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IFPRI Discussion Paper 00715

September 2007

Risk Aversion in Low Income Countries

Experimental Evidence from Ethiopia

Mahmud Yesuf, Ethiopian Development Research Institute and Addis Ababa University

and

Randy Bluffstone, Portland State University

Environment and Production Technology Division

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IFPRI's research, capacity strengthening, and communications work is made possible by its financial contributors and partners. IFPRI gratefully acknowledges generous unrestricted funding from Australia, Canada, China, Denmark, Finland, France, Germany, India, Ireland, Italy, Japan, the Netherlands, Norway, the Philippines, Sweden, Switzerland, the United Kingdom, the United States, and the World Bank.

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ACKNOWLEDGMENTS

The authors particularly thank Gunnar Köhlin, Fredrik Carlsson, Thomas Sterner, Olof Johansson-Stenman, Gardner Brown, Ephraim Nkonya, Claudia Ringler, and Stein Holden for their comments. Suggestions and encouragements from Beijer Institute board members at Beijer workshop are also acknowledged. The study is financed by Sida. The paper forms part of a brownbag and working paper series supported by BEAF under the project "Food and Water Security under Global Change: Developing Adaptive Capacity with a Focus on Rural Africa," which is associated with the CGIAR Challenge Program on Water and Food.

ABSTRACT

Production systems in low-income developing countries are generally poorly diversified, focusing on rainfed staple crop production and raising livestock. 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 the expected net return is high, households are reluctant to adopt new agricultural technologies when they involve risk. Better understanding risk behavior will be essential for identifying appropriate farm-level strategies for adaptation to climate change by low-income farmers.

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 an experimental approach applied to 262 households in the Ethiopian highlands with real payoffs. By incorporating both small and large stakes and gains and losses into the experiment, we test for the presence of low stake risk aversion and loss aversion. We find that more than 50 percent of the households are severely or extremely risk averse. This contrasts with studies in Asia where most household 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 losses as well as gains may face systematic resistance by farmers in low-income, high-risk environments. Promotion of technologies with downside risks – even if the upside potential is enormous – should therefore be combined with insurance or other support. We also find that even without the possibility of losses households are much more averse to risk when stakes are high.

Results indicate that insurance or other support can likely be phased out. After initial successes have convinced farmers that technologies are viable, risk aversion declines. There are also significant differences in risk averting behavior between relatively poorer and wealthier farm households, which is consistent with decreasing absolute risk aversion. This suggests that as wealth is built up households are willing to take on more risk in exchange for higher returns. Both these findings suggest a strong path dependence. Efforts to develop poor rural areas through promotion of risky technologies should take this path dependence into account. Early successes are important, but households should also be allowed to build up wealth 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 on larger gambles.

Key Words: Ethiopian farm households; experimental studies; loss aversion; risk aversion

1. INTRODUCTION

Agricultural production in low-income countries is generally poorly diversified, focusing on rain-fed staple crop 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 livestock diseases and changing output prices. Furthermore, agricultural production 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 overshadowed and dominated by, a multitude of risks.

The existence of such risks has been found to alter household 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 they would have used had they simply maximized expected profits. It is also not uncommon to observe farm households in developing countries being reluctant to adopt new technologies even when those technologies provide higher returns to land and labor than traditional technologies. One aspect of this reluctance is reaction to risk.

Foregoing welfare-improving opportunities because of perceptions of risks involved by resource-poor farmers has important policy implications under average production conditions, but even more so in the facing of growing climate variability and climate change. A 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 in the former futures and insurance markets do not exist for virtually any type of agricultural risk and credit markets, which allow a sharing of risk by debtors and creditors, are extremely thin. An alternative to a status quo where households simply forego such opportunities is to therefore develop or improve the functioning of these markets. This may involve using policies or public resources to make insurance available and to thicken rural credit markets, for example. Other measures could be to provide new technologies or inputs together with long-term support through extension services, for example.

Some advances have been made in these areas. Small microcredit schemes now abound throughout the developing world and have allowed villagers to accept opportunities without risking their basic livelihoods. There are also initiatives in Sub-Saharan Africa under the auspices of the World Bank and the World Food Programme of the United Nations to develop crop insurance markets.

The existence of agricultural risk and its effects in low-income countries where 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 this context. For example, is it the simple possibility of loss that drives aversion to risk or do the levels of potential gains and losses affect behavior in response to risk in low-income rural settings? Does the buildup of wealth at very low income levels affect risk behavior? Do past successes within risky environments have an impact on future choices? 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, in an environment of missing markets and low incomes there might be important linkages between attitudes toward risk and seemingly disparate elements such as household fertility behavior, educational decisions and even gender policies. Working on these elements could thus improve outcomes for technology adoption. It is therefore important to better understand household responses to agricultural risk and the contributors to those responses

This paper uses an experimental approach with real payoffs to contribute to closing 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 the experiment, 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 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 experimental results. An econometric model of risk averting behavior is presented and the results are discussed in Section 6. Section 7 concludes the paper and draws out policy implications.

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 several 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 the works of 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 the experiments are launched in purely hypothetical settings. As we use an experimental approach, we attempt to avoid this problem by using real payoffs.

Risk aversion is generally defined with reference to the von Neumann-Morgensten expected utility function. Specifically, the second derivative of this utility function contains important information regarding the risk aversion of a decision maker. 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 will be more willing to accept a risky prospect as wealth increases. Increasing Relative Risk Aversion (IRRA) indicates that a person's willingness to accept a risky prospect 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, this theory of behavior has lost ground to other theories due to growing empirical evidence. For example, Rabin (2000) and Rabin and Thaler (2001) show how EU theory fails to describe risk aversion to small stake outcomes. Kahneman and Tversky (1979), and later Benartzi and Thaler (1995) and Thaler et al. (1997) show the presence of loss aversion from different weights people attach to gains and losses and to high and low probability 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 therefore 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 risk averse for small stakes, this therefore implies they are not expected-utility maximizers. Given the assumption of diminishing marginal utility, risk aversion in small stakes also implies extreme risk aversion for larger stakes. Rabin (2000) and Rabin and Thaler (2001) for example show how for any concave utility function, even very little risk aversion over modest stakes leads to very high risk aversion over large stakes. According to Rabin and Thaler, most people are not virtually risk neutral over small stakes and are also very risk averse over large stakes implies that expected utility does not describe the risk behavior of most people accurately. This claim of Rabin and Thaler is supported in a number of studies that show evidence of risk aversion in low stake experiments (Davis and Holt 1993; Eggert and Martinsson (forthcoming); and Holt and Laury (forthcoming).

The assumption that decision-makers should give equal weights for choices that involve gains and losses has also been challenged by modern research in behavioral economics, where it is generally found that individuals are more sensitive to losses than gains. Loss aversion was introduced by Kahneman and Tversky (1979) as part of prospect theory. In conjunction with other new concepts in behavioral economics, such as mental accounting and narrow bracketing, Benartzi and Thaler (1995) and Thaler et al. (1997) use loss aversion to describe discrepancies in choices for gains and losses.

3. DESCRIPTION OF THE STUDY SITE AND HOUSEHOLD DESCRIPTIVE STATISTICS

The purpose of this research is to contribute to the empirical literature on the nature and level of behavioral responses 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 risk behavior findings are then used as the dependent variable in an ordered probit model that tries to explain those behavioral 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 12 villages in the Ethiopian Highlands in the State of Amhara. A random sample of 262 farm households was chosen from seven villages to participate in the experiment. Ethiopia is one of the poorest countries in the world, with a per capita gross national income of US$160 per day, which is less half the cutoff level for extreme poverty under the Millennium Development Goals adopted 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. 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 would be best described as 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 US$170. Even if we apply the 2005 purchasing power parity adjustment factor of 6.25 to these households as is often done on the national level to compare incomes, per capita incomes are only US$0.50 per person per day. Though not at all atypical of very low-income countries – and perhaps more than 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 the mean off-farm income is only 10 percent of total household income. In such an environment, consumption and production decisions are made jointly by households. This implies that endowments, such as wealth and family size and household characteristics, will affect production outcomes (Jacoby 1993).

Table 1 presents descriptive statistics for the sample households. These variables are also the regressors included in the ordered probit model presented in Section 5. Households typically hold animals, including bulls, cows, sheep and goats. Products from these animals are sold to earn income and the animals themselves are significant assets sold to finance consumption needs. Bulls are the most important and valuable animal held by households, because of their role in providing traction. In the larger sample, over half of all households had at least one bull and mean holding was 2.3. In the smaller sample used here households, on average, have less than a pair of oxen and the total value of animals is ETB 1950 (US$229).

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 '000 Ethiopian Birr (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[1]	0.39	0.34	0	0.83

* $1US= ETB 8.50

We see that in general respondents (typically household "heads") are men, who are illiterate. Indeed, more than 70 percent of the sampled household heads are illiterate and fewer than 5 percent 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 5 plots. Farm plots in these hill villages tend to be small. In Ethiopia land is state property and farm households are granted 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 valued at ETB 350 or US$42, implying significant scarcity of cash.

[1] 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).

4. DESCRIPTION OF THE EXPERIMENT

In our experiment, subjects are offered choices to reveal their risk preferences for both 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 with important policy implications. This offers a test for 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.

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 very low, so the amounts listed indeed provide significant incentive for respondents to carefully consider the options and reveal their true preferences. On average, each household won a sum of ETB 30, which is about 10 percent of the monthly income of unskilled labor in the country.[2]

In our experiment we explicitly test for DARA, IRRA and IPRA-type behaviors, that is, Decreasing Absolute Risk Aversion, Increasing Relative Risk Aversion, and Increasing Partial Risk Aversion, respectively, as described above. The state of absolute risk aversion across farm households is investigated by presenting an identical choice set given as Set 1 in the Appendix to farm households with different levels of initial wealth. To examine the nature of partial risk aversion for each farm household, we then increase the outcome of the first choice set by factors of 5, 10, 20 and 30. These are represented as Sets 2 – 5 in the Appendix.

Table 2. The basic structure of the experiment

Prospects	Bad harvest	Good harvest	Expected gain (EV)	Standard deviation (SDV) or 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

We follow the experimental design developed by Binswanger (1980) to reveal risk preferences and frame the choices to reflect real life farming decisions. The basic structure of the experiment using Set 1 as an example is given in Table 2. The farm households were told to assume there are six different

[2] $1US = Birr (ETB) 8.50

farming systems, all with similar costs but different output levels depending on a 50 percent probability of a good or bad harvest. Then they were shown the good and the bad outcomes of each of the six different systems. For each alternative, the expected gain and spread increased. Once they had chosen one of the techniques, a coin was tossed to determine whether they would be given the good or bad outcome as a reward. It is typically useful to compute a risk aversion coefficient that can serve as a measure of household level 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 upper and lower limits of the CPRA coefficients for each prospect of our experiment are given in Table 2.

To test for significant differences in behavior when faced with the possibility of losses as opposed to gains-only, choice sets 1 to 4 involving actual losses to farm households were incorporated into the experiment. In these four games households could actually lose money. Only those farm households who won enough money in the gains-only part and were willing 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 problems of possible 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. As will be shown in the following sections, however, these problems are easily addressed and the econometric model is adjusted accordingly.

5. EXPERIMENTAL RESULTS

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 for each level of the experiment. In Table 3, we observe that a majority of the farm households exhibit intermediate, severe, and extreme risk aversion. Even at the lowest level of the game, about 29 percent of the farm households chose the alternatives representing severe to extreme risk aversion. This proportion increases to about 56 percent at the highest level of the game. This contrasts with slight risk aversion, neutrality and risk preferring, where the proportion declined from 34 percent in game 1 to 16.8 percent in game 5. The share of responses falling into intermediate and moderate risk aversion categories remain stable between games 1 to 4 (34% and 37%), but decline to 28 percent 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 individual farm households are more risk averse as the size of the game increases.

Table 3. Distribution of risk averting behavior by 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).

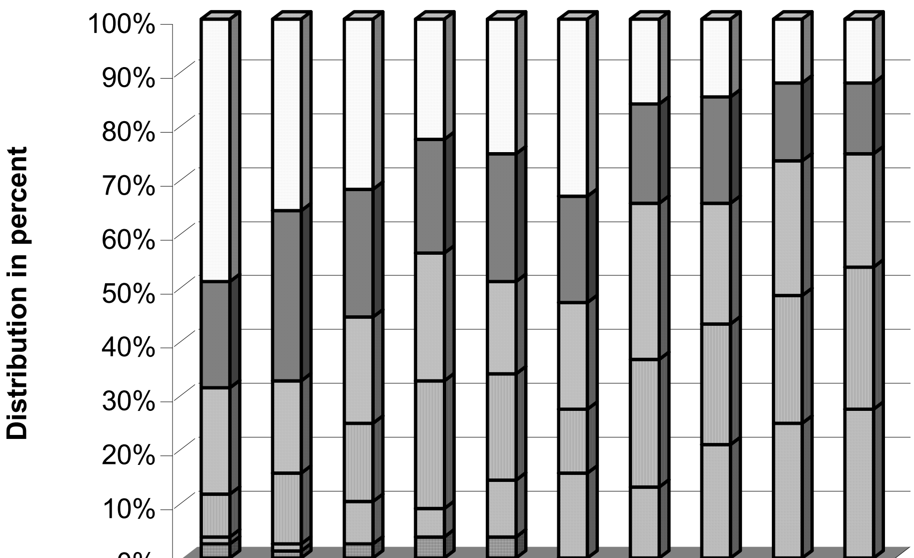
Comparing the distribution of risk preferences in Table 3 to other similar studies in developing countries, Binswanger (1980), and Wik and Holden (1998) found the proportion of respondents in the intermediate to moderate risk category to be 83 percent in India and 52 percent in Zambia. That our sample has so many more respondents exhibiting higher levels of risk aversion suggests that farm households in Ethiopia are much more risk averse than in India and Zambia.

With 29 percent of the respondents severely to extremely risk averse for an ETB 0.50 (i.e. US$0.06) bet implies very high risk aversion at relatively larger stakes, following Rabin and Thaler

(2001). Calculated at ETB 1000 (US$118) as a monetary reward from a modest farming activity, an extreme or severe risk aversion for this group implies a relative risk aversion of around 15, given an average wealth level of ETB 2000 (US$235), as shown in Table 1 (stock of domestic animals, which is a proxy for total wealth). This level of risk aversion is very high,[3] suggesting that a process other than expected utility maximization is occurring.

A comparison of choices between games involving only gains and gains and actual losses (in the sub sample of 76 respondents who participated in both sections of the experiment) shows an inclination of farm households to be more risk averse when there are actual losses. Figure 1 presents these results graphically.

Figure 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)

The null hypothesis that the subjects' risk preferences are equivalent in both kinds of games is also rejected for each portion of the experiment. The results of the chi-square tests are summarized in Table 4.

[3] Following the definition of risk aversion in Section 2, a CPRA coefficient of 7.48 for a smaller stake (50 cent) implies an absolute risk aversion of 0.00748 at a monetary gain of ETB 1000. Assuming a lifetime wealth of ETB 2000, this implies a relative risk aversion of 15.

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)

a) Hypothesis	b) 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 chi-square statistics are calculated based on the distribution of risk preferences, given in the Appendix under Fig. 1. 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).

The results of these tests show a significant difference in risk preference in gains-only and gains-and-losses games. 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 can be expected to be more responsive to the possibility of agricultural losses than stochastic output gains. Providing some type of insurance or other support to farmers who try new, but risky technologies is therefore suggested by our findings.

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 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 and the probability of each outcome is the same, simply increasing the stakes causes households to become more risk averse. This 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. Similarly, technologies that support adaptation to climate change should be implemented incrementally and should be as low-risk as possible, at least at the outset.

We also note that the median respondent in South Wollo is substantially more risk averse than the median respondent 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 than in East Gojjam and the region has a more dramatic history of severe food shortages. This suggests two conclusions. First, the level of income – even at such low average levels - may matter for risk aversion. Extension programs therefore must be particularly careful and move much more slowly with very low-income households than higher-income households even in a situation of overall general poverty levels.

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 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 were permitted to participate in the gains-and-losses game. These findings suggest that even in very poor regions success can build on success, with people being more 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 using an econometric model tailored to the experimental results. Our experimental data has the feature that it is ordinal in nature, ranging 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:

$$y_i = m \text{ if } \alpha_{m-1} \le y_i^* \le \alpha_m \text{ for } m = 1,...,6 \qquad (2)$$

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 $\alpha_6=\infty$.

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

We assume the disturbance term has a standard normal distribution yielding the ordered probit model.[4] Regressors and associated descriptive statistics have already been presented in Table 1.

[4] 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.

Several characteristics of the game are 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. 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 games involving losses, we include dummy variables 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 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, household land size and the number of cultivated plots.

The importance of these different 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 among different forms of wealth (Reardon and Vosti 1995; Holden et al. 1998) we expect that each wealth category would 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 very 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 the 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 increased labor force for the household and should therefore reduce risk aversion. On the other hand, a larger 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.

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. The 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).

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***	-0.183	-0.613***
		(0.105)	(0.151)	(0.089)
Previous luck		0.105***	0.123***	0.119***
		(0.028)	(0.038)	(0.023)
Expected payoff		-0.013***	-0.008***	-0.010***
		(0.001)	(0.002)	(0.001)
Land size (in hectares)		-0.099	1.107***	0.127*
		(0.090)	(0.087)	(0.079)
Number of plots		0.104***	-0.070*	0.084***
		(0.025)	(0.041)	(0.019)
Number of oxen		0.621***	0.297***	0.473***
		(0.054)	(0.087)	(0.048)
Value of domestic animals Proxy for total capital (in '000 Birr)		0.314***	0.685***	0.385***
		(0.038)	(0.060)	(0.033)
Cash liquidity (in '000 Birr)		0.108*	0.032	0.063***
		(0.059)	(0.022)	(0.021)
Gender of the household head (Male=1)		0.716***	0.048**	0.247**
		(0.170)	(0.187)	(0.119)
Age of the household head		-0.017***	-0.010***	-0.012***
		(0.003)	(0.003)	(0.002)
Literacy (1=literate)		-0.150*	0.304***	-0.027
		(0.020)	(0.098)	(0.064)
Family Size		0.053*	-0.013	-0.018
		(0.029)	(0.019)	(0.015)
Dependency ratio		-0.407***	-0.018	-0.232***
		(0.070)	(0.064)	(0.045)
Dummy for hypothetical games (1=hypothetical games)		0.393***	0.236	0.299***
		(0.136)	(0.175)	(0.108)
Site dummy[++] (1=Machakel *wereda*)		-0.566***		-0.572***
		(0.144)		(0.121)
Site dummy (1=Gozamin *wereda*)				-0.356***
				(0.101)
Site dummy (1=Enemay *wereda*)		0.319***		0.095
		(0.109)		(0.105)
Site dummy (1=Tehuldere *wereda*)			0.0002	-0.218**
			(0.114)	(0.109)
Ancillary parameters (Threshold parameters)	Cut1 (α_1)	-0.948	-0.365	-0.896
		(0.239)	(0.269)	(0.188)
	Cut2(α_2)	0.287	0.513	0.062
		(0.234)	(0.272)	(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 Chi-Squared (18)		676.13	404.11	725.97
Pseudo R2		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.

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. In general, most variables have a significant effect and the coefficients have the expected signs. All the wealth indicators are significant and positive at the 1 percent 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 the variables indicating the game characteristics are significant and formally confirm the basic results presented in Tables 3 and 5. First, as indicated by 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 differently. This confirms the need for some type of support to be combined with agricultural extension when promoted technologies carry with them a downside risk.

Second, there is a highly significant relationship between prior success and degree of risk aversion, as indicated by a significant positive coefficient estimate for the previous luck variable. This implies that people revise their expectations as the game level progresses even if the actual probability of success 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 throughout those periods.

Finally, there is a positive relationship between the expected payoff variable and the degree of risk aversion, implying that people are likely to take less risk when high gains are at stake. 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; the possibility of high opportunity losses may increase risk averting behavior.

A number of household and respondent characteristics are also significantly related to risk aversion. Households with a higher number of 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 heads are found to be less risk averse than female heads. 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 in results across the two zones. Significant *wereda* dummies indicate systematic, but unobservable differences in risk aversion across study sites.

Figure 2. Predicted probabilities

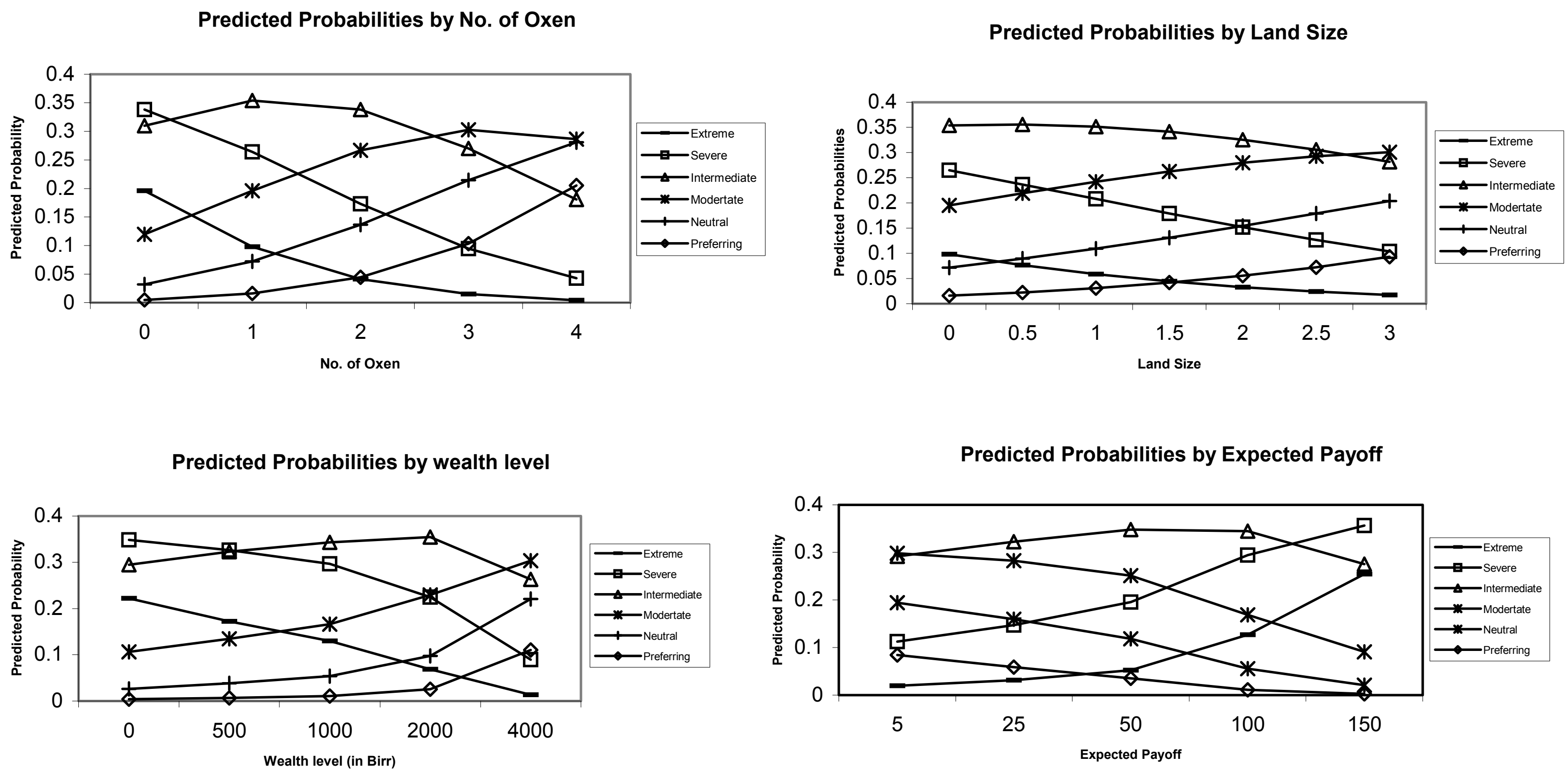


Table 7. Changes in predicted probabilities (marginal effects) by risk categories

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 (in 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 domestic animals (in '000 Birr)	-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 (in '000 Birr)	-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 *wereda*)	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 *wereda*)	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 *wereda*)	-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 *wereda*)	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 games)	-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.

The marginal effects of the observed risk aversion outcomes computed at the means of all variables are provided in Table 7. Simulations of predicted probabilities from varying levels of select independent variables are also 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 percent and severe risk aversion by about 13 percent. At the same time, these games tend 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.

Second, past successes (i.e. previous luck) tends 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 percent and a 2.5 percent 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 very quickly, suggesting that first introducing agricultural extension measures with very high probabilities of success can quickly help villagers be more comfortable with taking on subsequent risks.

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. This is consistent with a DARA-type hypothesis. 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 in the household is correlated with an increased chance of being in the extreme, severe or intermediate risk aversion categories by 9 percent. In the real world this translates into an avoidance of risky, but high expected value technologies, such as improved seeds and chemical fertilizers among families with a large number of dependents. 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 of farm households 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 these risks to a third party. As a result, it is often found that households are reluctant to adopt new technologies when they involve risk.

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 developing countries. This study is one attempt to reveal farmers' risk preferences and use these estimates to draw policy inferences. Using household data from the Ethiopian highlands we find that more than 50 percent of the households are in the severe to extreme risk aversion categories. This contrasts with similar studies in Asia where most household decision-makers exhibit moderate to intermediate risk aversion.

Looking deeper, we are able to disaggregate risk averting behavior and its determinants. We find that children have a statistically and empirically significant effect in promoting risk aversion among adult decision makers. This result is intuitive to any parent, but suggests yet another potentially 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 the possibility of 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 losses as well as gains may face legitimate, systematic 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 or other supporting measures.

Our results suggest, however, that this support could be temporary. After initial successes have convinced farmers that technologies are viable (i.e. after they have had some good luck) risk aversion declines. We also find significant differences in risk averting behavior between relatively poor and wealthy farm households, which is consistent with decreasing absolute risk aversion (DARA). This suggests that as wealth is built up households are willing to take on more risk in exchange for higher returns.

Both these findings suggest a strong path dependence associated with risk behavior. Efforts to develop poor rural areas though promotion of risky technologies must therefore take path dependence into account. For example, farm household level technologies under climate change must rely on proven methods that provide large gains and few losses, if any. 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 more risk averse when stakes are higher, suggests that agricultural extension should start modestly before asking households to take on larger gambles. And again, until the important positive history is in place and wealth is built up it is likely that households will need insurance if they are 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.

APPENDIX: RISK GAMES USED IN THE EXPERIMENT

$1.00 US = Birr (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

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