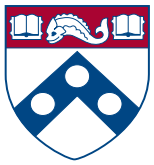
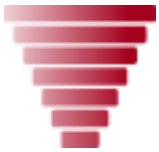


POPULATION AGING RESEARCH CENTER
UNIVERSITY of PENNSYLVANIA



Time Preference and Its Relationship with Age, Health, and Longevity Expectations

Li-Wei Chao, Helena Szrek, Nuno Sousa Pereira, Mark V. Pauly

PARC Working Paper Series

WPS 07-05

"The authors acknowledge the support of the National Institutes of Health - National Institute on Aging, Grant number P30 AG12836, B.J. Soldo, PI"

3718 Locust Walk • Philadelphia, PA 19104-6298 • Tel 215-898-6441 • Fax 215-898-2124

Time Preference and Its Relationship with Age, Health, and Longevity Expectations

LI-WEI CHAO[a], HELENA SZREK[b,c], NUNO SOUSA PEREIRA[b,c], MARK V. PAULY[d]*

WORKING PAPER
PLEASE DO NOT CITE WITHOUT PERMISSION.
COMMENTS ARE WELCOME.

(Version Date: 15 April 2007)

[a] Population Studies Department, University of Pennsylvania, 3718 Locust Walk, Room 239, Philadelphia, Pennsylvania 19104-6298 U.S.A.

[b] Faculdade de Economia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-464 Porto, Portugal

[c] CETE (Research Center in Industrial, Labour, and Managerial Economics, Universidade do Porto, Rua Dr. Roberto Frias, 4200-464 Porto, Portugal

[d] Health Care Systems Department, The Wharton School, University of Pennsylvania, 3641 Locust Walk, Room 204, Philadelphia, Pennsylvania 19104-6257 U.S.A.

Email addresses:
chao69@wharton.upenn.edu (L.W. Chao),
hszrek@fep.up.pt hszrek@wharton.upenn.edu (H. Szrek),
npereira@fep.up.pt (N. Sousa Pereira),
pauly@wharton.upenn.edu (M.V. Pauly)

Acknowledgement:
We gratefully acknowledge financial support for the study provided by the National Institutes of Health National Institute on Ageing (P30AG12836, B.J. Soldo, P.I.) and the Fogarty International Center (R01TW005611, M.V. Pauly, P.I.; K01TW06658, L.W.Chao, P.I.). Nuno Sousa Pereira also gratefully acknowledges support from CETE, Research Center on Industrial, Labour and Managerial Economics, which is supported by the Fundacao para a Ciencia e a Tecnologia, Programa de Financiamento Plurianual, through the Programa Operacional Ciencia, Tecnologia e Inovacao (POCTI) of the Quadro Comunitario de Apoio III. All errors are our own.

ABSTRACT

Although theories in both evolutionary biology and economics predict that an individual's health should be associated with the individual's time preference, no prior study has been done to empirically support or refute such predictions. By collecting detailed measures of health, time preference, and expected longevity on a sample of individuals in townships around Durban, South Africa, this study breaks new ground by being the first to analyze in detail the relationship between time preference and health, in an area of the world with high mortality and morbidity. Interestingly, we find that both physical health and expectations of longevity have a U-shaped relationship with the person's subjective discount rate. This suggests that those in very poor health have high discount rates, but those in very good health also have high discount rates. Similarly those with longevity expectations on the extremes have high discount rates. The research question addressed by this pilot project is policy relevant, as the study tries to determine the importance of health in economic development, not from the commonly asserted productivity-gain argument, but from a much broader investment-for-the-future argument.

INTRODUCTION

The utility from consumption in the future is, ceteris paribus, often "discounted" relative to the utility from consuming the same commodity bundle in the current period. "Time preference" is the term used to describe the phenomenon that people attach different values to the same consumption bundle depending on when consumption of that commodity bundle occurs. In this paper, we are concerned with the degree to which an individual discounts future consumption relative to current consumption, which we call the *subjective discount rate* or *level of impatience*. Where patience is the willingness to wait for something in the future, which corresponds to forgoing current consumption and its associated utility in exchange for future consumption and utility, impatience is the unwillingness to wait.

Although time preference is commonly assumed in models of intertemporal choice, the literature does not fully explain why some people are more impatient than others. For example, some individuals manage to save money for retirement, whereas others with otherwise similar personal characteristics (like income, education, race, age, and sex) do not manage to save. Understanding the determinants of a person's subjective discount rate is important because policies could be better tuned to induce more desirable results if they included an accurate estimate of people's intertemporal optimization decisions, while, at the same time, decision tools and policy manipulable variables could be developed to shape people's intrinsic subjective discount rates. In other words, policy analysts should be concerned about impatience because individuals underinvest in the future in many domains, including retirement savings and health. Furthermore, individuals could be encouraged to counter this underinvestment behavior if pre-commitment devices were more readily available. An example is a pre-commitment to save, such as a retirement plan with savings rates tied to future salary increases (Thaler and Bernartzi, 2004)

or a fixed deposit account with large penalties for early withdrawal (Ashraf, Karlan, and Yin, 2006), or even a pre-commitment to fertility control such as an implantable contraceptive device that lasts two or more years instead of the condom that often requires last minute decision-making. The intrinsic interest in policies or strategies that entail pre-commitment arises in situations where an individual would rather invest for the future but finds it difficult to resist the temptations of consuming in the present period.

Recent advances in evolutionary biology, economics, psychology, and neuroscience have provided some clues as to the potential determinants of subjective discount rates (for a succinct review, see Read & Read 2004). Evolutionary biology assumes that subjective discount rates are exogenously dictated by one's genes and models a person's subjective discount rate as a product of natural selection to maximally propagate one's genes (e.g., Rogers 1994; Sozou & Seymour 2003). These models predict a subjective discount rate that peaks at a time in life (as proxied by age) when reproductive potential is high, so that resources can be expended on sexual reproduction to propagate genes, rather than saved.

In contrast to the evolutionary biology approach, the field of economics models time preference from a utility maximization framework and derives subjective discount rates as outcomes of endogenous choice. Becker & Mulligan (1997) assume that each person is endowed with an initial level of subjective discount rate, but that rate can be modified by the individual investing time and resources to produce "future-oriented capital" to make the future more salient, allowing one to appreciate the future more and to place more weight on future utility of consumption -- leading to a lower subjective discount rate. Their model implies that an exogenous increase in longevity will correspondingly give consumers incentives to invest in "future-oriented capital" so that the extra life years gained can be better appreciated – resulting

in a lower subjective discount rate. In addition to longevity, subjective discount rate may also be related to health. Trostel & Taylor (2001) show that the increasing rate of decline in one's ability to enjoy visceral pleasures, such as with natural ageing and declines in health over the lifecycle, is associated with increasing decline of marginal utility of consumption over time, resulting in an inverse relationship between subjective discount rate and age (as a proxy for health). Recently, neuroimaging data provide a physiological explanation of impatience. Data derived from participants' choices between smaller sooner monetary rewards versus larger later monetary rewards show that separate processes (limbic areas versus the lateral prefrontal areas, respectively) regulate decisions regarding immediate rewards versus delayed rewards (McClure et al. 2004) and that a quasi-hyperbolic discount function (e.g., Laibson 1997) approximates neuroimaging and survey data better than alternative functional forms. Nevertheless, it is unclear at this time what factors (such as ageing, illness, or experience), if any, might alter the activities of these brain regions in making temporal decisions.

We build our hypotheses based on the above theories and relate them to existing empirical findings. First, we expect the discount rate to be U-shaped when plotted against age, based on the theory developed in evolutionary biology and described above. Read & Read (2004) found evidence of a mostly U-shaped function using a survey of young, middle, and older aged adults in the United Kingdom.

H1: The discount rate is high for young adults, low for middle-aged individuals, and high for older individuals.

Second, the subjective discount rate may vary with health. We can expect this to be the case for a few reasons. Those in poor health may have a high subjective discount rate because they do not expect to live as long. Besides longevity reasons, those in poor health may expend

more resources to improve health (or prevent further health decline) than to build "future oriented capital" as in Becker & Mulligan (1997), resulting in a higher subjective discount rate. Although poor health may be associated with a high subjective discount rate, the theory by Trostel and Taylor (2004) suggests that those in very good health may also have a high subjective discount rate because they derive greater utility from consumption when healthy than when sick. A few studies have also empirically examined the relationship between one's health and one's subjective discount rate, but these studies used somewhat limited measures for health and found mixed results. Kirby et al. (2002) used body mass index (BMI) and found no relationship; Read & Read (2004) used two dichotomous variables for health (good vs. bad health; existence of disease in last year vs. no existence of disease in last year) and found poor health to be unrelated to the subjective discount rate for money but related to the subjective discount rate for vacation; and Tu et al. (2004) found BMI and general health to be positively associated with the subjective discount rate for money, linking obesity with impatience but also good health with impatience. Based on these theories and empirical studies, we expect the discount rate to be U-shaped when plotted against health.

H2: Those in very poor or very good health have a high subjective discount rate, and those with average health have a lower discount rate.

Third, we expect the subjective discount rate to be inversely correlated with expected longevity. Individuals that do not expect to live long will expend their resources in the current period. Bloom et al. (2003), in a cross country panel study of national savings rates, found evidence of a relationship between increased longevity and increased savings behavior. Picone et al. (2004), using the U.S. Health and Retirement Study population, found that increased longevity is associated with investments in health. Thornton (2007) found that people in Malawi

who learned they were HIV negative *and* were optimistic about their future infection risks had higher subjective life expectancies and were more likely to invest in agricultural inputs than those who tested positive or were pessimistic about their future risks.

H3: The subjective discount rate will be inversely correlated with expected longevity.

In this paper, we try to add some insight into the determinants of subjective discount rates by testing the above hypotheses. We continue by discussing the survey data that we collected, and then we describe our results. Next, we explore potential explanations for our results, list the weaknesses and strengths of our study, and conclude with policy implications.

METHOD

Participants and Procedures

This study is part of a larger study on the impact of poor health and HIV/AIDS on micro and small enterprises (MSEs) around Durban, South Africa. The sample is described in detail in Chao et. al. (2007). Surveys were conducted over a three year period in select townships around Durban, South Africa, with information on health, business activity, and general demographics. Time preference measures were collected during the third year of the survey, and this paper is based on the results from the total of 175 individuals that had complete responses to questions on time preference, health, and other related variables collected during the third-year survey.

Measures

Five parts of the questionnaire were used to measure the respondent's subjective discount rate, physical and mental health, subjective probabilities of one-, five-, and ten-year survival, planning and savings behavior, expectations of future economic condition and income.

Subjective discount rate. The first set of questions adopts the time preference instrument

originally developed by Kirby and Marakovic (1996) and also used in Kirby et al. (1999). The questionnaire presents participants with a set of 27 hypothetical choices between *smaller sooner rewards* and *larger later rewards*. An example of one of the choices in this instrument is "Would you prefer $34 today to $50 in 30 days?" From these choices, an overall subjective discount rate can be calculated. The respondents in Kirby et al. (1999) had a one in six chance of actually receiving real payoffs. In our experiment, all responses were hypothetical, and we used the South African Rand (which had an exchange rate at the time of survey of about 6.7 rand to the dollar). It is not obvious whether having a real payoff from the time preference questions would have resulted in better measures of impatience. The literature provides conflicting evidence as to whether answers to hypothetical time preference questions differed from those with real payoffs. Coller and Williams (1999), using a between subject design, found the discount rates from hypothetical questions to be larger than those from questions with real payoffs; however, Johnson and Bickel (2002), using a within subject design, found no statistical difference in discount rates derived from real and hypothetical questions.

In this study, we decided not to use real payoffs for two pressing issues. First, we were unable to make a 100% guarantee of delivery of the *future* reward to our participants (due to respondent trust, relocation, and other logistical issues). Without 100% certainty that a chosen future reward would be delivered, the measured discount rates would reflect not only impatience, but also the risk premium that the participants attach to the uncertainty of receiving the chosen future reward. Although the direction of such a bias would likely be choice for the immediate reward (i.e., a higher measured discount rate), the magnitude of such a bias would be unobserved and would likely differ by participants. Eliciting time preference using real money, thus, would more likely result in this kind of bias that could not be controlled for by our statistical procedures

in the analysis. We have shown elsewhere that health is related to trusting behavior (Chao & Kohler 2007). Because health is a key explanatory variable in our regressions, we did not want to create an omitted variable bias (i.e., "trust in the interviewer's ability to deliver a future reward") that was correlated with both health and discount rates.

The second reason that we did not give real monetary rewards was that we did not want the participants to "think too much" about the monetary tradeoffs. Real monetary rewards have been purported to create incentives for participants to exert cognitive effort in answering survey questions (Camerer & Hogarth 1999; Read 2005), but time preference questions of the type asked in our survey have also been scrutinized and criticized for measuring outside lending and borrowing opportunities rather than impatience in consumption (Coller & Williams 1999; Cubitt & Read 2007). Because the goal of our study was to find determinants of impatience rather than outside financial opportunities, we used monetary tradeoffs that were hypothetical, so as to minimize the incentive for the participants to answer after careful calculations. In fact, our interviewers were trained to instruct the respondents to answer these monetary tradeoff questions quickly and based on "gut feeling" rather than careful introspective mathematical calculation.

Health Measures. We used the SF12 health status instrument, which consists of 12 questions that assess symptoms, functioning, and quality of life among two dimensions: mental and physical health. Examples of questions included in the SF12 are "Do you have any health problems that limit you in carrying out moderate activities? (For example walking to transport or helping at home. If so, how much?)" and "How much of the time during the past 4 weeks did you have a lot of energy?" Also, one of the 12 questions is a self-assessed general health question in which the respondent is asked to rate his/her health into five categories, ranging from excellent to poor. Separate scores for physical health (PCS12) and for mental health (MCS12)

are obtained by weighting each question according to a formula (Ware et al. 1995). This instrument was designed to be easily administered and answered even by individuals that cannot read and has been validated in many developing countries in various languages.

Subjective Probabilities of Survival. The next set of questions asked individuals about their subjective probabilities of survival from 0% to 100% to measure how certain the respondent is that he/she will not die in the next 1, 5, or 10 years. (Although, we are not technically calculating longevity, in the text we sometimes refer to longevity, so the reader should be aware that we are calculating subjective survival probabilities.) A similar question is asked in the Health and Retirement Study (HRS) in the U.S. Smith et al. (2001) `demonstrate that respondents not only can answer these questions, but that their answers indeed predict how long they will live.

Planning and Savings Behavior. We asked two questions about the respondents' planning behavior and another two questions about the respondents' savings behavior. For the planning behavior, we asked whether the respondents classified themselves as planning ahead all the time or living from day to day. Similarly, for savings behavior, we asked whether the respondents classified themselves as preferring to spend money to enjoy life today or to save more for the future. These questions were modeled after the US Panel Study of Income Dynamics.

Expectations of Economic and Business Situation in the Next Two Years. Because current versus future marginal utility of consumption depends on the income level in the two time periods, we asked all respondents whether they expected the economic situation of their community to improve a lot, improve a little, remain the same, decline a little, or decline a lot in the next two years. Among the owners of small businesses, we also asked an additional question on their expectations of income growth from their own business for the following two years.

Data Analysis

To estimate a subjective discount rate for each individual, we assume a hyperbolic discount function, where the present value V of a delayed reward is determined by

$$V = \frac{A}{1 + kD},$$

where A is the reward, D is the delay, and k is the parameter that determines the subjective discount rate (Mazur 1987; Kirby & Marakovic 1996). This function has been shown by many authors to provide a good fit to time preference data elicited by similar methods (e.g., Kirby et. al. 1999; Laibson 1997; McClure 2004). Unlike exponential discount functions (which assume a constant per-period discount rate regardless of the time interval), hyperbolic discount functions allow for a higher per-period discount rate for delays in the immediate future but lower per-period discount rate for long delays – allowing for the function to better approximate time preferences with an immediacy premium. Given the high mortality and morbidity rates and the overall uncertainty in the environment of our sample population, our respondents may have a preference for immediate reward above and beyond a constant level of impatience. The hyperbolic discount function is not without controversy, however, as various recent experiments using similar time preference elicitation methods suggest that a constant per-period discount function like the exponential discount function cannot be rejected by the data, especially after a fixed cost to any delay is allowed (Benhabib, Bisin, & Schotter 2006; Coller, Harrison, & Rustrom 2003; Read, Airoldi, & Loewe 2005). Because two of the major papers most related to ours used different functions to calculate the subjective discount rate (Read & Read 2004 used an exponential function and Kirby et al. 2002 used a hyperbolic function), we also used the exponential discount function in our analyses and found that the results and conclusions did not differ by discount function.

Using the calculated subjective discount rate for each participant, we analyzed the

bivariate relationships between the subjective discount rate and the respondents' demographic characteristics, as well as their age, health, and expectations of their own subjective survival probability to live a certain number of years. We then performed multivariate regressions. Because the subjective discount rates elicited by the hypothetical monetary tradeoffs are constrained to be between 0.00016 and 0.25, we used two-sided tobit regressions to account for the left- and right-side censoring of the calculated subjective discount rate.

RESULTS

Descriptive Statistics

We have 175 individuals in the sample, 73% are female, 46% are married or have a cohabiting partner. The mean age of the sample is just above 46 years, ranging from 18 to 91. In terms of education, 6% of respondents have no formal education, 20% have some primary, 13% have finished primary school, 29% have some secondary, 21% have finished secondary school, 4% have some tertiary school, and 7% have finished tertiary school. Of the 175 respondents in our sample, 95 (55%) are either currently running a small business or ran a business that has recently closed.

Health Status: The respondents' mean physical and mental health scores for the SF12 are 42.4 and 51.8, respectively, with standard deviations of 12.1 and 10.9. The mean health score in our population is lower than that in the United States (which has a normalized score of 50), although the standard deviation is similar (at around 10) (Ware et al. 1995). Twenty-two percent of respondents report their health to be excellent, 25% report their health to be very good, 28% report their health to be good, 21% report their health to be fair, and 4% report their health to be poor.

Subjective Probability of Survival: An analysis of the time horizon questions shows that

there is some variance in individuals' expectations regarding how long they will live. Although 38% say they are 100% confident that they will "live to this time next year," 21% state at least a 60% chance of not living until the next year. The mean response is an 82% confidence to live to the next year. When we asked individuals their expectations to living to this time in five years, 25% expressed a 100% confidence that they would live to this time in 5 years, and 31% of respondents expressed a 50-50 chance of living to the next 5 years. The mean response was just above a 70% chance of living to the next 5 years. A similar pattern is found when we consider individuals' expectations to live 10 years. While 19% of respondents are 100% confident that they will be alive, 48% of respondents expressed a 50-50 percent chance or lower of being alive in 10 years.

//Table 1: Descriptive Statistics of the Sample//

Means Subjective discount rates: Subjective discount rates as calculated by the Kirby-Marakovic method were relatively high in our sample, at 0.078, which is substantially higher than the subjective discount rates of both heroin addicts (0.025) and controls (0.013) studied by Kirby et al. (1999) in the U.S., but lower than the median subjective discount rates (0.12) found by Kirby et al. (2002) among the Tsimane' Amerindians in Bolivia. We found a skewed distribution of subjective discount rates. Although a large number of individuals exhibit subjective discount rates that are within the ranges found in other studies such as Kirby et al. (1999), there is also a large number of individuals displaying the highest subjective discount rate (31 in 175), and a significant number of individuals displaying the lowest subjective discount rate (7 in 175), which reflects the censoring of the subjective discount rates due to the nature of the monetary-choice tradeoffs in our questionnaire. The high proportion of right-censored observations confirms the hypothesis that individuals suffer from a bias towards immediate

gratification in this subsample. Figures 1a and 1b show the frequency distributions of the subjective discount rates and of the natural log of the subjective discount rates, with the lines representing a kernel density estimation and the best-fitting normal distribution.

//Figure 1a and 1b; Frequency Diagram of dr and ln(dr)//

Subjective discount rate, Socioeconomics, Age, Health, Survival.

We also looked at the bivariate relationship between the subjective discount rate and the various socioeconomic variables, age, health, and survival expectations, and these are presented in Table 2a. It is interesting to note that gender, marital status, business ownership, and income level of the respondent's area of residence were not statistically significantly related to subjective discount rate.

//Table 2a: (need new revised table) Mean Subjective discount rate, by Sociodemographics//

We also examined the Spearman rank correlations between the individual subjective discount rate and education, age, physical health, mental health, and subjective survival probability. The results are shown in the bottom half of Table 2a. It is interesting to note that none of these variables is rank-correlated with subjective discount rate. This could either be because a relationship between these variables and the subjective discount rate does not exist, or that the relationship is non-linear. Because the theoretical predictions (see Introduction above) suggest that the relationship between age and subjective discount rate may be non-linear and perhaps U-shaped, we also plotted the subjective discount rate against age, health, and subjective survival probability. We do not find any relationship between subjective discount rate and age, but the relationship between subjective discount rate and health and between subjective discount rate and survival probability are both U-shaped.

//Figure 2a,b,c: Subjective discount rate vs. Age, PCS12, Survival//

We also examined the relationship between subjective discount rates and several behavioral variables that are often linked with time preference, such as willingness to plan for the future and to save money. We found that respondents that claimed that they "planned their life ahead all the time" had lower subjective discount rates than those that claimed to "live more from day to day" (0.066 compared to 0.106, p=0.0085, one-tailed). Also, those that preferred to "spend money and enjoy life now" had higher subjective discount rates than those that preferred to "save more for the future" (0.110 compared to 0.067, p=0.01, one-tailed). Because planning and savings require a preference for waiting for a larger reward in the future, these behaviors are good tests for the construct validity of our discount rate measure. Indeed, the results in Table 2b suggest that the level of patience as measured by our subjective discount rate is consistent with the planning and savings behaviors in our sample.

//Table 2b: Spearman Correlation: Subjective discount rate, by Selected Behavioral Variables//

Two-Sided Tobit Regressions

We performed a series of regressions using both ordinary least squares and two-sided tobit, with both subjective discount rate and the natural log of the subjective discount rate as the dependent variable. The results were similar but not identical, and our main conclusions remain the same with the various specifications. Given that the subjective discount rate is censored from the left and the right and that the subjective discount rate is highly skewed without the log transformation, we present below the results obtained from two-sided tobit regressions with ln(subjective discount rate) as the dependent variable.

In order to test Hypothesis 1 that the subjective discount rate should be related to age, we first regressed ln(subjective discount rate) on age and age square. The results are shown in column one. It is noteworthy that although the subjective discount rate appeared to have a U-

shape relationship with respect to age, the estimates were only marginally significant, while at the same time, age and age-squared were not jointly significant. Gender and marital status were insignificant. Those who had no education had a very significantly higher subjective discount rate than those with at least some primary school education.

//Table 3: Two-Sided Tobit Regression of ln(subjective discount rate)//

We next examined Hypotheses 2 and 3 to test whether health and survival probability were associated with subjective discount rates, and these results are presented in specifications (2) through (5) in Table 3. Physical health, but not mental health, was highly significantly associated with the subjective discount rate. The significance of the age variable disappeared with the inclusion of the health variables; this suggests that rather than age, it may be the level of physical health that explains the U-shaped pattern found in previous studies. Given that health may be associated with the subjective discount rate through its effect on mortality risk, we next added the one-year subjective probability of survival to the regression. (Because the questions to elicit the subjective discount rates were all framed with a delay that is less than one year, we use the 1-year survival probability in our analyses below; the results from using the 5- or 10-year survival probability variable bear similar trends as the 1-year.) Interestingly, as shown in specification (5) of Table 3, survival was not only highly significant, but inclusion of the survival variables reduced both the magnitude and the significance level of the physical health variables – suggesting that part of the effect of the health variable on subjective discount rate was via the relationship between health and survival. In regressions not reported in Table 3, we also included one-year survival without the health variables; the coefficient magnitude and significance level of the survival variables were not reduced with the inclusion of the health variables. This suggests that the effect of survival on discounting is not via health, but part of the effect of health

on discounting is via survival.

From specification (5) in Table 3, it is apparent that the relationship between the subjective discount rate and both health and survival was U-shaped, supporting hypothesis 2 but in contrast to hypothesis 3. This suggests that those in very poor health have high subjective discount rates, but those in very good health also have high subjective discount rates. Similarly those with both high and low survival probabilities (but not those in between), display high subjective discount rates. In fact, the nadir of the U-relationship between subjective discount rate and health occured when PCS12 was 37.8, or slightly below the mean physical health level of the sample. The nadir for the U-shaped relationship between the subjective discount rate and the one-year survival probability occured at around 75%, or slightly below the mean subjective survival probability for the sample.

Expanding income or consumption opportunity in the future may reduce the marginal utility of consumption in the future (and hence lead to greater discounting of the future). To control for the potential confounding effects that this might have on our results, we included a variable on the respondent's subjective outlook for the overall economic environment in their community in the next two years. (Ten respondents did not answer this question and were excluded from subsequent analysis.) Although this variable is not the same as the respondents' subjective outlook for their own future consumption opportunity, to the extent that the subjective outlook for own future consumption is correlated with that for their community, our variable may still proxy for the effect of expanding or declining consumption or income possibilities on the subjective discount rate. The results, shown in specification (6), show that those who thought the economy was going to worsen a lot in the next two years (the omitted dummy) had the lowest subjective discount rate. We also find that people with good future income prospects have a

higher subjective discount rate, but also that the U-shaped relationship between the subjective discount rate and health persists. Although the linear term is no longer significant at conventional levels, the linear and quadratic terms combined are jointly significant in the model. Moreover, because 6% of our sample did not respond to the question on prospects of future income, our sample size was further reduced when we controlled for income expectations in the model. Nevertheless, these results suggest that both health and longevity have a U-shaped relationship with the subjective discount rate and that both are independent predictors of time preference.

DISCUSSION

Several of our main findings are surprising. Our first main finding is that age is not a significant predictor of time preference, and is in contrast to the findings in Kirby et al. (2002) and Read & Read (2004). In our sample, age was only significant in models where physical health level was not included as a regressor. Our findings differ from those of these authors for at least two reasons. One is that only 25% of our sample consists of people over the age of 55 and that our sample may not contain enough older people to show an age effect, whereas Read & Read (2004) concentrated their sample selection based on three age strata, with the oldest strata around age 70. Notably, we are comparing different kinds of people in very different environments. The other reason is that expected longevity, not age, may be a true underlying determinant of people's subjective discount rates. In populations where age does correlate well with expected longevity, the effect of longevity on subjective discount rates can be well-manifested by the effects from age. However, because causes of mortality in South Africa are not necessarily related to age (e.g., mortality from HIV/AIDS affects more people less than age 40 than above), age is no longer a strong predictor of subjective discount rates.

Our second main finding is the U-shaped relationship between health and the subjective

discount rate. This is a very interesting and important finding, and although we predicted this relationship, no one else has either tested for it or found evidence for it. The few studies that did examine the relationship between health and the subjective discount rate use of crude measures of health. Furthermore, a non-linear relationship between health and the subjective discount rate could have also contributed to the lack of any significant (linear) relationship assumed in these other studies. We give more detail here to better explain the U-shaped relationship between the subjective discount rate and health; however, we cannot yet determine which of the explanations is driving the real relationship that we find, and it is even very likely that they coexist and that it is exactly the interaction that determined the observed pattern. Our finding that those with average health have lower discount rate than those who are very healthy or very sick could be due to several reasons. First, according to Trostel & Taylor (2002) and Olsho (2006), the ability to enjoy consumption depends on an individual's health, and the healthier an individual, the greater the enjoyment of the same commodity bundle. Because health generally declines over the life cycle, individuals should have a high subjective discount rate when healthy and, thus, enjoy the consumption while they still can. Second, people who are not very healthy are likely those who were once very healthy but have now experienced some health decline; these people may long for their better health in the past, which motivates them to start examining the past and the future in general, so that the future becomes more salient (as in Liu & Aaker 2006 and Becker & Mulligan 1997), resulting in a lower subjective discount rate for the future. The foregoing explains why people of average health may have lower subjective discount rates than those with very good health. We also find a higher subjective discount rate among people with very poor health, and this finding is robust to having controlled for longevity (and hence wanting to spend resources before death cannot explain this finding). People with very poor health may have more

immediate need for cash to pay for medical care or for daily survival (perhaps because they are too sick to work), hence the unwillingness to wait for the larger reward.

Our third main finding is the U-shaped relationship between the subjective discount rate and survival probability after controlling for current physical and mental health status. It is reasonable for people with low expected survival to have a high subjective discount rate, because their future consumption may never come. This is what we expected to find (Hypothesis 3). It is somewhat perplexing as to why those with a very high expected survival probability also highly discount the future. We believe that saliency of time may explain this finding (as in the argument for the saliency of health and its decline above). Liu & Aaker (2006) showed that personal experience with someone who died of cancer is associated with decisions that favor long-term future over the short-term present, and this effect seems to be related to the "salience and concreteness regarding one's future life course, shifting focus away from the present toward the long run." It is thus plausible that people who expect a very high probability of survival may not have had cues from the environment to tell them otherwise; mortality to them is nonexistent. However, as they experience deaths from social and family networks, death becomes more salient. They not only start to revise downward their expected survival probability, but they also start to think more about the future. As the future becomes more salient, they are more likely to invest in "future oriented capital" and will discount the future less (as in Becker & Mulligan 1997).

LIMITATIONS & STRENGTHS

Our study provides seminal and thought provoking findings in terms of the relationship between the individual subjective discount rate and age, health, survival, and future consumption or income opportunities. While the study is subject to many limitations, our study also has

strengths that overcome many other studies´ weaknesses. We first discuss the limitations, followed by the strengths, and we end with some policy implications of our results.

The first limitation to our study is that we had a small sample that consisted of a majority of business operators. While this gave us confidence that the answers to questions involving monetary tradeoffs were less likely to be subject to the problems of low mathematical literacy, it is unclear whether our results from a mostly mathematically-literate population are fully generalizable to the general population in the developing world.

The second limitation is that we did not have good measures of household assets and income; we only have measures of business profit and the income strata where the respondents resided. Relative to the highest income area, the fixed effects for low and middle income areas were consistently negative and some statistically significantly negative, which indicates that respondents in the lower income areas have lower subjective discount rates than those from the highest income area. This finding is opposite to that found by Read & Read (2004), who also included income strata for their time preference study among populations of the United Kingdom and found that high income strata were associated with a lower subjective discount rate. This seeming contradiction may be because all of our respondents are poor, just that some are less poor than others. Even our "high income" strata would be considered the lowest income strata in Read & Read's study population.

The third limitation is that although most theoretical models of time preference assume that ability to enjoy consumption now and ability to enjoy consumption in the future (and their difference) would be important determinants of subjective discount rate, our study did not have a measure for "ability to enjoy future consumption." We also lack a variable on expected health in the future, which might have been a good proxy for the felicity function as expounded by Trostel

& Taylor (2001) and as implicitly assumed in Becker & Mulligan (1997). Other studies also suffer from this problem. To try and address this issue, we used data on the respondents´ current and prior health, instead of future physical health, but these past health and past health change variables were all insignificant determinants of subjective discount rates.

Despite the foregoing limitations, our study does have many strengths that improve on others' studies. First, our results are compelling because, despite a small sample size, our results are robust to different specifications. We found that physical health, physical health squared, survival probability, and survival probability squared were significant in most of the specifications explained here as well as numerous others that we tried.

Second, we used comprehensive measures of health status that have been culturally validated in Zulu speaking populations in South Africa (personal communication with Michelle Koch of Qualitymetrics). The SF12 instrument combines multiple symptoms into one summary scale each for physical health and for mental health, and is less subject to systematic measurement error than single question health status measures (Dow et al. 1997). No other study on time preference that we are aware of has incorporated the use of health status instruments; most used only dichotomous categorization of good versus bad health or body mass index, which may not be sensitive enough to capture the multiple dimensions of health and health differences in the sample population. As suggested in the discussion, our use of a comprehensive measure of health may be what contributed to our capturing the U-shaped relationship between health and the subjective discount rate.

Third, our study is also the first to incorporate subjective probabilities of survival as a determinant of time preference. Although most theories on why there is time preference make use of mortality risk as one factor that reduces the utility of future consumption, most empirical

studies on time preference resort to the use of age as the variable of interest. However, age proxies for a lot of factors in life, with mortality risk as only one such factor. In particular, many studies confound the differential effects of age and expected length of life on discounting. Although age is correlated with health and expected survival probability, in sub-Saharan Africa where morbidity and mortality risks are very high and where disease profiles are not necessarily related to ageing, age may not be a good proxy for morbidity and mortality. For instance, HIV morbidity and mortality afflict people age 20-40 far more than those below 20 or above 40 (Shisana et al. 2005).

Fourth, our study is the first to simultaneously control for age, health, survival, and future consumption opportunities as co-determinants of the subjective discount rate. We separately measure age, health, and expected length of life – all of which are very distinct. This teases apart the contributions of each of these variables to time preference. For example, up to 15% of all mortality in South Africa is non-health related and non-age related (e.g., homicide, suicide, accidents; Statistics South Africa 2005). This should be reflected in longevity expectations, not in health or in age. Further, our use of two-sided tobit regression also allows for less bias in the estimation of these relationships, especially in the face of both left and right censoring of the calculated subjective discount rate.

Fifth, our study incorporates a subjective economic outlook variable that may proxy for consumption and income opportunities in the near future. Although all economic theories of time preference subsume future consumption opportunity as a determinant of subjective discount rate, no empirical study has included such a variable.

Finally, despite the set of 27 questions used to measure time preference, the consistency of the answers is above 90%, which suggests that the respondents were not answering randomly.

Moreover, based on the answers to the other questions in the survey about planning and savings behavior, our time preference measure also shows strong construct validity in measuring willingness to wait for the future.

In view of the strengths but also the limitations of our data, our results should be interpreted with caution. Nevertheless, we find important and novel results regarding the relationship between health and the subjective discount rate and longevity and the subjective discount rate.

Our study has important policy implications. Our finding that subjective discount rates differ by health levels implies that economic evaluation of healthcare programs that use results from surveys of the public (who are likely to be healthier than those that are helped by the potential health programs) may be inaccurately weighting future costs and benefits by not taking into consideration that the subjective discount rate is a function of health status. Furthermore, the provision of healthcare and health insurance (especially in countries with low health levels) may improve health and survival, leading to more future-oriented thinking and investments for the future; this positive externality should not be neglected in welfare analysis of these social programs. Finally, there is the possibility that those who think they are extremely healthy or will live forever discount the future more because of lack of information. This impedes their ability to put the future into proper perspective, resulting in non-optimal inter-temporal trade-offs with potential for regret later in life. Here, public health education to make the future more salient may be an additional policy tool; alternatively, development and provision of pre-commitment devices may also be welfare improving.

REFERENCES

Ashraf N, Karlan D, Yin W. Tying Odysseus to the mast: Evidence from a commitment savings product in the Philippines. Quarterly Journal of Economics 121(2):635-672. 2006.

Becker GS, Mulligan CB. The endogenous determination of time preference. Quarterly Journal of Economics 112:729-798. 1997.

Benhabib J, Bisin A, Schotter A. Present-bias, quasi-hyperbolic discounting, and fixed costs. Working Paper. January 2006.

Bloom DE, Canning D, Graham B. Longevity and life-cycle savings. Scand J of Economics 105(3):319-338. 2003.

Camerer CF, Hogarth RM. The effects of financial incentives in experiments: a review and capital-labor-production framework. Journal of Risk and Uncertainty 19:7-42. 1999.

Chao LW, Kohler HP. The behavioral economics of altruism, reciprocity and transfers within families and rural communities: evidence from sub-Saharan Africa. Population Association of America 2007 Annual Conference, New York City. March 30, 2007.

Chao LW, Pauly MV, Szrek H, Sousa Pereira N, Bundred F, Cross C, Gow J. Poor health kills small business: Illness and microenterprises in South Africa. Health Affairs 26(2):474-482. 2007.

Coller M, Harrison GW, Rustrom EE. Are discount rates constant? Reconciling theory and observation. University of South Carolina Moore School of Business Working Paper. December 2003.

Coller M, Williams MB. Eliciting individual discount rates. Experimental Economics 2:1027-127. 1999.

Cubitt RP, Read D. Can intertermporal choice experiments elicit time preferences for

consumption? Experimental Economics DOI 10.1007/s10683-006-9140-2, (February 1, 2007)

Domeij D, Johannesson M. Consumption and health. Department of Economics Working Paper, Stockholm School of Economics. January 2006.

Dow WH, Gertler P, Schoeni RF, Strauss J, Thomas D. Health care prices, health and labor outcomes: experimental evidence. RAND Labor and Population Program Working Paper 97-01. 1997.

Johnson MW, Bickel WK. Within-subject comparison of real and hypothetical money rewards in delay discounting. Journal of the Experimental Analysis of Behavior 77(2):129-146. 2002.

Kirby KN, Godoy R, Reyes-Garcia V, Byron E, Apaza L, Leonard W, Perez E, Vadez V, Wilkie D. Correlates of delay-discount rates: Evidence from Tsimane' Amerindians of the Bolivian rain forest. Journal of Economic Psychology 23:291-316. 2002.

Kirby KN, Marakovic NN. Modeling myopic decisions: Evidence of hyperbolic delay-discounting within subjects and amounts. Organizational Behavior and Human Decision Processes 64:22-30. 1995.

Kirby KN, Petry NM, Bickel WK. Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. Journal of Experimental Psychology: General 128(7):78-87. 1999.

Laibson D. Golden eggs and hyperbolic discounting. Quarterly Journal of Economics 112(2):443-477. 1997.

Liu W, Aaker J. Do you look to the future or focus on today? The impact of life experience on intertemporal decisions. Organizational Behavior and Human Decision Processes. (forthcoming in 2006).

Mazur JE. An adjusting procedure for studying delayed reinforcement. In M.L. Commons, J.E. Mazur, J.A. Nevin, & H. Rachlin (Eds.), *Quantitative analyses of behavior: Vol. 5. The effect of delay and of intervening events on reinforcement value* (Hillsdale, NJ: Erlbaum), pp. 55-73. 1987.

McClure SM, Laibson DI, Loewenstein G, Cohen JD. Separate neural systems value immediate and delayed monetary rewards. Science 306. 503-507. 15 October 2004.

Olsho L. Spend it while you can still enjoy it: Health, longevity, aging, and consumption in the life cycle. Department of Economics Working Paper, University of Wisconsin-Madison. August 2006.

Picone G, Sloan F, Taylor D. Jr. Effects of risk and time preference and expected longevity on demand for medical tests. J of Risk and Uncertainty 28(1):39-53. 2004.

Read D. Monetary incentives, what are they good for? Journal of Economic Methodology 12(2):265-276. 2005.

Read D, Airoldi M, Loewe G. Intertemporal tradeoffs priced in interest rates and amounts: A study of method variance. London School of Economics and Political Science Department of Operational Research Working Paper. 2005.

Read D, Read NL. Time discounting over the lifespan. Organizational Behavior and Human Decision Processes 94:22-32. 2004.

Rogers AR. Evolution of time preference by natural selection. American Economic Review 84(3):461-481. 1994.

Shisana O, Rehle T, Simbayi LC, Parker W, Zuma K, Bhana A, Connolly C, Jooste S, Pillay V, et. al. 2005. South African National HIV Prevalence, HIV Incidence, Behaviour and Communication Survey, 2005. South African Human Sciences Research Council

(HSRC),(http://www.hsrcpress.co.za/index.asp?id=2134 accessed on 25 January 2006)

Smith VK, Taylor DH, Sloan FA. Longevity expectations and death: can people predict their own demise? American Economic Review 91(4):1126-1134. 2001.

Sozou PD, Seymour RM. Augmented discounting: interaction between ageing and time-preference behaviour. Proc. R. Soc. Lond. B 270:1047-1053. 2003.

Statistics South Africa. Mortality and causes of death in South Africa, 1997-2003: Findings from death notification. Statistical release P0309.3. 18 February 2005.

Thaler RH, Benartzi S. Save more tomorrow: Using behavioral economics to increase employee saving. Journal of Political Economy 112(1 part 2):S164-S187. 2004.

Thornton RL. Hope for the future: How learning HIV status affects savings and expenditures. Harvard University Kennedy School Working Paper. April 18, 2006.

Trostel PA, Taylor GA. A theory of time preference. Economic Inquiry 39(3):379-395. 2001.

Tu Q, Donkers B, Melenberg B, van Soest A. 2004. The time preference of gains and losses. Working Paper, Tilburg University.

Ware JE, Kosinski M, Keller SD. How to Score the SF-12 Physical and Mental Health Summary Scale, 2d ed. (Boston: Health Institute, New England Medical Center, 1995).

Table 1: Descriptive Statistics of the Sample

	Mean (S.D.)
Female (%)	72.57
Married or Cohabiting (%)	45.71
Education (% with no education)	6.29
Belief that the economy will worsen a lot (%)	6.10
Belief that income will decrease a lot (%)	4.82
Age	46.52 (15.09)
SF12 Scores	
PCS12 (physical health score)	47.48 (12.06)
MCS12 (mental health score)	51.90 (10.86)
Subjective probability of survival	
Probability of being alive in 1 year (%)	81.83 (19.71)
Probability of being alive in 5 years (%)	70.23 (26.04)
Probability of being alive in 10 years (%)	57.77 (31.11)
Overall Discount Rates	0.078 (0.084)
Number of observations	175

Figure 1a: Frequency Diagram of Discount Rate

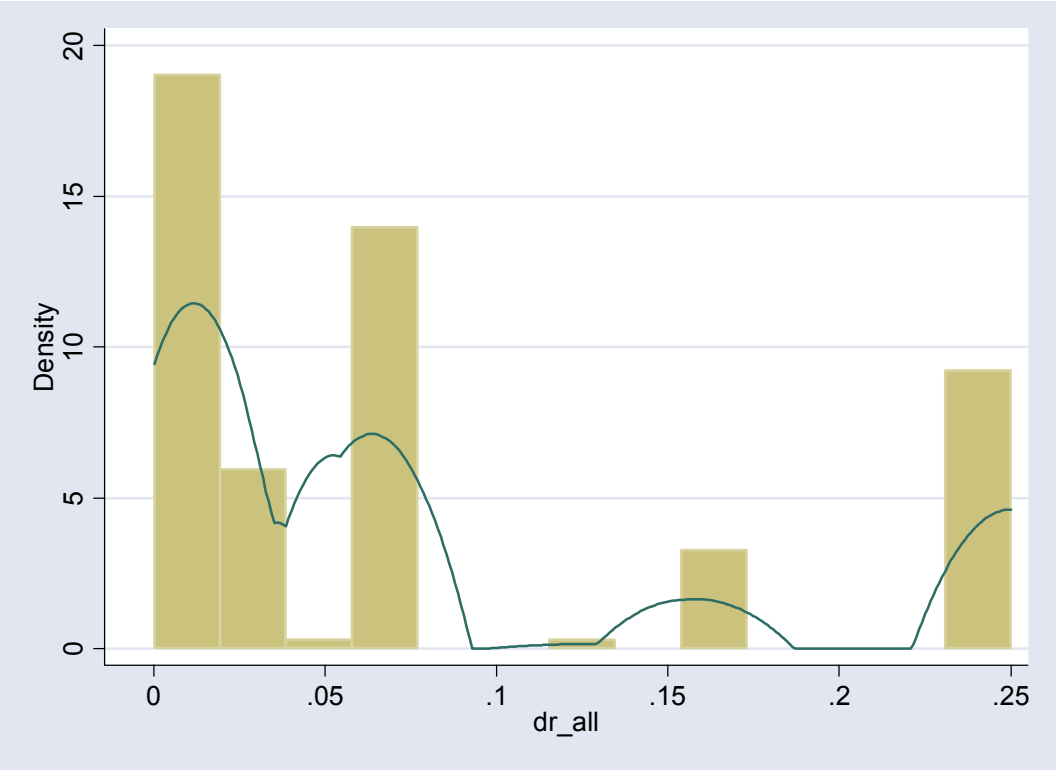


Figure 1b: Frequency Diagram of ln(Discount Rate)

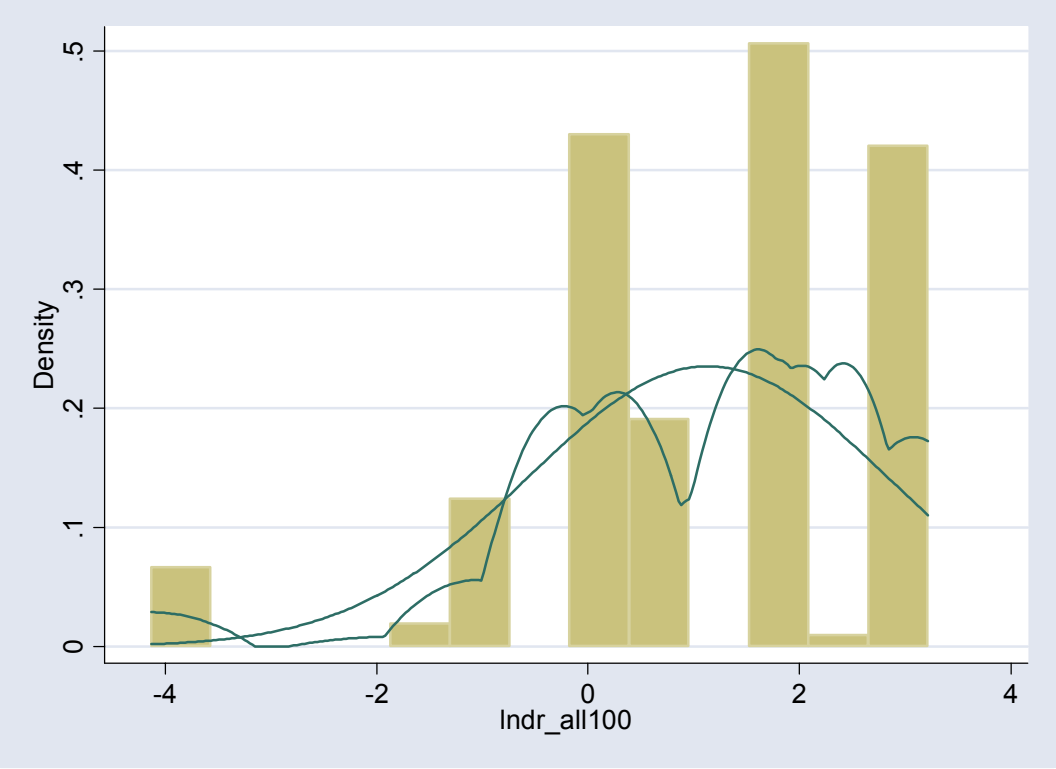


Table 2a: Mean Discount Rate, by Sociodemographic Variables

	Mean Discount Rate	Significance of Difference Between Groups
Gender		
Male	0.071	Kruskal Wallace = 0.000; df = 1
Female	0.081	p = 0.992
Marital Status		
Married or Cohabiting	0.089	Krukal Wallace = 0.244; df = 1
Single, Divorced, Widowed	0.069	p = 0.621
Business Ownership		
Business Owner or Past Owner	0.083	Kruskal Wallace = 0.614; df = 1
Never Owner	0.077	p = 0.433
Income		
High Income	0.083	Kruskal Wallace = 1.706; df = 2
Middle Income	0.067	p = 0.426
Low Income	0.087	
Education		
Lowest Quintile	0.099	Spearman Rank Correlation
2nd Quintile	0.063	rho = -0.040
3rd Quintile	0.057	p = 0.603
4th Quintile	0.070	
Highest Quintile	0.073	
Age		
Lowest Quintile	0.080	Spearman Rank Correlation
2nd Quintile	0.065	rho = -0.042
3rd Quintile	0.071	p = 0.585
4th Quintile	0.072	
Highest Quintile	0.079	
Physical Health (pcs12)		
Lowest Quintile	0.082	Spearman Rank Correlation
2nd Quintile	0.074	rho = 0.072
3rd Quintile	0.065	p = 0.344
4th Quintile	0.044	
Highest Quintile	0.095	
Mental Health (mcs12)		
Lowest Quintile	0.077	Spearman Rank Correlation
2nd Quintile	0.051	rho = 0.028
3rd Quintile	0.080	p = 0.714
4th Quintile	0.067	
Highest Quintile	0.088	
1-Year Survival Probability		
Lowest Quintile	0.114	Spearman Rank Correlation
2nd Quintile	0.075	rho = 0.108
3rd Quintile	0.050	p = 0.156
4th Quintile	0.065	
Highest Quintile	0.075	

Table 2b: Mean Discount Rate, by Selected Behavioral Variables

Planning Horizon		
Plan Ahead All the Time	0.066	one-tailed ttest
Live from Day to Day	0.106	p = 0.009
Savings Behavior		
Prefer Saving Money	0.067	one-tailed ttest
Prefer Spending Money	0.110	p = 0.010

Figure 2a: Discount Rate vs. Age, Plot and Fitted Values

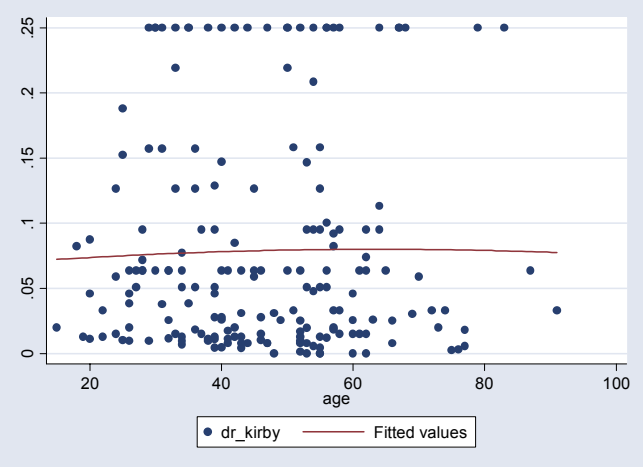


Figure 2b: Discount Rate vs. PCS12, Plot and Fitted Values

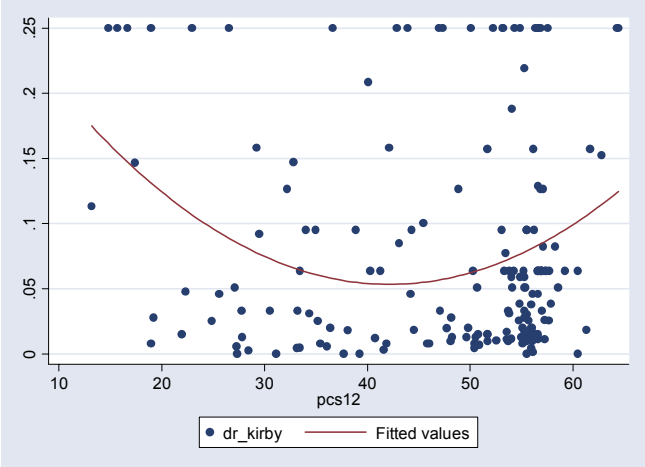


Figure 2c: Discount Rate vs. One-Year Survival Probability, Plot and Fitted Values

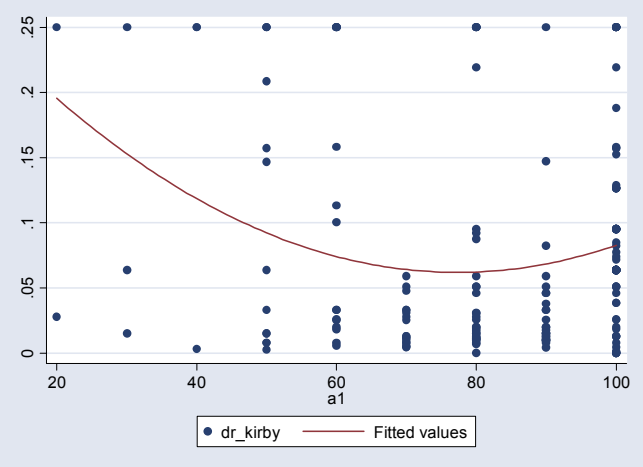


Table 3: Double-Sided Tobit Regression: ln(dr_kirby*100) as the dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	3.855***	7.292***	2.619	6.988**	9.623***	7.469**
	(1.291)	(2.234)	(2.754)	(3.415)	(3.577)	(3.664)
Age	-0.093*	-0.080	-0.082	-0.067	-0.039	-0.030
	(0.055)	(0.056)	(0.058)	(0.057)	(0.058)	(0.057)
Age*Age	0.001	0.001	0.001	0.001	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Female	0.414	0.434	0.416	0.422	0.448	0.242
	(0.362)	(0.360)	(0.363)	(0.361)	(0.355)	(0.344)
Married or Cohabiting	0.087	0.040	0.076	0.025	-0.046	0.175
	(0.351)	(0.348)	(0.352)	(0.349)	(0.343)	(0.333)
Area Dummy = Ntuzuma C	-0.911	-0.903	-0.866	-0.856	-0.792	-0.854
	(0.570)	(0.563)	(0.572)	(0.566)	(0.573)	(0.562)
Area Dummy = Klaarwater	-0.456	-0.457	-0.446	-0.462	-0.628	-0.314
	(0.513)	(0.508)	(0.516)	(0.511)	(0.504)	(0.486)
Area Dummy = Umlazi J	-0.881	-0.744	-0.825	-0.676	-0.761	-1.056**
	(0.543)	(0.538)	(0.547)	(0.542)	(0.474)	(0.532)
Area Dummy = Kwa Mgaga	-0.897	-0.962*	-0.855	-0.911*	-0.926*	-0.667
	(0.560)	(0.555)	(0.562)	(0.557)	(0.550)	(0.530)
Area Dummy = Clare Estates	-1.313**	-1.341**	-1.281**	-1.297**	-1.444***	-1.322**
	(0.553)	(0.545)	(0.555)	(0.548)	(0.540)	(0.508)
No education	2.330***	2.171***	2.391***	2.163***	2.322***	3.003***
	(0.725)	(0.730)	(0.749)	(0.754)	(0.752)	(0.770)
PCS12		-0.233**		-0.240**	-0.165*	-0.131
		(0.096)		(0.097)	(0.099)	(0.097)
PCS12 squared		0.003***		0.003***	0.002**	0.002*
		(0.001)		(0.001)	(0.001)	(0.001)
MCS12			0.024	-0.015	0.001	-0.045
			(0.110)	(0.109)	(0.000)	(0.112)
MCS12 squared			-0.001	0.000	0.000	0.000
			(0.001)	(0.001)	(0.001)	(0.001)
Longevity					-0.156***	-0.118**
					(0.059)	(0.059)
Longevity squared					0.001***	0.001**
					(0.000)	(0.000)
Economic Outlook for Next 2 Years						
Improve a lot						1.144
						(0.875)
Improve a little						1.727***
						(0.679)
Remain the same						1.417**
						(0.666)
Worsen a little						1.642**
						(0.689)
Observations			175			164
Mean of the Dependent Variable			1.117			1.134
Pr > Chi-square	0.025	0.001	0.050	0.017	0.001	0.000
Pseudo R-square	0.029	0.039	0.031	0.040	0.051	0.069

Note: Values in parentheses represent standard errors. *p < .10; **p < .05; ***p < .01