchasing insurance. This interpretation is also consistent with qualitative evidence: lack of understanding about the product was the most commonly cited explanation for not purchasing insurance, while a significant fraction of purchasers cite 'advice from others' as a reason for their decision to buy.

These results represent an early step towards understanding barriers to household participation in 'micro-insurance' contracts, and should be viewed as a progress report of our research to date. A new survey implemented during the 2006 Kharif, involving a randomized field experiment, will provide more detailed and robust results about the determinants of participation, as well as the impact of insurance participation on other household decisions.

Section 2 of this paper outlines the concept of index insurance. Section 3 describes the insurance contract features and related institutional details. Section 4 discusses theoretical determinants of insurance participation, and states hypotheses to be tested. Section 5 discusses our survey, and presents summary statistics. Section 6 presents empirical results. Section 7 concludes.

2. The Promise of Index Insurance

Index insurance provides a payout based on the realization of a publicly-verifiable aggregate index, such as rainfall at a local rain gauge or an area-wide measure of crop yields. The goal of such insurance is to insulate household income and consumption against aggregate shocks that are plausibly exogenous to the household unit.

A properly designed index insurance policy minimizes or eliminates moral hazard and adverse selection problems that otherwise distort behavior in insurance markets. This is because payouts are determined by exogenous information which is unaffected by either unobserved household characteristics (adverse selection) or ex-post household decisions (moral hazard). Desirable features of an index include the following: (i) the index is transparent and verifiable to policy-holders, (ii) the calculation of the index is free of tampering or manipulation, (iii) the probability distribution of the index can be accurately estimated, so that the product can be appropriately priced, and the expected return assessed by households, (iv) the index can be measured inexpensively and in a timely fashion, and (v) the realization of the index, or a transformation of the index, is highly correlated with household income and consumption risk.

The most widespread index-type insurance available in India is the government-operated National Agriculture Insurance Scheme (NAIS), which provides a payout based on measured area-level yields on individual crops. In participating states, farmers are required to purchase NAIS insurance if they take a crop loan from a formal financial institution; other farmers can choose to purchase the insurance voluntarily (Kalavakonda and Mahul, 2005; Mahul and Rao, 2005). For more information, we refer readers to Appendix B, in which we describe the features of NAIS in more detail, and summarize the costs and benefits of NAIS relative to rainfall insurance. (This text is omitted from the main text due to space constraints).

A necessary feature of any insurance contract is that payoffs are correlated with household income and consumption. Available evidence suggests deficient rainfall is a key risk faced by rural Indian households. Table 1 presents self-reported rankings from our survey data of the importance of different risks faced by households. An overwhelming proportion (88%) cite drought as the most important risk they face; crop failure for reasons other than drought, and crop disease, are cited second and third most frequently. Consistent with these self-reports, World Bank (2005b) estimates that a severe drought in Ananthapur and Mahbubnagar, the districts studied in our empirical work, would reduce average rice yields by 45% and 26% respectively, a potentially devastating loss of income for a household near subsistence level.

[[INSERT TABLE 1]]

3. Policy Design and Marketing

The rainfall insurance product studied in this paper is designed to insure farmers in semi-arid tropical areas of India against deficient rainfall. It was developed by the general insurer ICICI Lombard, with technical assistance provided by the World Bank. ICICI Lombard partners with local financial institutions who market the product to farmers. In the Mahaboobnagar and Anantapur districts of Andhra Pradesh, where the product was piloted in 2003, and where our survey villages are located, this role is performed by BASIX, a microfinance institution.

Below, we describe the insurance contract design, focusing on 2004, the year of our survey evidence. Our discussion draws in part on World Bank (2005a) and Giné, Lilleor, Townsend and Vickery (2005). Cole and Tufano (2007) also present additional detail about the product background, and BASIX's commercial incentives in marketing rainfall insurance policies.

3.1 2004 Contract Design

Rainfall insurance policies for 2004 were designed for the two main cash crops in the region: castor and groundnut. These two crops are more profitable than food crops, such as pulses, but are also more sensitive to drought. In addition, since the seeds are relatively expensive, some farmers purchase them using crop loans, but when the harvest fails these loans are often difficult to repay (Hess, 2002).

The coverage for all policies is the Kharif (monsoon season), which is the prime cropping season, running from June to September. The insurance contract divides the Kharif into three phases, sowing, podding/flowering and harvest. The payout structure in each phase is summarized in Figure 1. An upper and lower threshold is specified for each phase. The policy pays zero if accumulated rainfall exceeds the upper threshold. Otherwise, the policy pays a fixed amount for each mm of rainfall below the upper threshold, until the lower threshold is reached. If rainfall falls below the lower threshold, the policy pays a fixed, higher payout. The total payout is the sum of payouts across the three phases.

[[INSERT FIGURE 1]]

The timing of phases, thresholds and other parameters of the contract were determined using the PNUTGRO crop model (Gadgil, Rao and Rao, 2002) and interactions with farmers. The upper threshold corresponds to the crop's water requirement, while the second trigger is intended to equal the water requirement necessary to avoid complete harvest failure.

The policy premium was initially benchmarked on projected payouts using historical rainfall data (at least 25 years of data for each rain gauge was used). The premium was initially calculated as the sum of the expected payout, 25 percent of its standard deviation and 1 percent of the maximum sum insured in a year, plus a 25% administrative charge and 10.2% government service tax. In some cases, the premium dictated by this formula was then reduced, since it was believed to exceed farmers' willingness to pay. The policy was targeted towards small and medium size farmers with 2-10 acres of land. However, sales were not limited to this group; any household in the targeted villages was eligible to purchase the insurance product.

3.2 Example

Table 2 presents contract details and actual payouts for castor insurance policies sold in Mahaboobnagar in 2004. Mahaboobnagar includes three mandals (counties) with a reference weather station, Atmakur, Mahaboobnagar and Narayanpet, against which contracts are written.

[[INSERT TABLE 2]]

For example, in Narayanpet, the per-policy premium for a policy covering all three phases of the monsoon is Rs. 200. One policy is considered to be equivalent of one acre of coverage. In 2004, the start date for the monsoon is a fixed calendar date, June 10, and the first phase is 35 days in length. Narayanpet received 12mm of rain in the first phase, 84mm of rain in the second phase and 177mm of rain in the third phase. This resulted in a maximum lump sum payout of Rs. 1500 in the first phase, since accumulated rainfall fell below the lower trigger of 60 mm. Rainfall during the second phase was also deficient, but exceeded the lower trigger level, resulting in a payout at Rs. 240 per acre insured (240 = [100mm - 84mm] x 15). Rainfall exceeded the upper threshold value in the third phase. Thus, insured households in Narayanpet received total payouts of Rs. 1740 per policy.

3.3 *BASIX Distribution and Marketing*

BASIX has extensive local distribution networks, since it also provides microfinance loans to households in villages where the insurance product is marketed. Moreover, since defaults on micro-credit loans in rural areas tend to be associated with deficient rainfall, BASIX has clear incentives to market rainfall insurance, in particular to their own clients.

The insurance product was piloted in 2003 in two villages in Mahaboobnagar, and expanded to 43 pilot villages in Mahaboobnagar and Ananthapur in 2004. BASIX used four criteria to determine whether a village was suitable for insurance marketing in 2004: (i) the presence of exisiting BASIX customers to ensure some degree of trust in the institution; (ii) 200-300 of acres of groundnut and/or castor crops; (iii) a reasonable number of small and medium sized farms with 2-10 acres of land; and (iv) a village location within 20km of the nearest rainfall reference station, to minimize basis risk. Due to time constraints, BASIX offered insurance in only a subset of villages meeting these four suitability criteria.

BASIX's strategy in marketed villages was to first explain the insurance product to a trusted opinion leader, who then functioned as a motivator, informing other households about the product and an upcoming marketing meeting to be held a few days later. BASIX provided a general introduction to the insurance product at the marketing meeting. Policies were sold both at the meeting itself, and at individual visits to interested households following the meeting. BASIX agents generally spent one day in each village for insurance marketing and sales.

In conversations with us, BASIX representatives ascribed differences in insurance takeup rates across pilot villages to the choice of the motivator (eg. his understanding of insurance product and status in the village), the extent of BASIX's market presence, the number of rainy spells prior to and on the day of marketing (it being hard to sell rainfall insurance on a rainy day!), and the liquid assets of farmers on the day of marketing. This varied substantially; in some villages farmers had just received payments for their milk delivery and therefore had cash in hand, while in other villages, particularly in Anantapur, government subsidies for groundnut seeds had recently been made available, and most farmers had spend their savings purchasing seeds.

Based on feedback from farmers and BASIX field agents, the rainfall insurance contract design was refined in two important respects between 2004 and 2006. First, separate castor and groundnut policies were combined into a single policy for each rain gauge, to simplify marketing and appeal to farmers growing other crops, and based on a judgement that separate policies generated limited benefits for policyholders. Second, the start of the first phase is now triggered by the monsoon rains (namely, by the recording of at least 50mm of rain since June 1), rather than a fixed calendar date.

3.5 Aggregate insurance participation

Summary statistics for insurance takeup in 2003 and 2004 are presented in Table 3. In 2003, rainfall insurance was sold to 148 farmers in two villages, mostly members of borewell users associations. This increased to 315 farmers across 43 pilot villages in 2004. Policies sold covered 570 acres of crop, insuring a total sum of Rs. 3,409,200; equivalent to Rs. 10,822 per farmer (USD $240, based on an exchange rate of $1US = Rs. 45).

[[INSERT TABLE 3]]

4. Determinants of Insurance Participation: Theoretical Predictions

What does economic theory predict regarding the determinants of insurance market participation? In a simple setting without asymmetric information, a household's willingness-to-pay for an insurance contract will be (i) increasing in risk aversion, (ii) increasing in the expected insurance payout, (iii) increasing in the size of the insured risk, and (iv) decreasing in basis risk (in other words, increasing in the correlation between the insurance payout and the risk to be insured, or more generally, the household's consumption risk). As shorthand, we refer to this as the 'benchmark' model of insurance participation.

To fix ideas, in Appendix B we present a simple parametric example of this benchmark model for a household with mean-variance expected utility. The model yields a simple closed-form expression for the household's willingness to pay for insurance which illustrates the four comparative statics predictions listed above.

It is often noted, however, that many households remain uninsured against significant income risks (for example, many US households do not have health insurance). Deviating from the full-information benchmark, a large literature has considered adverse selection and moral hazard as potential explanations for barriers to trade in insurance (eg. Abbring, Chiappori and Pinquet, 2003; Cawley and Philipson, 1996; Rothschild and Stiglitz, 1976). Empirical evidence for asymmetric information models of insurance is mixed. For example, Cawley and Philipson (1996) find that conditional on observables, life insurance premia are *decreasing* in the quantity of insurance purchased, opposite to the separating equilibrium in Rothschild and Stiglitz (1976).

Models of adverse selection and moral hazard have relatively applicability to the rainfall insurance contract studied here. Historical rainfall patterns at mandal rain gauges are public information, ruling out adverse selection, while moral hazard only presents a problem to the extent that households tamper with the measurement of rainfall at the gauge. We have no evidence to believe that this is a problem in practice.

Mulligan and Philipson (2003) introduce fixed participation costs to a benchmark insurance demand model. They argue such costs help account for empirical patterns like the positive correlation between wealth and insurance participation identified by Cawley and Philipson (1996). However, it is not obvious whether any significant fixed costs apply in our setting. Administrative loadings are proportional to the amount insured, and there is no discount for multiple policies. One possibility is that since insurance policies are indivisible, it may be difficult for poor households to purchase even a single policy. Alternatively, there may be other, non-monetary fixed costs, for example the time cost of attending the marketing meeting, or cognitive costs associated with understanding the product.

4.1 Predictions

Hypothesis 1: 'Benchmark' model. *Insurance participation is higher when risk aversion is high, basis risk is low, and the risk to be insured is large.*

Our first hypothesis is simply that insurance participation decisions are consistent with the benchmark model described above.

Hypothesis 2: Heterogeneous Beliefs. *Insurance participation is higher when beliefs imply higher expected payouts.*

Historical rainfall patterns are publicly observable, which suggests households may share common expectations about the distribution of insurance payouts. However, to the extent that beliefs differ, households who expect lower rainfall would view the insurance contract as having a higher expected return, and be more likely to participate.

Hypothesis 3: Credit constraints. *Insurance participation is higher when households are less credit constrained (that is, when the shadow value of liquid assets is lower).*

In our setting, financial constraints potentially play a key role in insurance participation decisions. One one hand, credit constrained households may value the reduction in income volatility provided by insurance more highly, because they have a lesser ability to smooth consumption ex post by other means. On the other hand, at the start of the monsoon when insurance purchase decisions are made, credit constrained rural households have limited funds to purchase seeds, fertilizer and other materials needed for sowing. Even if such households are risk-averse and would benefit from insurance, the shadow value of liquid assets may be extremely high at such times, making the purchase of insurance unattractive.

We illustrate the intuition of this second mechanism through a simple extension of the benchmark model in Appendix B. We model a household with mean-variance utility, so in the baseline model, risk aversion and willingness-to-pay for insurance are independent of wealth. However, in the extension, we assume the household has limited funds, which can be used to purchase insurance or invest in sowing (eg. seeds, fertilizer etc.). We show willingness to pay for insurance is unambiguously lower when credit constraints bind, and within that region is uniformly increasing in wealth. This result reflects a simple intuition: the more binding are credit constraints, the higher the shadow value of liquid assets, reflecting the high marginal product of the alternative use of those funds, investment in sowing.

It should be emphasized that the unambiguous nature of this prediction is at least partially an artefact of the static nature of our model. In a multi-period setting, credit constrained households would presumably also place higher value on the reduction in income volatility provided by insurance, because they have a lesser ability to smooth consumption ex post by other means, and because they are also more likely to be constrained at the beginning of future monsoons. (We view building such a fully-specified dynamic model as an interesting topic for future research.) This potential ambiguity suggests the correct sign of the relationship is an empirical question. A negative correlation between credit constraints and insurance purchase would suggest that the ex ante credit constraints emphasized in the model in Appendix B are dominant empirically, while the opposite correlation would suggest they are not.

Hypothesis 4: 'Early adoption', limited cognition and networks

Our empirical setting also relates closely to the literature on technology adoption and diffusion (Grilliches, 1957, Caswell and Zilberman, 1985). We study a new financial product. Households in our sample have been offered the opportunity to purchase rainfall insurance at most only once previously. Even with the help of the BASIX agent, the household may be uncertain about the contract design, or the timing or magnitudes of payouts. Alternatively, the household may not fully trust the insurance provider to pay out on claims. Although we do not formally extend our theoretical framework to model these factors, we consider three interrelated hypotheses relating to takeup of a new product that is not well-understood by households:

(i) <u>Familiarity With Insurance Provider</u>: In an environment where a product is not well understood, it seems plausible households will draw inferences based on their degree of experience and familiarity with the vendor, BASIX, and their trust in it.

(ii) Networks: Closely related, households are likely to rely on information gleaned from social networks, such as whether other trusted farmers also purchase insurance.

(iii) Limited cognition: Households may vary in their cognitive ability to understand the product, as well as their willingness to experiment with it. We study whether members of the Gram Panchayat (local council), and self-identified ‘progressive’ households disproportionately purchase insurance. We also hypothesize that younger and more educated household heads will understand the product more easily, and be more likely to participate.

5. The Survey

Our data comes from a household survey conducted after the 2004 Kharif, designed to study households’ experiences with ICICI Lombard rainfall insurance. The survey questions were developed by ourselves and implemented by ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) in late 2004.

The survey sampling frame is a census of landowner households across 37 villages in Mahboobnagar and Ananthapur. We survey all villages where at least five households purchase insurance in 2004, accounting for the selection of 25 of the 37 villages. The other 12 villages are ‘controls’, villages identified by BASIX as being suitable for insurance marketing, but where no policies were sold in 2004 due to time constraints. Since there is no participation in the control villages, empirical analysis in this paper is based only on data from the 25 marketed villages.

Amongst marketed villages, we select a stratified random sample of households, so as to survey as many purchasers of insurance as possible. Details of the stratification are presented in Table 4. The three strata used are: (i) household purchased insurance (267 households), (ii) household attended insurance marketing meeting but did not purchase insurance (233 households) and (iii) household did not attend marketing meeting (252 households). The total sample size is 752 households. The sample of 267 purchasers represents a large fraction of the 315 total households that purchased insurance in 2004.

[[INSERT TABLE 4]]

Weighted statistics in Table 4 reflect the size of the underlying population from which each sample is drawn, based on the landowner census and BASIX administrative records. The underlying population is 5805 households across 25 villages; since 266 households purchase insurance, the insurance takeup rate is 4.6%.

Note that we use 'purchased insurance' as the dependent variable in most of our regressions. Since we also stratify on this variable, our sampling approach is an example of choice-based sampling (Manski and Lerman, 1977). Following Manski and Lerman, we estimate a weighted probit regression using the sampling weights from Table 4 to recover consistent estimates of the slope coefficients. (If instead stratification was based on right-hand-side variables, either weighted or unweighted regressions would provide consistent estimates).

5.1 Summary statistics and variable construction

Summary statistics for the sample are presented in Table 5. Full-sample averages are weighted by population weights, and thus are close to non-buyer averages, given the low takeup rate. For 25 households data is missing for one or more variables, in which case we impute missing values iteratively as a function of other variables. No single variable is missing more than 11 times, and our empirical results are almost unchanged if we restrict the sample to households without missing data, rather than impute missing values. Specific details of each variable's construction is presented in Appendix C.

Demographic and wealth data confirms our sample consists of poor and middle-income smallholder farmers. Mean landholdings are 5.8 acres (median = 4 acres). Household heads have an average of 3.3 years of formal education, although the median household head has no formal education. 97% of household heads have spent their entire life in the village. Mean household liquid assets are Rs. 14,100 (median = Rs. 8,300), equivalent to US$300 (US$200), the sum of cash, bank account deposits, jewelry, silver, gold, revolving funds and miscellaneous liquid assets.

There are significant differences between the characteristics of insurance buyers and non-buyers. Buyers report around 50% more land and nearly twice as much in liquid assets. Buyers are also less risk averse than the overall sample. Around a third of insurance purchasers belong to borewell user associations (BUAs), compared to only a small fraction (4%) of the overall population. 46% of buyers have outstanding credit from BASIX at the start of the Kharif, compared to 7% of the overall population.

Summary statistics in Table 5 include several variables intended to elicit parameters of the household head's utility function. The variable 'risk aversion' is measured on a 0 to 1 scale, and is constructed from a game where the household head chooses between a series of gambles indexed by increasing risk and return; the household is then given a cash payout of between 0 and Rs. 200 based on their answer and the outcome of a coin toss. A related question is used to elicit a dummy variable for ambiguity aversion. The variable 'patience' indicates the proportionate amount that a household head must receive today for them to be indifferent to a fixed amount promised in one month's time. The average for this variable is 0.8, suggesting a high monthly discount rate for the households in the sample.

We also construct a variable that measures household pessimism regarding the start of an average monsoon season. Households are asked to assess the probability of the monsoon starting after several different dates, from which we estimate the household head's subjective probability density function for the start of the monsoon. The pessimism variable is the area under this density function one standard deviation or more to the right of the historical average start of the monsoon season (thus a larger value represents more weight on a later monsoon start).

Finally, the variable 'credit constraints' is a proxy for whether the household is credit constrained, based on the household's explanation for why they do not have one more loan. If the household cites a supply-side reason such as 'lack of collateral' or 'bank will not give additional loan' this variable is set equal to 1. It is set equal to 0 if the household responds 'no need for credit', 'do not like to be in debt' or 'other'.

6. Empirical Results

6.1 Self-reported explanations for insurance takeup decisions

We ask households who attended a marketing meeting to provide up to three reasons for their decision whether to purchase BASIX rainfall insurance. Table 6 presents frequencies for the three most important reasons cited by households, in order of their importance. The final column is a weighted sum across the three responses (giving more weight to higher-cited reasons).

[[INSERT TABLE 6]]

Amongst purchasers, households' self-reported explanations emphasize the risk-reduction benefits of insurance. 'Security/risk reduction' was the most popular response, while the second most cited reason is 'household needs harvest income'. 65% of households cited one of these explanations as the most important reason for purchasing insurance. Responses also emphasize the role of networks and learning: 'advice from progressive farmers', 'other trusted farmers purchased insurance' and 'advice from village officials' together comprise 19% of the weighted responses. 12.5% of responses cited either the high expected payout or low premium of the insurance. A small fraction of households (5.7%) purchased the insurance because of reasons related to 'luck'.

Strikingly, the most frequently cited reason amongst non-purchasers is that the consumer did not understand the insurance product, representing 25% of weighted responses. 21% of responses stated the household did not have sufficient cash or credit to pay the premium, consistent with the hypothesis that credit constraints are important for insurance participation. 24% of responses cited responses related to basis risk: either 'rain gauge is too far away', or 'household does not grow castor or groundnut'. 16.6% of weighted responses stated that the actuarial value of insurance was low relative to premiums: i.e. either that the insurance is too expensive (14.1% of responses), or the payouts are too small (2.5% of responses). Only a small percentage of household responses (2.5%) stated the household had no need for insurance against rainfall risk.

Many of these qualitative responses match well with the simple 'benchmark' model of insurance participation under symmetric information. Namely, the degree of risk-reduction, the payout relative to the premium, and the degree of basis risk are all important factors considered by households when making purchase decisions. Two types of responses however are inconsistent with the benchmark model. Firstly, the results suggest a significant proportion of households who purchased insurance did so on the advice of trusted farmers or village leaders; conversely 25% of explanations for non-purchase cite a lack of understanding of the product. Secondly, a significant proportion of non-purchasers cite a lack of liquid funds or credit to pay for the premium, suggestive of the importance of credit constraints.

6.2 Regression Estimates

We next estimate a reduced-form probit regression model of insurance participation. The dependent variable is equal to 1 if the household purchases BASIX rainfall insurance in 2004, and 0 otherwise. Results are presented in Table 7.

The first column of results normalizes coefficients to reflect the marginal effect of a one-unit change in the explanatory variable on the probability of insurance purchase. For expository purposes, in column 2, we present the same results dividing the coefficients by the population mean participation rate of 0.046; these coefficients indicate the *percentage* change in the probability of takeup for a one-unit shock to the relevant covariate (i.e. a coefficient of 1 indicates one unit shock to the explanatory variable doubles the probability of insurance participation for a household whose initial participation probability equals the population average).

[[INSERT TABLE 7]]

I. Benchmark model. A first prediction of the benchmark model is that insurance participation is decreasing in basis risk between payouts and household income, and increasing in the size of the risk to be insured. Coefficients in Table 7 under 'basis risk' appear generally consistent with these predictions. In particular, we include two variables measuring the proportion of cultivated land used for castor and groundnut in the previous year, 2003. Since these are the two crops against which policies are written, the basis risk from using insurance to hedge rainfall risk is presumably smaller when these crops predominate, assuming the crop model is correctly specified. Consistent with this prediction, both 'percentage groundnut' and 'percentage castor' are positively signed and statistically significant at the 1% level. Coefficients in column 2 show that for a household at the population takeup probability of 0.046, moving from growing no groundnut to all groundnut increases the probability of purchasing insurance in 2004 by 59% (35% for castor).

The second prediction of the benchmark model is that risk-averse households have a higher willingness-to-pay for insurance. In fact we instead find that risk-averse households are marginally *less* likely to purchase rainfall insurance, significant at the 10% level. Quantitatively, shifting the risk aversion parameter from its minimum to maximum value (i.e. 0 to 1) reduces the probability of purchase by 24% (1.1 percentage points). Potential explanations for this result are discussed in Sections 6.3 and 6.4.

The regression also includes proxies for two other dimensions of the household's utility function: ambiguity aversion and discount rate. Neither of these variables is statistically significant, although it is not clear the extent to which this is due to measurement error.

II. Credit constraints and wealth. In Appendix B we show that binding borrowing constraints, equivalent in our setup to low wealth, implies a higher shadow value of wealth and lower willingness-to-pay for insurance. The baseline regression includes two wealth variables, log(1+landholdings) and log(wealth), both measured at the beginning of the Kharif. Both these measures are positively signed, and although neither is individually significant, they are jointly significant at the 2% level. (These variables are strongly collinear; in an unreported regression excluding log(wealth), the coefficient on landholdings increases by a factor of 4 and becomes statistically significant at the 1% level.)

Our covariates also include a direct proxy for credit rationing, derived as described earlier from household self-reports about why they do not have one more loan. This coefficient is negatively signed as predicted, and statistically significant at the 1% level. Quantitatively, switching on this variable reduces the probability of takeup by 30% (1.4 percentage points).

III. Heterogeneous beliefs. We next estimate whether a proxy for beliefs about the insurance payout influences participation. We include a variable that measures the household's expectation about the start date of the monsoon. Our prediction is that households who expect the monsoon to start later will expect a higher payout, because the insurance payout is inversely correlated with rainfall from a fixed calendar date. This measure of pessimism is positively correlated with takeup as predicted, although it is statistically insignificant.

IV. 'Early adoption', limited cognition and networks. Qualitative responses suggest a significant fraction of households do not fully understand the insurance product, and that many relied on recommendations from other farmers or village leaders for insurance participation decisions. Here we test three hypotheses described earlier about household behavior in this kind of 'incomplete information' environment. The first hypothesis is that households with a greater degree of familiarity with BASIX, the insurance provider, will have higher participation rates. First, we include a dummy variable equal to 1 if the household is a member of a borewell user association (BUA). A BUA is a group of households who jointly use and maintain a water bore or set of bores. Historically, BASIX provides group lending to BUAs, and in 2003, when the insurance was first piloted, the insurance was explicitly targeted to BUA members. BUA members are more likely to know the BASIX sales representative in the village, and a BUA also provides a close-knit network of households who share information and advice.

Membership of a BUA has a very large and statistically significant effect on participation decisions; our marginal effects estimates suggest it increases the probability of insurance participation by a factor of 8 times ($p < 0.01$). A second variable indicating whether the household is an existing BASIX borrower at the start of the Kharif also strongly predicts takeup.

Quantitatively, existing BASIX customers are 143% more likely to purchase insurance ($p<0.01$). These two variables (along with Gran Panchayat membership) are quantitatively the strongest predictors of insurance participation decisions. This likely reflects a both households' greater familiarity and trust with respect to the insurance provider, as well as more intensive marketing to these groups by BASIX. In either case, our findings are inconsistent with a full-information benchmark, since all households in the village are eligible to purchase insurance.

Second, we provide some suggestive evidence consistent with the hypothesis that social networks influence insurance takeup decisions. First, households who are members of the town Gran Panchayat are significantly more likely to purchase insurance ($p < 0.01$), as are households who are members of a larger number of other formal and informal village networks ($p < 0.01$), such as self help groups, Raithu Mitra groups and caste committees. More directly, we also include a variable that measures the number of other well-known households in the respondent's self-identified primary social group who purchased insurance. This variable is positive and statistically significant ($p < 0.01$). Quantitatively, an additional purchasing household amongst the respondent's primary group raises the probability of the household purchasing insurance by 13%.

These results, along with the qualitative self-reports presented earlier, are suggestive of the role of network effects. However, caution should be exercised in interpreting our results, since we cannot rule out the hypothesis that our estimates reflect unobserved heterogeneity across groups, rather than the effect of local social interactions (see Manski, 1993, for a discussion). For example, BASIX may have marketed the insurance at greater intensity to particular groups in the village, which would generate correlation in insurance takeup decisions amongst members of a group.

Our third hypothesis is that households vary in their cognitive ability to comprehend the insurance product. We first consider self-identified 'progressive' farmers, that is, farmers which other villagers ask for advice (perhaps because they are more knowledgeable or intelligent). Such households are around 15% more likely to purchase insurance ($p<0.05$) than non-progressives. Households with a younger household head, or a household head that has lived outside the village, are also statistically significantly more likely to purchase insurance ($p<0.01$ and $p<0.10$ respectively). A doubling of the household head's age reduces the probability of insurance purchase by 33%, consistent with our prior that the cost of evaluating new products and technologies is lower for younger individuals. Surprisingly, however, conditional on age and other covariates, education is not statistically significantly correlated with insurance participation decisions, although it is correctly signed.

6.3 Risk-aversion interaction effects

An apparently puzzling finding from Table 7 is that risk-averse household are less, rather than more, likely to purchase rainfall insurance, opposite to the prediction of the benchmark model. Here we explore a potential explanation for this result, namely that risk-averse households are also averse to uncertainty about the insurance policy itself, and the potential risks associated with it, given their imperfect understanding of the product.

To test this hypothesis, we interact risk aversion with three variables indicating the household's familiarity either with BASIX or the concept of insurance, namely dummy variables for: (i) whether the household belongs to a BUA, (ii) whether the household is a debtor of BASIX at the start of the Kharif, and (iii) whether the household holds any other type of insurance. Under the 'product uncertainty' explanation, we expect the wrong-signed risk aversion coefficient to be concentrated amongst households that are unfamiliar with BASIX or with insurance. We then re-estimate the specification from Table 7 including these three additional interaction terms together, and then one at a time. Results are presented in Table 8.

[[INSERT TABLE 8]]

The estimates are consistent with the 'product uncertainty' explanation. Each interaction term is positively signed as predicted, and the coefficients are jointly significant at the 5% level. The interaction term: 'Risk Aversion x Credit from BASIX' is individually significant at the 5% level when included on its own (Column 3), and at the 10% level when all three interaction terms are included (Column 1). Our point estimates imply that for a household where each interaction term is switched from 0 to 1, the combined coefficient on risk aversion switches from -0.024 to +0.017, and thus shifts to the 'correct' positive sign (although the combined coefficient is not statistically different to zero).

6.4 Conditional probit

As described earlier, BASIX follows a two-step procedure in selling rainfall insurance: households are first invited to attend a marketing meeting; households who attend are then educated about insurance, and given the opportunity to purchase policies.

In Table 9 we present estimates using a conditional probit model that accounts for these two sequential steps of the insurance participation decision. We estimate two equations; the first equation is estimated on the whole sample, and has a dependent variable equal to 1 if the household attended the marketing meeting and 0 otherwise. The second equation is estimated on the subsample of households who attended the marketing meeting, and has a dependent variable equal to one if the household purchases insurance; that is, it studies participation conditional on meeting attendance. Results are presented in Table 9.

[[INSERT TABLE 9]]

In general, our previous estimates hold in a similar way across both steps of the participation decision, although in some cases the statistical significance of some results is reduced. Most notably, BUA members and BASIX borrowers are both more likely to attend the marketing meeting, as well as more likely to purchase insurance conditional on attendance, in each case statistically significant at the 5% or 1% level. Thus suggests the high rates of participation amongst these groups do not just reflect encouragement by BASIX to attend the meeting, since this mechanism alone would generate selection bias to produce *negative* coefficients on these variables in the second step.

6.5 Other analysis

Table 10 presents calculations of the quantitative magnitude of the insurance purchases of participating households. Households on average purchase 1.8 policies at a cost of Rs. 362, corresponding to 1.5% of liquid assets at the start of the Kharif, and 0.7% of 2004 gross Kharif agricultural revenue. These numbers are relatively small, consistent with our claim that households are experimenting with a new, imperfectly understood product, although still non-trivial (for example, in a US context, these figures would be equivalent to an expenditure on insurance of $700-$1400 per year for a small business owner with annual sales revenue of $100,000-200,000). It is important to highlight that returns on the insurance are quite skewed, a maximum payout on the insurance, corresponding to a 'crop failure' levels of rainfall across all three phases of the Kharif, yields a payout of 35% of gross farm revenue for an average household purchasing 1.8 policies.

[[INSERT TABLE 10]]

The large coefficients on 'BUA member' and 'BASIX customer' in our results raise potential concerns that the strength of other relationships may be significantly different across members and non-members of these two groups. As a final robustness exercise, in unreported regressions we re-estimate our results on the subsample of households who are not BUA members or BASIX customers. Our point estimates are similar, although the statistical significance of the results is sometimes reduced, reflecting the smaller sample size (results available on request).

7. Summary and Conclusions

We describe an innovative rainfall insurance product offered to smallholder farmers in the Andhra Pradesh region of southern India, and present preliminary evidence on the determinants of insurance participation. Our empirical findings highlight two main deviations from a benchmark model of insurance participation. First, credit constraints appear to be an impediment to purchasing insurance. Households with less land and less wealth, as well as households who directly report being credit constrained, are less likely to participate in insurance, consistent with the extension of a 'benchmark' one-period model of insurance to include financial constraints. Insurance participation is generally increasing in wealth in developed countries also, a fact attributed to asymmetric information or fixed participation costs (Mulligan and Philipson, 2003). It is notable that we find the same result in a setting where these explanations appear unlikely to hold.

Second, a variety of results together suggest limited familiarity with the insurance product plays a key role in participation decisions: (i) Takeup rates are higher amongst prior customers of the insurance vendor BASIX, or members of BUAs, who are amongst BASIX's primary clients; (ii) risk averse households are less likely to purchase insurance, but only amongst households who are unfamiliar with insurance or with BASIX; (iii) households who are more connected to village networks are more likely to purchase insurance, especially when other members of the household's primary group participate; (iv) respondents who likely have lower cognitive costs of understanding and experimenting with insurance, such as young farmers and self-identified 'progressive' farmers, are more likely to purchase the product; (v) in self-reports, a significant fraction of households cite advice from other farmers and limited understanding of the product as important determinants of participation decisions.

Our finding of the significance of credit constraints has practical implications for insurance contract design. A first implication is that insurance payouts should be made as promptly as possible after rainfall is measured and verified. Our survey asks households to identify which times of the year they are in most need of additional liquid assets; unsurprisingly, households report that they are most credit constrained at the start of the sowing season, and least constrained in November when crops are harvested and sold. However, in 2004, insurance payouts were not paid to farmers until around November. Our results suggest farmers would benefit from payouts being made available as soon as possible, preferably phase-by-phase as each stage of the Kharif is completed. One impediment to early payouts is that the Indian Meteorological Department takes an average of two months to verify rainfall data. ICICI Lombard is in the process of setting up a private network of automated rain gauges, which in the future will facilitate faster payouts as well as minimize basis risk. A second potential innovation would be to combine insurance with a short-term loan that helps credit-constrained households pay for the premium (stated differently, BASIX could offer state-contingent loans). We raised this possibility with BASIX; they are currently reluctant to mix products in this way, because they want to clearly establish to customers the conceptual difference between insurance and micro-credit products.

The overall conclusion of our empirical work is that, early in its introduction, the insurance product we study has not yet succeeded in proportionately reaching the most vulnerable households (e.g. poor, credit-constrained households, or households that are not members of social networks), who presumably would benefit most from protection against drought. These stylized facts likely in part reflect persistent real barriers to trade in insurance such as credit constraints, but also in part are due to a normal pattern of diffusion of a new product. Still in the early stages of introduction, the insurance product is not fully understood, and takeup rates are low. Early adopters are likely to be households where the cost of experimenting is low; participation will then filter through to other households over time.

A less sanguine perspective is provided by Morduch (2004), who highlights potentially adverse general-equilibrium implication of differential rates of insurance participation between rich and poor households. Morduch suggests that if rainfall insurance is only purchased by the wealthy, such households may have additional income to bid up the price of local non-traded goods during periods of low rainfall, making non-purchasers worse off. He also suggests that formal insurance may undermine existing risk-sharing mechanisms, by raising the threat point of households who seek to withdraw from implicit risk sharing arrangements.

Relatively little academic research on ‘micro-insurance’ has been conducted to date, and many important questions remain unanswered. Some examples include: (i) the causal effect of rainfall insurance on income-smoothing and consumption smoothing; (ii) the price elasticity of demand for insurance, an important policy question given potential government subsidies on insurance contracts; (iii) the interaction between rainfall insurance and existing risk-bearing mechanisms; and (iv) the pattern of diffusion of insurance participation over time. In ongoing research, we are conducting a randomized field experiment amongst survey households, which we believe will help shed light on some of these questions.

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Appendix A: National Agricultural Insurance Scheme (NAIS)

This Appendix presents additional information about the main Indian crop insurance scheme, NAIS, and compares the costs and benefits of rainfall insurance and area yield insurance (This discussion was removed from the main text due to space constraints.)

NAIS is the most widespread form of index-like agricultural insurance currently available in India. In participating states, farmers are required to purchase NAIS insurance if they take a crop loan (typically for seeds) from a formal financial institution; other farmers can also choose to purchase the insurance voluntarily (Kalavakonda and Mahul, 2005; Mahul and Rao, 2005). NAIS insurance payouts are based on area yields on individual crops, measured via crop-cutting experiments. Policyholders in each designated policy area are given a payout based on the shortfall (if any) on the measured crop yield relative to a threshold value set according to historical yields, which are estimated over a rolling window (the window depends on the crop, but is generally 3-5 years).

Like most government crop insurance programs, NAIS operates at a substantial loss. Between late 1999 and early 2004, NAIS collected premia of Rs. 12.5 billion, but paid Rs. 47.5 billion in claims (Mahul and Rao, 2005). Kalavakonda and Mahul (2005), who present a detailed case-study of the operation of NAIS in the southern Indian state of Karnataka, find a claims-to-premia ratio of approximate 7 to 1 for the between 2000 and 2002; taking administrative costs into account, policy premia provide only 12 per cent of program costs.[1]

Despite these heavy subsidies and the scheme's availability to all farmers, NAIS has a relatively low penetration rate. In the 2004 Kharif, 12.7 million farmers across India were even partially covered by the program, representing 9 per cent of the total rural population of 138 million households (sources: Mahul and Rao, 2005; 2001 Indian Census). Moreover, insurance participation is particularly low amongst small and marginal farmers. In Karnathaka in 2002, Kalavakonda and Mahul estimate that 11.6 per cent of small and marginal farmers participated in NAIS, compared to 27.0 per cent of medium and large farmers. This disparity exists despite explicitly targeted subsidies; small and marginal farmers received a 40 per cent premium subsidy in 2002 (Kalavakonda and Mahul, 2005).

This low participation rate likely in part reflects shortcomings in the design and marketing of NAIS insurance contracts. First, NAIS appplies a uniform premium rate throughout India for each crop type, rather than a premium based on the actuarial expected payout in the local

[1] NAIS was introduced in 2000, replacing the Comprehensive Crop Insurance Scheme (CCIS), which covered only farmers borrowing from formal financial institutions. The CCIS also generally operated at a substantial loss. Over the period 1985-2001, the two schemes combined paid out claims in excess of premia collected in all but three years (1988, 1994 and 2000).

geographic area. This mispricing induces adverse selection; farmers in high-risk areas enjoy a larger subsidy than those in low risk areas, and are more likely to participate. Second, Kalavakonda and Mahul (2005) suggest that knowledge of the scheme is relatively limited amongst bankers and district administration officials, and that purchasing and claiming insurance involves sometimes burdensome administrative costs. Third, not all crops are covered by the scheme (for example, tea, coffee, rubber and sugarcane are excluded). Fourth, in some areas, the designated geographic unit is relatively large, generating excessive basis risk between the farmer's yield and the yield on the crop cutting experiments. Fifth, claims can take a substantial period of time to be settled. Table 3 of Kalavakonda and Mahul (2005) shows that insurance claims are on average made available to households around 12 months after the end of the growing season. Given the credit constraints and high discount rates of households in developing countries, this delay is likely to be a significant disincentive to participate in the insurance program. Unfortunately, little systematic evidence exists to disentangle the relative importance of these and other explanations for the low NAIS partipation rate.

Partially in response to the design problems outlined above, a number of private institutions have begun to offer alternatives to the NAIS crop insurance program. Several of these, including the product considered in this paper, provide a payoff based on rainfall at local rain gauges. Rainfall insurance presents several advantages relative to area-level crop insurance:

1. Cost. Rainfall data is already collected at a disaggregated level for other purposes by the Indian Meterological Department (IMD), and readily available at little or no cost. In contrast, area-yield index insurance requires a large sample of crop-yield measurements, involving significant fixed costs. (These fixed costs are likely to be prohibitive for private insurers seeking to develop alternative products to NAIS).

2. Availability of Historical Data. Reliable daily rainfall data is available at the mandal level over a historical period of several decades. By modelling this data, it is possible to generate a relatively accurate estimate of the actuarial value of a wide variety of potential insurance contracts.

3. Objectivity of index construction. Maintaining a standardized methodology for measuring crop yields is not trivial, since yields depend on the seed type used, amount of fertilizer and other inputs applied to the crop and other factors. This subjectivity also introduces the potential for manipulation of the index. In contrast, the methodology for the measurement of rainfall is relatively well-agreed upon.

4. Timely calculation and payment of returns. Since rainfall data becomes available on an almost real-time basis, in principle it is possible to calculate payouts and pay policyholders in a timely fashion. This feature is potentially attractive to households; for example in situations where initial monsoon rains are followed by an extended dry period, necessitating a replanting of crops.

The primary disadvantage of index-based rainfall insurance is basis risk; that is, rainfall is imperfectly correlated with household income and consumption. Basis risk arises from several sources: (i) the relationship between measured rainfall and crop yields varys with soil type, slope of the plot, temperature and other factors (eg. rainfall at night is more likely to soak into the soil rather than evaporating); (ii) Rainfall measured at the local weather station is not perfectly correlated with rainfall at an individual plot; (iii) Crop yields at the plot level are affected by non-weather factors like pests and disease that are not closely correlated with rainfall.

Area-yield insurance also involves basis risk; yields at the plots where crop-cutting measurements are taken will deviate from yields and earned income on other nearby plots, due to idiosyncratic differences in agricultural practices, soil, rainfall, the impact of disease and so on. However, the basis risk is likely to be less than for rainfall insurance, since it is directly an index of crop yields, and thus sidesteps the imperfect correlation between rainfall and average yields.

Our overall reading of these factors is that rainfall insurance has both advantages and disadvantages relative to area-yield insurance. An optimal insurance arrangement would likely depend on both types of indices.

Appendix B: Simple model of insurance participation under symmetric information

In this Appendix we present a simple model of insurance participation under symmetric information with and without credit constraints. Section A.3 summarizes the empirical predictions of this model.

A.1 Basic setup

Consider a risk-averse household with quadratic expected utility $E[U(c)] = E(c) - \gamma.\text{var}(c)$. (This mean-variance form is consistent with a household with CARA utility facing normally distributed shocks.) Household income is assumed to be $y = y^* + e$, where e has zero mean and variance σ^2_y. The household has access to an insurance policy that insures against this income volatility e.

The timing of events is as follows:

1. The household decides whether to purchase insurance.
2. Income is realized (i.e. e is revealed).
3. Insurance payouts (if any) are made. The household consumes its income y plus any insurance payout.

The policy costs premium p. The payout on the insurance is $r = -e + \mu + u$. μ is the household's expectation of the average insurance payout. u reflects basis risk associated with the insurance; u has mean 0 and variance σ^2_u (if $\sigma^2_u = 0$ the insurance perfectly offsets the variability in income due to e). Thus, if the household purchases insurance it consumes $c = y^* + \mu + u - p$, while if it does not purchase insurance it consumes $c = y^* + e$. Under these assumptions the household's willingness-to-pay is given by:

[A.1] $$p_{max} = \mu + \gamma[\sigma^2_y - \sigma^2_u]$$

Thus, the household has a higher willingness to pay if: (i) it is more risk averse (higher γ), (ii) the insurance involves smaller basis risk (lower σ^2_u), (iii) the insured risk is larger (higher σ^2_y) or (iv) the expected payout of the insurance is higher (higher μ).

A.2 Credit Constraints

Now consider a simple extension of this model which introduces credit constraints. Assume that farmers begin with wealth W, which they may use either to purchase insurance or invest in seeds. This investment in seeds then determines household income; mean household income $y^* = f(I)$

where I is investment in seeds, and f(.) is concave. Households are unable to borrow against their future income to purchase seeds or buy insurance (i.e. $W \geq I + p$). Any wealth not used for insurance or seeds is assumed to be stored at an interest rate of zero.

If the household has a high level of wealth, it will simply invest up to the point where $f(I) = 1$. In this case, willingness to pay for insurance is still given by formula [A.1]. Participation is independent of W, reflecting the fact that the household has CARA utility.

In the region where W is low and credit constraints bind, the household decides whether or not to purchase the insurance, and invests all residual wealth in seeds. Thus, if the household purchases insurance, investment is $I = W - p$, and household consumption is $c = f(W\text{-}p) + \mu + u$. If the household does not purchase insurance, investment in seeds is given by $I = W$, and consumption is $c = f(W) + e$. Taking expectations of these two expressions, the household's willingness to pay is given implicitly by:

[A.2] $$f(W) - f(W\text{-}p_{max}) = \mu - \gamma[\sigma^2_y - \sigma^2_u].$$

$f(W) - f(W\text{-}p_{max}) = \int_{W-p}^{W} f'(x)dx$. Since f(.) is concave, f(W) - f(W-p) is decreasing in W, and therefore $dp_{max} / dW > 0$, that is, the willingness-to-pay for insurance is increasing in wealth. Also, since $f'(W) > 1$, p_{max} is lower in the region in credit constraints than in the region where credit constraints do not bind.

A.3 Summary of results

This simple model of insurance participation under symmetric information predicts that willingness-to-pay for insurance will be higher when:

(i) Risk aversion is high (high γ).

(ii) The risk to be insured is large.

(iii) Basis risk is low.

(iv) The household is less credit constrained (i.e. the shadow value of W is lower).

Appendix C: Definition of Variables

Variable name	Values	Description of Variable	Question in Survey
Accumulated rainfall	0,1	Equal to 1 if household decides when to sow based on accumulated rainfall. Equal to zero if decision instead based on other factors: soil moisture, advice from other farmers etc.	How do you/your household determine when to sow? [8 answer choices]
Ambiguity aversion	0,1	Equal to 1 if household is "ambiguity averse", ie. respondent selects Bag 1 in question listed to right.	You have to draw a ball out of a bag without looking. If the ball you choose is the "right" color, then you win Rs. 70. Which of the two bags would you like to choose from? In Bag One there are 2 RED balls and 3 YELLOW balls. You win if you pick a RED ball. In Bag Two there are 5 balls; some are RED and some are YELLOW. You decide what color ball wins. You win if you pick a ball of the color you chose.
Attend rainfall insurance meeting	0,1	Equal to 1 if household attended BASIX insurance marketing meeting.	Have you attended a meeting where the BASIX/ Bhartiya Samruddi/ KBS Local Area Bank rainfall insurance was explained and sold?
BUA member	0,1	Equal to 1 if any household member has been a member of a borewell users association (BUA) for at least one year.	Does anyone in your household belong to any of the following groups? How many years has this household been a member of the group?
Buyer identifier	0,1	Equal to 1 if household bought the rainfall insurance in 2004.	Which years did you/your household buy the rainfall insurance?
Credit constrained	0,1	Household is asked why they do not have one more loan. Equal to 1 if household cites reasons relating to lack of credit availability, high interest rates or bank fees. Equal to 0 if household cites no need for credit or dislike for debt.	What are the main reasons this household does not have one more loan? OR What are the main reasons why this household did not ask for credit during this Kharif [for hh with no loan applications]? Variable = 1 if household answers (i) lack of collateral; (ii) high interest rates / bank fees; (iii) no access to credit institution; (iv) no more credit worthiness or (v) bank will not give additional loan. Variable = 0 if household answers (i) no need for credit, (ii) do not like to be in debt or (iii) other.
Credit from BASIX	0,1	Equal to 1 if household had credit outstanding from BASIX in Mrigashira Kartis (start of 2004 monsoon).	Please list all the loans that have been active at any point since Mrigashira Kartis, whom you borrowed from, how much you borrowed, and when you borrowed.
Farming Income	0 - ∞	Gross revenue of crop production.	What was the total amount harvested for each crop? What price (per kg) did you receive for the crop?
Lived in village whole life	0,1	Equal to 1 if the household head has lived in the village his whole life.	How long has the household lived in this village?
Log of acres owned	0 - ∞	Log (1+Acres owned).	What is the total area of the plot in acres? Do you own this plot?
Log of household head's age	0 - ∞	Log (1+age of household head).	What is the age of the household head?
Log of household head's education level	0 - ∞	Log (1+highest level of schooling completed by the household head).	What is the highest level of schooling completed by the household head?
Log of household size	0 - ∞	Log (1+Household size).	Please list the names of people normally living in this household (this includes both family members and nonfamily members, e.g. residing servants). Start with the household head, the spouse, and their children. Then list the most immediate family subsequently.
Log of Wealth	log(1000) - ∞	Log (1000+ liquid assets in Mrigashira Kartis + market value of livestock + estimated value of primary dwelling +other house plots value).	What was the money value of this saving in Mrigashira Kartis? If you had sold all your livestock then, how much money would you have gotten? What is the present market value of the house and the house plot? What would you be able to get if you sold it today? Do you own any other house plots elsewhere? If so, what are PRESENT MARKET VALUE, Rs. the value of these including any residential construction?
Member of another group for at least 1 year	0,1	Equal to 1 if any household member has been a member of a large village group other than the BUA and Gran Panchayet for at least one year.	Does anyone in your household belong to any of the following groups? How many years has this household been a member of the group?
Member of Gran Panchayet	0,1	Equal to 1 if any household member has been a member of the Gran Panchayet for at least one year.	Does anyone in your household belong to any of the following groups? How many years has this household been a member of the group?

Appendix B: Definition of Variables (cont.)

Nonfarm Income	0 - ∞	Gross revenue from non-agricultural work.	How much nonfarm income was earned by each household member per month? Separated into 9 categories: agricultural labor not on own farm; non-agricultural sector work; in-kind wages; self-employment; sales of non-agricultural goods; caste occupation; migration income; government assistance; and pensions.
Number of BUA members	0 - ∞	The number of members on the BUA that the household head knows well and talks to on a regular basis.	Please list the members of your BUA, (OR GROUP 1), who you know well and talk to on a regular basis.
Number of insured BUA members	0 - ∞	The number of members on the BUA that the household head knows well and talks to on a regular basis, and who also bought rainfall insurance.	Please list the members of your BUA, (OR GROUP 1), who you know well and talk to on a regular basis. Has he/she bought rainfall insurance?
Patience	0...1	Implied monthly discount rate (ie. number of rupees today equivalent to 1 rupee received a month into the future).	Imagine that you bought a lottery ticket and you have just won. The price is Rs. 100. In order to get the full 100 rupees you have to wait 30 days. So if you wait 30 days, you will get the 100 Rs. for sure. However, if you are willing to accept less today, you can get the money now. What is the lowest amount that you are willing to accept today instead of waiting 30 days? [PROMPT IF UNSURE]
Percent of castor planted in 2003	0...1	Total acres of castor planted in 2003 / total area planted in 2003	How many acres were planted under castor in the Kharif of 2003?
Percent of cultivated irrigated land	0...6.5	Total acres of irrigated land / total land owned. The source of irrigation must be either dugwell, tank, or canal. The land must be owned, leased in, or share-cropped in by the household.	What is the total area of the plot in acres? Do you own this plot? In the Kharif that just ended, did you use the plot yourself or rent it out? What allowed you to use this plot in the past Kharif? What is the source of irrigation for this plot, besides rain?
Percent of groundnut planted in 2003	0...1	Total acres of groundnut planted in 2003 / total area planted in 2003	How many acres were planted under groundnut in the Kharif of 2003?
Pessimism	0...1	The degree to which the household head is pessimistic about the start of the monsoon. Equal to 1 if the household head is very pessimistic, and equal to 0 if he is very optimistic.	Now, I would like you to use the 10 beans to indicate, based on your past experience, how likely you think it is that the (SW) monsoon will start in a given Kartis here in your village. You should distribute all 10 beans in the different boxes in such a way that the Kartis where you think the monsoon is most likely to start has the most beans, and Kartises where you think the monsoon is least likely to start have the least number of beans or even no beans.
Presence of other non-weather insurance	0,1	Equal to 1 if household has crop insurance, life insurance, and/or other insurance	Does your household have any of the following kinds of insurance? If so, from where? 9 Choices: Government Crop insurance (2004); Other Crop insurance (2004); Weather or rainfall insurance (2004); Life insurance; Health insurance; Fire insurance; Vehicle insurance; Livestock / poultry insurance; Other--specify
Progressive household	0,1	Equal to 1 if the household head is considered a progressive farmer by others in the village.	Do other farmers consider you a progressive farmer?
Risk aversion	0, 0.2, ..., 0.8, 1	Equal to 1 if household head is risk averse, incrementing down by 0.2 to 0 if household head is risk seeking.	Imagine you are going to flip a coin and you win the amount shown under the GREEN area if it lands on heads or the amount shown under WHITE area if it lands on tails. The amount you win depends on the bet you choose. Which bet would you choose? SHOW PICTURE TO RESPONDENT WITH Rs. Choices: a. 50/50 Rs.; b. 40/100 Rs.; c. 30/130 Rs.; d. 20/160 Rs.; e. 10/190 Rs.; f. 0/200 Rs.
Sex of the household head	0,1	Equal to 1 if the household head is male; equal to 0 if the household head is female.	What is the gender of the household head?
Total Income	0 - ∞	Total income: sum of farming income and nonfarming income.	What was the total amount harvested for each crop? What price (per kg) did you receive for the crop? How much nonfarm income was earned by each household member per month? Broken down by 9 types of income: agricultural labor not on own farm; non-agricultural sector work; in-kind wages; self-employment; sales of non-agricultural goods; caste occupation; migration income; government assistance; and pensions.

Table 1: Sources of risk

Households were asked to list the most important, second most important and third most important sources of risk that they face. Responses were classified into the categories listed below. The 'weighted sum' percentage is the sum across all three categories where 1st, 2nd and 3rd most important reasons are given weights of 1, 2/3 and 1/3 respectively. Questions 5 and 6 from Part O of the survey: Risk Response.

What are the major sources of risk that you face?

	Frequency			weighted
	1st reason	2nd reason	3rd reason	sum
Drought	925	69	9	49.9%
Crop Failure	31	521	200	22.8%
Crop Disease	51	320	149	16.1%
Dramatic drop in crop prices	6	35	142	3.9%
Unsuccessful Investment	4	28	48	2.0%
Loss of livestock/disease	7	27	12	1.5%
Price changes	1	8	38	1.0%
Illness	3	13	9	0.8%
Job Loss	6	10	5	0.7%
Sudden death of household member	7	6	3	0.6%
Other, specify	2	2	6	0.3%
Fires	5	0	0	0.3%
Flood	2	1	0	0.1%
Loss of land	0	2	0	0.1%
Total	**1050**	**1042**	**621**	100%

Figure 1: Structure of Insurance Contract

BASIX rainfall insurance divides the monsoon season into three phases. The graph below shows how rainfall during the phase translates into the insurance payout for the phase. Figures in brackets are actual trigger points and payouts for a representative insurance contract, namely Phase 2 payouts on rainfall insurance linked to castor for the Narayanpet mandal of Mahboobnagar.

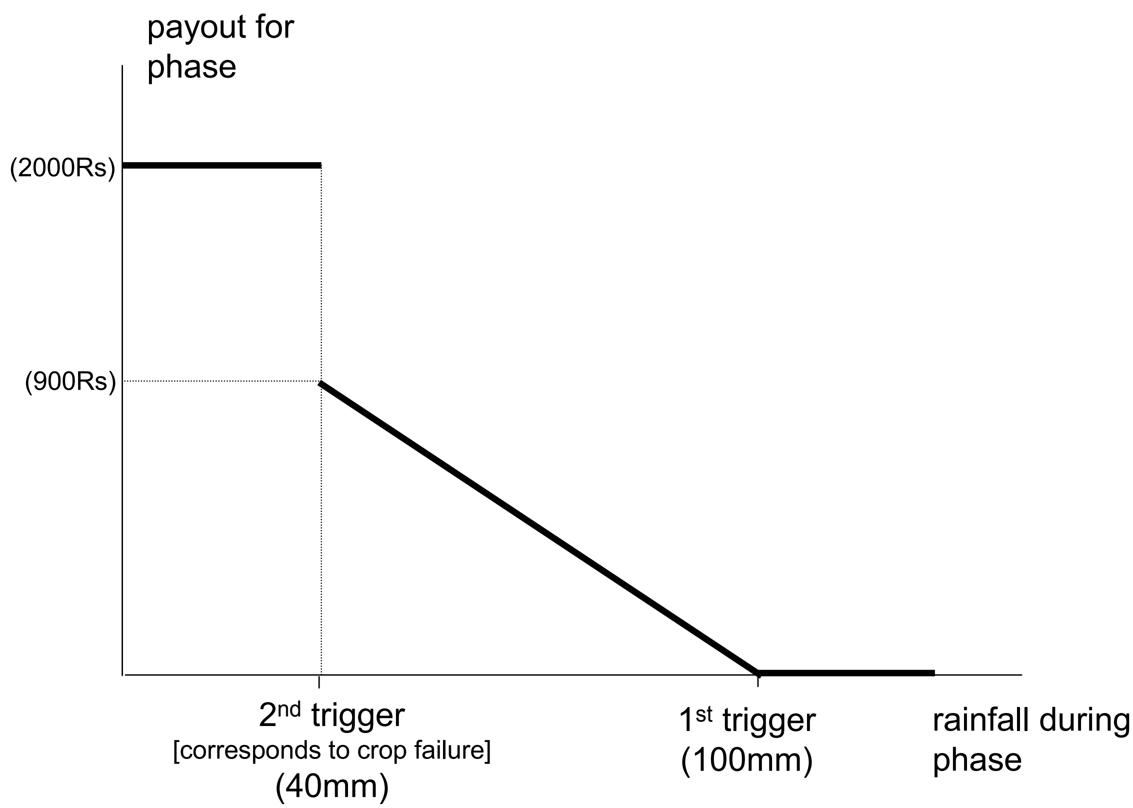

Table 2: Example Terms of Rainfall Insurance Contracts

This table presents data on the terms of 2004 rainfall insurance contracts linked to castor in Mahboobnagar. 1st trigger level refers to the level of rainfall above which the phase payout is zero. Payout per mm deficient rain lists the amount paid for each mm below the 1st trigger level, until the 2nd trigger is reached. Below the 2nd trigger level, the policy pays the maximum lump sum payout listed.

Mandal	Premium per acre Rs	Phase	1st trigger level mm.	Payout per mm deficient rain Rs	2nd trigger level mm.	Maximum lump sum payout Rs	Actual rain mm.	Actual payouts per acre Rs
Atmakur	250	*1*	60	10	25	1500	94.2	-
		2	100	15	5	2000	90.0	150
		3	75	15	30	2500	184.0	-
Mahboobnagar	150	*1*	60	10	20	1500	31.0	290
		2	100	15	50	2000	96.0	60
		3	75	15	50	2500	171.0	-
Narayanpet	200	*1*	60	10	20	1500	12.0	1500
		2	100	15	40	2000	84.0	240
		3	75	15	50	2500	177.0	-

Note: Phase 1: June 10 - July 14, phase 2: July 15 - August 28, phase 3: August 29 - October 12.

Table 3: Insurance Participation, 2003-2004

Table below presents data on insurance purchases for mandals where survey villages are located. Dataset used in this paper includes information on 267 of the 315 buyers in 2004.

	Number of buyers		**Number of which were BASIX clients**		**Number of acres covered**		**Total sum insured (Rs)**		**Number of villages**	
	2003	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**	**2003**	**2004**
Rain gauges of Mahaboobnagar district										
Atmakur	56	32		27		83		498,000	1	4
Mahaboobnagar		75		26		128		768,000		12
Narayanpet	92	125		90		199		1,183,200	1	12
Rain gauge of Anantapur district										
Hindupur		83		50		160		960,000		15
Total	**148**	**315**		**193**		**570**		**3,409,200**	**2**	**43**

Table 4: Sampling Methodology, Marketed Villages

'Unweighted observations' is the number of households appearing in the sample. 'Weighted observations' is the number of households in the underlying population represented by the sample.

	observations	
	Unweighted	Weighted
Sample size	752	5805
Did not attend marketing meeting	252	5205
Attended marketing meeting	500	600
Purchased insurance	267	267
Did not purchase insurance	233	333

Table 5: Summary Statistics

		Mean (and Median, where applicable)			Std. Dev.	Min	Max
		Buyers	Non-buyers	Full Sample			
Utility function							
Risk aversion*		0.733	0.829	0.824	0.190	0.000	1.000
Ambiguity aversion*		0.507	0.553	0.551	0.498	0.000	1.000
Patience		0.830	0.801	0.802	0.135	0.300	1.000
Beliefs about return on insurance							
Pessimism		0.334	0.308	0.309	0.310	0.000	1.000
Basis risk							
Use acc. rainfall to decide to sow*		0.052	0.076	0.075	0.264	0.000	1.000
% cultivated land used for groundut		0.216	0.225	0.224	0.348	0.000	1.000
% cultivated land used for castor		0.263	0.252	0.252	0.314	0.000	1.000
Credit constraints							
Household is constrained*		0.760	0.811	0.808	0.394	0.000	1.000
Leadership / networks							
Member of borewell user association*		0.345	0.022	0.037	0.189	0.000	1.000
Progressive household*		0.513	0.306	0.316	0.465	0.000	1.000
Member Gran Panchayet*		0.041	0.016	0.018	0.132	0.000	1.000
Number other groups hh is member of		1.097	0.836	0.848	0.745	0.000	4.000
Number of BUA members		7.543	5.423	5.521	4.423	0.000	15.000
Number of insured BUA members		2.936	0.245	0.369	1.280	0.000	12.000
Knowledge of insurance and BASIX							
Past credit from BASIX*		0.303	0.030	0.043	0.203	0.000	1.000
Has other insurance*		0.753	0.553	0.562	0.496	0.000	1.000
Know insurance in abstract		0.767	0.302	0.323	0.417	0.000	1.000
Income (during Kharif)							
Farming income		55538	29605	30801	178622	0	5621360
Nonfarming income		3092	3096	3096	3301	0	40000
Wealth (beginning of Kharif)							
Liquid savings (Rs, 000s)	[mean]	22.95	13.50	13.94	18.76	0.00	453.00
	[median]	14.80	8.00	8.00			
Total wealth (Rs, 000s)	[mean]	558.7	346.2	356.0	504.9	21.4	21360.5
	[median]	349.5	228.0	232.3			
Landholdings (acres)	[mean]	8.66	5.66	5.80	4.95	0.30	79.50
	[median]	6.00	4.00	4.00			
% of cultivated land that is irrigated		0.50	0.27	0.28	0.40	0.00	2.20
Other variables							
Education of household head (years)	[mean]	5.30	3.18	3.28	4.43	0.00	18.00
	[median]	5.00	0.00	0.00			
Age of household head	[mean]	43.64	47.06	46.90	11.44	21.00	80.00
	[median]	44.00	46.00	46.00			
Head spent whole life in village*		0.970	0.971	0.971	0.169	0.000	1.000
Gender of household head (1=male)		0.936	0.920	0.921	0.270	0.000	1.000
Household size	[mean]	6.674	6.485	6.494	2.808	1.000	17.000
	[median]	6.000	6.000	6.000			
Unweighted number of observations		267	484	751			
Weighted number of observations		267	5520	5787			

* Denotes a dummy variable where 1=yes.

Table 6: Self-Reported Reasons for Insurance Purchase

Households who attended the marketing meeting were asked to list the most important, second most important and third most important reasons why they did or did not purchase insurance. Responses were classified into the categories listed below. The 'weighted sum' percentage is the sum across all three categories where 1st, 2nd and 3rd most important reasons are given weights of 1, 2/3 and 1/3 respectively.

Why did the household purchase insurance?

	Frequency			weighted
	1st reason	2nd reason	3rd reason	sum
Security/risk reduction	139	53	20	40.1%
Need harvest income	25	62	12	15.6%
Advice from progressive farmers	17	28	12	8.8%
High payout	9	27	11	6.8%
Other trusted farmers purchased insurance	16	11	16	6.3%
Low premium	17	10	6	5.7%
Luck	4	22	21	5.7%
Advice from village officials	9	14	3	4.3%
Product was well explained	5	9	4	2.7%
Lot of castor	7	2	6	2.3%
Lot of groundnut	4	5	2	1.8%
Total	**252**	**243**	**113**	100%

Why did the household not purchase insurance?

	Frequency			weighted
	1st reason	2nd reason	3rd reason	sum
Do not understand the product	45	59	11	24.9%
No cash / credit to pay the premium	58	21	11	21.4%
Rain gauge too far away	38	39	9	19.0%
Too expensive	32	23	7	14.1%
No castor, groundnut	13	6	1	4.9%
Do not trust BASIX	5	8	2	3.1%
Other	6	7	0	3.0%
No need	6	4	1	2.5%
Payouts are too small	3	7	4	2.5%
Dislike insurance	4	7	1	2.5%
Purchased in 2003 but not satisfied	2	1	0	0.8%
Purchased in 2003 but no payout	2	1	0	0.8%
Cloud seeding promised by government	0	1	3	0.5%
Total	**214**	**184**	**50**	100%

Table 7: Baseline Estimates

Dependent variable = 1 if purchased insurance, = 0 if did not purchase. Weighted probit model . Robust z-statistics in parentheses. Coefficients normalized to display marginal effects. Regression also includes village dummy variables (results omitted).

	Marginal effects	Marginal effects scaled by population takeup rate
Utility function		
Risk aversion	-0.011	-0.24
	(1.84)*	(1.84)*
Ambiguity aversion	-0.000	0.00
	(0.07)	(0.07)
Patience	0.009	0.20
	(0.95)	(0.95)
Beliefs about return on insurance		
Pessimism	0.004	0.09
	(1.19)	(1.19)
Basis risk		
Use acc. rainfall to decide to sow	-0.000	0.00
	(0.05)	(0.05)
% cultivated land used for groundut	0.027	0.59
	(3.40)***	(3.40)***
% cultivated land used for castor	0.016	0.35
	(2.84)***	(2.84)***
Wealth and credit constraints		
log(wealth in Rs, start of Kharif)	0.004	0.09
	(1.19)	(1.19)
log(landholdings, start of Kharif)	0.002	0.04
	(0.70)	(0.70)
F-test: wealth and land [p-value]	0.02**	0.02**
% of cultivated land that is irrigated	0.003	0.07
	(1.12)	(1.12)
Household is constrained (1=yes)	-0.014	-0.30
	(3.29)***	(3.29)***
Familiarity with insurance and BASIX		
BUA member (1=yes)	0.368	8.00
	(4.70)***	(4.70)***
Credit from BASIX (1=yes)	0.066	1.43
	(4.83)***	(4.83)***
Has other insurance (1=yes)	0.003	0.07
	(1.35)	(1.35)
Technology diffusion / networks		
Progressive household	0.007	0.15
	(2.12)**	(2.12)**
Member Gran Panchayat	0.081	1.76
	(2.87)***	(2.87)***
No. other groups hh is member of	0.007	0.15
	(3.51)***	(3.51)***
No. of well known households	0.000	0.00
	(0.36)	(0.36)
No. well known hhs who bought insurance	0.006	0.13
	(5.06)***	(5.06)***
Other covariates		
Education of household head (years)	0.001	0.02
	(1.09)	(1.09)
log(age of household head)	-0.015	-0.33
	(2.59)***	(2.59)***
Head spent whole life in village (1=yes)	-0.030	-0.65
	(1.79)*	(1.79)*
Gender of household head (1=male)	-0.008	-0.17
	(1.37)	(1.37)
log(household size)	0.002	0.04
	(0.41)	(0.41)
Village dummies	yes	yes
Number of observations	752	752
Pseudo R^2	0.44	0.44

Robust z-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at

Table 8: Risk Aversion Interation Effects

Dependent variable = 1 if purchased insurance, = 0 otherwise. Weighted probit model. Robust z-statistics in parentheses. Coefficients normalized to display marginal effects. Regression includes same variables as baseline regression results (other results omitted; similar to previous table).

	Baseline specification + interaction terms			
	combined	interaction terms added individually		
Interaction terms				
Risk aversion * BUA	0.005	0.024		
	(0.25)	(1.23)		
Risk aversion * credit from BASIX	0.028		0.032	
	(1.74)*		(2.14)**	
Risk aversion * other insurance	0.008			0.014
	(0.72)			(1.18)
F-test [joint significance, p-value]	0.043**			
Underlying variables				
Risk aversion	-0.024	-0.016	-0.018	-0.021
	(2.42)**	(2.81)***	(3.22)***	(2.17)**
BUA	0.262	0.078	0.344	0.082
	(1.82)*	(2.84)***	(4.43)***	(4.72)***
Credit from BASIX	-0.001	0.064	-0.003	0.066
	(0.08)	(4.73)***	(0.32)	(4.92)***
Other insurance	-0.003	0.004	0.003	-0.008
	(0.32)	(1.43)	(1.38)	(0.79)

Table 9: Meeting Participation and Purchase Conditional on Participation

Dependent variable = 1 if purchased insurance, = 0 if did not purchase. Weighted probit model . Robust z-statistics in parentheses. Coefficients normalized to display marginal effects. Regression also includes village dummy variables (results omitted).

	attended meeting	bought conditional on attendance
Utility function		
Risk aversion	-0.049	-0.163
	(1.39)	(1.36)
Ambiguity aversion	-0.003	-0.054
	(0.26)	(0.96)
Patience	-0.009	0.075
	(0.18)	(0.34)
Beliefs about return on insurance		
Pessimism	0.008	0.444
	(1.19)	(2.23)**
Basis risk		
Use acc. rainfall to decide to sow	0.056	-0.112
	(1.71)*	(0.98)
% cultivated land used for groundut	0.092	0.294
	(2.48)**	(1.82)*
% cultivated land used for castor	0.040	0.250
	(1.31)	(1.90)*
Wealth and credit constraints		
log(wealth in Rs, start of Kharif)	0.029	-0.080
	(1.72)*	(1.03)
log(landholdings, start of Kharif)	-0.006	0.124
	(0.31)	(1.45)
% of cultivated land that is irrigated	0.048	-0.091
	(2.83)***	(1.15)
Household is constrained (1=yes)	-0.026	-0.030
	(1.55)	(0.41)
Familiarity with insurance and BASIX		
BUA member (1=yes)	0.313	0.383
	(2.96)***	(2.43)**
Credit from BASIX (1=yes)	0.177	0.157
	(3.62)***	(2.03)**
Has other insurance (1=yes)	0.012	-0.011
	(0.91)	(0.18)
Technology diffusion / networks		
Progressive household	0.034	0.072
	(2.05)**	(1.16)
Member Gran Panchayat	0.165	0.143
	(2.22)**	(2.43)**
No. other groups hh is member of	0.020	0.117
	(1.59)	(2.39)**
No. of well known households	0.001	-0.007
	(0.61)	(0.69)
No. well known hhs who bought insurance	0.012	0.145
	(2.04)**	(5.69)***
Other covariates		
Education of household head (years)	0.005	0.057
	(0.76)	(1.77)*
log(age of household head)	-0.005	-0.433
	(0.16)	(3.09)***
Head spent whole life in village (1=yes)	0.005	-0.258
	(0.12)	(1.61)
Gender of household head (1=male)	0.031	-0.242
	(1.57)	(1.84)*
log(household size)	-0.005	0.208
	(0.27)	(2.21)**
Village dummies	yes	yes
Number of observations	752	500
Pseudo R^2	0.26	0.35

Robust z-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant

Table 10: Economic Magnitude of Insurance Expenditures

The table below calculates average expenditures on rainfall insurance, and the maximum payout on insurance purchased, as a fraction of average household liquid assets and gross farm revenues for the 2006 Kharif. Expenditures and payouts are based on the average of 1.81 policies per purchasing household.

Average number of policies per purchasing household: 1.81

			as fraction of....	
	per policy	per policyholder (based on 1.81 policies per household)	liquid assets, start of Kharif	gross farm revenue
Insurance expenditure	200	362	1.5%	0.7%
Maximum payout	6000	10860	84.1%	35.4%