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Wealth and Time Preference in Rural Ethiopia

Mahmud Yesuf and Randall Bluffstone

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Abstract

This study measured the discount rates of a sample of 262 farm households in the Ethiopian highlands, using a time preference experiment with real payoffs. In general, the median discount rate was very high—more than double the interest rate on the outstanding debt—and varied systematically with wealth and risk aversion. Although we do not have a good theory for explaining the linkage between rates-of-time preferences (RTPs) and risk aversion, our findings warn that these two aspects of household behavior reinforce each other and are easily confused. Our results have important implications for understanding households' behavior. Because the RTPs were so high, what might seem like profitable investments from the outside might not seem so from the farmers' perspectives. Furthermore, when future returns were uncertain, risk-averse decision makers favored projects with shorter payback periods and were less willing to invest in projects with long-term benefits. Formal capital market development, including lending and mortgage markets—currently non-existent in most of rural Ethiopia—may help reduce RTPs and cause more investments to be acceptable. The results also suggested the need for more research on the linkages between risk aversion and RTPs in low-income countries.

Key Words: Discounting, Ethiopian farm households, experimental studies, interval regression, time preference

JEL Classification Numbers: C24, C93, D12, D91, Q12, Q21

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Introduction

It has been argued in the literature that poverty in developing countries may lead to short planning horizons in which people exploit resources, fail to invest, or degrade existing assets to meet short-term needs, regardless of the long-term consequences. Relevant examples of such behavior in rural areas of low-income countries, such as Ethiopia, include unwillingness to invest in education for children, soil conservation measures, on-farm tree growing, or livestock. Yet, these are exactly the types of investments that farmers in low-income countries need to make to improve the prospects of their households. Indeed, without capital accumulation, there is little reason to believe future incomes will differ appreciably from the current minimal levels in countries like Ethiopia (Bluffstone et al. 2007).

Reducing poverty and its correlates is now at the top of the international policy agenda. This is perhaps best illustrated by the Millennium Development Goals (MDGs), which were adopted unanimously by United Nations member nations in September 2000 and focus on improving human well-being in a variety of dimensions. There are eight goals, but perhaps goal 1—to halve extreme poverty and hunger—is the premier goal among them. In goal 1, extreme poverty is defined as incomes of less than US$ 1 per person per day (United Nations 2003).

Countries like Ethiopia have a long way to go to meet this goal. With its gross national income per capita a mere US$ 160 per year, average income is *much less* than $1 per person per day, and places Ethiopia 202nd out of 208 countries (World Bank 2006). In 2006, Ethiopia ranked 170th out of 177 countries, according to the Human Development Index (UNDP 2006). Ethiopia's situation is by no means unique in Africa. Of 49 African countries, only Burundi's gross national income per capita was lower than Ethiopia's in 2005; four countries (Burundi, Malawi, Liberia, and Guinea-Bissau) are within $50 per capita per year of Ethiopia; seven countries are within $100 per capita; and 10 countries are within $150 (IMF 2007).

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Rural areas are typically the poorest. As concluded by Bluffstone et al. (2007), MDG goal 1 is quite ambitious for rural Ethiopia and achieving it will require major increases in incomes. Indeed, using data from the same areas analyzed in this paper, they found that, in 2005, median per capita income was only US$ 102, and that 91 percent of Ethiopian households were below the extreme poverty cutoff of $1 per day. Figuring out the prospects for farm-level investments—and the barriers to them—that are needed to increase incomes and reduce poverty is of primary importance.

This paper presents estimates of rates-of-time preferences (RTPs). They were tested to see whether they could be considered "excessive," compared to market interest rates, and evaluated to see if RTP barriers to investment exist in rural Ethiopia. Our estimates were made using an experimental approach to directly measure the degree to which household heads prefer incomes today rather than investing for higher returns in the future; the experiment directly mimicked on-farm investment and consumption tradeoffs. We found that in all experiments median discount rates were substantially above market interest rates, suggesting a serious reluctance to invest. The determinants of RTPs were then estimated and showed that RTPs were decreasing in a variety of assets and increasing in degree of risk aversion.

In this paper, section 1 presents the literature, with a particular focus on estimation of RTPs. Section 2 discusses the underlying economic theory of time preferences under two different credit market scenarios. In section 3, the data, study site, and experimental design are described, followed by results in section 4. Section 5 concludes the paper and discusses policy implications.

1. Literature

The notion that poor people have higher discount rates than those with more resources was strongly emphasized in the influential Brundtland report (WCED 1987). As so many investments in rural areas of low-income countries have environmental implications (e.g., soil conservation, on-farm tree growing, livestock), it is of special relevance that this notion was particularly applied to environmental investments and conservation in the Brundtland commission report (WCED 1987), by the World Bank (1996), and in the academic literature by Larson and Bromley (1991).

It is also well established that the higher the discount rate, the faster the optimal rate of depletion of non-renewable resources (Hotelling 1931), and the lower the optimal steady-state stock of renewable resources (Clark 1976). These findings suggest that the implications of high discount rates in poor areas of poor countries are lower levels of investment and savings with regard to all goods, including environmental goods.

There is currently a concerted international push to raise incomes in the lowest-income countries; we know that most poor people in these countries live in rural areas; we understand the critical role of investment in raising incomes and the linkages with decision-maker RTPs. Strangely, though, there has been relatively little empirical work to help us understand (1) how high or how low RTPs are in low-income countries, and (2) the determinants of RTPs and how we might expect them to change as households accumulate wealth and incomes. Frederick et al. (2002) tabulated about 40 attempts at empirical estimations of discount rates, but of these only two (Pender 1996; and Holden et al. 1998) were done in farm villages in developing countries. Our paper attempts to add to what is currently a relatively limited literature.

In the empirical literature, two procedures have been used to estimate RTPs. The first uses consumption surveys to infer discount rates from economic decisions (e.g., Hausman 1979; Moore and Viscusi 1990; and Dreyfus and Viscusi 1995). The second approach, which is employed here and is the most common, uses experimental methods in which people evaluate stylized inter-temporal prospects involving real or hypothetical outcomes.

Potentially, problems can arise when using experiments to elicit discount rates. One key concern is the possibility of hypothetical bias if hypothetical payoffs are used. The use of real and meaningful payoffs is therefore desirable, and our paper follows this finding of the literature. Another concern with the use of experiments is the difficulty in controlling for factors other than pure time preference, which are relevant when making inter-temporal decisions. Frederik et al. (2002) suggested inter-temporal arbitrage, inflation considerations, and habit formation as some of the factors affecting subjects' inter-temporal decisions. Given that our experiment was conducted where capital markets were thin and people had no limited inflation experience, we believed the effects of inter-temporal arbitrage and inflation to be minimal.

The other concern with the experimental approach is the reliance on a single-parameter discounted utility model, which uses a single discount rate to explain subjects' inter-temporal choices. Frederick et al. (2002) enumerated a number of anomalous results potentially resulting from this single rate. Many researchers have now explored these anomalies (e.g., Loewenstein and Thaler 1989; and Loewenstein and Prelec 1992), prompting researchers to think about other representations of discounting behavior.

In our experiment, we tested for the presence of the most common types of anomalies discussed by these researchers, including whether subjects had the same preferences for small and large rewards (magnitude effect), similar preferences over short and long periods (time frame effect), and whether framing the experiment as a delay or speeding up of consumption from a certain reference point affected their preferences (delay/speed-up asymmetry or framing effect).

2. Theoretical Model

To motivate our empirical analysis, which seeks to understand whether rural household behavior is consistent with under-investment, we derived the inter-temporal rate of substitution of consumption under two credit market regimes. This trade-off between outcomes occurring at different points in time has traditionally been explained by the discounted utility model, with the RTP being the sum of two components as given in equation (1).[1] The first term δ captures the marginal rate of substitution for the same level of consumption and is a "pure" or "myopic" preference for consuming a good sooner rather than later. The second term μ_g describes the effect of the future change in the consumption on the marginal rate of substitution between the two periods. μ is the negative of the elasticity of marginal utility of consumption, and g is the expected rate of growth in per capita consumption.

$$RTP = \delta + \mu g \quad . \tag{1}$$

2.1 Case 1: RTP When Access to Borrowing Is Unlimited

Consider a household whose task is to find out the optimal level of borrowing B^* at a fixed interest rate r that maximizes expected discounted utility with uncertain consumption. The utility function is twice differentiable with $U^{'}(C) > 0,\ \ U^{''}(C) < 0$.

$$\underset{B}{Max} U(C_t) + EU(C_{t+1}) \tag{2}$$

where $C_t = W_t + B$, $C_{t+1} = W_{t+1} - (1+r)B$, and $W_{t+1} = Y + V$. W_t and W_{t+1} are wealth (income) levels in the current and the future period, and the future income is composed of certain (Y) and uncertain (V) income. Maximizing equation (2) and deriving the first order condition of the borrower's problem, we find the following:

[1] See Markandya and Pearce (1988) for a lucid derivation of this equation.

$$1+r=\frac{U_t^{'}(C_t)}{EU_{t+1}^{'}(C_{t+1})}=RTP\ . \tag{3}$$

We therefore find that when households have unlimited borrowing possibilities, the RTP is equal to 1 plus the fixed market rate of interest. Only exogenous factors affecting the market rate of interest thus determine households' RTP. For example, neither wealth nor the shape of the utility function is relevant for RTP formation.

2.2 Case 2: RTP Formation When Credit Is Constrained

Consider the same problem as in equation (2), but with a binding credit constraint. Our household now cannot borrow more than B_{max}, which is the constraint. We want to emphasize that credit constraints are very common in rural areas of developing countries because of a variety of factors that make credit markets highly imperfect (Stigliz and Weiss 1981; Binswanger and Sillers 1983).

$$1+r+\frac{\lambda}{EU'_{t+1}(C_{t+1})}=\frac{U'_t(C_t)}{EU'_{t+1}(C_{t+1})}=RTP\ . \tag{4}$$

The first order condition for this constrained optimum is given in equation (4), where λ is the shadow value of alleviating the credit constraint. There are two main observations relevant to this paper. First, a simple comparison of equations (3) and (4) shows that a positive λ increases the inter-temporal marginal rate of substitution; RTPs are therefore higher when individuals face binding credit constraints. Second, with credit constrained, a variety of factors affecting the expected marginal utility of future consumption (such as wealth, risk to future incomes, and possibilities of insurance) are important determinants of RTP. For example, with lower expected future income due to higher risk and incomplete or nonexistent insurance markets, the expected marginal utility is higher, leading to a higher RTP.

The differing first order conditions with and without credit constraints lead directly to hypotheses that are tested in section 4. First, because we know that credit-constrained households will incorporate the shadow value of credit (i.e., $\lambda > 0$) into their RTP formation, we know that households under case-1 conditions (i.e., with access to credit) will have lower RTPs than those facing constraints, and that the RTPs will be no higher than market interest rates.

We also know from equation (4) that households operating under case-2 circumstances will include the marginal utility of expected future income in their formation of RTPs. Because marginal utility of income is affected by a variety of household characteristics, including wealth, we hypothesized that households facing credit constraints would have RTPs that were functions of household characteristics. Furthermore, because we knew from basic utility theory that wealth is inversely related to marginal utility of income, we particularly focused our attention on the relationship between wealth and RTPs. In section 5, positive coefficient estimates on wealth variables therefore indicated the presence of credit constraints.

Finally, from the literature and our own previous findings (Yesuf and Bluffstone 2007) we knew that households that faced more risk and were unable to insure would have higher levels of risk aversion. From equation (4), we also knew that households facing more risk would have higher RTPs. We therefore expected that more risk-averse households would have higher RTPs.

3. Description of the Experiment and Study Site

Following Pender's design, an experimental approach was applied to a random sample of households in seven villages in two different zones (East Gojjam and South Wollo) in the Ethiopian highlands. We utilized a sample of 262 households that were surveyed as part of a larger survey conducted in February 2002. With the exception of six households, reported results came from the heads of the households. East Gojjam is generally considered to have a good potential for agriculture, whereas South Wollo is considered to be seriously affected by soil erosion and subjected to recurrent drought.

In the study area, as in the rest of Ethiopia, there is limited irrigation and agricultural production depends on timely rainfall, which occurs during the long rainy period from June to September (*meher)* and again during the short rains from March to April (*belg)*. Not all areas have a belg season and output is more variable. Nationally, the belg season makes up a bit less than 10 percent of agricultural output (Gebre-ab 2007). During 2000, collection of belg season data was attempted, but due to respondent fatigue it proved infeasible. In the following section, we thus assumed that the belg season made up 10 percent of total agricultural output.

The major crops grown in the study area include teff[2] (27–34 percent of households), wheat (9–15 percent), barley (6–7 percent), maize (9–10 percent), beans (5–7 percent), and sorghum (5–12 percent), but a variety of vegetables (such as garlic, tomatoes, potatoes, cabbage, pumpkins, onions, sugar cane) and tree crops (such as lemons, oranges, and coffee) are also

[2] Teff is a cereal crop grown as an alternative to wheat (it is the main ingredient of *injera*), and its straw is used to feed livestock and to reinforce the mud or plaster used in buildings.

grown. In 2002, households grew 50 different crops. Most households are subsistence farmers that complement their production with outside incomes. These households produce from small plots and have limited access to capital markets. The average time to the nearest road is 32 minutes walking and 70 minutes to the nearest town.

Rural Amhara is very representative of the non-urban regions of the country. According to the government of Ethiopia's Household Income Consumption and Expenditure Survey, conducted in 2000 (which sampled a total of 17,332 households in Ethiopia, including 1740 in rural Amhara), real per capita expenditure in the rural parts of Amhara is very close to the rural national mean, as is the 2,614-calorie average adult intake. In rural Amhara, 42.9 percent of households are poor with an average income less than $0.36 per adult per day, compared to 45.4 percent for the country as a whole; 20 percent are extremely poor, versus 23 percent nationally. Food makes up 71 percent of income, which is close to the national average of 67 percent. (MOFED 2002).

The most important problem in experimental settings is hypothetical bias, and if respondents lack confidence, they may systematically choose current rewards, irrespective of their actual discount rates. Recognizing this problem, the experiment was conducted using real-payoffs; we believed that they were appropriate incentives to induce farm households to reveal their true preferences. Each farm household was offered four experiment sets, each of which had a number of choices between a specific amount of money to be received now and an alternative amount to be received in the future. Each choice set was presented on a card, on which the respondent's preference was also recorded. After completing all 28 cards, participants randomly chose a card. The selected card determined the payment to the participant.

To test for the presence of magnitude and time frame effects, each set of the experiment reflected different magnitudes of rewards (ETB 15 and 40)[3] and time frames (3, 6, and 12 months). To test for the presence of delay/speed-up asymmetry, two versions of the experiment were used. In version 1, current rewards were fixed and future rewards were changed in order to determine RTPs. In the second version, future rewards were fixed and current rewards were varied to determine RTPs. On average, each household won a sum of ETB 25, which is about 8 percent of the monthly income of unskilled workers. This was felt to be a significant incentive

[3] ETB is Ethiopian birr, the unit of currency; US$ 1= ETB 8.5. These nominal payoffs are equivalent to US$ 1.76 and US$ 4.7, respectively, corresponding to 5% and 13% of monthly income of unskilled labor in the country, respectively.

for respondents to carefully consider the options and reveal true preferences. The full format of the experiment is presented in the appendix. Descriptive statistics are given in table 1.

Table 1 Basic Descriptive Statistics of Participating Farm Households (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 (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 less than 15 years of age to household members greater than 15 years of age)	1.02	0.80	0	5
Household farm size	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 ETB (cash collected from all sources of cash revenue less cash expenditure in one year)	0.35	0.93	-2.37	9.57
Level of risk aversion (1 = extreme risk aversion, 6 = risk lover[‡])	2.94	1.55	1	6

[‡] Six levels were used to classify risk levels of farm households, where 1 equaled extreme risk aversion and 6 was risk-loving behaviors. For more insights on data collection and estimation of the level of risk aversion, see Yesuf (2003).

ETB = Ethiopian birr; US$ 1 = ETB 8.5; Std. dev. = standard deviation.

4. Results

For each set of choices, RTPs were inferred by calculating the implicit discount rate that made respondents indifferent between current and future rewards.[4] Discount rates were right-censored if the participants always chose current rewards, left-censored if they always preferred future rewards, or interval if respondents switched from current to future rewards depending on the payoff. Participants’ responses were considered consistent if they only chose current rewards

[4] Discount rates were calculated by the formula $d=[\ln (f/p)]/(s-t)$, where f is future reward at time s, and p is current reward at time t, where s and t are expressed in years.

(right censored), future rewards (left censored), or chose part current and part future rewards—as long as those preferences changed only once. If participants changed preference more than once during an experiment set, they were considered inconsistent, and no RTP was inferred from their choices.[5] Table 2 displays outcomes from the experiment.

Table 2 shows three important patterns. First, in all of the experiments, many participants preferred the current rather than the future reward, with the proportion ranging 36–39 percent in set 1, and 64–67 percent in set 4. Second, there might be both time frame and magnitude effects in the responses. The proportion of right-censored responses (preference for current reward) increased from 37 percent in the shorter period and smaller reward experiment (set 1) to 65 percent in the longer period and larger reward experiment (set 4) for the entire sample, whereas the proportion of left-censored responses (preference for future reward) declined from 19 percent to 8 percent from set 1 to set 4. The existence of many left-censored observations in version 2 (19 percent in total), compared to version 1 (9 percent in total), suggests the presence of delay/speed-up asymmetries. This conforms to the findings of Loewenstein and Prelec (1992) that subjects demand more to delay consumption than they are willing to sacrifice to speed up consumption.

Next we turned our attention to measuring the discount rates for each set of the experiment. The median discount rates are presented in table 3. In general, the discount rates were very high—indeed, much higher than interest rates on outstanding debt of households, which were reported to be 20 percent on average. These results suggested that credit markets were highly distorted in all of the study areas. Households appeared to be operating under serious credit constraints and, as shown by our theoretical model time preferences, should be functions of household characteristics (such as wealth); whereas, if markets work well, only market factors determine RTPs. We therefore needed to evaluate whether characteristics indeed affect RTPs and estimate the magnitude of those effects.

[5] In the experiment, only 2% of responses were inconsistent.

Table 2 Structure of Discount Rate Responses[+]

Experiment sets	Version 1 (Reference date = current)				Version 2 (Reference date = future)				All			
	Left censored	*Right censored*	*Interval discount rates*	*Inconsistent responses*	*Left censored*	*Right censored*	*Interval discount rates*	*Inconsistent responses*	*Left censored*	*Right censored*	*Interval discount rates*	*Inconsistent responses*
3 months, ETB 15	15%	39%	42%	4%	22%	36%	42%	0%	19%	37%	42%	2%
6 months, ETB 15	9%	54%	33%	4%	19%	58%	23%	0%	15%	56%	27%	2%
6 months, ETB 40	9%	28%	58%	5%	21%	36%	43%	0%	16%	32%	50%	2%
12 months, ETB 40	3%	67%	27%	3%	12%	64%	24%	0%	8%	65%	26%	1%
Total	9%	47%	40%	4%	19%	48%	33%	0%	14%	48%	36%	2%

[+] Percentage shares should be read as row percentages for each version and each experiment set.

ETB = Ethiopian birr; US$ 1 = ETB 8.5

Table 3 Median Discount Rates[+]

Time frame	Median discount rate (in %)		
	East Gojjam	*South Wollo*	*All households*
3 months, ETB 15	106	105	105
6 months, ETB 15	81	58	58
6 months, ETB 40	50	72	63
12 months, ETB 40	43	56	43

[+] We use mid-points for interval discount rates and end points for left or right censored discount rates.

Comparing the median annual rates (the last row in table 3) to other studies, we found that, depending on the time frame, our estimated rates were similar to others' findings. Pender (1996), for example, found discount rates of 30–60 percent in Indian villages, and Holden et al. (1998) found mean rates of 93 percent in Indonesia, 104 percent in Zambia, and 53 percent in a village in Ethiopia.

We then turned our focus to estimating the determinants of RTPs derived from the experiments. As shown in table 2, estimated RTPs were observed to fall within a range for each set. The observed information concerning the dependent variable falls within an interval divided into K intervals, the K^{th} being given by (A_{k-1}, A_k) and $A_0 = -\infty$ and $A_k = +\infty$.

$$y^*_{ij} = x_{ij}\beta + u_{ij}\,;\; u_{ij} \sim iidN(0, \sigma^2) \qquad (5)$$

In terms of our estimation, this means that interval regression is the most appropriate model for this type of data, with the latent structure of the model given in equation (5). y_{ij}^* is the unobserved RTP of the i^{th} individual in the j^{th} experiment, x is a vector of regressors, and β and σ are unknown parameters to be estimated.

In addition to using the econometric model to explain variations in discount rates within each set of the experiment, we also used the model to explain variations in discount rates across the experiments. Explanatory variables were chosen based on the predictions of equation (4), and all variables given in table 1 were included. Note that we particularly included four measures of wealth in the model. These variables were agricultural land area, number of oxen, total value of capital stock, and total cash liquidity of the household. We included all four forms of wealth in the model because they captured wealth for different types of households. For example, wealth of households focused on subsistence crop agriculture is best measured by land area, whereas households with a more pastoralist focus will have more animals and oxen and are by far the most important in the study area (Bluffstone et al. 2007).

On the other hand, households with more diversified incomes will have more capital, captured by total value of capital, and likely more cash earnings and savings, represented by cash liquidity. Cash liquidity was calculated as the difference between all sources of cash revenue (e.g., crop sales, off-farm income, remittances) and cash expenditure (e.g., crop and household item purchases and debt payments). Our variables therefore measured very different aspects of accumulated wealth.

Table 4 Correlation Coefficients of Major Wealth Indicators

	Land size (hectares)	Number of oxen	Annual cash liquidity	Value of cattle
Land size (hectares)	1.00			
Number of oxen	0.3305	1.00		
Annual cash liquidity	0.1875	0.1910	1.00	
Value of cattle	0.3526	0.6110	0.1519	1.00

A concern of including all four wealth measures in one empirical model was that they might be correlated with each other and significant effects might be obscured. As shown in table 4, however, correlations between these variables were less than 62 percent, implying that we did not need to be terribly concerned with multicollinearity.

Because our theoretical model suggested that risk aversion should be positively correlated with RTPs, we also included estimated risk aversion as a right-hand side variable. This variable was also of interest because, to our knowledge, it is the first time that the relationship between RTPs and risk aversion has been estimated. We also expected, however, that these two variables were simultaneously determined, so we included an instrumental variable for risk aversion using predicted values of the ordered probit model presented in Yesuf and Bluffstone (2007).

To test for magnitude and time frame effects in the pooled regression models, we included dummy variables for experiment sets 1, 2, and 3. Given the structure of our experiments, the existence of effects would be indicated by positive estimated coefficients. To test for delay/speed-up asymmetry effects, version dummies were included in the experiment set-specific and pooled regression models. Positive coefficient estimates suggested speed-up asymmetry, negative estimates indicated delay effects, and zero or insignificant estimates suggested no asymmetry. Site dummies and household characteristics were also included with no *a priori* expectation of the signs.

Model results for each of the four experiment sets and the pooled data are given in table 5, with all robust standard errors estimated using the method of White (1980). In the interval regressions, none of the demographic variables—such as gender, age, family size, and education—was significant and they are not reported in the table. In terms of our measures of wealth, coefficient estimates for all wealth variables in all models were negative. Value of capital stock, number of oxen, and land size were negative and highly significant for the pooled data.

Table 5 Interval Regression

Variable	Parameter estimates+						
	Exp. Set 1	Exp. Set 2	Exp. Set 3	Exp. Set 4	E. Gojjam	S. Wollo	Pooled
Constant	2.296 *** (0.452)	1.126*** (0.366)	1.372*** (0.308)	1.333*** (0.221)	2.391*** (0.302)	1.383 (0.253)	1.741*** (0.209)
Land size (in hectares)	-0.248** (0.117)	-0.385*** (0.103)	-0.188** (0.082)	-0.172*** (0.053)	-0.195*** (0.066)	-0.351*** (0.081)	-0.265*** (0.050)
Number of oxen	-0.150 (0.107)	-0.105 (0.090)	-0.057 (0.061)	-0.099** (0.046)	-0.233*** (0.066)	-0.016 (0.054)	-0.119*** (0.042)
Value of capital stock (in '000 ETB)	-0.122* (0.067)	-0.108** (0.054)	-0.122*** (0.039)	-0.066** (0.026)	-0.127*** (0.033)	-0.077* (0.043)	-0.115*** (0.026)
Cash liquidity (in '000 ETB)	-0.133* (0.070)	-0.028 (0.045)	-0.049 (0.038)	-0.055** (0.024)	-0.030 (0.053)	-0.037 (0.027)	-0.022 (0.026)
Risk aversion	-0.312*** (0.066)	-0.120** (0.058)	-0.153*** (0.041)	-0.096*** (0.035)	-0.1849*** (0.044)	-0.161*** (0.036)	-0.184*** (0.028)
Site dummy++ (1=Gozamin wereda)	0.117 (0.206)	0.274 (0.194)	0.0008 (0.130)	0.127 (0.091)	0.142 (0.100)		0.136 (0.089)
Site dummy (1=Enemay wereda)	-0.111 (0.219)	-0.499** (0.209)	-0.051 (0.152)	-0.316** (0.133)	0.086 (0.120)		-0.247** (0.102)
Site dummy (1=Tehuldere wereda)	0.142 (0.179)	0.115 (0.148)	-0.007 (0.115)	-0.006 (0.104)		0.124 (0.077)	0.032 (0.076)
Version dummy (1=set 2)	0.755*** (0.172)	0.323** (0.135)	0.223** (0.110)	-0.050 (0.080			0.340*** (0.073)
Experiment dummy (1=set 1)					0.093 (0.100)	0.053 (0.086)	0.075 (0.070)
Experiment dummy (1=set 3)					-0.346*** (0.094)	-0.070 (0.080)	-0.220*** (0.064)
Experiment dummy (1=set4)					0.044 (0.094)	0.227*** (0.086)	0.133** (0.068)

Variable		Parameter estimates[+]						
		Exp. Set 1	**Exp. Set 2**	**Exp. Set 3**	**Exp. Set 4**	**E. Gojjam**	**S. Wollo**	**Pooled**
Number of observations: Uncensored	Overall	228	228	228	232	512	404	916
	Uncensored	0	0	0	0	0	0	0
	Left censored	45	34	36	20	99	36	135
	Right censored	76	127	69	149	229	192	421
	Interval observations	107	67	123	63	184	176	360
Sigma (σ)		0.696 (0.053)	0.542 (0.053)	0.467 (0.033)	0.301 (0.033)	0.580 (0.038)	0.500 (0.029)	0.567 (0.024)
Log-likelihood function		-318.58	-267.41	-396.95	-233.12	-652.81	-586.89	-1262.220
Chi-squared		202.99	107.49	189.85	138.81	411.44	213.73	538.99

Notes: Figures in parentheses are robust standard errors. ETB = Ethiopian birr; US$ 1 = ETB 8.5. ***, **, * indicate significance levels at 1%, 5%, and 10% levels, respectively.

[+] Computed at mean of other regressors. All household demographic variables were found to be insignificant and hence are not reported in the table.

[++] Kalu is the reference site for the South Wollo as well as pooled data, whereas Machakel is the reference site for East Gojjam.

Indeed, with the exception of oxen (which was significant in three of seven models) and cash liquidity (significant in only two models), wealth came in negative and significant in all models. These results were consistent with case 2 of our theoretical model, where more wealth implied lower marginal utility of income and lower discount rates.

We also found that the degree of risk aversion was positively and significantly correlated with risk aversion in all models (higher numbers implied less aversion). As predicted by our theoretical model—based on the known lack of insurance—risk-averse farmers were more likely to have high discount rates as well. We do not have a good theory for why such results would hold: it could be because risk averse households are myopic in their consumption decision (higher δ), they have lower elasticity of marginal utility of future consumption (lower μ), or they participate less in the existing formal credit market and hence are confronted with higher shadow prices (higher λ).

The results of formal statistical tests on magnitude, time frame, and version effects in all experiments are presented in table 6. From the results of the tests, we clearly observed the

Table 6 Chi-Square and Standardized t-Tests for Experimental Effects for the Pooled Data

Effect	Hypothesis	Statistics	Result of the test
Pure magnitude effects	Exp 2 = Exp 3	-3.44 (0.001)	Rejected at 1% level
Time frame effect	Exp 3 = Exp 4	30.21 (0.000)	Rejected at 1% level
	Exp 1 = Exp 2	1.08 (0.281)	Not rejected
Combined effects (magnitude, and time frame effects)	Exp 1= Exp 3	23.02 (0.000)	Rejected at 1% level
	Exp 1 = Exp 4	0.69 (0.398)	Not rejected
	Exp 2 = Exp 4	1.95 (0.051)	Rejected at 10% level
Version effect	Version 1= Version 2	4.67 (0.000)	Rejected at 1% level

Figures in parentheses are p-values.

presence of magnitude effects in our experiment because, controlling for time frames and other factors, discount rates were a declining function of rewards offered. We also found evidence of time frame effects and in two cases both magnitude and time frame effects. Consistent with the emerging literature, we found the types of “anomalies” in RTP formation that others have discussed.

In general, we found that the discount rates from set 2 were lower than those in set 4, higher than those in set 3, but not statistically different from those in set 1. Furthermore, there existed a time frame effect for longer waiting times (6–12 months) than in shorter time frame (3–6 months) sets. In our design of the experiment, sets 1 and 2, and sets 3 and 4 reflected the same level of reward, but had different time frames. Therefore, the only conceivable explanation for the differences in discount rates between sets 1 and 2 (shorter time frame) and sets 3 and 4 (longer time frame) is a time frame effect. Sets 2 and 3 were designed to capture the pure magnitude effects in the time preference experiment. Both experiment sets reflected the same time frames (6 months), but differed in the magnitude of the rewards. Apart from magnitude and time frame effects, we also observed significant differences in experiment outcomes in the two versions of the experiment, suggesting delay/speed-up effects.

5. Conclusions and Policy Implications

Rural credit markets in developing countries are often dominated by informal sources, characterized by the segmentation, rationing, and high interest rates of small sums offered for short durations. In a well-functioning capital market without large information imperfections, all farmers have the same discount rate, which is equal to the market interest rate. However, cash liquidity constraints and consumption-smoothing problems might drive the subjective discount rates far beyond the market interest rate. This study measured discount rates for a sample of 262 farm households in the Ethiopian highlands, using a time preference experiment with real payoffs. In general, the median discount rate was very high—more than double the interest rate on the outstanding debt—and varied systematically with wealth and risk aversion.

Our results have three important implications for understanding households’ behavior. First, because the RTPs were so high, what may seem like profitable investments from the outside may not seem so from the farmers’ perspectives. In other words, households may fail to undertake investments because the rates of return are lower than their subjective rates of discount. For example, even with complete information and property rights, such high rates might lead farmers to ignore on-site costs of soil erosion. Second, when future returns are uncertain, risk-averse decision makers will favor projects with shorter payback periods and will be less willing to invest in projects with long-term benefits.

Although we do not have a good theory for explaining the linkage between RTPs and risk aversion, our findings warn that these two aspects of household behavior reinforce each other and are easily confused. Indeed, in many circumstances, it will be difficult to know whether reluctance to invest is due to credit market imperfections or risk aversion, but the policy responses to help make rural households comfortable with investing are, of course, quite different. Formal capital market development, including lending and mortgage markets—currently non-existent in most of rural Ethiopia—may help reduce RTPs and cause more investments to be acceptable. As discussed in our earlier work (Yesuf and Bluffstone 2007), however, risk-aversion barriers may be overcome by insurance or simply by reducing the magnitude of gains and losses, for example, in agricultural extension. Clearly, much more research on the linkages between risk aversion and RTPs in low-income countries is needed.

This paper also tested for the presence of what some have described as anomalies and confirmed the presence of magnitude, time frame effect, and delay/speed-up asymmetry effects in the time preference experiment. These results support the research of others who have raised doubts about the applicability of single-parameter discounted utility models in various circumstances and who have developed a variety of alternative theoretical models. These findings challenge us to loosen our conceptual framework for understanding discount rates so that what has now been widely observed will no longer be considered anomalous.

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