DECISION-MAKING UNDER RISK: EVIDENCE FROM NORTHERN ETHIOPIA[1]

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Abstract

There is a long standing discussion of whether expected utility theory (EU) or prospect theory (PT) best explains the behavior with respect to risky choices. Often these two approaches are compared by putting questions to students in laboratory situations. Here we try to investigate stated preferences of farmers who are functioning under high levels of risk in real life. As part of a larger survey, four binary choices were offered during two successive years. The experimental test was performed 199 farmers in two districts in Tigray, Northern Ethiopia. Three items were central in comparing the risk attitude according to EU and PT: the asymmetry of risk perceptions, the independence axiom and the shape of the utility function. The farmers in the two different districts (Enderta and Hintalo-Wajerat) differed significantly in their risk attitude. Enderta farmers were significantly risk-averse for gains and risk-seeking for losses; their preferences conformed to the hypothesis of prospect theory. However, expected utility maximization was found to be an appropriate descriptor for Hintalo-Wajerat farmers.

In order to identify the factors that affect farmer's preferences, a binary choice model was used. Household income was found to be positive and significant while value of livestock had the expected negative sign and was directly related to a decrease in risk aversion. Knowledge of farmers' attitude toward risk has important implications for policy makers to devise policies that can overcome the critical constraints they face in meeting their basic needs.

Keywords: risky choice, risk attitude, expected utility, prospect theory, Tigray.

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[1] The final version of this article was submitted in May, 2010.
This paper is part of my PhD work at the Wageningen University, The Netherlands. The Netherlands Foundation for the Advancement of Tropical Research (WOTRO) was highly acknowledged for the financial support.
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1 Introduction

In semi-subsistence agriculture, farm households face numerous natural, market and institutional risks in generating means of survival. Yield risk, crop price risk and risk of illness and injuries are important factors that prevail in developing economies. Households have developed various mechanisms for coping with risk. Some of these mechanisms offer short-term protection at long-term cost (e.g. diversification versus specialization). Therefore, their attitude towards risk gives an explanation for their observed economic decisions.

In measuring attitude towards risk, two approaches are identified: econometric and experimental. The econometric approach is based on farmers' actual behavioral data, which typically assumes that farmers maximize the expected utility of income. Given a production technology, the risk associated with production and market conditions, the observed level of input use can reveal the underlying degree of farmers' risk aversion. Examples of this line of research include Bar-Shira *et al*., 1997; Kumbhakar, 2002. The experimental approach is based on questionnaires regarding hypothetical risky alternatives with or without real payments. Here, respondents are asked to choose between lotteries that differ in payoffs, probabilities, or both. The experimental approach is further classified into expected utility and non-expected utility approaches. For example, Binswanger (1981) measured attitude towards risk in rural India. His approach is embedded in expected utility theory. Humphrey and Verschoor (2004) reported an experimental test of individual decision making behavior under risk in rural east Uganda. They found that east Ugandan farmers' risk attitude exhibit systematic deviations from expected utility theory. Binswanger (1981) measured risk attitude to a set of real payments while Humphrey and Verschoor (2004) used real money payments in eight of the twelve decision problems. However, all choice problems were considered as if they were being played for real money (Humphrey and Verschoor, 2004: 67). Real money payments may result in incentive effects and may not reveal the true risk preferences of farmers.

Using the experimental approach without real payments, this paper will identify which choice model best describes risk attitude of Northern Ethiopian subsistence farmers.[4] The objective of this paper is to measure farmer's attitude toward risk and to see how an individual's attitude toward risk relates to observed characteristics. Specifically, this study seeks to answer: (1) does the expected utility theory explains risk attitude of north Ethiopian farmers better than the non-expected utility approach (such as prospect theory); (2) Are farmers risk-averse to gains and risk-seeking to losses; and are there concave utility shapes for gains and convex utility shapes for losses; (3) Are there systematic differences in attitudes amongst farmers; (4) Is there any evidence to suggest that farmers' socio-economic variables determine aversion to risk. From the research question, it is tested whether or not the farmers made decisions according to the expected utility theory or the non-expected utility theory (prospect theory). Empirical studies on how risk varies across individuals can be useful in predicting households' technology adoption, participation on off-farm work and crop portfolio selection since risk and risk aversion behavior play important roles in these decisions.

In the next section a data set containing farmers' choices of hypothetical binary lotteries are presented. Experimental results on the shape of the utility function and a test of the independence axiom are discussed in section 3. In section 4, factors affecting risk behavior are econometrically determined. Section 5 presents a conclusion.

2 Expected Utility versus Non-expected Utility: Literature Review

2.1 Expected Utility: Background

In general, for several decades the expected utility (EU) model has been dominant in modeling behavior under risk. Von Neumann and Morgenstern (vNM, 1944) are the major contributors to a large body of work that provides the justification for the use of the expected utility model by a rational decision maker. This model views decision making under risk as a choice between alternatives. Decision makers are assumed to have a preference ordering defined over the probability distributions for which the

[4] As the econometric approach is criticized for confounding risk behavior with other factors that are unrelated to risk preferences such as physical constraints and market imperfections (Just and Pope, 2003: 1255). This is particularly important in Ethiopia where market imperfections are prominent.

axioms of the EU model hold (Mas-Colell *et al.*, 1995). Risky alternatives can be evaluated under these assumptions using the expected utility function, $U(x)$.

In maximizing the decision maker's utility, consider a risk prospect in which the decision maker does not know ex-ante which state of the world will occur. However, he can list the various alternatives and can attach probabilities to them. For simplicity, assume two possible states of the world, state 1 and state 2, with respective probabilities p1 and p2. Denote x_1 was the individual's monetary gained if state 1 occurs and x_2 if state 2 occurs. The individual must choose ex-ante between the risky bundles (x_1, x_2). Ex-post, the individual gets x_1 or x_2 depending upon which state of the world has occurred. If the decision maker's preference ordering over risky alternatives satisfies all the axioms of expected utility, including the independence and continuity axioms (see next section), then there exists a vNM expected utility function. This vNM expected utility function reflects the decision maker's choice as if he maximizes utility of the different states weighted by the probabilities for each state to occur.

vNM began by stating that utility maximization is a rational goal when a decision maker is faced with risky choices. In this framework, an individual will evaluate the expected value and objectively given probability of occurrence of each alternative. This evaluation is carried out by first entering the probabilities and expected outcomes into an individual's utility function. It is then a matter of selecting the combination of available alternatives that maximizes the function. The manner in which individuals choose among available alternatives is then dependent upon their utility function. For this setting the vNM expected utility function can be specified as:

$$U(p_1,..,p_i,..,p_N) = \sum_{i=1}^{N} p_i u(x_i) \qquad \textbf{(1)}$$

Where, U is the vNM expected utility function, $u(x_i)$ is the utility of the ith element of a vector of possible outcomes, and p_i is the probability of outcome x_i, $\sum p_i = 1$. The vNM expected utility function $U(p_1,..., p_i,..., p_n)$, defined up to a positive linear transformation, characterizes both the utility of the outcome and the individual's attitude toward risk. The curvature of this utility function contains information about the degree of individual's risk aversion (Mas-Colell *et al.*, 1995: 173).

Axioms of the expected utility theory

There are three main axioms in the expected utility framework. They are defined over a binary relation where:

$\succeq$ denotes weak preference,

$\succ$ denotes strict preference, and

~ denotes indifference.

For preferences over probability distributions $p, q, r \in P$ that are defined over a common (discrete or continuous) outcome vector X. The three axioms that are necessary and sufficient for the expected utility representation $U(\cdot)$ over preferences are:

Axiom O (Order):

The binary relation $\succ$ on P is asymmetric and transitive. The asymmetric part of axiom O says that the decision maker will not both prefer p to q and prefer q to p. According to expected utility theory, it is irrational to hold a definite preference for p over q and a definite preference for q over p at a time. However, there is a possibility that neither p nor q is preferred (i.e. $p \sim q$, the decision maker is indifferent between p and q).

The transitivity part of axiom O holds if and only if both $\succ$ and ~are transitive, i.e., for all $p, q, r \in P$, ($p \succeq q$, and $q \succeq r$) $\Rightarrow p \succeq r$; ($p \sim q$ and $q \sim r$) $\Rightarrow p \sim r$. Transitivity implies that it is impossible to face the decision maker with a sequence of pair wise choices in which preferences appear to cycle. For example, a decision maker feels that an apple is at least as good as a banana and that a banana is at least as good as an orange but then also prefers an orange over an apple.

Axiom C (Continuity):

For all $p,q,r \in P$ with $p \succeq q$ and $q \succeq r$ there exists $\alpha, \beta \in (0,1)$ such that: $\alpha p + (1-\alpha) r \succeq q$ and $q \succeq \beta p + (1-\beta) r$. This axiom gives continuity to the preferences. Continuity means that small changes in probabilities do not change the nature of the ordering between two lotteries (see Mas-Colell *et al.*, 1995: 171). Continuity rules out lexicographic preferences.

Axiom I (Independence):

For all $p,q,r \in P$ and for all $\alpha \in (0,1)$, if $p \succeq q$, then $\alpha p + (1-\alpha) r \succeq \alpha q + (1-\alpha) r$. This axiom states that preferences over probability distributions should only depend on the portions of the distributions that differ (p and q) and not on their common elements (r) and of the level of α that defines the linear combination. In other words, if we mix each of two lotteries with a third one, then the preference ordering of the two resulting mixtures does not depend on the particular third lottery used.

Axioms O, C, and I can be shown to be necessary and sufficient for the existence of a function $U(\cdot)$ on the outcomes $x \in X$ that represents preferences through $\succeq$. The role of the order, completeness and continuity axioms are essential to establish the existence of a continuous preference function over probability distributions. It is the independence axiom which gives the theory its empirical content and power in determining rational behavior. That is, the preference function is constrained to be a linear function over the set of probability distribution functions, i.e. linear in probabilities (Machina, 1982: 278).

If an individual obeys the expected utility axioms, then a utility function can be formulated that reflects the individual preferences (Mas-Colell *et al.*, 1995: 175; Robison and *et al.*, 1984: 13). Further individual's risk attitude can be inferred from the shape of his/her utility function. Since vNM (1944), the expected utility model has been the dominant model in predicting choice behavior under risk. Starting with the well-known paradox of Allais (1953), however, a large body of experimental evidence has been documented which indicates that individuals tend to violate the axioms underlying the expected utility model systematically. This empirical evidence has motivated researchers to develop alternative theories of choice under risk able to accommodate the observed patterns of behavior. A wave of theories designed to explain the violation of expected utility theory began to emerge at the end of the 1970. Examples are prospect theory (Kahneman and Tversky, 1979), regret theory (Loomes and Sugden, 1982), dual theory (Yaari, 1987), cumulative prospect theory (Tversky and Kahneman, 1992), and rank-dependent utility (Quiggin, 1993). For a thorough review see Starmer (2000). In the empirical literature, prospect theory is the dominant theory. Therefore, it will be discussed in section 2.2.

2.1.1. Violation of the independence axiom

The common consequence effect. The well-known risky choice provided by Allais is given in a paper by Kahneman and Tversky (1979). They synthesize the work by Allais and by others who have shown experimental violations of expected utility. The Allais paradox depicted in Table1 is the leading example of this class of anomalies. There are two different choice sets, for each choice set there are two lotteries from which you can choose. For example, in lottery A1 there is a guaranteed payoff of \$1M and zero probability of winning nothing. In lottery A2, there is a 0.10 probability of winning \$5M, a 0.89 probability of winning \$1M, and a 0.01 probability of winning nothing. Then one has to choose between A1 and A2, and between A3 and A4. Where A_1, A_2, A_3, A_4 are lotteries.

Table 1: The Allais paradox: the common consequence effect

Choice 1	A1	{1 M, 1; 0 M, 0}	A2	{5 M, 0.1; 1 M, 0.89; 0 M, 0.01}
Choice 2	A3	{5 M, 0.1; 0 M, 0.9}	A4	{1 M, 0.11; 0 M, 0.89}

Note outcomes are in Dollars and 1M = \$1,000,000.

Many agents prefer lottery A1 to A2 and prefer lottery A3 to A4. This empirical tendency directly contradicts expected utility theory. According to expected utility theory $A1 \succ A2$ if and only if $1u(\$1M) > 0.10u(\$5M) + 0.89u(\$1M) + u0.01u(\$0)$. Subtracting $0.89u(\$1M)$ from each side, it follows that $0.11u(\$1M) > 0.10u(\$5M) + 0.01u(\$0)$. Adding $0.89u(\$0)$ to both sides, we have $0.11u(\$1M) + 0.89u(\$0) > 0.10u((\$5M) + 0.90u(\$0)$ which holds if and only if $A4 \succ A3$. Thus, from expected utility theory, one can deduce that

$A1 \succ A2 \Leftrightarrow A4 \succ A3$. However, many people choose $A1$ over $A2$ and prefer $A3$ over $A4$. This pattern of choice violates the independence axiom and hence the expected utility theory. The Allais Paradox is now commonly known as a special case of a general empirical pattern called the common consequence effect. The name comes from the “common consequence” 1M in gamble 1 and 0 in gamble 2. The independence axiom requires that preferences be unaffected by changes in a common consequences. The Allais Paradox demonstrates that individuals are sensitive to shifts in probability mass. According to the independence axiom, an individual’s preferences in one event should not depend on the outcome in another event. Thus, it can be shown that violation of the independence axiom explains the observed inconsistencies in the measurement of the vNM utility model. If an agent is an expected utility maximizer then he must prefer A1 to A2 and A4 to A3. Agents may prefer A1 to A2 because they like to be a millionaire with certainty, implying risk aversion. But in choice set 2, the gambles are quite different with a high probability in each lottery of not winning any money. So, the agent may simply choose A3 because the chance of winning \$5M is very similar to the chance of winning \$1M and \$5M is much more. The typical agent responds in a more risk-averse manner in choice set 1 and more risk neutral in choice set 2.

2.1.2. Violation of the Order Axiom

In addition to the violation of the independence axiom, there is experimental evidence suggesting that descriptive failures of expected utility may run deeper than violations of the independence axiom (Starmer 2000: 338). The two hidden assumptions in any conventional theory of choice are procedure invariance and descriptive invariance, which constitute another source of weak descriptive power for expected utility. Procedure invariance suggests that preferences over prospects and acts are independent of the method used to elicit them. However, description invariance stipulates that preferences over prospects are purely a function of the probability distributions and do not depend on how these objects are described.

The most serious blow for the procedure invariance assumption may have been the discovery of preference reversal. Preference reversal, first reported by Lichtenstein and Slovic (1971), describes experimental results that appear to indicate systematic violations of transitivity of preferences. In their experiment, subjects were asked to choose between two bets and then to give their true certainty equivalents for the bets in the form of a selling and a buying price. In many cases the subjects set the lowest price for the preferred lottery. In other words, individuals were presented with two gambles, one featuring a high probability of winning a modest sum of money (the P bet), the other featuring a low probability of winning a large amount of money (the $ bet). The typical finding is that people often choose the P-bet but assign a larger monetary value to the $-bet. In their 1971 article, Lichtenstein and Slovic presented the following pair of gambles (see Table 2).

Table 2: Preference reversal bets

P-bet	{$4, 0.99; -$1, 0.01}	Expected outcome of the P-bet = $3.95
$-bet	{$16, 0.33; -$2, 0.67}	Expected outcome of the $-bet = $3.94

The P-bet says that there is a 99 percent chance of winning $4 and a 1 percent chance of losing $1. The $-bet says that there is a 33 percent chance of winning $16 and a 67 percent chance of losing $2. Expected outcomes of the two lotteries are almost the same. The subjects were asked to choose which game they would like to play. Later they were told that they had the ticket to play the bet and were asked to name a minimum selling price for the ticket. Lichtenstein and Slovic found that 73% of the participants consistently have a higher price to the $-bet even though they had chosen the P-bet. The EU theory implies that the bet which is actually chosen will be the one assigned the largest selling or buying price. In an earlier study, Slovic and Lichtenstein (1963) observed that choices among pairs of gambles appeared to be influenced primarily by probabilities of winning and losing. On the other hand, buying and selling prices were more highly correlated with payoffs than with probability of winning. Following this observation they argue that if the method used to elicit preferences affected the weighing of the gamble's components, it should be possible to construct pairs of gambles such that the same individual would choose one member of the pair but set a higher price for the other. When viewed from the standard theory perspective, this gamble presents a puzzle. Both choices constitute ways of asking essentially the same question. However, the ordering revealed in these experiments appears to depend upon the elicitation procedures. Moreover, choice and valuation tasks may invoke a different mental process, which in turn generates different ordering of a given pair of prospects. Consequently, the ranking observed in choice tasks cannot be explained with reference to a single preference ordering (Starmer, 2000: 338).

2.2 The Non-expected Utility Model: Prospect Theory

As mentioned earlier the most commonly accepted model of decision making under risk is the expected utility theory. In the late 1970s, the completeness of EU theory in explaining behavior was challenged. These challenges give rise to the development of competing theories that attempt to explain individual behavior under risk. This section presents one of these alternative theories: prospect theory (PT).

PT was first developed by Kahneman and Tversky (1979). They developed their theory as an alternative to expected utility theory for explaining the outcomes of individual decision making under risk. They argue that the choices individuals make in risky situations exhibit several characteristics that are inconsistent with the basic axioms of expected utility theory. They argued that individuals under-weigh probable outcomes in comparison with outcomes that are certain; they called this phenomenon the certainty effect. They also pointed out that the certainty effect brings about risk-aversion in choices involving certain gains and brings about risk-seeking in choices involving certain losses (Kahneman and Tversky, 1979).

Kahneman and Tversky (1979) distinguished two sequential phases in a decision process: the editing phase and the evaluation phase. In the editing phase, decision makers contemplate the choice situation and, if possible, simplify the problem. This includes the operation of coding. That is, outcomes are coded as gains or losses; prospects are simplified by combining probabilities associated with identical outcomes; risky components of a prospect are separated from the risk-less components of the prospect; and finally, components of choices common to all prospects are discarded. The edited prospects are then evaluated and the most highly valued risky outcome is chosen. Prospect theory employs two functions: a probability weighing function $\pi(p)$, and a value function $v(x)$. These functions are combined to form the basic equation of the theory which determines the overall value of a prospect. Following is the equation that Kahneman and Tversky (1979) used for simple prospects with the form $(x, p; y, q)$, a gamble between two outcomes (x, y) with associated probabilities (p, q) which has at most two nonzero outcomes:

$$V(x, p; y, q) = \pi(p)v(x) + \pi(q)v(y) \quad \textbf{(2)}$$

When the prospects are strictly positive or negative, the evaluation follows a different rule. In the editing phase the prospects are separated into a risk less (the minimum gain or loss which is certain to be gained or paid) and a risky component (the additional gain or loss which is actually at stake). Thus, if $p + q = 1$ and either $x > y > 0$ or $x < y < 0$, so $\pi(q) = [1 - \pi(p)]$, then,

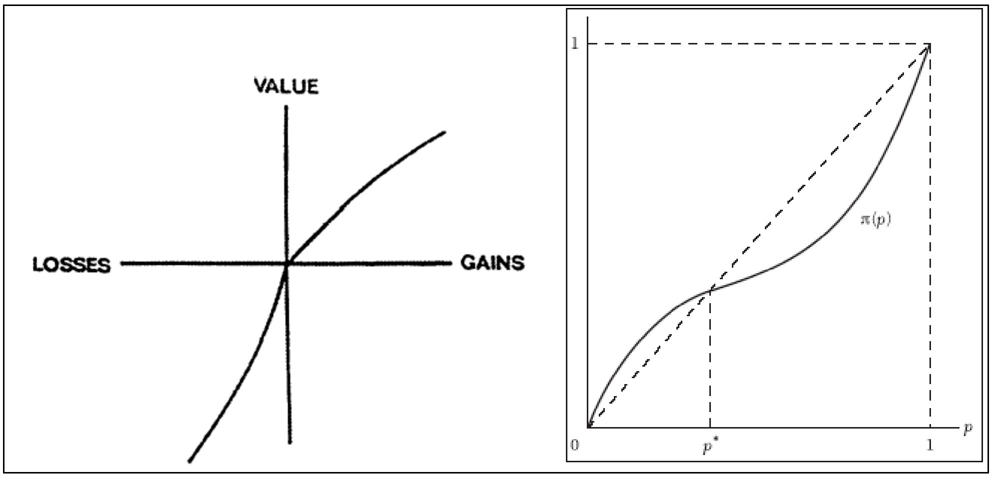
$$V(x, p; y, q) = v(y) + \pi(p)[v(x) - v(y)] \quad \textbf{(3)}$$

One of the essential features of prospect theory is that the overall value of a prospect is based on changes in a decision-maker's wealth reference point rather than on final wealth states, as in the case of the EU theory. Kahneman and Tversky propose the value function, one of the most widely used components of prospect theory, a function that is commonly S-shaped. It is generally concave for gains (implying risk aversion), convex for losses (implying risk-seeking), and steeper for losses than for gains (see Figure 1).

Another major departure of prospect theory from the EU theory is the treatment of the probabilities. In EU models, the uncertain outcome is weighed by its probability, the uncertain outcome in prospect theory is multiplied by the decision weight $\pi(p)$. The weighing function, π, which relates decision weights to stated probabilities, is a monotonic function of p, with $\pi(0) = 0$ and $\pi(1) = 1$, but is not a probability and should not be interpreted as a measure of degree of belief.

According to prospect theory, very low probabilities are over-weighed, that is, the decision weight attached to the rare event is larger than the probability $\pi(p) > p$. Furthermore, prospect theory suggests that for all $0 < p < 1, \pi(p) + \pi(1-p) < 1$, this is sub-certainty. It implies that as low probabilities are over-weighted, moderate and high probabilities are underweighted. That is the decision weight is smaller than the probability $\pi(p) < p$.

Figure 1: A hypothetical value function and a weighting function (Kahneman and Tversky, 1979: 279)



As in the EU model, values and weights are combined in prospect theory. Outcomes transferred into values by the value function, are weighed by the decision weights and then summed. This summed index is used to rank probability distributions; the subject is assumed to choose the distribution with the highest index (Smidts, 1990). Consider, the choice between the gamble $(x, p; y, q)$, a gamble between two outcomes (x, y) with associated probabilities (p, q). In expected utility maximization theory the value of the utility function is $U(X) = pu(x) + qu(y)$ and in prospect theory, the value function is a $V(X) = \pi(p)v(x) + \pi(q)v(y)$. In both cases, the summed function is maximized and the highest value is chosen. Prospect theory and EU theory coincide when $\pi(p) = p$ for all p and when $u(x) = v(x)$. In this case, the expected utility of a lottery defined on $U(X)$ equals the value $V(X)$ of the gamble in prospect theory.

It can be concluded that prospect theory seems much more descriptive than expected utility theory. Prospect theory is capable of explaining decisions that expected utility theory is incapable of explaining. For example, expected utility theory cannot account for certainty gains, such as the certainty effect that may have a strong influence on individual's decision preferences.

3 Data Collection Methodology and Description

Risk assessment data were collected for two years (2001 and 2002) from Tigray, northern Ethiopia. The respondents also participated in a survey on crop production, labor allocation, and consumption decisions. The questionnaire was framed as a farm decision problem and the respondents were the head of their household. In 2001, two hypothetical questions were asked: one question without loss and the other question with loss. The same hypothetical questions from 2001 were also asked in 2002. The purpose of this was to stimulate the actual process of decision making and to see whether there is a learning effect in the decision process. Seven additional questions were asked in 2002, which did not involve loss (for details of the questions asked and description of the experimental designs see Appendix I and Appendix II). It is assumed that farmers' choice between the binary hypothetical outcomes was taken as an indication of his/her risk attitude behavior. The two hypothetical questions consisted of two possible outcomes with given objective probabilities; the respondents were asked to state which of the two options (s)he prefers. It was mentioned that there was no right or wrong answers to these questions. In each year, a total of 199 households participated. It is assumed that by answering the hypothetical questions farmers exhibited their true preferences.

All outcomes of the hypothetical questions are in Ethiopian Birr.[5] For example, in choice 1, the choice is between the safest (certain) option S1 and the riskier option R1 (the probabilistic gain option).[6] The mean is the expected monetary value of the lottery and its standard deviation is denoted by SD. In all of the choice problems, the expected mean value of the riskier option is higher than the safest option. This can be considered as a control for the behavior of risk-aversion of experimental subjects. Accordingly, each decision problem is considered as a choice between a relatively safe and a relatively risky alternative. It can also be considered that the low variance

[5] Ethiopian Birr is a local currency with exchange rate as of 2005 is 1$=8.66 Ethiopian Birr.
[6] In this study safest option means a lottery with lower expected mean value but higher probability of winning the lottery. Riskier option means a lottery with higher expected mean and low probability of winning the lottery.

choice is the safer option and the high variance choice is the riskier option.[7] Farmers opting for the safe option are called more risk-averse than farmers who choose the risky option. The percentage of farmers choosing the safest option for each choice is presented below. For choice 1, most of the respondents choose the certain gain rather than the gamble of the certainty effect. Farmers who choose the gamble show risk-seeking behavior while those who choose the certain outcome show risk-averse behavior.

Choice patterns of farmers in the year 2001 and 2002

Table 3: Choice 1

	Proportion safest choice chosen		Safest option: S1		Riskier option: R1	
	2001	**2002**	**Mean**	**SD**	**Mean**	**SD**
S1: (500,1) vs. R1: (1000,0.75) [8]	83.42	81.41	500	0	750	433

Choice 1 (S1) offered a 100 percent chance of receiving 500 Birr while R1 offers a 75 percent chance of receiving 1000 Birr. The expected value for lottery S1 is 500 Birr with standard deviation zero. For lottery R1 the expected mean is 750 Birr with a standard deviation of 433. Thus, the two lotteries have a relatively large difference in expected values. More than 80 percent of the farmers chose the safest choice in both years (year 2001 and 2002). When farmers are confronted with the sure gain and probability gain, they tend to choose the sure gain rather than the probability gain. Roughly an equal number of farmers chose the sure gain in 2001 and 2002, as choice problem 1 involves no losses.

[7] The measure of variability used is the variance of outcomes around the expected mean value.

[8] (x, p) denotes the hypothetical gain x with corresponding probability p.

Table 4: Choice 2

	Proportion safest choice chosen		Safest option: S2		Riskier option: R2	
	2001	2002	Mean	SD	Mean	SD
S2: (-500, 1) vs. R2: (-1000,0.75)	49.75	56.78	-500	0	-750	433

Choice 2 is the opposite of choice 1; the sign is reversed so that gains are replaced by losses. Table 4 shows that almost half of the farmers choose the sure loss in both years. The mean equality test for the choices occurring in both years indicates that there is no significant difference in means (t=0.52). This choice pattern implies that farmers' preference between negative prospects is not the mirror image of the preference between positive prospects. This finding is in contrast with most of the findings of laboratory experimental studies with students as subjects (e.g. Kahnemans and Tversky, 1979).

Choice patterns in the year 2002

Table 5: Choice 3

	Proportion safest choice chosen	Safest option: S3		Riskier option: R3	
		Mean	SD	Mean	SD
R3: (5000,0.25) vs. S3: (2000,0.50)	51.3	1000	1000	1250	2165

In choice 3, about half of the farmers chose the safest choice. Here the safest choice has an expected value of 1000 Ethiopian Birr with a probability of winning equal to 50 percent. The riskier option has an expected mean of 1250 with a probability of 25 percent. It seems that half of the sample farmers exhibit risk-seeking behavior; they opt for the gamble rather than for the safest choice.

Table 6: Choice 4

	Proportion of safest choice	Safest option: S4		Riskier option: R4	
		Mean	SD	Mean	SD
R4:(9000,0.50) vs.S4: (4500,0.75)	48.7	3375	1949	4500	4500

Similar to choice 3, almost half of the farmers in choice 4, chose the riskier option. In choice 4, the safest choice has low variance (with standard deviation 1949) when compared to the riskier option (with standard deviation 4500). In this choice set, about 48.7% of farmers chose the safest choice. However, more than half of the subjects opt for the riskier option, suggesting that they were more risk-lover in this choice set.

4. Test of the Expected Utility Axiom

4.1 Test on the Shape of the Utility Function

Table 7 presents the proportion of choice in the gain and loss domain of the utility function; 82% of choices significantly reflect a concave shape for gains. That is, Tigray farmers are very attracted to a sure gain compared to risky prospects, which risk-averse behavior (the certainty effect).[9] Furthermore the result for gains confirmed that the utility function is concave implying that the utility function has a diminishing marginal utility, which is also a well-known empirical finding in the agricultural economics literature. In Enderta and Hintalo-Wajerat, 89% and 76% of subjects respectively were classified as showing a concave utility for gains. Thus, was a significantly larger proportion of respondents classified as being concave than convex (the proportion is significant at 5% significance level). In these tests, the null hypothesis states that a concave classification is at least as likely as a convex classification; tests are therefore two-tailed. As the experimental procedure in elicitation of utility did not use certainty equivalent procedures, linear classifications were not treated here.

[9] The result is consistent with the findings of Humphrey and Verschoor, 2004.

Table 7: Percentage of concave and convex parts for gains and losses [choice1 vs. choice2]

	Gains			Losses		
	Full Sample	**2001**	**2002**	**Full Sample**	**2001**	**2002**
Enderta						
Concave	89	96	82	36	20	52
Convex	11	4	18	64	78	48
Hintalo-Wajerat						
Concave	76	71	81	71	79	62
Convex	24	29	19	29	21	38
Total Sample						
Concave	82	83	81	53	50	57
Convex	18	17	19	47	50	43

The utility shape for losses was also identified; the finding in this case is mixed. In Enderta, about 64% of subjects exhibit a convex utility function for losses. This empirical finding is consistent with most of the findings in psychological studies. It says that losses loom larger than gains so that people display loss aversion in the domain of losses, resulting in a utility function that is steeper for losses than for gains. Thus Enderta farmers can be classified as a risk-taking behavior over losses so that a risky loss is preferred to a certain one (i.e. they tend to choose the gamble rather than the sure loss). However, in Hintalo-Wajerat a significant proportion (about 71%) of subjects exhibit concave utility for losses. Hintalo-Wajerat farmers' utility function for losses is concave rather than convex. This finding is not in accordance with the prospect theory, in that an individual's value function is convex in losses and much more sensitive to certain losses than to a risky loss. However, Hintalo-Wajerat farmers preferred a certain loss to a risky loss. Therefore, loss aversion would not help in explaining Hintalo-Wajerat farmers' behavior.

In Hintalo-Wajerat, the experimental evidence revealed that subjects are increasingly inclined to select the safe choice in the domain of gains, while the opposite happens in the loss domain (more subjects are inclined to be more risk seeking in 2002 than in 2001). Subjects might realize that the riskier option has a higher expected value than the safer option and become more risk-seeking in the loss domain. This is contrary to what an expected utility maximization would prescribe. In Enderta, the choice is more stable and consistent in the gain domain. However, in the loss domain more subjects' choices converge to a utility maximization hypothesis in the year 2002.

4.2 Test on the Independence Axiom

The independence axiom of the expected utility theory requires that if a person chooses a safe option in the gain domain, he must also choose the safe option in the loss domain. If this does not hold, the expected utility theory will be violated. To test the independence axiom we only used Choice set 1 and Choice set 2 (see Appendix I for details of the choices offered to farmers).

Table 8 reports the result of choice for the independence axiom. SS and RR choice responses are consistent with expected utility theory whereas RS and SR choice responses are not (SS response denote the safer S option being chosen in both the first and second choice and RR response denotes the riskier option being chosen in both the first and the second choice problems). In this test, the null hypothesis states that the proportion of choice consistent with expected utility maximization (i.e., SS and RR choice) is equal to the proportion of choice to the prospect theory maximization (SR and RS).

Table 8: Proportion of choice responses in the lottery pair (choice 1 vs. choice 2)

	Enderta (n=99)					Hintalo-Wajerat (n=100)				
	SS	RR	SR	RS	p-value	SS	RR	SR	RS	p-value
2001	19	3	76	1	0.00(z=-7.82)	58	8	13	21	0.000(z=4.53)
2002	46	13	35	5	0.007(z=2.70)	51	8	31	10	0.011(z=2.55)

Table 9 clearly shows that in Enderta and Hintalo-Wajerat, 40% and 63% of choice responses are consistent with expected utility theory. In Enderta, subjects chose the sure gain rather than the risky gain in the first choice problem. In the second choice problem, subjects preferred the risky loss rather than the sure one in 2001 and 2002. About 79% and 41% of choices in Enderta are not consistent with expected utility maximization. There is a significant difference of choice proportions between 2001 and 2002. Learning effects, market factors, and environmental factors might explain the difference. In Hintalo-Wajerat, although the choice in 2002 reveals slightly more violations than in 2001, the independence axiom does seem to hold.

Table 9: Summary proportion of choice consistent with expected utility theory

	Full Sample	2001	2002
Enderta	40	21	59
Hintalo-Wajerat	63	66	59
Total sample	51.5	44.22	58.79

Furthermore, Table 9 reports that 37% of subjects' responses are contradictory with the expected utility maximization theory in Hintalo-Wajerat. The majority of choice responses are consistent with expected utility theory. Therefore, the expected utility model would be the best descriptor of decision behavior under risk for Hintalo-Wajerat farmers. Moreover, the difference between the proportions of expected utility theory choices in Enderta and Hintalo-Wajerat is significant at the 5% level (t=2.48 with a two-tailed test of a difference in sample proportions based on the normal distribution). It appears that the difference is primarily driven by a higher proportion of risk-averse behavior (i.e., choosing the safest option in both choice problems) in Hintalo-Wajerat than in Enderta (there is a higher proportion of relatively risk-seeking behavior SR in Enderta). Thus, expected utility theory does appear to be an appropriate descriptor of risky choices made by rural households in Hintalo-Wajerat. However, in Enderta, the result suggests that risk aversion may be an appropriate assumption in the domain of gains and risk-seeking in the domain of losses.

5. Factors Affecting the Risk Attitude of Farmers

It was shown that almost all of the farmers surveyed were risk-averse; they chose the safest choice options (see choice 2 to choice 4 in Appendix II). Here, it is important to know the factors that influence farmers' risk attitude. Defining the set of factors that influence risk attitudes is difficult, since many are part of the psychological makeup of the individual. However, there are several observable physical and economic factors that might influence risk attitudes (Grisley and Kellog, 1987).

Empirical model

In order to identify the factors that affect farmers' preferences a binary choice model was used. When several continuous variables are used as explanatory variables in only one choice, then estimating a *logit* model is necessary (Pindyck and Rubinfeld, 1998: 312). Therefore, the proportion of choices favoring the safest option is regressed on household specific characteristics. The model takes the form:

$$P(SC = 1/x) = \frac{\exp(\beta x_i)}{1 + \sum \exp(\beta x_i)} = x_i'\beta + \varepsilon \qquad \textbf{(4)}^{10}$$

where x is a $1 \times k$ matrix of explanatory variables pertaining to observation i, $P(SC = 1/x)$ is the probability that the safest choice is chosen given the full set of explanatory variables x that influence the choice [such as age of the head, gender, family size, and total household income (off-farm and farm income)]. SC is the qualitative variable that indexed the safest choice with $SC = 1$ indicating that the safest choice has been chosen, and $SC = 0$ indicating that the safest choice is not chosen. β is a $k \times 1$ vector of parameters, ε is an error term having a logistic distribution.

The probability model of equation (4) can take the form:

$$P(SC / x_i) = 0(1 - (x_i'\beta)) + 1((x_i'\beta)) = x_i'\beta + \varepsilon \qquad \textbf{(5)}$$

Because the sign and magnitude of the estimated coefficients are relative to the response probability, direct estimation of the binary choice model is difficult. It is often more insightful to estimate the marginal effects of changes in the independent variables on the probabilities of choosing the safest option (Greene, 2003: 668; Long and Freese, 2003: 139). The marginal effects of changes in each of the k independent variables can be calculated and used to map the impacts on the probability space.

[10] P(.) is non-linearly related to $x_i'\beta + \varepsilon$. This means that the ordinary least square (OLS) procedure cannot be used to estimate the parameters (Judge *et al*., 1982).

$$\frac{\partial P(SC/x)}{\partial x_k} = (x_i'\beta)((1-(x_i'\beta))\beta \qquad \textbf{(6)}$$

The dependent variable is a dummy indicating whether the safest choice is chosen.[11] The dependent variables are household head characteristics (age and education), household size, household wealth (value of livestock including cattle, camel, horses, mules, donkey, sheep and goat), year dummy, district dummy and mean district 10-year rainfall. Household size is measured by the number of persons living in the household for at least 9 out of 12 months. Household age is measured as completed years. Head education is a dummy indicating whether the household head is literate. Year dummy captures the differences in rainfall between 2001 and 2002. District dummy captures differences in access to markets and other district characteristics. The descriptive statistics of variables are presented in Appendix 4 III.

Estimation Results[12]

The results are presented in Table 10, which includes the values of the logit estimated coefficients, t-statistics, and marginal coefficients. None of the household head characteristics (age and education) are significant influences on risk attitude behavior. It is often assumed that older people are more risk-averse, numerous studies have confirmed this. In this study neither age nor education of the household head, predicts risk preferences. Moreover, the insignificant results obtained for the household characteristics indicate that these variables may not be exogenous in determining household's risk preferences. The wealth variable (livestock value) is significantly and negatively associated with the safest choice. This result is in line with many empirical findings which confirmed that wealthier households are more likely to undertake risky activities (Rosenzweig and Binswanger, 1993). The expectation that wealthier groups should be more risk

[11] If the respondents choose the safest choice in one of the four choices, then *SC* takes the value of 1.
[12] The unrestricted log-likelihood for the *logit* model is -244.01. the Chi-squared statistic is, therefore, 53.07. The critical value from the chi-squared distribution with 8 degrees of freedom is 15.51, so the null hypothesis that all slope coefficients are zero is rejected at 5 percent significance level..

taking is supported, but not significantly. The result is consistent with Yesuf (2004), who found negative correlations between wealth and risk aversion.

Table 10: Estimation results and marginal effects of the probability of choosing the safest option

	Coefficient	z-value	Marginal effect
Intercept	-2.02*	-2.30	
Head age	-0.00	-0.01	-0.00
Head education dummy	-0.29	-1.16	-0.06
Family size	0.02	0.34	0.01
Value of livestock	-0.08*	-2.11	-0.02
District dummy (Enderta=1)	-0.74**	-2.98	-0.14
Year dummy (2001=1)	-2.13***	-4.19	-0.48
District mean rainfall	0.04***	3.64	0.01
Log likelihood	-244.01		
LR chi2(8)	53.07***		
Number of observation	398		

*Significant at 0.05 significance level; ** significant at 0.01 significance level; *** significance at 0.001 significance level.

The district dummy significantly affects risk-aversion behavior. This result confirms our expectations because Enderta is better-off than Hintalo-Wajerat with respect to the annual precipitation amount, access to markets, etc. The results suggest that farmers in Enderta are more risk-loving than farmers in Hintalo-Wajerat. Finally, the most important variable that predicts risk preferences is the 10 year mean rainfall and year dummy. The year dummy is a good predictor of risky behavior. Since 2001 was a good harvest year, households had more risk-taking behavior in 2001 than in 2002.

6. Discussion and Conclusions

In this paper we used experimental data from Enderta and Hintalo-Wajerat districts in Tigray. A set of hypothetical questions on lotteries were asked to farmers. Using the answers to these hypothetical lottery questions, we investigated: (1) whether farmer's preferences are consistent with expected utility theory or prospect theory, (2) whether farmers are risk-averse to gains and risk-seeking to losses, and have concave utility for gains and convex utility for losses, and (3) whether there is any relationship between farmers' socio-economic variables and preferences. In the experiment it is said that farmers opting for the safe option are called more risk-averse than farmer who choose the risky option.

The result indicates that more than 80 percent of the farmers chose the safest choice. When farmers are confronted with sure gain and probability gain, they tend to choose sure gain; this is the certainty effect. However, when farmers' are confronted with sure loss and probabilistic loss, about 53 percent of farmers choose the safest choice (i.e., the sure loss). This finding is in contradiction with the findings of Kahneman and Tversky (1979). With respect to the shape of the utility function the finding is mixed. In Enderta about 64 percent of the subjects exhibit a convex utility for losses. This finding is consistent with most of the psychology literature findings. Prospect theory or loss-averse behavior is the appropriate model for explaining Enderta farmers' risk attitude. While in Hintalo-Wajerat a significant proportion of choice (about 71%) of the subject exhibit concave utility for losses. This is in contrast to what prospect theory suggests. Here, expected utility maximization would be the appropriate model in explaining and modeling Hintalo-Wajerat farmers' risk preferences. None of the household head characteristics (age and education) are significant influences on risk attitude behavior of Tigray farm household heads. District dummy, ten years mean rainfall, and household income significantly influence risk preferences of farmers.

Knowing and understanding the behavior of individual farmers' attitude toward risk would enable policy makers to devise policies that can overcome some of the critical constraints they now face in meeting their basic needs.

References

Allais, M. 1953. The foundations of a positive theory of choice involving risk and a criticism of the postulates and axioms of the American school, in: Allais, M., and Hagen, O. (eds.), Expected utility hypotheses and the Allais paradox, 27-145. Dordrecht: Reidel, 1979.

Bar-Shira, Z., Just, R., Zilberman, D. 1997. Estimation of farmers' risk attitude: an econometric approach. *Agricultural Economics* 17, 211-222.

Binswanger, H. 1980. Attitude toward risk: experimental measurement in rural India. *American Journal of Agricultural Economics* 62, 395-407.

Binswanger, H. 1981. Attitude toward risk: theoretical implications of an experiment in rural India. *Economic Journal* 91, 867–890.

Fennema, H., and Van Assen, M. 1999. Measuring the utility of losses by means of the Tradeoff Method. *Journal of Risk and Uncertainty* 17 (3), 277-295.

Greene, W. H. 2003. *Econometric Analysis.* Upper Saddle River, NJ: Prentice Hall.

Grisley, W., Kellog, E. 1987. Risk-Taking Preferences of Farmers in Northern Thailand: Measurements and Implications. *Agricultural Economics* 1, 127-142.

Humphrey, S., Verschoor, A. 2004. Decision-making under risk among small farmers in East Uganda. *Journal of African Economies* 13 (1), 44-101.

Judge, G. G., Carter Hill, R., Griffiths, W. E., Lütkepohl, H., and Lee, T. 1982. *Introduction to the theory and practice of econometrics*. New York: John Wiley and Sons.

Just, R., and Pope, R. 2003. Agricultural risk analysis adequacy of models, data, and issues. *American Journal of Agricultural Economics* 85 (5), 1249-1256.

Kahneman, D., Tversky, A. 1979. Prospect Theory: an analysis of decision under risk. *Econometrica* 47 (2), 263-291.

Kumbhakar, S. 2002. Specification and estimation of production risk, risk preferences and technical efficiency. *American Journal of Agricultural Economics* 84 (1), 8-22.

Lichtenstein, S., and Slovic, P. 1971. Reversals of preference between bids and choices in gambling decisions. *Journal of Experimental Psychology* 89, 46-55.

Long, J., and Freese, J. 2003. *Regression models for categorical dependent variables using stata*. A Stata Press Publication. STATA CORPORATION. College Station, Texas.

Loomes, G. and Sugden, R. 1982. Regret theory: an alternative theory of rational choice under uncertainty. *Economic Journal* 92, 805-24.

Mas Colell, A. Whinston, M., and Green, J. 1995. *Microeconomic Theory*. Oxford: Oxford University Press.

Mosley, P. and Verschoor. 2005. Risk Attitudes and the 'Vicious Circle of Poverty'. *European Journal of Development Research* 17 (1), 59-88.

Neumann, von, J., and Morgenstern, O. 1944. *The theory of games and economic behaviour*. Princeton: Princeton University Press.

Pindyck, R., Rubinfeld, L. 1998. *Econometric Models and Economic Forecasts*. New York: McGraw-Hill, Inc.

Quiggin, J. 1993. *Generalized expected utility theory. The rank dependent model*. Boston: Kluwer Academic Publishers.

Robison, L., Barry, P. Kliebenstein, J., and Patrick, G. 1984. Risk attitudes: concepts and measurement approaches, *Risk Management in Agriculture*. Peter J. Barry, ed. Ames IA: Iowa State University Press.

Rosenzweig, M., Binswanger, H. 1993. Wealth, weather risk and the composition and profitability of agricultural investments. *The Economic Journal* 103, 56-78.

Starmer, C. 2000. Developments in non-expected utility theory: the hunt for a descriptive theory of choice under risk. *Journal of Economic Literature*, *Vol. XXXVIII .* 332-382.

Tversky, A., Kahneman, D. 1992. Advances in prospect theory: cumulative representation of uncertainty. *Journal of Risk and Uncertainty* 5 (4), 297-323.

Wik, M., Holden, S. 1998. Experimental studies of peasant's attitudes toward risk in Northern Zambia. Discussion Paper #D-14/1998 Department of Economics and Social Science, Agricultural University of Norway.

Yaari, M. 1987. The dual theory of choice under risk. *Econometrica* 55, 95-115.

Yesuf, M. 2004. *Risk, Time and Land Management under Market Imperfections: Applications to Ethiopia*. Department of Economics, Göteborg University. PhD. Dissertation.

Appendix I: The type of hypothetical questions offered to the farmer

Choice1. If you are given the choice between A and B which option would you select?

1. A sure gain of Birr 500.
2. A risky prospect that offers a 75 percent chance of winning Birr 1000 and a 25 percent chance of winning nothing.

Choice2. If you are given the choice between A and B which option would you select?

1. A sure loss of Birr 500.
2. A risky prospect that offers a 75 percent chance of losing Birr 1000 and a 25 percent chance of losing nothing

Choice3. If you are given the choice between A and B which option would you select?

1. A sure gain of Birr 2000
2. A risky prospect that offers a 25 percent chance of winning 5000 Birr, a 50 percent chance of winning 2000 and a 25 percent chance of winning nothing.

Choice4. If you are given the choice between A and B which option would you select?

1. A risky prospect that offers a 25 percent chance of winning 5000 Birr and a 75 percent chance of winning nothing.
2. A risky prospect that offers a 50 percent chance of winning 2000 Birr and a 50 percent chance of winning nothing.

Appendix II Experimental Design and questionnaire

A hypothetical questionnaire was developed using 25 test interviews to ensure that the hypothetical questions would be interpreted correctly. All the interviewers had prior experience and received two days training. Because of their district background and two time contact with the farm households, we believe that the effect of interviewer bias could be minimized. In the experiment, subjects were offered with four sets of hypothetical choice, involving no real money payment (see Appendix I). A total of 398 subjects participated in the experiments. To minimize the order effects, the hypothetical questions were randomly arranged and randomly offered to the respondents. The hypothetical questions offered can best be understood by examining the pair of lotteries in Table 1.

Table 1: Descriptive statistics of proportion of choice response in the lottery pairs by year.

Questions	Proportion safest		Safest Option		Riskiest Option	
	2001	2002	Mean	SD	Mean	SD
Choice1 S1: (500,1) vs. R1: (1000,0.75)	83.4	81.4	500	0	750	433
Choice2 S2: (-500, 1) vs. R2: (-1000,0.75)	49.7	56.8	-500	0	-750	433
Choice3 S3: (2000,1) vs. R3: (5000,0.25; 2000,0.50)		77.4	2000	0	2250	1785
Choice4 R4: (5000,0.25) vs. S4: (2000,0.50)		51.3	1000	1000	1250	2165

Note: (x, p) denotes the hypothetical gains x with corresponding probability p and zero otherwise.

As indicated in the data description section of this paper, S and R correspond to the safest and riskier choice respectively. We call the low variance lottery the safe option and the high variance lottery as the risky option. For example in the year 2001 about 83.4% of subjects chose the safest option.

Appendix III. Descriptive statistics of household characteristics

Variables	Mean	Standard deviation	Min	Max
Age of head	51.82	11.90	22	83
Family size	5.95	2.19	1	11
Head education dummy (=1 if literate)	0.37	0.48	0	1
Value of livestock	3596.94	3941.48	0	25200