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Why Farmers Sometimes Love Risks

Evidence from India

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Why Farmers Sometimes Love Risks: Evidence from India*

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Abstract

Using a unique dataset collected among farmers in India's semi-arid tropics, we document the surprising prevalence of risk-taking behavior in the face of high-stakes gambles. The evidence suggests that this apparently anomalous behavior is due to a combination of credit constraints and non-convexities in production. In particular, the high-stakes nature of the gambles creates the potential for a farmer to undertake a productive investment that would normally be unaffordable and thereby move to a permanently higher level of income. The degree to which farmers are willing to accept risk in return for this opportunity appears to relate in an intuitive way to their current agricultural production technology as well as the demographic composition of their household.

1 Introduction

In developing countries, where the majority of the population depends on agriculture, incomes often display a considerable amount of variation due to fluctuations in rainfall, disease and pest pressure. As few insurance possibilities exist,¹ attitudes towards risk are crucial determinants of economic decisions and in particular investment behavior.²

The extensive literature that tries to measure risk attitudes has sometimes inferred them from economic decisions (see for example, Moscardi and De Janvry 1977 and Antle 1987). Other studies have attempted to directly elicit preferences over risky distributions (see for example Binswanger 1980, Dillon and Scandizzo 1978, Liu 2008, Just and Lybbert 2009, Yesuf and Bluffstone 2009). Following in the line of this second strand of the literature, we conducted experiments to measure the attitudes towards risk among cotton farmers in three villages in India. These attitudes were elicited via farmers' evaluations of hypothetical (but realistic) production alternatives involving various risky outcomes. Each alternative was presented as a probability distribution over cotton yield outcomes. The farmers then indicated their willingness to pay for a bag of cotton seeds which would result in such a distribution.

The results point to the surprising prevalence of risk-seeking in the households in our sample. As many as 85% of the sampled farmers expressed a willingness to pay more for riskier distributions. The willingness to accept risk in return for the potential to achieve high payoffs bears a strong negative relation to household wealth. Qualitative as well as statistical evidence suggests that these apparently anomalous results can be

¹While several studies have confirmed the existence of informal insurance networks in village economies (see for instance Townsend, (1994) for a study in the context of this article), full insurance has not been confirmed as of yet for households facing large non-idiosyncratic risk (where risk co-moves within the insurance network). See also Mahul and Wright (2003) for a discussion on the welfare implications of crop insurance.

²The literature on risk in agriculture and risk in the contexts of developing countries is vast, and any attempt to summarize it would necessarily be incomplete. For an overview, see (among others) Moschini and Hennessy (2001)

rationalized by credit constraints in combination with non-convexities in production associated with large fixed-cost investments. Irrigation and higher education in children appear to be two prominent examples of such investments.

Our findings on risk attitudes are markedly different from the existing literature, which has by and large found moderate to large degrees of risk aversion. For example, Binswanger (1980) measures attitudes towards risk among the same households studied in this article using two methods: an experimental approach with real and hypothetical payoffs of various magnitudes and an interview method. The results of the experimental method indicate that at medium-sized payoff levels (equivalent to the monthly salary of an unskilled laborer), virtually all individuals are moderately risk averse with little variation according to personal characteristics. He finds no statistical difference in the risk aversion estimates based on real gambles versus hypothetical gambles, but a larger coefficient of partial risk aversion when comparing high-stakes gambles to low-stakes gambles. More recently, Liu (2008), using a low-stakes, real payoff, experimental method, finds evidence of both risk and loss aversion among Chinese cotton farmers, in addition to overweighting of low probabilities. Yesuf and Bluffstone (2009) conduct medium-stakes experiments in Ethiopia with real payoffs set in an agricultural context. They find that depending on the expected payoff and range, one-third to two-thirds of households are severely risk averse.

We believe the distinctiveness of our results is due to the high-stakes involved: for the average farmer in our sample, achieving the best outcome in the hypothetical distribution would generate over 16,000 rupees in revenue on a per acre basis, a very sizeable amount that is comparable to the farmer's annual income.³ At such levels, it appears likely that the tendency to avert risk is over-ridden by the possibility of moving to a new, permanently higher level of income by undertaking a large investment that would normally be unaffordable.

The idea that non-convexities can induce risk-taking, while intuitive, has so far largely remained a theoretical possibility (see for example Lybbert and Barrett forthcoming and Lybbert et al. 2010). We believe ours to be the first experimental confirmation of the empirical relevance of this idea. More generally, this article answers the call of Just and Pope (2003) who argue that many alternative explanations can be offered for observed behavior under risk, only one of which is curvature of the utility function. The observed risk response might also be due to technology, physical constraints, or financial asymmetries. In order to properly infer or measure risk aversion from observed choices, one needs to carefully isolate the impacts of

³Dillon and Scandizzo (1978) is the only other paper that we are aware of that has found any evidence of risk-loving behavior among farmers. They report that a small, but significant fraction of farmers in their study (set in Brazil) could be classified as risk-loving on the basis of their measure. Although the difference in context, time period and methodology makes comparisons with our study difficult, it is interesting that their experiment also presented farmers with high-stakes gambles.

all these factors.

The paper proceeds as follows: Section 2 describes the study site and the experiment; Section 3 analyzes the results of the risk experiment; Section 4 presents an illustrative model and Section 5 concludes.

2 Description of the study site and experiment

2.1 Study site

Table 1 introduces the three villages selected for this study. These villages have been followed for over 35 years by the Village Level Studies (VLS) program of the International Crop Research Institute of the Semi-Arid Tropics (ICRISAT).⁴ The experimental data were collected by the first author in 2007-2008 among 205 of the 246 ICRISAT-VLS respondents in Aurepalle, Kanzara and Kinkhed.⁵

Aurepalle, with 925 households, is the largest of the three villages. It is located in the drought-prone, poor, Telangana region of Andhra Pradesh, and in terms of average income is situated between the richer Kanzara and poorer Kinkhed. Kanzara and Kinkhed, with 319 and 189 households, respectively, are located in the less drought-prone Akola district of West Maharashtra. The VLS sample includes 128, 63 and 55 households in Aurepalle, Kanzara and Kinkhed, respectively. In both Akola villages, households own, on average, 5 to 6 acres of land. In Aurepalle, this is significantly less, about 3.2 acres. The average size of a household is 4 to 5 members in all three villages.

The average education level of the respondent (i.e., the main decision-maker with regard to agriculture) is low, especially in Aurepalle (2.3 years). It is important to note that in these villages, enrollment in school is very high (93% of the children between 6 and 15 years are in school), but the rate drops sharply at the higher education level (21% of the young adults between 19 and 21 years are enrolled in an education institute). This might be partially due to credit constraints. Higher education can be expensive in India, ranging from a thousand to a hundred thousand Rs for a degree, yet very few of the farmers in Aurepalle and Kinkhed report having access to bank credit. In Kanzara 18% have access to bank credit.⁶

In all three villages, agriculture is one of the main sources of income and cotton is the main cash crop. Over 80% of the households in Kanzara and Kinkhed farm cotton. In Aurepalle, due to the relatively large

⁴For an overview of the goals, methods and outcomes of the VLS see: Singh et al. (1985), Walker and Ryan (1990), Bantilan et al. (2006) and Rao and Charyulu (2007).

⁵We conducted the experiment among the ICRISAT-VLS respondents who have farmed in the recent past or were thinking of farming in the future. More information on this set of respondents can be found in Appendix A.

⁶While credit is available from other sources, such as input dealers, moneylenders and informal networks (see Besley (1995) for an introduction), the respondents reported that in terms of large amounts of credit for productive purposes only the banks (and in some case the company selling the equipment) are an option.

number of landless families, this number is lower, 60%.⁷ The average cotton yield varies strongly from year to year. In 2007-08, it is around 9 Q/acre in Aurepalle, 3.5 Q/acre in Kanzara and 2 Q/acre in Kinkhed.⁸

Losses in cotton production in this region are due (among others) to its predominant cultivation under rainfed conditions: both droughts and, more recently, floods are an issue. The average cotton yield in Kanzara and Kinkhed during the last few years was lower in comparison to the period 2001-04, a result the farmers attribute to excess rainfall and flooding. In 2007-08, 42%, 30% and 27% of the respondents in Aurepalle, Kanzara and Kinkhed, respectively, reported having access to irrigation at some point during the year. Irrigation not only reduces rainfall related risks during the rainy season but also allows for cultivation during the dry season.⁹ Both surface water (rivers, canals, ponds and basins) and groundwater (wells) are used as irrigation sources. The water is applied on the field through flood irrigation, drip irrigation or sprinkler irrigation. We have no information on the installation of drainage systems, but have data on whether the farmer perceives waterlogging to be a (general) problem on his plots: fewer than 1% of the plots are considered to have problems. The cost of a well, irrigation or drainage system is substantial, amounting to several times the average annual income. In addition, the investment entails risk as not all wells successfully reach the groundwater table.

2.2 Description of the experiment

The farmers' risk attitudes were assessed by presenting them with a set of hypothetical yield distributions. While we recognize that the context of the experiment ("framing") is important in terms of interpreting the results (see Harrison and List 2004) we did not opt for a context-free set-up, the main reason being that it was exactly this context which made it easy for farmers to imagine this high-stakes decision making process. The experiments were conducted among all ICRISAT-VLS respondents who had farmed in the past seven years or who were thinking of farming in the future. Henceforth, we refer to this set of respondents as the "farmers". Details on the experimental set-up are included in Appendix A.

The risk experiment, based on Lybbert and Just (2007) and Just and Lybbert (2009), consisted of four hypothetical farming seasons.¹⁰ For each "season" the farmer was asked through a verbal exercise based on

⁷Data of the last seven years.

⁸1 Quintal (Q) = 100 kg.

⁹Considering the benefits of irrigation in the rainy season, the average profit for an irrigated cotton plot is 6,030 Rs/acre (st. dev. 8,298 Rs/acre) versus 4,051 Rs/acre (st. dev. 5,348 Rs/acre) for an unirrigated plot.

¹⁰The effect of using hypothetical payments versus real payments has not yet been settled in the literature. The validity depends on the nature of the experiment and elicitation method. In this case, "the subjects have no special reason to disguise their true preferences" (Kahneman and Tversky, 1979, p. 265) as their decision has no financial consequences. Hence, it is often considered preferable to use high hypothetical payments over the low real payments that would have been feasible within the project's budget. Binswanger (1980), who conducted monetary experiments among the same households as we

a Becker-DeGroot-Marschak (1964) mechanism his willingness to pay (WTP) for a bag of cotton seed with a particular yield distribution (sufficient to sow one acre of cotton). To deal with illiteracy and innumeracy, we used a visual method based on Lybbert et al. (2007): Fisher Price building blocks were vertically stacked, to present the various cotton yield distributions (in quintal (Q) per acre). We use a total of 20 blocks, each block representing 5%, and three different colors. Green represents the high yield, i.e., 8 Q/acre. Yellow represents the average yield, i.e., 6 Q/acre and red represents the low yield, i.e., 4 Q/acre. We started with two trial distributions to help the farmers learn the game and then did four experiments, in the order reflected in table 2.¹¹

We aimed to design the experiment such that the average yields one could obtain were comparable to what farmers are actually obtaining in the field. However, as the average yield on the field appeared to vary a lot from year to year, this was not an easy task. We tried out various specifications during the trial round, first basing ourselves on the average yield obtained in the period 2001-2007 (which is about 4 Q/acre, so the yields offered were 2 Q/acre, 4 Q/acre and 6 Q/acre), but according to the farmers' own account this was much too low for them to even consider buying these seeds. They explained to us that with the new genetically modified seeds on the market, the average yields were on the increase. Hence, we decided to redesign the experiment and base ourselves on their current reference point, i.e., the average yield in 2007-08 was 5.5 Q/acres. Comparing these outcomes with the average yield levels in three villages, one can see that for the Aurepalle farmers, this distribution is at the lower end of what they are currently achieving, while for the Akola farmers it is at the higher end, especially for Kinkhed (mainly due to the excess rainfall in the last few years in Akola). We take into account these potential differences in reference points in the analysis.

The first baseline distribution has an expected yield of 6 Q/acre and a variance of 2 Q/acre. The second distribution has the same expected yield, but a higher variance than the first distribution, namely 2.4 Q/acre. Thus the first distribution second-order stochastically dominates the second distribution (SOSD). The third distribution has a higher expected yield than the first one, but also a considerably higher variance, 6.2 Q/acre

did, confirms that hypothetical and real gambles eliciting risk preferences produce comparable results for low and medium stakes gambles. However, Holt and Laury (2002), who conducted experiments with students at three US universities, find that respondents behave more risk loving when using hypothetical high stakes (over 100 US dollar) experiments versus real high-stakes experiment. They conclude that "respondents cannot imagine how they would actually behave under high-incentive conditions". Both these experiments tried to provide a context-free environment, implying that the difference cannot be due to framing (Harrison and List, 2004). See also Kuhnberger et al. (2002) and Laury and Holt (2008) for a general discussion. As the experiment we conducted was framed as a seed buying experience, we suggest that our respondents had less trouble imagining how they would react.

¹¹We did not randomize the order of the distributions. However, as the WTP does not appear to increase systematically as the experiment progresses (detailed individual results are available on request), we believe that order effects do not play an important role.

and 2.76 Q/acre, respectively. The fourth distribution first-order stochastically dominates (FOSD) the first distribution with an expected yield of 6.5 Q/acre and a variance of 1.55 Q/acre, and FOSD a distribution that SOSD the third distribution. Note also that both the fourth and the third distribution FOSD the second distribution.

3 Analyzing preferences

3.1 Risk loving behavior

We refer to the lotteries in Table 2 as L_1, L_2, L_3 and L_4 . We begin with a number of checks of internal consistency of preferences that follow from First-Order Stochastic Dominance and transitivity (summarized in Table 3): (1) Anyone who prefers L_3 to L_4 must also prefer L_3 to L_1 : this turns out to be true 94% of the time. (2) Further, anyone who prefers L_3 to L_4 , and also prefers L_1 to L_2 must then also prefer L_3 to L_2 : this turns out to be true 100% of the time. (3) Anyone who prefers L_4 to L_3 must also prefer L_4 to L_2 : this happens 100% of the time. (4) Anyone who prefers L_1 to L_2 must also prefer L_4 to L_2 : this happens 94% of the time, (5) Anyone who prefers L_2 to L_1 must also prefer L_3 to L_1 : this is true 99% of the time. So preferences look by and large internally consistent.

We now test the implications of risk-aversion. A risk averse farmer obeying standard expected-utility theory (EUT) should be willing to pay less for the L_2 than for L_1 , and less for the L_3 than for L_4 . Table 3 shows the percentage of sampled individuals whose stated preferences are in line with these predictions. Remarkably, only 16% of the respondents appear to be risk averse when choosing between lotteries L_1 and L_2 . In the intermediate comparison involving L_3 and L_4 , nearly 40% of respondents violate the predictions of risk aversion. Also remarkable is that nearly 95% of respondents prefer L_3 to L_1 .

To gain a better understanding of what drives WTP, we regress WTP on the probabilities of the distributions, input costs and output prices¹², education level, and wealth. The intuition behind this is the following:

¹²To obtain the individual-level output prices and input costs, we regress the output price and input costs of 2007-08 on numbers of children, numbers of adult household members, acreage of dryland, acreage of irrigated land, soil fertility (how many plots the farmer has of self-reported good and very good quality), education of the decision maker and a village dummy variable. The input cost excluded the cost of seed but included the value of family labor and self-produced inputs. Using the predicted values instead of the actual values has the advantage of providing a value for all farmers, not only the ones who farmed cotton in 2007-08, and of avoiding the bias caused by unobservables correlated with both price and the other explanatory variables in the main regression (see Appendix C). The average output price is 2,086 Rs/Q (st. dev. 253 Rs/Q). There is little variation among farmers, but some variation between states (Andhra Pradesh versus Maharashtra). The average cost of inputs, other than seeds (not including the costs of the quasi-fixed investments such as land and irrigation) is 5,781 Rs/acre (st. dev. 2,942 Rs/acre). Because the first-stage data is available for only a small portion of the sample, clustered bootstrapping causes selection issues

If the farmer obeys EU and displays risk aversion, then the magnitude of the effect of increasing the probability of the best outcome (while reducing the probability of the middle outcome) should be smaller compared to the effect of increasing the probability of the worst outcome (while reducing the probability of the middle outcome). Expressed mathematically, define x_i as the outcome and p_i as the probability of achieving outcome i . If $u'(\cdot) > 0$, $u''(\cdot) < 0$, $0 < x_2 - x_1 = x_3 - x_2$ (note that in our case $x_1 = oQ_1 - c$, $x_2 = oQ_2 - c$, $x_3 = oQ_3 - c$ with $Q_1 = 4$, $Q_2 = 6$, $Q_3 = 8$ and o = output price and c = input cost), then:

$$\frac{\partial WTP}{\partial p_1} = \frac{u_1 - u_2}{u'_1.p_1 + u'_2.p_2 + u'_3.p_3} \quad (1)$$

$$\frac{\partial WTP}{\partial p_3} = \frac{u_3 - u_2}{u'_1.p_1 + u'_2.p_2 + u'_3.p_3} \quad (2)$$

$$|u_3 - u_2| < |u_1 - u_2| \Rightarrow \left| \frac{\partial WTP}{\partial p_3} \right| < \left| \frac{\partial WTP}{\partial p_1} \right| \quad (3)$$

with WTP is defined as (4):

$$u(w + outside) = \sum p_i.u(w - WTP + x_i) \quad (4)$$

where w = initial wealth and $outside$ = outside option (i.e., sowing non-cotton crops).

Table 4 presents the results of this analysis. We approximate the WTP function with a linear model.¹³ Model 1 includes input costs, output prices, education level, village-level fixed effects and wealth. Model 2 additionally includes the 2007-08 cotton yield as a regressor, as this may influence the results by setting a reference point in the farmer's mind. Note that the number of observations used to estimate the model is substantially fewer than model 1 as it includes only the respondents who farmed cotton in 2007-08, as opposed to all farmers. Model 3 includes farmer-level fixed effects.¹⁴

The results in Table 4 indicate that WTP is largely driven by the probability of the best outcome. Increasing the probability of the best outcome by 10% increases WTP by, on average, 152 to 157 Rs, while increasing the probability of the worst outcome with the same magnitude decreases WTP by, on average, 32 to 37 Rs. Comparing these with the average and variance of the WTP, respectively, 838 Rs and 493 Rs, in the second stage. Despite this, the results using the predicted price beliefs from the survey are similar to estimates obtained by calculating standard errors from full two-stage estimation. In the tables, we opt to report the results using the predicted price beliefs from the survey directly.

¹³Note also that even when one uses a simple expected utility model to explain the variation in the WTP, the WTP will depend in a non-linear manner on the characteristics of the distribution of the outside option and the distribution of the gamble presented to the respondent, the output price and input cost, and the respondent's preferences with regard to risk.

¹⁴Recall that each respondent plays the game four times.

these numbers are clearly not insignificant. As such, it is clear that standard static EUT will not explain the variation in the data unless farmers are risk loving.

Overall, the three models give very similar results. The yield of the last season (2007-08) has a negative but statistically insignificant effect on WTP in model 2. However, as the regressions include a village-level fixed effect, one cannot conclude from this result that the reference point has no impact on WTP, as the village-level fixed effects might be absorbing the majority of this effect.

Increasing the output price of cotton has, as expected, a positive effect on WTP while increasing the input costs has a negative effect, but neither is significantly different from zero at the 10% level. We included two separate wealth controls as asset market imperfections might constrain substitution across types of wealth, but neither are statistically significant from zero at the 10% level.

The Aurepalle and Kinkhed fixed effects are substantial in magnitude. These fixed effects represent between village-level variation in climatic conditions, characteristics of the agricultural system (such as intercropping), the outside options available to the farmer if the "bet" is rejected, or reference point effects. As the climate and agricultural conditions in Kanzara are similar to the ones in Kinkhed, the positive sign on the Kinkhed dummy variable could imply that the outside options for farmers in Kinkhed are less favorable compared to the Kanzara farmers. Education, which could potentially influence WTP through changing the outside option of the farmer, does not appear to have any relation to WTP.

3.2 Correlates of risk-loving behavior

The violations of risk-aversion in the data are striking in terms of what they indicate about the prevalence of risk-taking behavior. Interviews with the farmers indicated that they were disproportionately attracted to the possibility of achieving the high payoff associated with 8 Q/acre. Some of the farmers explicitly justified their choices by explaining that if the high outcome were achieved they would be able to invest in large projects such as irrigation for their farm or higher education for their children.

With this in mind, we now examine some of the correlates of risk-taking behavior. We begin with some simple summary statistics. We group the respondents into four groups in Table 5: Group I consists of respondents who are risk-averse in that they prefer L_1 to L_2 and also prefer L_4 to L_3 ; Group II respondents are moderately risk-seeking in that prefer L_2 over L_1 but prefer L_4 to L_3 ; Group III respondents are extremely risk-seeking in that they prefer L_2 over L_1 and also prefer L_3 to L_4 ; Group IV is an unusual group in that these respondents prefer L_1 to L_2 but then prefer L_3 to L_4 .

Table 5 shows that both wealth and income are negatively correlated with risk-seeking behavior when we compare groups I, II and III. Interestingly, Group IV respondents appear to be wealthier and have

higher incomes than the other groups, which makes us think their stated preferences may not necessarily be "mistakes" (although we have not found a satisfactory explanation for these preferences). Turning back to Groups I-III, we find that risk-seeking is also associated with more dry land as well as more children who are currently in school (although neither of these two associations appears statistically significant when we test the differences in means across groups), which appears to fit with the qualitative evidence. As we would expect, Group III respondents have a significantly higher valuation for L_2 relative to L_1 (i.e. $WTP_2 - WTP_1$) than Group II respondents.

Consider the difference in WTP between distribution 2 and distribution 1, and the difference in WTP between distribution 3 and distribution 4, as a measure of willingness to take risks.¹⁵ Thus, a positive difference indicates a risk loving attitude, while a negative difference indicates risk aversion. Figure 1 presents the distribution of these two variables. The mean of the first distribution ($WTP_2 - WTP_1$) is 85 Rs and the standard deviation is 128 Rs. The mean of the second distribution ($WTP_3 - WTP_4$) is -4 Rs and the standard deviation is 166 Rs.

In figure 2A we plot the predicted values of ($WTP_2 - WTP_1$) and ($WTP_3 - WTP_4$) from a regression of these variables on the total value of assets (see table C2 in the appendix for the regression results), where we have assumed a quadratic specification. We see that the predicted willingness to assume risk in order to achieve high outcomes has a U-shaped relationship with wealth. Note however in figure 2B and the results in table C2 that the increasing leg of the U shape appears not to be strongly present in the raw data, and only the decreasing relationship remains. The results are qualitatively similar when using the yield of 2007-08 as a reference point, or income (results available on request). This shape is inconsistent with prospect theory, which would predict a positive relationship as wealthier farmers are more prone to loss aversion as their reference point lies to the right of a less wealthy farmer (Kahneman and Tversky 1979, Starmer 2001).

In Tables 6 and 7 we investigate the relationship between asset composition and the willingness to take on risks. Table 6 presents the regression results using the difference in WTP between the first two distributions as a measure of willingness to take on risk. The first column presents the results of a simple probit regression in which the dependent variable is 0 or 1 depending on whether the individual prefers L_2 to L_1 . The second column presents the results of a linear regression model in which the dependent variable is the actual difference in WTP across the two distributions, and the third column adds quadratic terms to this model. The fourth column uses the ratio, i.e., $(WTP_2 - WTP_1)/WTP_1$ as a dependent variable, i.e. we take into account the variation in WTP_1 .

The results are qualitatively similar across the various specifications. Having an additional child under the age of 15 years (an additional adult in the household) statistically significantly decreases (increases) the

¹⁵Using the language of Just and Lybbert (2009), this is a measure of marginal risk aversion.

difference in WTP in most specifications. The linear regression estimates these effects at, on average, -15 Rs for the child and 21 Rs for the adult. Comparing the estimated coefficient on "young adults out of school" and "young adults in school" it appears that the latter is larger in all specifications. The difference in these coefficients is statistically significantly different from zero in the quadratic specification and in the probit. This implies that having a school-going young adult (i.e. over the age of 15 years) in the household increases the difference in WTP, over the usual increase of having a non school-going young adult of that age in the household. This average marginal effect is estimated at, on average, 56 Rs in the quadratic specification. Thus, while adults and children affect the willingness to take on risks through traditional wealth effects, having a school-going young adult over the age of 15 years increases the willingness to take on risks even further. Comparing the coefficients on "dryland" and "irrigated land" it appears that the former is larger in all specifications. The difference in these effects is statistically significantly different from zero in the ratio specification and in the probit specification, and is estimated in the range of, on average, 2% to 6% in the linear and the quadratic specification.

Table 7 presents the regression results using the difference in WTP between the third and the fourth distribution as a measure of willingness to take on risk. Having a school-going young adult in the household statistically significantly increases the difference in WTP, over the usual increase of having a non-school going young adult, with, on average, 20 Rs in the linear specification. This difference is only statistically significantly different from zero in the quadratic specification. Increasing the dryland owned by one acre statistically significantly increases the difference in WTP in the probit specification and in the linear specification (by, on average, about 4 Rs in the latter), but the difference between the coefficient on "dryland" and "irrigated land" is not statistically significantly different from zero in any of the specifications.

Increasing the output price decreases the difference in WTP. Note that an increase in output price increases the variance of each distribution. There is little variation in the output price of cotton within villages, but as the larger farmers tend to fetch a somewhat higher price (as they have better storage, and often do not need cash urgently), this relatively large effect might partially capture some residual (unobserved) wealth effects. Increasing the education level of the main decision maker increases the difference in WTP. Note that, again, the village fixed effects are substantial. In Table 6, the difference between what one pays for the higher variance gamble and the lower variance gamble is, on average, about 180-185 Rs more for Kinkhed farmers compared to Kanzara farmers; and, on average, about 268-283 less in Aurepalle. This is inconsistent with an explanation of loss aversion as for many of the Kinkhed farmers, as opposed to the Aurepalle farmers, the distributions presented exceed the typical yields they would expect. Finally, it is worth noting that the wealth variable is generally significant in all regressions, with higher wealth being associated with lower preference for risk-taking. This suggests that higher education and irrigation may not

be the only potential investments that farmers have in mind.

Overall, these results are consistent with the notion that asset dynamics are driving at least some of the risk behavior within our hypothetical experiment. Individuals could potentially increase their overall profitability through increased education of their children, or by irrigating their land. Irrigated land, on the other hand, will not be easily improved by added investment.

4 A simple model of risk loving behavior

We outline here a simple illustrative model to capture the idea that non-convexities can induce risk-taking. Imagine a credit-constrained farmer who lives for two periods and is risk neutral, i.e. his Bernoulli utility function is a linear function of wealth, and that he can choose each period between a risky technology and a safe technology.¹⁶ In Appendix B we show that the essential logic extends to the case where the farmer is strictly risk-averse.

If we assume that the two technologies give the same expected profit, the farmer will be indifferent between the two in both periods. However, the farmer can also invest in an asset that increases profits in the second period (this could represent an irrigation project, for example). The farmer may then opt for the risky technology in the first period if the safe technology does not generate enough profit to cover the fixed cost needed for the irrigation project.

It is clear that the potential returns to this investment will depend on the asset position of the farmer. For instance, a farmer who owns more dryland will - under certain conditions - benefit more from installing an irrigation system compared to a farmer who owns less dryland. Similarly, a farmer who has school-going children of an age where they might benefit from an investment in higher education, might benefit more compared to a farmer who does not have school-going children of that age group.

We purposely abstract from several aspects of the agricultural decision-making process, such as pesticide, fertilizer and other variable-input decisions. In addition, we assume the farmer is credit-constrained (he has no access to credit), has a fixed amount of land $\bar{L} > 0$, and during the first period has no savings or irrigation system. For simplicity, we will assume that no storage is possible, so that the only way to transfer consumption from the first period to the second is to invest in the asset. It is important to note that while we discuss the decision to invest in a new irrigation system, a similar model could apply to any type of large fixed-cost investment that allows the farmer to move to a superior production function.

Assume that in each time period $t \in \{1, 2\}$, the farmer can choose between two technologies: a ‘safe’ technology which always yields $f(\bar{L}, R)$ where R indicates whether or not the land is irrigated ($R \in \{0, 1\}$),

¹⁶This model is inspired by the work of Lybbert and Barrett (forthcoming) and Lybbert et al. (2010).

and a ‘risky’ technology which yields $f(\bar{L}, R) + \epsilon$ with probability 1/2 and $f(\bar{L}, R) - \epsilon$ with probability 1/2, with ϵ denoting the random component of the production function. Assume that $f(\bar{L}, 1) > f(\bar{L}, 0)$, i.e., irrigation increases average land productivity, and that $f(\bar{L}, R) - \epsilon > 0$, i.e., subsistence (defined as zero consumption) is guaranteed even if one obtains the low yield. For simplicity, we assume that the production function exhibits constant returns to scale, i.e., $f(\bar{L}, \cdot) = \bar{L}f(1, \cdot)$ and that no land results in no production, i.e., $f(0, \cdot) = 0$. The former assumption implies that we can readily extend the model to the experimental set-up as we elicited willingness-to-pay for a bag of seeds for one acre of land.¹⁷

The per-period Bernoulli utility function is given as $u(c)$, where c denotes consumption. The utility function is assumed linear, i.e. $u(c) = c$.¹⁸ We assume that a farmer cannot opt for negative consumption. Acquiring an irrigation system requires a lump sum fixed investment $r > 0$. We assume that the cost of an irrigation system is substantial but feasible, and in particular that:

$$f(\bar{L}, 0) + \epsilon > r > f(\bar{L}, 0) \quad (5)$$

At the start of the first period, the farmer choose between the safe and risky technologies. After the uncertainty is revealed and the proceeds are obtained, the farmer decides whether or not to invest in the irrigation technology, and finally consumes. At the start of the second period, the farmer again makes a decision between the safe and risky technology, after which the uncertainty is revealed, proceeds are collected and he consumes.

Let us approach this two-period problem using backward induction, starting from the second period. From the set-up, it is clear that in the second period the farmer will be indifferent between the risky and safe technologies.

Now note that if the farmer chooses the safe technology in the first period, following (5) he will be unable

¹⁷Note that if one assumes increasing, or more commonly decreasing, returns to scale, the WTP depends on the amount of land one has. It is not obvious whether the elicited WTP would in that case refer to the average WTP or the marginal WTP (of, for instance, the first acre of land). Intuitively, an increasing returns to scale production function does not change the results of the model as the potential returns to the investment can be magnified and the results continue to hold for a L^α , where $\alpha > 0$ production functions. However, additional assumptions need to be imposed for the results to continue to hold for a decreasing returns to scale production function. For a discussion on returns to scale in similar contexts, see Binswanger et al. (1995) and Ray (1998) for a more general discussion.

¹⁸For simplicity, we assume that intertemporal utility is additive. A more flexible model could be constructed using Epstein and Zin’s (1989) non-expected-utility framework for intertemporal choice. This model uses a recursive framework to disassociate the elasticity of intertemporal substitution and the level of instantaneous absolute risk aversion. This stylized model is used simply to illustrate the potential for moving to a superior production technology after a large investment could lead one to make risky choices in the current period even if risk-averse. The generality of Epstein-Zin would add no further insight beyond this, while introducing substantial complication. We thus employ the standard additive utility model.

to invest in an irrigation system. However, if the farmer chooses the risky technology in the first period and obtains the high yield, he has the option to invest in an irrigation system. In that case, he will compare the outcome with irrigation to the outcome without irrigation:

$$\begin{aligned} \text{without irrigation:} & \quad [f(\bar{L}, 0) + \epsilon] + \delta f(\bar{L}, 0) \\ \text{with irrigation:} & \quad [f(\bar{L}, 0) + \epsilon - r] + \delta f(\bar{L}, 1) \end{aligned} \tag{6}$$

where $\delta \in (0, 1)$ is the discount factor, summarizing preferences over time. The farmer opts for the irrigation system if and only if:

$$\delta [f(\bar{L}, 1) - f(\bar{L}, 0)] > r \tag{7}$$

Under conditions (5) and (7),¹⁹ the difference in *WTP* between the risky and safe technology is:

$$\begin{aligned} WTP_{RISKY} - WTP_{SAFE} &= \frac{1}{2} [f(\bar{L}, 0) - \epsilon + \delta f(\bar{L}, 0)] + \\ &\quad \frac{1}{2} [f(\bar{L}, 0) + \epsilon - r + \delta f(\bar{L}, 1)] - [f(\bar{L}, 0) + \delta f(\bar{L}, 0)] \end{aligned} \tag{8}$$

Rewriting (8):

$$WTP_{RISKY} - WTP_{SAFE} = \frac{1}{2} [\delta f(\bar{L}, 1) - \delta f(\bar{L}, 0) - r] \tag{9}$$

Following (7), $(WTP_{RISKY} - WTP_{SAFE})$ is strictly positive. Note now that whether (5) and (7) are satisfied depends (among other factors) on $\bar{L}$. Assuming that these conditions continue to hold, one could take the derivative (9) with respect to land, obtaining:

$$\frac{1}{2} \delta \left[\frac{\partial f(\bar{L}, 1)}{\partial L} - \frac{\partial f(\bar{L}, 0)}{\partial L} \right] \tag{10}$$

Assuming constant returns to scale, expression (10) is strictly positive. Thus, the difference in *WTP* increases as one has more dryland. Moreover, this increase in *WTP* is increasing in the returns to irrigation.

¹⁹(5) and (7) imply that the returns to investment are very large compared to the base return. This condition might be difficult to meet in a two-period model, but could be easily met if one imagines the increased return to be sustained over a longer period of time.

Conclusion

In this article we have analyzed the relationship between attitudes towards risk and investment possibilities. We are able to take advantage of a unique data set collected among farmers in India's semi-arid tropics, which contains information on farmers' assets and the results of a risk experiment. This risk experiment consisted of four hypothetical farming seasons. For each season the farmer was asked how much he would be willing to pay for a bag of cotton seed resulting in a particular yield distribution.

Comparing the willingness to pay for the various yield distributions, we find that 85% of the farmers are willing to pay more for a yield distribution which is second-order stochastically dominated by the baseline distribution presented to them. Risk-taking behavior appears to be driven by credit constraints in combination with non-convexities in production. In particular, the potential for investment in higher education and irrigation are strongly related to risk-taking behavior.

We believe ours is the first experimental validation of the notion that non-convexities can generate risk-taking incentives. We conjecture that the novelty of these results is due to the high-stakes nature of the gambles, which may be creating a real potential for investment in high-cost projects that overwhelms the natural tendency to avert risk. One caveat to be borne in mind is that the experiments that we conducted were context-specific and hypothetical. Imitating the experience of a farmer choosing a type of seed in the input dealer's shop aided the often illiterate and innumerate respondents to understand the game but did not allow for an actual payout. It is also not immediately clear that the results of these experiments can be extrapolated to non-agricultural settings.

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Appendix A

The experiment was conducted among all households who have made farming decisions in the past seven years and/or intend to make farming decisions in the future. The reason for this selection is the experiment's context-specific nature, which would make little sense to non-agricultural households (as we had found out during the trial round). To obtain responses based on recent experiences, we decided to interview only the households who farmed within the past seven years, since in that timeframe many new technologies were introduced, such as genetically modified cotton seeds. The households which did not satisfy these criteria did not participate in the experiment.

The experiment took place at the end of a 3-5 hour long interview, interrupted with a few tea breaks. The respondent, who was the main decision-maker with regard to agriculture, received about 1.5 US dollar for participating in the interview, the equivalent of about one day's labor. In addition, the respondents in each village were invited every 2-3 years to participate in a day trip funded by this study together with other studies. The interview took place in the respondent's residence. No active effort was undertaken to separate the respondent from other family members, but as the interview took several hours, only in a few cases were family members present throughout the interview. For the more subjective questions (such as this experiment), the respondent was not allowed to discuss the answers with his family members.

The respondent was given ample time to learn the game. As the game was preceded by another game involving visual representations of a distribution function, the respondents were comfortable with the Fisher-Price Blocks of various colors. The instructions for the enumerators are given below. The first author taught the enumerators this game, both in a lab setting and subsequently in a field setting, so we are confident that all enumerators understood the game and conducted it in the same manner. For each distribution the farmer was asked to imagine going to the store and buying seeds for this season.

Instructions for the enumerators:

The goal of this part of the questionnaire is to get an idea of the risk aversion of the respondents. This question is asked of all households who have made farming decisions in the past 7 years and/or intend to make farming decisions in the future. We will use Fisher Price building blocks to represent yield distributions of cotton, and ask the respondent how much they would be willing to pay for a bag of these seeds (sufficient for 1 acre of land). Tell the respondent that we will play another game with him/her. You say: "Just like on your own farm, you will have the chance to buy seeds at the beginning of each season, but not know the yield until the end of the season. On your own farm, how much you earn depends on whether it is a good year or a bad year. In this game it is the same. In a good year, you will harvest more, in a bad year you will harvest less"

Then, place the building blocks on the white board. One block represents 5%, requiring a total of 20 blocks for the game.

- The green blocks = high yield (8 quintal/acre) good season
- The yellow blocks = average yield (6 quintal/acre) average season
- The red blocks = low yield (4 quintal/acre) bad season

Explain to the respondent the meaning of the different blocks. Do several exercises holding up one block, two blocks etc. to check whether he can associate the percentages with the blocks. Once the respondent understands the meaning of the blocks, make 2 trial distributions to learn the game. Then proceed with the 4 distributions given in the questionnaire. For each distribution ask how much the respondent is willing to pay at most, starting from 100 Rs and working your way up in steps of 50 Rs until the farmer changes his answer. Then, decrease the amount to identify the exact point (to the nearest 5 Rs). After the respondent has answered, verify and write down the answers (in Rs) in the boxes.

- Trial experiment 1 [100% in low yield]
- Trial experiment 2 [50% in low yield and 50% in average yield]
- Experiment 1 [25% in low yield, 50% in average yield and 25% in high yield]
- Experiment 2 [30% in low yield, 40% in average yield and 30% in high yield]
- Experiment 3 [30% in low yield, 30% in average yield and 40% in high yield]
- Experiment 4 [10% in low yield, 55% in average yield and 35% in high yield]

Appendix B

We now lay out the farmer's decision problem when $u''(c) < 0$. As before, let us approach this two-period problem using backward induction, starting from the second period. In the second period, after the farmer has made his irrigation investment decision, he compares the expected utility of the safe and risky technologies. As his Bernoulli utility function is (strictly) concave, he opts for the safe technology. Again, if the farmer chooses the safe technology in the first period, following (5), he is unable to invest in an irrigation system. However, if he chooses the risky technology in the first period and obtains the high yield, he has the option to invest in an irrigation system. In that case, he will compare the outcomes with and without irrigation:

$$\begin{aligned} \text{without irrigation:} \quad & u[f(\bar{L}, 0) + \epsilon] + \delta u[f(\bar{L}, 0)] \\ \text{with irrigation:} \quad & u[f(\bar{L}, 0) + \epsilon - r] + \delta u[f(\bar{L}, 1)] \end{aligned} \tag{11}$$

where $\delta \in (0, 1)$ is the discount factor, summarizing preferences over time. In this case, the farmer opts for the irrigation system if and only if:

$$u[f(\bar{L}, 0) + \epsilon - r] + \delta u[f(\bar{L}, 1)] > u[f(\bar{L}, 0) + \epsilon] + \delta u[f(\bar{L}, 0)] \tag{12}$$

Under conditions (5) and (12), the difference in WTP between the risky and safe technology in the first period is:²⁰

$$\begin{aligned} WTP_{RISKY} - WTP_{SAFE} &= \frac{1}{2} [u[f(\bar{L}, 0) - \epsilon] + \delta u[f(\bar{L}, 0)]] \\ &\quad + \frac{1}{2} [u[f(\bar{L}, 0) + \epsilon - r] + \delta u[f(\bar{L}, 1)]] \\ &\quad - [u[f(\bar{L}, 0)] + \delta(u[f(\bar{L}, 0)])] \end{aligned} \tag{13}$$

The sign of (13) is ambiguous and depends on further assumptions on the returns to the investment. However, assuming constant returns to scale, and $\delta > 1$, the derivative of (13) with respect to land is strictly positive. Thus, once more the difference in WTP increases as one has more dryland.

²⁰Note here that we simplified the farmer's decision making problem by equating the WTP to the discounted expected value, thereby ignoring the initial wealth. This simplification does not change the main result.

Table 1: Basic descriptive statistics of Aurepalle, Kanzara and Kinkhed

	Aurepalle	Kanzara	Kinkhed
Number of households in village	925	319	189
Number of households in sample	128	63	55
Number of households in the experiment	95	57	54
Median rainfall (mm/year) ¹	434	748	745
Distance to nearest town (km)	10	9	12
Average land owned (acre) ²	3.4	5.2	6
Average dryland owned (acre) ²	2.4	2.1	2.6
Average irrigated land owned (acre) ²	1.0	3.0	3.0
Average number of household members	4.23	4.87	4.50
Average annual income (Rs) ³	43,543	53,720	38,087
Average education level of respondent (in years)	2.31	6.61	6.89
Average maximum level of education in HH (in years)	7.08	10.41	10
% of children enrolled in school ⁴	91	100	95
% of young adults enrolled in an educational institute ⁴	32	32	27
% of households that farm cotton ⁴	60	84	82
Average cotton yield, 2007-08 (Q/acre)	8.97	3.50	1.88
Average cotton yield, 2001-04 ⁵ (Q/acre)	3.53	5.76	4.90
Average cotton yield, 2005-07 ⁵ (Q/acre)	4.46	2.47	3.21
Income from agriculture (% of <i>kharif</i> income) ⁶	55	70	66
Average seed price non-Bt cotton (Rs/acre) ⁷	650	411	625
Average seed price Bt cotton (Rs/acre) ⁷	1,280	929	1,196
% of respondents who have access to irrigation	42	30	27
% of respondents with access to bank credit ⁸	1.12	17.54	0

Notes: The average/percentage/median statistics refer to the sample in each village in 2007-08 unless otherwise noted; ¹2001-2007; ²Including the landless households who own no land; ³2004-2005, household-level income as reported in the ICRISAT-VLS; ⁴Children are defined as being between the ages of 6 and 15 and young adults are defined as being between the ages of 15 and 26; ⁵2001-08; ⁶Calculated using the ICRISAT-VLS input-output data; ⁷Based on the income earned from all agriculture related activities at the time of interview during the *kharif* season (rainy season, the main agricultural season) (this might be an underestimate as not all of the harvest was sold at that point in time); ⁸This is the average of what respondents - on average - expect a bag sufficient for one acre of seed will cost, note that the expected seed cost varies a lot by cultivar; ⁸The respondent was asked to imagine he would need credit for agricultural inputs, who would he approach and how likely would he be to receive credit from this individual/organization. Multiple answers were possible. This percentage mentioned here corresponds to the respondents who said they have access to government bank or private bank credit.

Table 2: Hypothetical Yield Distributions

	Distribution 1 (L_1)	Distribution 2 (L_2)	Distribution 3 (L_3)	Distribution 4 (L_4)
4 Q/acre	25	30	30	10
6 Q/acre	50	40	30	55
8 Q/acre	25	30	40	35
Expected value	6.0	6.0	6.2	6.5
Variance	2.0	2.4	2.8	1.6

Notes: 1 quintal (Q) = 100kg. The table figures represent probabilities multiplied by 100.

Table 3: Do farmers obey FOSD and SOSD?

Prediction	Should be true for....	Validity in the data
$L_4 > L_2$	For everyone (by FOSD)	96.0%
$L_4 > L_1$	For everyone (by FOSD)	96.0%
$L_3 > L_2$	For everyone (by FOSD)	99.5%
$L_4 > L_3$	For risk averse individuals (by SOSD and then FOSD)	61.0%
$L_1 > L_2$	For risk averse individuals (SOSD)	16.0%
$L_3 > L_1$	Ambiguous	95.0%

Note: FOSD = First-Order Stochastic Dominance, SOSD = Second-Order Stochastic Dominance

Table 4: Correlates of Willingness-to-Pay

<i>OLS regression / fixed effects</i>	WTP		
	OLS		Fixed effects
	Model 1	Model 2	Model 3
Probability to obtain 4 Q/acre	-367.34*** (57.40)	-319.63*** (39.65)	-367.34*** (57.15)
Probability to obtain 8 Q/acre	1564.20*** (102.29)	1527.11*** (107.01)	1564.20*** (101.85)
Output price, predicted (Rs/Q)	-0.18 (0.80)	0.57 (0.82)	
Input costs, predicted (Rs/acre)	-0.05 (0.06)	-0.06 (0.07)	
Education level of decision-maker (years)	6.80 (8.93)	2.59 (10.00)	
Wealth (land) per capita (1000 Rs)	0.15 (0.10)	0.12 (0.11)	
Wealth (other assets) per capita (1000 Rs)	-0.22 (0.46)	-0.32 (0.56)	
Aurepalle fixed effect	57.38 (376.13)	376.92 (438.20)	
Kinkhed fixed effect	630.83*** (96.55)	729.28*** (121.50)	
Output produced in 2007-08 (Q/acre)		-5.56 (13.49)	
Constant	856.42 (1571.07)	-760.56 (1637.15)	416.57*** (33.51)

Notes: *** p<0.01; ** p<0.05; * p<0.1; standard errors clustered at the individual level are reported in parentheses below the coefficient. Number of observations model 1 = 816; number of observations model 2 = 516; number of observations model 3 = 816. The fixed effects refer to the inclusion of individual level fixed effects. Two observations had missing values, these were not included. The value of other assets was estimated using the 2006-07 ICRISAT data. The results do not change significantly in terms of signs and magnitude of the coefficient if we add a control for rainfall, split up per village or education level. Other assets include livestock, savings, borrowings and lendings, machinery, equipment, other durable goods, and stocks.

Table 5: Characteristics of risk-groups

	Income (rupees)	Wealth (rupees)	Dry Land (acres)	Irrigated Land (acres)	Children			Adults	Education (yrs)	WTP ₂ -WTP ₁	WTP ₃ -WTP ₄	Number
					0-15 yrs	15-25 yrs						
						Out of school	In School					
Risk-averse (I)	66760.60	283.53	2.50	3.73	0.80	0.80	0.20	2.90	8.40	-100.00	-80.00	10
(L ₁ >L ₂ & L ₄ >L ₃)	(15870.77)	(100.48)	(1.67)	(1.17)	(0.25)	(0.29)	(0.13)	(0.28)	(0.85)	(48.30)	(35.12)	
Moderately risk-seeking (II)	53417.52	160.15	2.76	1.39	0.77	0.57	0.32	2.37	2.95	62.57	-91.48	115
(L ₂ >L ₁ & L ₄ >L ₃)	(3814.84)	(19.58)	(0.26)	(0.24)	(0.09)	(0.09)	(0.06)	(0.07)	(0.35)	(6.15)	(13.39)	
Extremely risk-seeking (III)	42985.68	74.95	2.90	2.63	0.88	0.72	0.30	2.65	6.72	214.91	157.89	57
(L ₂ >L ₁ & L ₃ >L ₄)	(5835.84)	(16.62)	(0.62)	(0.67)	(0.15)	(0.15)	(0.07)	(0.14)	(0.50)	(15.22)	(13.87)	
Risk-averse/Risk-seeking (IV)	129781.40	269.37	2.50	5.76	0.50	1.05	0.36	2.55	7.00	-56.82	65.91	22
(L ₁ >L ₂ & L ₃ >L ₄)	(33906.88)	(56.86)	(1.24)	(1.68)	(0.17)	(0.19)	(0.12)	(0.24)	(1.07)	(14.07)	(5.83)	

Notes: Standard errors are in parentheses.

Table 6: Correlates of WTP₂-WTP₁

	<i>Probit regression</i> WTP ₂ -WTP ₁ <i>Marginal Effects</i>	<i>Linear regression</i> WTP ₂ -WTP ₁ Model 1 Model 2		<i>Linear regression</i> WTP ₂ -WTP ₁ /WTP ₁ Model 3
Children	-0.101** (0.049)	-15.32** (8.06)	-51.00** (22.22)	-0.016** (0.008)
Children^2			14.18 (9.19)	
Adults	0.140*** (0.069)	21.47*** (6.59)	14.27 (19.90)	0.015** (0.007)
Adults^2			1.40 (2.84)	
Young adults out of school	-0.014 (0.042)	18.87*** (6.62)	1.05 (14.94)	0.013** (0.007)
Young adults out of school^2			5.19 (4.32)	
Young adults in school	0.133* (0.092)	35.23*** (12.09)	79.4*** (28.74)	0.030** (0.012)
Young adults in school^2			-24.83** (12.7)	
Dryland (acre)	0.030*** (0.015)	5.04** (2.09)	6.56** (3.51)	0.003 (0.002)
Dryland (acre)^2			-0.13 (0.15)	
Irrigated land (acre)	0.001 (0.008)	3.07 (1.99)	0.34 (3.69)	-0.001 (0.002)
Irrigated land (acre)^2			0.13 (0.13)	
Output price, predicted (Rs/Q)	-0.005*** (0.002)	-1.05*** (0.28)	-1.03*** (0.27)	-0.001*** (0.000)
Input costs, predicted (Rs/acre)	0.000*** (0.000)	0.03 (0.02)	0.02 (0.02)	0.000** (0.000)
Education of DM (years)	0.042** (0.020)	7.18** (3.17)	6.96** (3.22)	0.005 (0.003)
Wealth (other assets) (1000 Rs)	-0.001*** (0.000)	-0.05* (0.03)	-0.05* (0.03)	0.000** (0.000)
Aurepalle fixed effect		-283.34* (108.34)	-268.31* (108.47)	-0.262** (0.112)
Kinkhed fixed effect	0.490*** (0.113)	185.1*** (28.17)	180.57*** (27.48)	0.180*** (0.033)
Constant		2083.67*** (541.24)	2077.87*** (530.07)	1.973*** (0.545)

Notes: *** p<0.01; ** p<0.05; * p<0.1. DM = decision maker. WTP =willingness-to-pay. Average marginal effects are reported in probit regression where (1=risk loving or risk neutral and 0=risk averse). Robust standard errors are reported in parentheses below the coefficient. Number of observations probit regression = 109 (only the Akola villages). Number of observations OLS regression= 204. Children are defined as being between the ages of 6 and 15 and young adults are defined as being between the ages of 15 and 26. The results do not change significantly in terms of size and magnitude of the coefficients if we add a control for rainfall, add the yield of the previous year, split up per village or education level. The (average) marginal effects of "young adults out of school" and "young adults in school" are statistically significantly different from each other at the 1% level in model 2 and at the 5% level in the probit; and the (average) marginal effects of "dryland" and "irrigated land" are statistically significantly different from each other at the 10% level in model 3 and at the 1% level in the probit. See also notes to table 4.

Table 7: Correlates of WTP₃-WTP₄

	<i>Probit regression</i> WTP ₃ -WTP ₄ <i>Marginal Effects</i>	<i>Linear regression</i> WTP ₃ -WTP ₄ Model 1 Model 2		<i>Linear regression</i> WTP ₃ -WTP ₄ /WTP ₃ Model 3
Children	0.067 (0.045)	14.56 (9.26)	-15.21 (31.06)	-0.014** (0.007)
Children^2			11.78 (13.90)	
Adults	0.018 (0.037)	-4.40 (7.06)	-21.07 (21.52)	0.013** (0.006)
Adults^2			2.62 (3.05)	
Young adults out of school	0.114*** (0.037)	10.53 (6.80)	-15.89 (23.89)	0.010** (0.005)
Young adults out of school^2			7.60 (6.57)	
Young adults in school	0.146** (0.063)	31.23** (14.01)	24.71 (34.97)	0.022** (0.009)
Young adults in school^2			4.53 (15.78)	
Dryland (acre)	0.026** (0.012)	3.60** (1.93)	4.24 (3.50)	0.002 (0.002)
Dryland (acre)^2			-0.05 (0.19)	
Irrigated land (acre)	0.024** (0.011)	3.21 (2.87)	-0.48 (3.63)	0.000 (0.002)
Irrigated land (acre)^2			0.17 (0.12)	
Output price, predicted (Rs/Q)	-0.002 (0.001)	-0.47 (0.33)	-0.41 (0.34)	-0.001*** (0.000)
Input costs, predicted (Rs/acre)	0.000 (0.000)	0.01 (0.04)	0.01 (0.04)	0.000** (0.000)
Education of DM (years)	0.011 (0.016)	4.13 (3.29)	3.28 (3.40)	0.003 (0.003)
Wealth (other assets) (1000 Rs)	0.000* (0.000)	-0.03 (0.03)	-0.03 (0.03)	0.000** (0.000)
Aurepalle fixed effect	-0.908** (0.173)	-281.11** (162.17)	-267.30 (164.48)	-0.206** (0.086)
Kinkhed fixed effect	0.067 (0.121)	59.59 (49.92)	53.64 (45.01)	0.140*** (0.021)
Constant		970.77 (708.27)	895.32 (736.90)	1.480*** (0.391)

Notes: *** p<0.01; ** p<0.05; * p<0.1. DM = decision maker. WTP =willingness-to-pay. Average marginal effects are reported in probit regression where (1=risk loving or risk neutral and 0=risk averse). Robust standard errors are reported in parentheses below the coefficient. Number of observations = 204. The coefficients on "young adults out of school" and "young adults in school" are statistically significantly different from each other at the 10% level in model 1. See also notes to table 6.

Figure 1A: Histogram of ($WTP_2 - WTP_1$)

Figure 1B: Histogram of ($WTP_3 - WTP_4$)

Note: one observation of -1500 was dropped to keep a similar scale as in 1A

Figure 2A: Predicted differences in WTP as a function of per capita wealth

Note: Wealth measure includes livestock, savings, borrowings and lendings, machinery, equipment, other durable goods, stocks and land.

Figure 2B: Differences in WTP as a function of per capita wealth

Note: Wealth measure includes livestock, savings, borrowings and lendings, machinery, equipment, other durable goods, stocks and land; one observation of -1500 in WTP3-WTP4 was dropped to keep a similar scale as in 1A

Appendix C:

Table C1: Predicting the individual level output price and input costs

<i>OLS regression</i>	output price [Rs/Q]	input cost [Rs/acre]
Number of members	-11.3 (17.3)	216.8 (155.8)
Number of adult members	20.3 (22.3)	-230.3 (199.8)
Dryland (acres)	2.7 (5.1)	-5.7 (45)
Irrigated land (acres)	3.4 (5.2)	40.6 (40.9)
Access to a plot of good soil quality	50.8 (81.2)	1044.9 (712.5)
Number of plots of good soil quality > 1 acre	14 (20.6)	-24.1 (182.7)
Education level of decision-maker (years)	9.6 (5.9)	-2.7 (53.7)
Aurepalle fixed effect	-211.2*** (57.8)	3763.8*** (522.6)
Kinkhed fixed effect	-39.8 (58.2)	-799.3 (508.2)
Constant	2037.1*** (95.1)	3133.6*** (836.7)

Notes: ** p<0.01; * p<0.05; * p<0.1; number of observations 130 ; Adj Rsquare output price = 0.23 ; Adj. Rsquare input costs 0.52.

Table C2: Regression results corresponding to Figure 2A

<i>OLS regression</i>	WTP ₂ -WTP ₁	WTP ₃ -WTP ₄
Per capita wealth (10,000 Rs)	-1.83*** (0.65)	-3.53*** (0.64)
Per capita wealth ^2	0.015*** (0.00)	0.02* (0.00)
Constant	124.05*** (12.46)	74.52*** (12.26)

Notes: *** p<0.01; ** p<0.05; * p<0.1; standard errors are reported in parentheses below the coefficient. Number of observations = 204. The dependent variable is the WTP for the second (third) distribution minus the WTP for the first (fourth) distribution in the first (second) column. Wealth includes livestock, savings, land, savings, borrowings, machinery, equipment, other durable goods, and stocks.