Agricultural Extension and Risk in Low Income Countries: Experimental Evidence from Ethiopia[i]

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Abstract

Livelihoods in low-income developing countries are generally undiversified and focus on crop production and animal raising. These activities are inherently risky and investment and production decisions by farm households are therefore made within environments that are affected by risk. Because of poorly developed or absent credit and insurance markets it is difficult to pass any of these risks to a third party. As a result, it is often found that even when expected net returns are high, households are reluctant to adopt risky technologies.

Despite risk's potentially central role in farm investment decisions, there have been few attempts to estimate the magnitude and nature of risk aversion of farm households in low-income developing countries. To partially close this gap, this paper uses a real payoff experimental approach applied to 262 households in the Ethiopian highlands. By incorporating both small and large stakes and gains and losses into the experiment, we test for the presence of low stake risk and loss aversion. We find that more than 50 percent of the households are severely or extremely risk averse. This contrasts with findings from Asia where most decision makers exhibit moderate to intermediate risk aversion.

We find that households that stand to lose as well as gain something from participation in games are significantly more risk averse than households playing gains-only games. This strongly suggests that agricultural extension efforts involving potential losses may face systematic resistance at the farm level in poor countries. Promotion of technologies with downside risks – even if the upside potential is enormous – should therefore be combined with cost effective insurance. We also find that even without the possibility of losses households are much more averse to risk when stakes are high than when they are low.

Results suggest that insurance does not need to be provided forever. After initial successes have convinced farmers that technologies are viable, risk aversion declines. There are also significant differences in risk averting behavior between relatively poor and wealthy farm households. This suggests that as wealth is built up households are willing to take on more risk in exchange for higher returns. These findings suggest strong path dependence. Efforts to develop poor rural areas through promotion of risky technologies must therefore take this path dependence into account. Early successes are important, but households should also be allowed to build up wealth in places like rural Ethiopia before they are challenged or tempted to take on more risky ventures. Furthermore, the finding that even without the possibility of losses households are much more risk averse when stakes are higher, suggests that agricultural extension should start modestly before asking households to take larger gambles

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Key Words: Ethiopian farm households; experimental studies; loss aversion; risk aversion
JEL Classification: C93; D81; Q12; Q21

1. Introduction

Livelihoods in low-income developing countries are generally undiversified and mainly focus on crop production and animal raising. These activities are inherently risky and include, but are not limited to, crop yield risks due to variance in rainfall timing and level, animal mortality due to infectious diseases and changing output prices. And that is not all. Production of farm households in developing countries is also affected by crop diseases, flooding, frost, illness of household members, war and crime, all of which can have major effects on rural livelihoods. Investment and production decisions by farm households in low-income countries are therefore made within environments that are at least affected by, but more likely dominated by, numerous risks (Rosenzweig, 1988; Dercon, 2005).

The existence of such risks has been found to alter behavior in ways that at first glance seem suboptimal. In the empirical literature many researchers have found that risks cause farmers to be less willing to undertake activities and investments that have higher expected outcomes, but carry with them risks of failure. For example, it has been found that farm households use less fertilizer, improved seeds and other production inputs than if they had simply maximized expected profits (Feder *et al*, 1985). It is also not uncommon to observe farm households in developing countries being reluctant to adopt new technologies because of the risks involved, even when they provide higher expected returns than traditional technologies. If households pass up welfare-improving opportunities because of risks this has important implications for agricultural extension and other policies, particularly if it is possible to address households' concerns. Knowing what triggers high levels of risk aversion is therefore of critical importance.

While all investments around the world are made in environments of risk, a key difference between investing in rural areas of most low-income countries, including Ethiopia, which is the focus of this study, and the US, Europe or Japan is that futures and insurance markets do not exist for virtually any type of agricultural risk. Credit markets – which allow a sharing of risk by debtors and creditors – are also extremely thin. An alternative to a status quo where households simply forego such opportunities is therefore to develop or improve the functioning of these markets. This may involve, for example, using policies or public resources to make available insurance and thicken rural credit markets in developing countries. These efforts are underway in a variety of contexts. Small microcredit schemes now abound throughout the developing world and have allowed villagers to accept opportunities without risking the basic livelihoods of their families (Yunus, 2006). There are also initiatives afoot in Sub-Saharan Africa under the auspices of the World Bank and World Food Programme (WFP) of the United Nations to develop crop insurance markets (WFP, 2006).

The existence of agricultural risk and its effects in low-income countries when so many key markets are missing is well-known, but there have been very few empirical efforts to estimate the magnitude and nature of risk aversion of farm households in low-income developing countries where those market failures are most pronounced. For example, in very low-income rural settings is it the simple possibility of loss that drives aversion to risk or do the levels of potential gains and losses affect responses to risk? Does the buildup of wealth at very, very low income levels affect risk behavior? Do past successes within risky environments have an effect? All these questions are still largely open, but critically important to policy formation. Little is also known about the basic household factors affecting risk behavior. For example, it may be true that in this environment of missing markets and low incomes there are important linkages between attitudes toward risk and seemingly disparate elements such as household fertility, educational decisions and even gender policies. It is therefore important to better understand household responses to agricultural risk and the contributors to those responses

This paper uses an experimental approach to partially close this gap. Using real pay-off experimental data we seek to measure farmers' risk attitudes. By incorporating both small and large stakes and gains and losses into experiments, we test for the presence of low stake risk aversion and loss aversion. We also use these experimental results as data in an econometric model to examine the determinants of risk aversion and draw a number of policy inferences from the results. The rest of the paper is organized as follows. Section 2 discusses the key literature. Section 3 describes the study setting in Ethiopia and presents key descriptive statistics. Section 4 presents the experimental design and Section 5 discusses the results. An econometric model of risk averting behavior is presented and the results are discussed in Section 6. Finally, Section 7 concludes the paper.

2. Literature

Sandmo (1971) was perhaps the first to establish that a risk averse firm facing output risk will produce less than a risk neutral firm. Following Sandmo's work, there have been attempts in the empirical literature to measure the degree of risk aversion of farm households. Some have used actual production data while others have applied an experimental approach to derive farm household risk aversion estimates. Studies using production data include work by Antle (1983; 1987; 1989), Pope and Just (1991), Chavas and Holt (1996) and Bar-Shira *et al.* (1997). Studies employing the experimental approach in developing countries include Binswanger (1980), and Wik and Holden (1998). The production data approach can be criticized for confounding risk behavior with other factors, such as resource constraints faced by economic actors (Eswaran and Kotwal, 1990). This is particularly important in developing countries where market imperfections are prominent and consumption and production decisions are non-separable (Wik and Holden, 1998). On the other hand, the most pervasive problem of the experimental approach is hypothetical bias when experiments are purely hypothetical (List and Shogren, 1998). We attempt to avoid this critique by using real payoffs in our experiments.

Risk aversion is generally defined with reference to the von Neumann-Morgenstern expected utility function. Specifically, the second derivative of the utility function contains important information regarding risk aversion of decision makers. In empirical studies, the three most commonly used measures of risk aversion are absolute risk aversion ($A(W) = -{U_{WW}}/{U_W}$), relative risk aversion ($R(W) = -W\,{U_{WW}}/{U_W}$) and partial risk aversion ($P(w,m) = -m\,{U_{WW}}/{U_W}$), where U indicates utility, m is a monetary gain or loss, w is initial wealth and $W = w+m$ is the final wealth level (Pratt, 1964; Arrow, 1965; Menezes and Hanson, 1970; Zeckhauser and Keeler, 1970).

Absolute risk aversion traces the behavior of an individual toward risk when his/her wealth rises and the prospect remains the same. Partial risk aversion examines behavior when the prospect changes, but wealth remains the same. Relative risk aversion looks at behavior when both the initial wealth and the level of the prospect rise proportionally. Decreasing absolute risk aversion (DARA) implies that a person is more willing to accept a risky prospect as wealth increases. Increasing relative risk aversion (IRRA) indicates that a person's willingness to accept risk declines when both the outcome and wealth increase proportionally. Increasing partial risk aversion (IPRA) implies a decrease in the willingness to take a gamble as the scale of the prospect increases.

For nearly half a century, the idea that economic actors should behave as expected utility maximizers has been the dominant theory of choice under uncertainty. Recently, however, due to growing empirical evidence this theory of behavior has lost ground to other hypotheses. For example, Rabin (2000) and Rabin and Thaler (2001) show how EU theory fails to describe risk aversion to small stake outcomes. Risk aversion is generally modeled under the assumption that the utility function over wealth is concave. Arrow (1971) shows that an expected-utility maximizer will always want to take a sufficiently small stake in any positive expected-value bet. That is, expected-utility maximizers are (almost everywhere) close to risk neutral when stakes are small. If subjects in experimental studies are found to be averse to small stakes risk, this suggests that expected utility maximization may not be the correct behavioral model and indeed a number of studies show evidence of risk aversion in low stake experiments. This suggests that expected utility maximization may not accurately describe the risk behavior of most people (Davis and Holt, 1993; Eggert and Martinsson, 2004; Holt and Laury, 2002). Given diminishing marginal utility, risk aversion in small stakes then implies extreme risk aversion for larger stakes (Rabin, 2000; Rabin and Thaler, 2001).

The hypothesis that decision makers give equal weights to choices that involve gains and losses has been challenged by Kahneman and Tversky (1979), Benartzi and Thaler (1995) and Thaler *et al*. (1997), who show that people put less weight on gains than losses and over-emphasize low probability outcomes. Research in behavioral economics has also generally found that individuals are more sensitive to losses than gains (Kahneman and Tversky, 1979). Using concepts such as mental accounting and narrow bracketing, Benartzi and Thaler (1995) and Thaler *et al*. (1997) find significant discrepancies in the treatment of gains and losses, which they characterize as loss aversion.

3. Description of the Study Site and Household Descriptive Statistics

The purpose of this paper is to contribute to the empirical literature on the nature and level of aversion to risks in rural areas of low-income countries. There are two aspects to the research. The first part is an experiment that seeks to help us understand how Ethiopian households respond to the presence of agricultural risk. The behavioral findings are then used as the dependent variable in an ordered probit model that tries to explain those choices in terms of household, game structure and site-specific characteristics.

The experiment was administered as part of a survey of 1522 households done in February 2002 in the Ethiopian Highlands. The survey included 122 villages in 12 local areas (*kebeles*) in the State of Amhara. A random sample of 262 farm households were chosen from seven *kebeles* to participate in the experiment. Ethiopia is one of the poorest countries in the world, with a per capita gross national income of $160 per day, which is less than half the cutoff level for extreme poverty under the Millennium Development

Goals adopted unanimously by the United Nations General Assembly in 2000. This ranks Ethiopia 202 out of 208 countries in terms of GNI per capita (World Bank, 2005)

The villages studied are very typical of rural Ethiopia and representative of the nation as a whole (Bluffstone *et al*, 2007). They are located in five counties (*weredas)* in two different zones (Eastern Gojjam and South Wollo) of highland Ethiopia. Eastern Gojjam is generally considered to have a good potential for agriculture, whereas South Wollo is seriously affected by soil erosion and subjected to recurrent drought. Virtually all households in the sample are subsistence farmers who rely on on-farm production for virtually all of their consumption needs. Incomes in the sample are extremely low. For example, the average annual household income was $170 and even if we apply the 2005 purchasing power parity adjustment factor of 6.25 to households as is often done at the national level to compare incomes, per capita incomes are only $0.50 per person per day. Though not at all atypical of very low-income countries – and over a billion people are in exactly the same situation worldwide - we nevertheless emphasize that incomes in the sample are very low.

Incomes are also not very diversified. In the sample, for example, more than half of households have no off-farm income and at the mean off-farm income is only 10% of total household income. In such an environment, consumption and production decisions are made jointly by households. This implies that endowments, such as wealth, family size and other household characteristics will affect production outcomes (Jacoby, 1993).

Table 1 presents descriptive statistics for the sample households. These are also the regressors included in the ordered probit model presented in Section 6. Households typically hold animals, including bulls, cows, sheep and goats. Products from these animals are sold to earn incomes and the animals themselves are stores of wealth to be sold to finance consumption needs. Oxen are the most important and valuable animal held by households, because of their role in providing traction. Over half of households had at least one ox, with a mean of 2.3 and average value of animals of ETB 1950 ($229).

TABLE 1 HERE

We see that in general respondents (typically household "heads") are men, who are illiterate. Indeed, more than 70% of the sampled household heads are illiterate and fewer than 5% have more than seven years of schooling. Average household size is about 5.4, with more adults than children. Farms tend to be small, with a mean of about one hectare and a maximum of only three hectares spread over an average of five small plots. Small plots are very typical of hill villages in Ethiopia. Land is state property and farm households only have user rights. As a result, there is no land market. This makes land a very constrained resource and a key to various farming decisions. Annual liquid cash availability (revenue minus expenditures) is only ETB 350 ($42), implying significant scarcity of cash. Given these findings, we emphasize that sample households are not only representative and low-income, but also lack wealth.

4. Description of the experiment

In our experiment, subjects are offered choices to reveal their risk preferences for small and large stake outcomes and gains and losses. This gives us the possibility to test whether respondents react to small and large stakes differently. We also test for asymmetric responses to gains and losses, which can help us understand whether opportunity losses are viewed differently than actual losses. This offers tests of so-called asset integration and loss aversion, but more importantly tells us something about whether farm households are more responsive to the possibility of agricultural losses than gains. Knowing whether loss aversion is feature of household behavior has the potential to inform a variety of agricultural extension activities related to technology adoption.

The Appendix presents the payoffs for the five choice sets offered to respondents. Though the amounts may seem low, it must be recalled that incomes in the study area are also extremely low, so the amounts listed indeed provide significant incentives for respondents to carefully consider the options and reveal their true preferences. On average, each household won ETB 30 ($3.53), which is about 10 percent of the monthly income of an unskilled laborer.[ii]

In our experiment we explicitly test for DARA and IPRA-type behaviors. The state of absolute risk aversion across farm households is investigated by presenting an identical choice set (Set 1 in the Appendix) to farm households who have different levels of actual wealth. To examine the nature of partial risk aversion, we then increase the outcome of the first choice set by factors 5, 10, 20 and 30. These are Sets 2 to 5 in the Appendix.

We follow the experimental design developed by Binswanger (1980) to reveal risk preferences and we frame the choices to reflect real life farming decisions. The farm households were told there are six farming systems, all with similar costs but different output levels depending on a 50% probability of good or bad harvest. Then they were shown the good and the bad outcomes of each of the six systems. For each alternative, the expected gain and spread increased. They then chose one of the techniques and a coin was tossed to determine whether they received the good or bad outcome as a reward.

TABLE 2 HERE

It is typically useful to compute a risk aversion coefficient that can serve as a measure of risk aversion. For this purpose we employ a constant partial risk aversion (CPRA) utility function of the form $U = (1-\gamma)c^{(1-\gamma)}$, where γ is the coefficient of risk aversion and c is the certainty equivalent of a prospect. The basic structure of the experiment, using Set 1 as an example and including the upper and lower limits of the CPRA coefficients, is given in table 2.

To test for significant differences in behavior when faced with the possibility of losses rather than only gains, choice sets 1 to 4 involving actual losses to farm households were also incorporated into the experiment; in these games households could therefore actually lose money. Only those farm households who won enough money in the gains-only part and were willing to take part actually participated in this part of the experiment. A total of 29 percent of farm households participated. To avoid the possibility of major financial losses for households, in the gains-and-losses experiment Set 5 was done hypothetically and no actual gains were won or losses incurred. These two features – self-selection and making Set 5 hypothetical – create possible problems of bias and noncomparability with other parts of the experiment. Given the nature of the study setting, however, there was no choice but to make the losses part of the experiment voluntary and Set 5 hypothetical. Results and any caveats should therefore be interpreted in this spirit.

As will be shown in the following sections, however, these issues are easily addressed and the econometric model is adjusted accordingly.

5. Experimental Results

TABLE 3 HERE

We start our analysis by exploring the responses of participants to each set of the experiment. Table 3 presents the distribution of risk averting behaviors. In table 3, we observe that a majority of farm households exhibit intermediate, severe and extreme risk aversion. Even at the lowest level of the game, about 29% of respondents chose the alternatives representing severe to extreme risk aversion. This proportion increases to about 56% at the highest level of the game, which is much different than for slight risk aversion, neutrality and risk preferring, where the proportion declines from 34% in game 1 to 16.8% in game 5. The share of responses falling into intermediate and moderate risk aversion categories remains stable between games 1 to 4 (34% and 37%), but declines to 28% in game 5 due to increases in the severe and extreme risk aversion categories. These results seem to indicate increasing partial risk aversion in which respondents become more risk averse as payoffs increase.

Comparing the distribution of risk preferences in table 3 to other studies in developing countries, Binswanger (1980) and Wik and Holden (1998) found that 83% of respondents in India and 52% in Zambia were in the intermediate to moderate risk category. This suggests that farm households in Ethiopia are much more risk averse than in India and Zambia. Following Rabin and Thaler (2001), our finding that 29% of the respondents are severely to extremely risk averse for an ETB 0.50 bet (i.e. $0.06) implies extremely high risk aversion at relatively larger stakes. Using ETB 1000 ($117) as the payoff from a modest farming activity and initial wealth level of ETB 2000, extreme or severe risk aversion implies a relative risk aversion of around 15. This level is very high, suggesting a process other than expected utility maximization.[iii]

TABLE 4 HERE

FIGURE 1 HERE

A comparison of choices between games involving only gains and both gains and losses (in the sub sample of 76 respondents who participated in both sections of the experiment) shows a tendency to be more risk averse when there are actual losses. As shown in Table 4, the null hypothesis that subjects' risk preferences are equivalent in both kinds of games is rejected for each portion of the experiment. Figure 1 presents these results graphically. This strongly suggests the absence of asset integration and the presence of loss aversion by our farm households. The implication of this finding for policies such as agricultural extension is that farm households are not only risk averse, but can be expected to be more responsive to the possibility of agricultural losses than stochastic output gains. Providing some type of insurance to farmers who try new, but risky technologies is therefore suggested by our findings

TABLE 5 HERE

Table 5 presents median levels of risk aversion for each level of the game along with the CPRA coefficients corresponding to each risk category. We see that median levels of risk aversion increase from moderate at the lowest level of the game to severe at the highest level for the entire sample in the gains-only games. The trend in the gains-and-losses game follows a similar pattern, going from risk-neutral in the low stakes game to intermediate risk aversion when the stakes are high. These findings suggest that even when only gains are possible – no losses – and the probability of each outcome is the same, simply increasing the stakes causes households to become more risk averse. This finding suggests that given the current situation in highland Ethiopia, incremental steps toward improved agricultural technologies are probably called for rather than "big jumps" that increase the stakes and cause households to become more risk averse.

We also note that the median respondent in South Wollo is substantially more risk averse than the median in East Gojjam and for all gains-only games except the first one (ETB 0.50) the median respondent was severely risk averse. The median household in South Wollo is substantially poorer and less wealthy than in East Gojjam. South Wollo also has a more dramatic history of severe food shortage than East Gojjam, which suggests two conclusions. First, levels of income and wealth – even at such low average levels - may matter for risk aversion. Extension programs therefore must be much more careful and move more slowly with lower income than higher income households even if ALL households are poor by conventional standards.

Second, the findings suggest hysteresis in risk preference formation. Households in East Gojjam not only have higher incomes, but have experienced fewer shocks than those in South Wollo. This past success may therefore make them more likely to choose more risky propositions if returns are sufficient. This conclusion is bolstered by the findings from the gains-and-losses game where risk aversion is systematically lower than in the gains-only game. A likely explanation is the past success these respondents had in the gains-only game. We recall that for practical reasons only households who were successful in the gains-only game could participate in the gains-and-losses game. These findings suggest that even in very poor regions success can build on success, with people being willing to accept risk if the past has gone well. Path dependence may therefore be a feature of the economics of agricultural extension as in so many other areas of economics.

6. Econometric Analysis of Risk Averting Behavior

The findings presented in table 5 suggest some explanations for why households might exhibit different levels of risk aversion. While those explanations point to testable hypotheses, they are not themselves tests. We therefore formally test whether the explanations above fit the experimental data well using an econometric model tailored to the experimental results. Our experimental data has the feature that it is ordinal in nature, ranging by integer from 1 (extreme risk aversion) to 6 (risk loving behavior). With such ordinal data, an ordered probit model is most appropriate. This approach has the advantage that we need not assume a particular form of the utility function and instead use the underlying latent variable to model the risk averting behavior of farm households.

Assume there is a latent variable y_i^* measuring the degree of risk aversion of the i^{th} decision maker that can be described as

$$y_i^* = x_i'\beta + u_i, \qquad 1)$$

for a *kx1* parameter vector β, stochastic disturbance term u_i and a vector of regressors x. The six outcomes for the observed variable y_i are assumed to be related to the latent variable through the following observability criterion:

$$y_i = m \text{ if } \alpha_{m-1} \le y_i^* \le \alpha_m \text{ for } m = 1,\ldots,6 \tag{2}$$

for a set of threshold parameters α_0 to α_6, where $\alpha_0<\alpha_1<\alpha_2<\alpha_3<\alpha_4<\alpha_5<\alpha_6$, $\alpha_0= -\infty$ and $\alpha_6=\infty$.

$$y_i=\begin{cases} 1 \Rightarrow \textit{Extreme} & \textit{if } \alpha_0 = -\infty \le y_i^* < \alpha_1 \\ 2 \Rightarrow \textit{Severe} & \textit{if } \alpha_1 \le y_i^* < \alpha_2 \\ 3 \Rightarrow \textit{Intermediate} & \textit{if } \alpha_2 \le y_i^* < \alpha_3 \\ 4 \Rightarrow \textit{Moderate} & \textit{if } \alpha_3 \le y_i^* < \alpha_4 \\ 5 \Rightarrow \textit{Slight to neutral} & \textit{if } \alpha_4 \le y_i^* < \alpha_5 \\ 6 \Rightarrow \textit{Neutral to preferring} & \textit{if } \alpha_5 \le y_i^* < \alpha_6 = \infty \end{cases}$$

We assume the disturbance term has a standard normal distribution yielding the ordered probit model.[iv] Regressors and associated descriptive statistics have already been presented in table 1, but we note that several characteristics of the game are also included as regressors. First, to formally test the IPRA hypothesis that is suggested by the results in table 3 we include the expected value of each game level as a scale variable. Because extreme risk aversion takes the value one and risk-loving is indicated by a value of six, a positive coefficient sign indicates a negative relationship with risk aversion. Given the results in table 3 we expect the sign of this coefficient to be positive.

Second, in order to test differences in behavior between gains-only games and those with potential losses, we include a dummy variable for games involving real losses. As discussed earlier, this is one way of formally testing for asset integration and loss aversion. If we find this coefficient to be statistically significant, then we can conclude that decision makers treat opportunity losses differently from real losses. Third, we also include a dummy variable for Set 5 in order to test for differences in behavior between real and hypothetical games. Finally, in order to test whether there is path dependence in preference formation and capture the effect of hysteresis, we include a variable defined as ΣX_i, where i is an index of previous game numbers, and X takes a value of 1 if the person wins and –1 if he/she loses. County (*wereda*) dummies are also included to condition for unobservable, site-specific factors affecting reaction to risk.

Our results and the literature on technology adoption suggest that households that have had past economic success and can better insulate themselves from shocks will be less risk averse. We therefore expect wealthier households to be less risk averse than poorer households. To capture this possible component of risk preference determination we include the value of domestic animals, the number of oxen, current cash availability, land size and number of cultivated plots.

The importance of these forms of wealth were discussed in Section 3, so in the interest of brevity we only note here that not only do our preliminary findings and the literature lead us to expect lower risk-aversion among wealthier households, but because of asset market imperfections that severely constrain substitution across different forms of wealth (Reardon and Vosti, 1995; Holden *et al*., 1998) we expect that each wealth category will have an independent effect on risk behavior. For example, because of the political land allocation system it is very difficult to substitute assets for land. Further, because of thin, segmented markets it is often difficult to sell assets for cash and most households are very cash constrained. Indeed, most farm and non-farm income is received in-kind.

We include several characteristics of the household head, including age, gender and educational level, without any *a priori* expectations of signs. As part of household characteristics we also include household size and dependency ratios in our model. The effect of family size on risk aversion is ambiguous. On the one hand, a large family size represents an asset - a larger labor force - and should therefore reduce risk aversion. On the other hand, a large family means more people to feed, which may increase risk aversion. To capture the latter effect separately, we include the dependency ratio (i.e. the ratio of number of individuals younger than 15 years to those older than 15 years) as a separate variable and expect a positive relationship with risk aversion.

TABLE 6 HERE

The results of the ordered probit model are given in table 6, where the dependent variable is the respondent's risk aversion category (1 to 6) for each game played. Sample size is therefore greater than 262, because all respondents played more than one game. All estimates are corrected for heteroskedasticity using robust standard errors (White, 1980). In general, most variables have significant effects and coefficients have the expected signs. All the wealth indicators are significant and positive at the 1% level, indicating that more wealth is indeed correlated with a lower degree of risk aversion. This result is consistent with the literature and our DARA hypothesis. All parameter estimates for variables indicating game characteristics are significant and formally confirm the preliminary results presented in tables 3 and 5. First, as indicated by the negative and a statistically significant loss-game dummy variable, people are more risk averse in games involving real losses than in gains-only games. Adjusting for other factors, therefore, we find that opportunity and real losses are treated very differently by households. This confirms the need for some type of cost effective insurance to be combined with agricultural extension when promoted technologies carry with them downside risk.

Second, there is a highly significant relationship between prior success and reduced risk aversion, as indicated by a significant positive coefficient for the previous luck variable. This implies that people revise their expectations of success even if the actual probability remains constant. Similar behaviors could also be observed in actual farm investment decisions where farm households who had encountered a series of droughts may be more reluctant to undertake risky investment decisions, at least for a while, even when probabilities and wealth levels are unchanged across periods.

Finally, there is a positive relationship between the expected payoff variable and the degree of risk aversion, implying that people are less likely to take risks when high standard deviations and potential gains are features of prospects. This result is consistent with our IPRA hypothesis and suggests that under the current circumstances in the Ethiopian highlands an incremental approach to technology promotion and extension is warranted; indeed, our findings suggest that the possibility of high opportunity losses may be enough to increase risk averting behavior.

A number of household and respondent characteristics are also significantly related to risk aversion. Households with more children per adult are found to be more risk averse than those with low dependency ratios. Age is also positively correlated with the degree of risk aversion, indicating that people become more risk averse as they age. Males are the major decision makers in most households in Ethiopia. In our model, male respondents are found to be less risk averse than females. Literacy appears to show mixed results depending on whether the household is located in South Wollo or East Gojjam, though there are relatively few other differences across the two zones. Significant *wereda* dummies indicate systematic unobservable differences in risk aversion across study sites.

TABLE 7 HERE

FIGURE 2 HERE

The marginal effects of independent variables on risk aversion outcomes computed at the means are provided in table 7. Simulations of predicted probabilities from varying levels of select independent variables are provided in Figure 2. A number of findings seem worth noting. For example, we see that holding all other variables at their means playing a game involving losses increases the probability of being in the extreme risk aversion category by almost 9% and severe risk aversion by about 13%. At the same time it tends to pull people out of the moderate risk aversion and risk-neutral categories. We can conclude from these results that the possibility of losses seems to have not only a statistically significant, but also an empirically large effect on risk aversion. Insurance therefore appears to be in order.

Second, past successes (i.e. previous luck) also tend to have empirically important effects. For example, if the respondent succeeded in one more game previously out of all those played there is a reduced probability of being in the extreme risk aversion category of 1.3% and a 2.5% lower chance of exhibiting severe risk averting behavior. Similar, but positive magnitudes are then observed for the probabilities of being in the moderate and risk-neutral categories. This tells us that not only do past successes build on each other, but they build on each other quickly, suggesting that initially introducing agricultural extension measures with very high probabilities of success can help villagers be more comfortable with taking subsequent risks that have higher expected payoffs.

We see that a number of wealth variables suggest that wealth accumulation – whether in the form of oxen, total domestic animals, cash or land - tends to reduce risk aversion and move respondents into moderate risk aversion, risk-neutral or risk-loving categories and away from extreme, severe and intermediate risk aversion. This is consistent with a DARA-type hypothesis. Particularly animal accumulation is empirically very important, with one more ox reducing the probability of being severely, extremely or intermediately risk averse by 18%. An additional ETB 1000 ($117) in total animal value is estimated to reduce the chance of being in these categories by 14.6%. This again suggests that building a history of success (e.g. asset accumulation) is important before more ambitious and risky projects are proposed to farmers.

We also find an empirically important link between household fertility (though not total household size) and risk aversion. Indeed an increase in the dependency ratio of one child per adult is correlated with an increased chance of being in the extreme, severe or intermediate risk aversion categories of 9.0%. In the real world this then translates into an avoidance of risky, but high expected-value, technologies such as improved seeds and chemical fertilizers. Such findings suggest an important avenue by which high fertility – as is the norm in Ethiopia – can reduce economic welfare.

7. Conclusions and policy implications

It has long been recognized that agricultural production and investment decisions in developing countries are affected by risks like drought, pests, flooding, livestock diseases and human illness. Because of poorly developed or absent credit and insurance markets it is difficult to pass any of these risks to third parties. As a result, it is often found that households are reluctant to adopt technologies when they involve risk. Despite risk's potentially central role in investment decisions, there have been few attempts to estimate the magnitude and particularly the nature of risk aversion of farm households in developing countries. This study attempts to determine farmers' risk preferences and use them to draw policy inferences. Using data from the Ethiopian highlands we find that over 50 percent of households are severely or extremely risk averse. This contrasts with studies from Asia that found most decision makers are moderately to intermediately risk averse.

Looking deeper, we are able to disaggregate risk averting behavior and its determinants. We find that children have a statistically and empirically significant affect in promoting risk aversion among adult decision makers. This result is intuitive to any parent, but suggests yet another important avenue by which reducing fertility can promote rural economic growth. Our results suggest that household heads will be more willing to accept risk in exchange for reward when there are fewer children to support.

We also find that households that stand to lose as well as gain something from participation in games are systematically – and empirically significantly - much more risk averse than households playing gains-only games. This strongly suggests that extension efforts involving possible losses may face legitimate, widespread resistance at the farm level in poor countries. Promotion of technology with downside risks – even if the upside potential is enormous – should therefore be combined with insurance.

Our results suggest, however, that insurance does not need to be provided forever. After initial successes have convinced farmers that technologies are viable (i.e. after they have had some luck) risk aversion declines. We also find significant differences in risk averting behavior between relatively poor and wealthy farm households. This suggests that as wealth is built up households will accept more risk in exchange for higher returns.

Both these findings suggest strong path dependence associated with risk behavior. Efforts to develop poor rural areas through promotion of risky technologies must therefore take this path dependence into account. Early successes seem to be important, but households should also be allowed to build up wealth in places like rural Ethiopia before they are challenged or tempted to take on more risky ventures. Furthermore, the finding that even without the possibility of losses households are much more risk averse when stakes are higher, suggests that agricultural extension should start modestly before asking households to take larger gambles. And again, until a positive history is in place and wealth is built up it is likely that households will need insurance to accept downside risk.

In the longer-run, of course, the development of private markets to spread risk is the key to success. Indeed, broad-based economic development including the development of credit and insurance markets is the most certain way to reduce the levels of risk aversion among farmers. Most practitioners would agree, however, that such developments are many years away, suggesting that interim risk mitigation solutions to promote rural development in low-income countries may be important for some time

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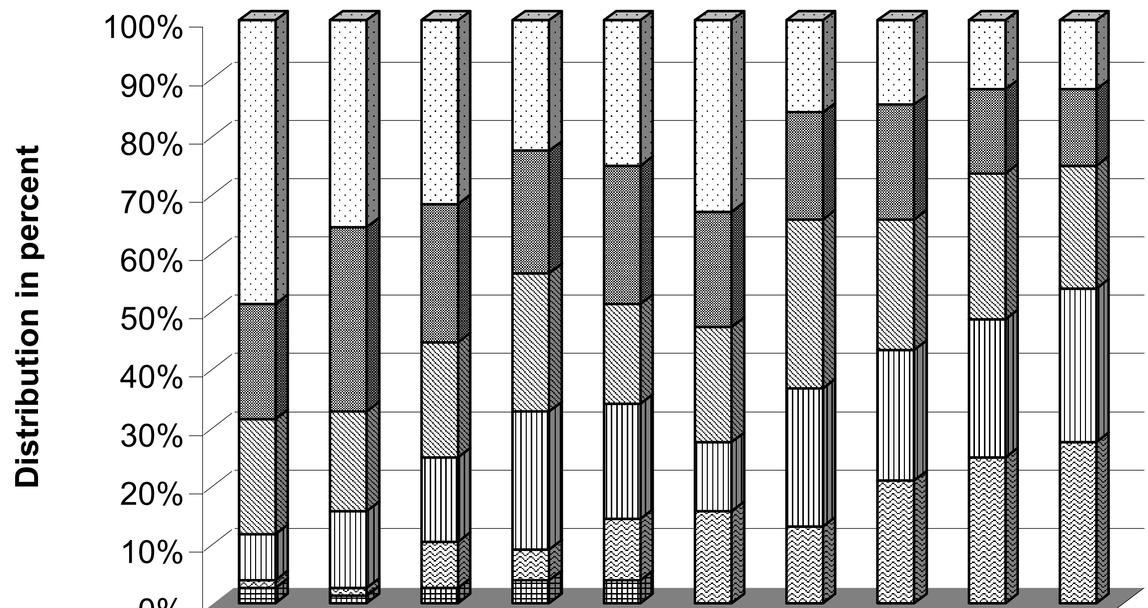
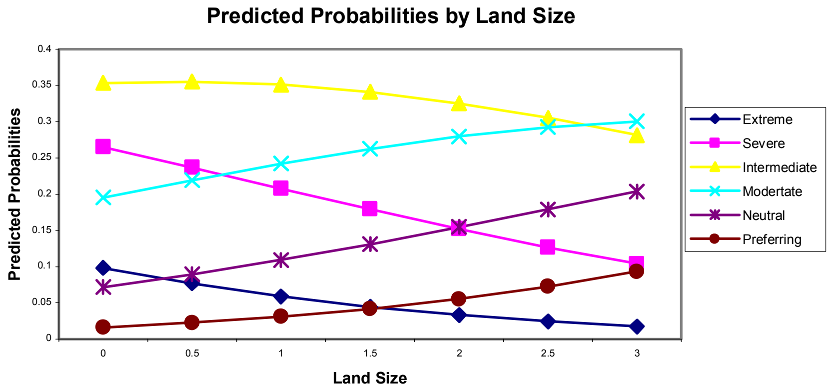
Fig. 1. Comparison of risk distribution between gains-only, and gains and losses games of the experiment (only those who played both)

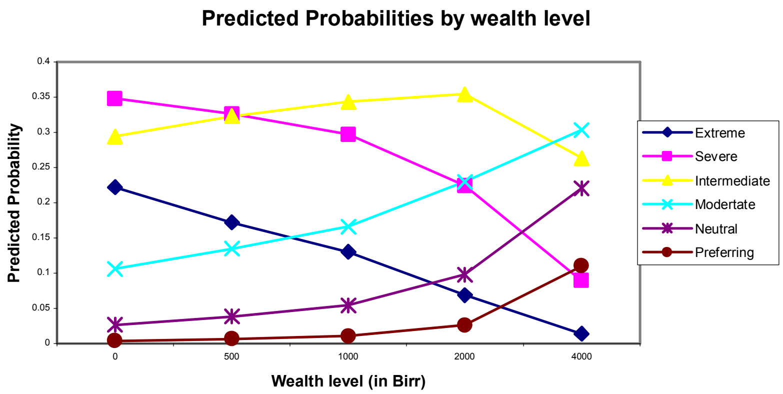


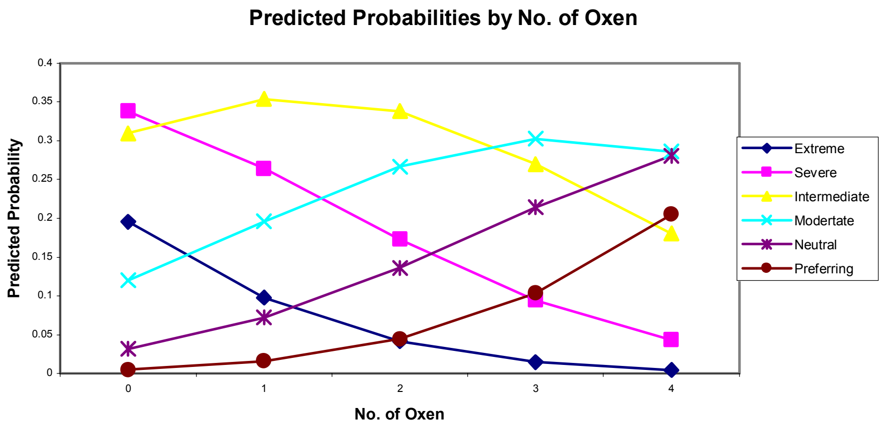
	1	2	3	4	5	6	7	8	9	10
Preferring	37	27	24	17	19	25	12	11	9	9
Nuetral	15	24	18	16	18	15	14	15	11	10
Moderate	15	13	15	18	13	15	22	17	19	16
Intermediate	6	10	11	18	15	9	18	17	18	20
Severe	1	1	6	4	8	12	10	16	19	21
Extreme	2	1	2	3	3	0	0	0	0	0

Game levels (Nos. 6 to 10 are loss games)

Fig. 2. Predicted probabilities






Predicted Probabilities by No. of Oxen
Predicted Probability
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
1
2
3
4
No. of Oxen
Extreme
Severe
Intermediate
Modertate
Neutral
Preferring

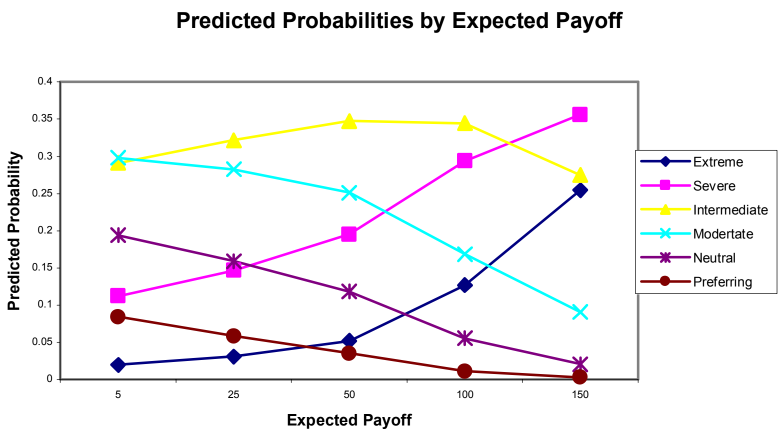

Predicted Probabilities by Expected Payoff
Predicted Probability
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5
25
50
100
150
Expected Payoff
Extreme
Severe
Intermediate
Modertate
Neutral
Preferring

Table 1: Descriptive Statistics and Regressors Used in Ordered Probit Model (n=262)

Variable	Mean	Std dev	Min	Max
Gender of the respondent (1=male)	0.85	0.34	0	1
Age of the respondent	46.73	15.77	15	90
Literacy of respondent (1=yes)	0.27	0.45	0	1
Family size	5.39	2.44	1	15
Household dependency ratio (the ratio of number of household members below age15 to above age 15)	1.02	0.80	0	5
Household farm size (hectares)	0.96	0.70	0.01	3.38
Number of plots	4.91	2.55	1	9
Number of oxen	1.38	1.15	0	4
Value of domestic animals in '000 Ethiopian Birr (Proxy for stock of wealth) *	1.95	1.76	0.01	8.87
Annual liquid cash availability to a household in ETB '000s (Cash collected from all sources of cash revenue less cash expenditure in one year) *	0.35	0.93	-2.37	9.57
Subjective discount rates[v]	0.39	0.34	0	0.83

* $1US= ETB 8.50

Table 2: The Basic Structure of the Experiment

Prospects	Bad harvest	Good harvest	Expected gain (EV)	Std.dev./ Spread	CPRA Coefficient (γ)	Risk classification
1	0.50	0.50	0.50	0	∞ to 7.47	Extreme
2	0.45	0.90	0.675	0.225	7.47 to 2.00	Severe
3	0.40	1.20	0.80	0.40	2.00 to 0.85	Intermediate
4	0.30	1.50	0.90	0.60	0.85 to 0.32	Moderate
5	0.10	1.90	1.00	0.90	0.32 to 0	Slight to neutral
6	0	2.00	1.00	1.00	0 to - ∞	Neutral to preferring

Table 3: Distribution of Risk Averting Behavior by Experiment Set[+].

Risk category	Gains-only games					Gains-and-losses games[++]				
	1	2	3	4	5	1	2	3	4	5
Extreme	15.3%	19.8%	24%	30.5%	36.6%					
Severe	13.4%	17.2%	21.4%	20.6%	19.1%	15.8%	13.2%	21.1%	25%	27.6%
Intermediate	19.5%	17.9%	21.8%	21.4%	18.3%	11.8%	23.7%	22.4%	23.7%	26.3%
Moderate	17.9%	17.9%	11.8%	12.2%	9.2%	19.7%	28.9%	22.4%	25%	21.1%
Slight to neutral	13.4%	13.7%	10.7%	8%	8.4%	19.7%	18.4%	19.7%	14.5%	13.2%
Neutral to preferring	20.6%	13.4%	10.3%	7.3%	8.4%	32.9%	15.8%	14.4%	11.8%	11.8%

+ Percentage shares are calculated for each game level, where 1 is the lowest and 5 is the highest game level. Percentages shares thus should be read as column percentages. A total of 262 households participated in the gains-only games and 76 participated in gains-and-loss games.

++ Distributions in the gain and loss games are conditional distributions (distributions given that a respondent played a gain and loss game).

Table 4: Chi-Square Tests for Equivalence of Risk Preferences for Gains-Only and Gains-and-Loss Games (a test of loss aversion or asset integration)

Hypothesis	Statistics+
Gain-only game in experiment 1 is equivalent to loss game in experiment 1	14.230 (0.0142)
Gain-only game in experiment 2 is equivalent to loss game in experiment 2	21.364 (0.0007)
Gain-only game in experiment 3 is equivalent to loss game in experiment 3	13.057 (0.023)
Gain-only game in experiment 4 is equivalent to loss game in experiment 4	16.197 (0.006)
Gain-only game in experiment 5 is equivalent to loss game in experiment 5	15.709 (0.008)

+ The X^2 statistics are calculated based on the distribution of risk preferences given in the Appendix. Numbers in parentheses are p-values. The degrees of freedom are calculated as *df* = (r-1)*(c-1), where r is the number of categories (6 in our case) and c is the number of columns to be compared (2 in our case).

Table 5: Median Levels of Risk Aversion

Experiment sets	Gains-only games			Gains-and-losses games		
	East Gojjam	South Wollo	All	East Gojjam	South Wollo	All
Set 1	4	3	4	5	4	5
Set 2	4	2	3	4	3	4
Set 3	3	2	3	4	3	4
Set 4	3	2	3	4	3	4
Set 5	3	2	2	4	3	3

1=Extreme ($\gamma=\infty$ to 7.47), 2= Severe (γ=2.00 to 7.47), 3=intermediate (γ=0.85 to 2.00), 4=moderate (γ=0.32 to 0.85), 5=slight to neutral (γ=0 to0.32), 6=neutral to loving(0 to - ∞)

Table 6: Ordered Probit Models of Risk Aversion

Variable		Parameter Estimates		
		E. Gojjam	S. Wollo	All sites
Dummy for loss games (1=loss games)		-1.055*** (0.105)	-0.183 (0.151)	-0.613*** (0.089)
Previous luck		0.105*** (0.028)	0.123*** (0.038)	0.119*** (0.023)
Expected payoff		-0.013*** (0.001)	-0.008*** (0.002)	-0.010*** (0.001)
Land size (hectares)		-0.099 (0.090)	1.107*** (0.087)	0.127* (0.079)
Number of plots		0.104*** (0.025)	-0.070* (0.041)	0.084*** (0.019)
Number of oxen		0.621*** (0.054)	0.297*** (0.087)	0.473*** (0.048)
Value of domestic animals (ETB '000)		0.314*** (0.038)	0.685*** (0.060)	0.385*** (0.033)
Cash liquidity (ETB '000)		0.108* (0.059)	0.032 (0.022)	0.063*** (0.021)
Gender of the household head (Male=1)		0.716*** (0.170)	0.048** (0.187)	0.247** (0.119)
Age of the household head		-0.017*** (0.003)	-0.010*** (0.003)	-0.012*** (0.002)
Literacy (1=literate)		-0.150* (0.020)	0.304*** (0.098)	-0.027 (0.064)
Family Size		0.053* (0.029)	-0.013 (0.019)	-0.018 (0.015)
Dependency ratio		-0.407*** (0.070)	-0.018 (0.064)	-0.232*** (0.045)
Dummy for hypothetical games (1=hypothetical games)		0.393*** (0.136)	0.236 (0.175)	0.299*** (0.108)
Site dummy[++] (1=Machakel)		-0.566*** (0.144)		-0.572*** (0.121)
Site dummy (1=Gozamin)				-0.356*** (0.101)
Site dummy (1=Enemay)		0.319*** (0.109)		0.095 (0.105)
Site dummy (1=Tehuldere)			0.0002 (0.114)	-0.218** (0.109)
Ancillary parameters (Threshold parameters)	Cut1 (α_1)	-0.948 (0.239)	-0.365 (0.269)	-0.896 (0.188)
	Cut2(α_2)	0.287 (0.234)	0.513 (0.272)	0.062 (0.186)

Cut3(α_3)	1.282	1.557	1.009
	(0.228)	(0.285)	(0.186)
Cut4(α_4)	2.159	2.325	1.803
	(0.229)	(0.303)	(0.192)
Cut5(α_5)	3.099	2.909	2.596
	(0.235)	(0.316)	(0.198)
Log likelihood function	-1109.073	-799.105	-1998.583
Wald X^2 (18)	676.13	404.11	725.97
Pseudo R^2	0.2922	0.261	0.265
Number of observations	885	645	1530

Dependent variable: degrees of risk aversion (1=extreme,….6=Neutral to risk loving).
Figures in parentheses are robust standard errors.
***, **, * indicate significance levels at 1%, 5% , and 10% levels, respectively.
++ Kalu is the reference site for South Wollo as well as pooled data, whereas Gozamin is the reference site for East Gojjam.

Table 7: Changes in Predicted Probabilities (marginal effects) by Risk Categories

Variables	Changes in Predicted Probabilities (marginal effects)					
	Extreme	Severe	Intermediate	Moderate	Neutral	Preferring
Dummy for loss games (1=loss games)	0.088*** (0.016)	0.127*** (0.019)	0.003 (0.008)	-0.105*** (0.018)	-0.081*** (0.011)	-0.032*** (0.005)
Previous luck	-0.013*** (0.003)	-0.025*** (0.005)	-0.007*** (0.002)	0.019*** (0.004)	0.018*** (0.004)	0.008*** (0.002)
Expected payoff	0.001*** (0.0001)	0.002*** (0.0002)	0.001*** (0.0001)	-0.002*** (0.0002)	-0.002*** (0.0002)	-0.0007*** (0.0001)
Land size (hectares)	-0.014*** (0.009)	-0.027*** (0.017)	-0.007 (0.005)	0.021 (0.013)	0.019 (0.012)	0.009 (0.005)
Number of plots	-0.009*** (0.002)	-0.018*** (0.004)	-0.005*** (0.001)	0.014*** (0.003)	0.013*** (0.003)	0.006*** (0.001)
Number of Oxen	-0.052*** (0.006)	-0.101*** (0.012)	-0.027*** (0.006)	0.077*** (0.011)	0.072*** (0.008)	0.032*** (0.005)
Value of animals (ETB '000)	-0.042*** (0.001)	-0.082*** (0.001)	-0.022*** (0.001)	0.062*** (0.001)	0.058*** (0.001)	0.026*** (0.001)
Cash liquidity (ETB '000)	-0.007*** (0.000)	-0.013*** (0.000)	-0.004*** (0.000)	0.010*** (0.000)	0.010*** (0.000)	0.004*** (0.000)
Gender of the household head (male=1)	-0.032* (0.019)	-0.053** (0.026)	-0.006* (0.003)	0.042* (0.022)	0.035** (0.016)	0.014** (0.006)
Age of the household head	0.001*** (0.0003)	0.003*** (0.0005)	0.0007*** (0.0002)	-0.002*** (0.0004)	-0.002*** (0.0004)	-0.0008*** (0.0002)
Literacy (1=literate)	0.003 (0.007)	0.006 (0.014)	0.002 (0.004)	-0.004 (0.011)	-0.004 (0.01)	-0.002 (0.004)
Family Size	0.002 (0.001)	0.004 (0.003)	0.001 (0.001)	-0.003 (0.002)	-0.003 (0.002)	-0.001 (0.001)
Dependency ratio	0.026*** (0.005)	0.050*** (0.010)	0.013*** (0.004)	-0.038*** (0.008)	-0.035*** (0.007)	-0.016*** (0.003)
Site dummy++ (1=Machakel)	0.084*** (0.022)	0.119*** (0.024)	-0.002 (0.009)	-0.099*** (0.022)	-0.074*** (0.014)	-0.028*** (0.006)
Site dummy (1=Gozamin)	0.046*** (0.015)	0.076*** (0.021)	0.009** (0.004)	-0.061*** (0.018)	-0.050*** (0.013)	-0.020*** (0.006)
Site dummy (1=Enemay)	-0.010 (0.010)	-0.020 (0.022)	-0.006 (0.008)	0.015 (0.016)	0.015 (0.017)	0.007 (0.008)
Site dummy (1=Tehuldere)	0.027* (0.015)	0.047** (0.023)	0.007*** (0.003)	-0.037* (0.019)	-0.031** (0.014)	-0.013** (0.006)
Dummy for hypothetical games (1=hypothetical)	-0.029*** (0.009)	-0.062*** (0.022)	-0.025** (0.013)	0.044*** (0.015)	0.048*** (0.018)	0.024** (0.011)

Dependent variable: degrees of risk aversion.
Figures in parentheses are standard errors.
***, **, * indicate significance levels at the 1%, 5%, and 10% levels respectively.
++ Kalu is the reference site.

Appendix
Risk Games Used in the Experiment
$1.00 US = ETB 8.5

Set 1: 0.50 Birr

Gains-only			Risk aversion class	Gains and losses	
Choice	Bad harvest	Good harvest		Bad harvest	Good harvest
1	0.50	0.50	Extreme	0	0
2	0.45	0.90	Severe	-0.05	0.40
3	0.40	1.20	Intermediate	-0.10	0.70
4	0.30	1.50	Moderate	-0.20	1.00
5	0.10	1.90	Slight to neutral	-0.40	1.40
6	0	2.00	Neutral to preferring	-0.50	1.50

Set 2: Birr 2.50

Gains-only			Risk aversion class	Gains and losses	
Choice	Bad harvest	Good harvest		Bad harvest	Good harvest
1	2.50	2.50	Extreme	0	0
2	2.25	4.50	Severe	-0.25	2.00
3	2.00	6.00	Intermediate	-0.50	3.50
4	1.50	7.50	Moderate	-1.00	5.00
5	0.50	9.00	Slight to neutral	-2.00	7.00
6	0	10.00	Neutral to preferring	-2.50	7.50

Set 3: Birr 5

Gains-only			Risk aversion class	Gains and losses	
Choice	Bad harvest	Good harvest		Bad harvest	Good harvest
1	5.00	5.00	Extreme	0	0
2	4.50	9.00	Severe	-0.50	4.00
3	4.00	12.00	Intermediate	-1.00	7.00
4	3.00	15.00	Moderate	-2.00	10.00
5	1.00	19.00	Slight to neutral	-4.00	14.00
6	0	20.00	Neutral to preferring	-5.00	15.00

Set 4: Birr 10

Gains-only			Risk aversion class	Gains and losses	
Choice	Bad harvest	Good harvest		Bad harvest	Good harvest
1	10.00	10.00	Extreme	0	0
2	9.00	18.00	Severe	-1.00	8.00
3	8.00	24.00	Intermediate	-2.00	14.00
4	6.00	30.00	Moderate	-4.00	20.00
5	2.00	38.00	Slight to neutral	-8.00	28.00
6	0	40.00	Neutral to preferring	-10.00	30.00

Set 5: Birr 15 (hypothetical)

Gains-only			Risk aversion class	Gains and losses	
Choice	Bad harvest	Good harvest		Bad harvest	Good Harvest
1	15.00	15.00	Extreme	0	0
2	13.50	27.00	Severe	-1.50	12.00
3	12.00	36.00	Intermediate	-3.00	21.00
4	9.00	45.00	Moderate	-6.00	30.00
5	3.00	57.00	Slight to neutral	-12.00	42.00
6	0	60.00	Neutral to preferring	-15.00	45.00

[i] The authors particularly thank Gunnar Köhlin, Fredrik Carlsson, Thomas Sterner, Olof Johansson-Stenman, Gardner Brown, Stein Holden, and Ephraim Nkonya for their comments. Suggestions and encouragements from Beijer Institute board members at Beijer workshops are also acknowledged. The study is financed by Sida.

[i] The authors particularly thank Gunnar Köhlin, Fredrik Carlsson, Thomas Sterner, Olof Johansson-Stenman, Gardner Brown, Stein Holden, and Ephraim Nkonya for their comments. Suggestions and encouragements from Beijer Institute board members at Beijer workshops are also acknowledged. The study is financed by Sida

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[iii] Where m is a monetary gain or loss, w is initial wealth, and $W (=w+m)$ is final wealth level.

[ii] \$1US = ETB 8.50

[iv] An average reward of ETB 30 is equivalent to US \$3.5 (US\$1=Birr 8.5).

[v] Households were confronted with choices of money that differ both in magnitude and time to calculate the implied subjective discount rate. For more insights on data collection and estimation of the individual subjective discount rates, see Yesuf (2003).

[iii] Following the definition of risk aversion, a CPRA coefficient of 7.48 to smaller stake (ETB 0.50) implies an absolute risk aversion of 0.00748 at a monetary gain of ETB 1000. Assuming an initial wealth of ETB 2000, this implies a relative risk aversion of 15.

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[iv] A logistic distribution could also be assumed, which would lead to an ordered logit model. Our results using both approaches are similar and so only the ordered probit results are presented.

[v] Households were confronted with choices of money that differ both in magnitude and time to calculate the implied subjective discount rate. For more insights on data collection and estimation of the individual subjective discount rates, see Yesuf (2003).