Discounting for Personal and Social Payments: Patience for Others, Impatience for Ourselves

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Abstract

The market rate of return on private investment is often used as the discount rate when conducting Cost-Benefit Analysis (CBA) of public projects. I argue that the decision to invest pits current consumption against future consumption, both of which accumulate to the private decision maker. Public projects, on the other hand, provide benefits that accrue to society in general. To examine the appropriateness of discount rates based on returns to private investment, this paper considers lab experiments designed to test whether individuals discount personal and social benefits at different rates. Personal benefits are captured through personal monetary payments, while social benefits are captured through anonymous donations to charitable organizations. I jointly elicit time and risk preferences and find that subjects discount charitable contributions at significantly lower rates than personal payments.

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Cost-benefit analysis (CBA) has been influential in determining government regulatory policy for at least the last 30 years. When conducting CBA, the discount rate chosen, with which future benefits and costs are converted into today's dollars, is of critical importance. While true for all projects, the impact of discount rate variation is especially salient when costs or benefits accrue over a time horizon of decades or centuries (see for example Weitzman 2007). This is the common feature of many environmental policies and regulations; such policies often incur costs today in order to provide benefits or avoid damages over an extended time horizon. Examples of environmental policies that exhibit these qualities include carbon mitigation, biodiversity preservation, nuclear waste disposal, and investment in water management.

The economic literature has put forward an array of methods for determining the proper discount rate for CBA. While there is no agreed-upon method, it is widely acknowledged that finding the correct discount rate for use in evaluating policies with long project lives is of the utmost importance (Dasgupta 2008 and Nordhaus 2007, with a dissenting opinion put forth by Neumayer 1999). The two main camps in the discussion of how best to determine the discount rate applied to public projects, which I will call the social discount rate or SDR, are the descriptivists, who assign discount rates that reflect real-world decisions, and the prescriptivists, who choose discount rates based on ethical considerations (for a discussion of prescriptive versus descriptive methods, see Arrow et al. 1996 and Baum 2009). United States government policy is, somewhat implicitly, to specify a discount rate based on the descriptive approach (U.S. Office of Management and Budget 1992).

When performing CBA for a government project, the descriptive approach sets the discount rate equal to the rate of return money would receive had it not been used in the project. It is generally assumed that money not used in a government project would stay in the hands of private citizens and be invested. As such, it is common practice to set the discount rate equal to some measure of the rate of return on investment in the private sector. This method implicitly assumes that the discount rate individuals apply to personal benefits and costs is the same discount rate individuals would apply to social benefits and costs. Put another way, the assumption is made that individuals will discount benefits and costs (monetary or otherwise) that accrue to themselves in the same fashion as benefits and costs that accrue to others, or society as a whole. The rate of return on private investment is determined by a series of decisions made by individuals (or firms) concerning their own personal wealth and well being. The decision to invest means that one is willing to forgo consumption today in order to consume a greater amount in the future. This decision, however, pits personal consumption today against personal consumption in the future, and as such is an accurate representation of the discount rate over personal consumption. If this rate is not the same rate at which the population discounts benefits and costs that accrue to others or society in general, discount rates that imply equality between these measures and are commonly utilized in the literature and in CBA are potentially flawed.

The goal of this paper is to explore whether individuals apply different utility discount rates, or pure rates of time preference, to different value streams. I elicit two distinct discount rates from individuals in a lab setting. These discount rates use monetary outcomes, with one involving monetary payments to the subject and the other involving anonymous monetary donations to charity. I use a joint elicitation method, which estimates risk preferences as well as time preferences. I find strong evidence that subjects treat personal and social payments differently, with social payments subjected to lower discounting than personal payments. This result is robust to several adjustments to the model and when controlling for potential confounds such as session, format, and order effects.

The issue of dual-rate discounting been suggested in Yang (2002), where an integrated assessment model for climate change was calibrated using different pure rates of time preference for consumption and environmental goods. Further, dual-rate discounting in individuals has been studied in the economic and psychology literature. While the focus has primarily been comparing monetary to health outcomes (Chapman and Elstein 1995, Chapman 1996, Meerding et al. 2010), studies have also compared monetary outcomes to food (Odum, Baumann, and Rimington 2006) and drugs (Odum et al. 2000). No consensus has emerged from these previous studies. Chapman and Elstein (1995) finds that personal health outcomes are discounted at a higher rate than monetary outcomes. Chapman (1996) finds no consistent relationship between personal health and monetary discounting. Meerding et al. (2010) finds that social health benefits are discounted at a lower rate than social monetary benefits. Robberstan (2005) is the only previous work to my knowledge that compares personal and social benefit streams, and this work limits its scope to discount rates for personal health versus the health of others. Robberstan finds personal and social discount rates to be roughly the same.

All previous findings in this literature assume risk neutrality, failing to account for the fact that individuals generally exhibit risk-averse preferences (Holt and Laury 2002, Andersen *et al*. 2008), and that risk preferences can vary across contexts (Dohmen *et al.* 2009). Assuming risk neutrality, as has been done in previous studies, creates a twofold problem: it biases discount rate estimates and it requires that subjects exhibit similar risk preferences for social and personal payments. This is the first study that uses the joint elicitation method of Andersen *et al*. (2008) and Harrison *et al.* (2005) to jointly estimate risk and time preferences for personal and social payments and the first work to contrast discount rates for personal payments versus payments to charitable groups. This methodology allows for the identification of divergent rates of pure time preference by controlling for risk preferences.

The rest of the paper proceeds as follows. The next section provides further background information regarding discounting. The subsequent sections outline the details of the experiment, establish the theoretical model being used to elicit discount rates in the experiment, and present empirical findings. The paper closes with a discussion of the circumstances under which behavior presented in this paper may be rational, and as such may have bearing on the analysis of public policy, and a discussion of possible extensions.

Discounting Background

The value of a benefit occurring in the future will differ from the value of an identical benefit occurring today. This difference is reflected in the discount rate, which represents the rate at which future value streams are converted into present value. There are two different discount rates that are discussed in the literature, each with its own meaning, derivation, and ethical implications. In the classic Samuelson (1937) discounted utility model, utility is additively separable across time periods for an infinitely-lived consumer. The rate at which this agent converts future utility to present utility is the pure rate of time preference, or utility discount rate. In discrete time, this is illustrated using the following welfare function:

$$W = \sum_{t=0}^{\infty} \frac{u(C_t)}{(1+\rho)^t}, \qquad (1)$$

where $u(C_t)$ is utility as a function of consumption for time t and ρ is the utility discount rate. This discount rate is not particularly useful in policy analysis, as it is difficult to measure changes in utility that result from increasing the amount of available potable water, for instance. Changes in consumption, on the other hand, are easier to measure. It is simpler (although still no small task) to gauge willingness to pay for an increase in the quantity of potable water, which represents the level of consumption an agent is willing to give up in exchange for the improvement. As such, discounting in policy analysis is implemented using the consumption discount rate. The consumption discount rate, as illustrated by the Ramsey equation (Ramsey 1928), is given by

$$d = \rho + \sigma g, \qquad (2)$$

where d is the consumption discount rate, σ is the intertemporal elasticity of substitution, and g is the per capita consumption growth rate.[1] The derivation of equation (2) can be found in Hoel and Sterner (2007) and Dasgupta (2008, with constant relative risk aversion (CRRA) utility).

As equation (2) illustrates, two distinct forces contribute to discounting future consumption. The first is the possibility of positive time preference. If an agent places greater value on utility today than utility in the future, she will value consumption today more than consumption in the future, *ceteris paribus*. This discounting is captured in the utility discount rate, but it may come from multiple sources (Frederick *et al*. 2002). For instance, discounting future utility can result from both impatience (she prefers utility today because she does not want to wait) and the hazard rate (she prefers utility today because she fears she will not be alive to enjoy it in the future). These are different motivations, but they are captured by the same parameter in this formulation. In addition to pure time preference, the assumption of decreasing

[1] In this formulation of the Ramsey equation I have made several simplifying assumptions. First, I have suggested that σ is constant, implying a CRRA utility function. In addition, it is possible (and indeed likely) that the per-capita consumption growth rate will vary over time, and so g will be a function of t instead of being constant as in equation (2).

marginal utility of consumption dictates that a second source of discounting occurs if consumption levels change over time. If the level of consumption in the future is higher than consumption today, as would be the case in the event of a positive consumption growth rate, one additional unit of consumption in the future contributes less to utility than one additional unit of consumption today even in the absence of pure time preference. This channel is captured by the second term on the right-hand side of equation (2), which depends on the rate at which consumption is growing (g) as well as the curvature of the utility function (σ, which is also the rate of relative risk aversion in CRRA utility). Experimental methods that elicit time preferences over consumption must impose *ex ante* restrictions to risk preferences (typically risk neutrality) in order to estimate the utility discount rate ρ. Assuming risk neutrality imposes utility that is linear in consumption, which will positively bias discount rates if subjects are risk-averse. This illustrates the imperative for eliciting risk preferences regarding both personal and social monetary payments in order to accurately determine whether subjects discount social and personal benefits at different rates.

The Experiment

The data were obtained from lab experiments conducted at Ohio State University from May 2011 to July 2011[2]. The subject population is comprised of undergraduate students, and as such is not representative of the general population, especially regarding education and age. The method of discount rate elicitation used in this paper jointly estimates a parameter for risk

[2] Instructions and forms used in the experiment are in the appendix.

preference as well as a parameter for time preference. In order to do so, two separate tasks are presented to subjects: a time preference task and a risk preference task.

Both tasks take the form of choice tasks. In choice tasks, subjects are presented with two payment options and must select which option they prefer[3]. This method was chosen over matching tasks, which present one payment option and ask for subjects to specify the payment that would be equally desirable to the payment presented[4]. Choice tasks have the disadvantage of specifying an interval estimate for the parameter in question while matching tasks specify a point estimate, which is preferable. However, this issue can be mitigated by allowing subjects to express indifference between payment options in the choice task format. If a subject expresses indifference in a choice task, the result is a point estimate similar to a matching task. In addition, choice tasks are likely to have the added advantage of being less cognitively demanding. It is much simpler for subjects to choose between two options than to identify their exact indifference point. Similarly, matching tasks are likely to suffer from rounding bias, where subjects tend to overwhelmingly present round numbers. This can lead to biased estimates of the discount rate, and the severity of this bias increases as the payment size shrinks (because rounding becomes larger relative to the payment size) and/or the time horizon between payment options decreases.

The risk preference task is adapted from Holt and Laury (2002). I use a multiple price list (MPL) format in which subjects must indicate their preferred payment option for each of a series of binary choices, or choice rows. Figure 1 presents an example of this risk preference task. Subjects must choose between two binary lotteries, a safe lottery (denoted Lottery A to subjects) and a risky lottery (Lottery B to subjects). The safe lottery offers two similar payments ($180

[3] In some cases, as in this paper, subjects may also indicate indifference between the two options in choice tasks.
[4] For example, the question may ask, “how much money must you receive in one year to be indifferent between this payment and $100 today?”

and $160), while the risky lottery offers the potential to earn far more and far less than the safe lottery ($300 and $20). The choice rows are identical in these payouts but differ in the probability assigned to the high and low payouts of each lottery. The final choice row acts as a rationality test, as it offers the choice between $180 with certainty and $300 with certainty.

The time preference task also uses the MPL format and is adapted from Coller and Williams (1999). Figure 2 presents an example of the time preference task. In each choice row, subjects are given two payment options. The proximate or early payment (denoted Payment Option A to subjects) offers a payment of $100 dollars, occurring in one week. This payment does not vary by choice row. The distant payment (Payment Option B to subjects) involves a value greater than or equal to $100 and occurs 14 weeks in the future. In addition, subjects were given the annual interest rate associated with accepting the distant payment[5].

Risk and time preference tasks were presented to subjects twice in order to capture two distinct discount rates. For one set of tasks, intended to capture discounting of personal benefits, subjects were told that their decisions related to personal monetary payments. The second set of tasks was intended to capture discounting of social benefits. Prior to receiving this set of tasks, subjects were given a list of 7 charities with a description of each. They were then asked, “If given money to donate to one of the above charities, which charity would you choose?” When completing the social risk and time preference tasks, subjects were told that their decisions related to anonymous charitable donations to their selected charity. This method of tying

[5] In the early sessions, the distant payment was presented as occurring 13 weeks, or approximately 3 months and 1 week, in the future. 3 months and 1 week is actually 14 weeks. In addition, the interest rates reported to correspond to the distant payment were accurate for 14 weeks rather than 13 weeks. It seems likely that subjects simply accepted that the difference between payments was 3 months, in which case the data should be treated as if the payment occurred in 14 weeks rather than 13. The data was tested assuming 13 and 14 weeks and there is no qualitative difference in the results.

decisions to a real charity selected by the subject was intended to ensure that subjects placed some value on the charitable donation. In addition, subjects were informed that all donations would be anonymous, ensuring that there were no benefits associated with tax write-offs or improved reputation that could result from their decisions. For each task, subjects were given time to read the instructions and had the instructions read to them by the experimenter. Task order was varied by session to control for order effects. In addition, subjects were randomly given one of two different MPLs for each task to control for formatting bias (Andersen *et al*. 2006).

Each time preference task consisted of 16 choice rows and each risk preference task consisted of 14 choice rows. In all, each subject made 60 decisions, split 30-30 relating to social-personal benefits and 32-28 relating to time-risk preference. Subjects were given a 1 in 12 chance of receiving payment based on their responses, in addition to the small show-up fee received by everyone. For subjects randomly selected to receive it, the additional payment was based on one choice row randomly selected from the 60 completed in the experiment. At the end of each session, subjects also completed a questionnaire containing demographic and background questions.

Empirical Model

The model used in this paper, and the resulting elicitation method applied to the data, is similar to the joint elicitation method developed by Andersen *et al.* (2008) and utilized in Laury *et al.* (2010). Maximum likelihood is used to jointly estimate four parameters: a CRRA parameter, a utility discount rate, and two noise parameters. The theoretical model assumes additively separable utility that is a function of a single consumption good and exhibits CRRA of the form

$$W = \sum_{t=0}^{\infty} \frac{C_t^{1-\sigma}}{(1-\sigma)(1+\rho)^t}. \tag{3}$$

In this formulation, ρ is the utility discount rate and σ is the coefficient of relative risk aversion, which in this model also translates to the intertemporal elasticity of substitution, as in equation (2). In this framework, the following equation implies indifference between payment X in time t and payment Y in time $t + \tau$:

$$\frac{(\omega + X)^{1-\sigma}}{(1-\sigma)} + \frac{\omega^{1-\sigma}}{(1-\sigma)(1+\rho)^{\tau}} = \frac{\omega^{1-\sigma}}{(1-\sigma)} + \frac{(\omega + Y)^{1-\sigma}}{(1-\sigma)(1+\rho)^{\tau}}, \tag{4}$$

where ω is background consumption. Much of the early literature in discount rate elicitation bore the assumption of risk neutrality (meaning $\sigma = 0$). With this assumption, equation (4) can be simplified to $X = Y/(1+\rho)^{\tau}$. However, there has been ample evidence in the literature suggesting that a majority of the population exhibits risk-averse ($\sigma > 0$) rather than risk-neutral or risk-loving behavior (Holt and Laury 2002 and 2005). Whatever the risk preferences of the population may be, it is instructive to allow the data to inform our estimates, rather than imposing an *ex-ante* assumption. While agents are probably risk neutral when the stakes are small and the winnings are integrated over lifetime wealth (implying ω is equal to your total expected lifetime income), it seems unlikely that decisions involving small stakes will be evaluated in such a manner. More likely, individuals will anticipate spending their winnings over a shorter time frame, greatly decreasing the background consumption into which winnings will be integrated and opening the door for risk-averse (or risk-loving) preferences.

In order to jointly elicit both the CRRA parameter and the utility discount rate, two different tasks are posed to subjects. As mentioned in the previous section, the risk preference task involves choosing between a safe and a risky lottery. Each lottery has two possible outcomes, so that even the safe lottery does not involve certainty. The task aimed at eliciting time preference requires subjects to choose between receiving a payment of $\$X$ in t weeks and receiving a payment of $\$Y$ in $t + \tau$ weeks, with $Y \geq X$ and $\tau \geq 0$. In the time preference task, both payments are delayed in order to avoid potential immediacy bias and the potential confound of quasi-hyperbolic discounting.

The log-likelihood function for the risk preference task is constructed as follows. The expected utility of playing a lottery for choice j of the risk preference task is given by

$$EU_{ij} = p_j(X_i)\frac{(\omega_t + X_i)^{1-\sigma}}{(1-\sigma)} + (1 - p_j(X_i))\frac{(\omega_t + Y_i)^{1-\sigma}}{(1-\sigma)}, \quad (5)$$

with $i = S, R$ representing the safe and risky lotteries, respectively. In this formulation, $p_j(X_i)$ is the probability of payout X in Lottery i for choice j and X_i and Y_i are the two possible payouts of Lottery i. Probability is indexed by j because the probabilities are the same for safe and risky lotteries but vary by choice row. Conversely, the payments X and Y are indexed by i because they stay the same in each choice row but are different in the different lotteries. For the sake of consistency, Y will represent the high payout and X will represent the low payout, as in the time preference notation. The probability of choosing the safe lottery in choice j of the risk preference task ($_S^{Risk}$), given the expected utilities from both lotteries, is defined as

$$Pr_S^{Risk}(j) = \frac{EU_{Sj}^{1/\mu R}}{EU_{Sj}^{1/\mu R} + EU_{Rj}^{1/\mu R}}, \quad (6)$$

where μR is a behavioral noise parameter or cognitive error term associated with the risk preference task and "*Risk*" identifies that the probability value pertains to the risk preference task. The behavioral noise parameter captures the possibility that agents will make an error by choosing the lottery with lower expected utility. A value of μR approaching zero collapses to the deterministic case where the subject always chooses the lottery with higher expected utility. As μR approaches infinity, the probability approaches 0.5, regardless of the expected utilities of the lotteries. The conditional log-likelihood function for the risk preference task can be written

$$ln\ L^{Risk}(\sigma, \mu_R \mid \omega_t, x) = \sum_j \ [ln(Pr_S^{Risk}(j) \mid x_j = S) + ln(1 - Pr_S^{Risk}(j) \mid x_j = R)], \quad (7)$$

where $x_j = S\ (R)$ means the subject chose the safe (risky) lottery for choice j of the risk preference task and x is the set of all choices made by the subject in the risk preference task.

The log-likelihood function for the time preference task is similarly constructed. Agents are given the choice between a proximate payment (Option A) and a distant payment (Option B). The present value (*PV*) of each payment for choice *j* of the time preference task is given by the following equations:

$$PV_{Aj} = \frac{(\omega_t + X_j)^{1-\sigma}}{(1-\sigma)(1+\rho)^t} + \frac{(\omega_{t+\tau})^{1-\sigma}}{(1-\sigma)(1+\rho)^{t+\tau}}, \quad (8)$$

$$PV_{Bj} = \frac{(\omega_t)^{1-\sigma}}{(1-\sigma)(1+\rho)^t} + \frac{(\omega_{t+\tau} + Y_j)^{1-\sigma}}{(1-\sigma)(1+\rho)^{t+\tau}}. \quad (9)$$

Using these present value formulations, the probability that a subject will choose Option A for choice *j* of the time preference task ($_A^{Disc}$) is defined as

$$Pr_A^{Disc}(j) = \frac{PV_{Aj}^{1/\mu D}}{PV_{Aj}^{1/\mu D} + PV_{Bj}^{1/\mu D}}, \quad (10)$$

where μD is a behavioral noise parameter or cognitive error term associated with the time preference task and "*Disc*" identifies that the probability value pertains to the time preference task. The behavioral noise parameter in this task captures the possibility that agents will make an error by choosing a payment option with lower present value. The conditional log-likelihood function for the time preference task can be written

$$\ln L^{Disc}(\sigma, \rho, \mu_D, \mu_R \mid \omega_t, \omega_{t+\tau}, x) =$$

$$\textstyle\sum_j \; [\ln(Pr_A^{Disc}(j) \mid x_j = A) + \ln(1 - Pr_A^{Disc}(j) \mid x_j = B)], \qquad (11)$$

where $x_j = A$ (B) means the subject chose Option A (B) for choice j of the time preference task and x is the set of all choices made by the subject in the time preference task. By combining equations (7) and (11), the joint log-likelihood function can be written

$$\ln L(\sigma, \rho, \mu_D, \mu_R \mid \omega_t, \omega_{t+\tau}, x) = \ln L^{Disc} + \ln L^{Risk}. \qquad (12)$$

I deviate from the work of previous authors by treating utility in each period as a function of two distinct goods, which I will call the consumption good (C) and the environmental/social good (S). In order to allow for the utility of each good to be discounted at a different rate, I also assume additive separability of the utility function in period t. The welfare function faced by the infinitely-lived agent now becomes

$$W = \sum_{t=0}^{\infty} \quad \frac{u(C_t)}{(1+\rho_C)^t} + \frac{v(S_t)}{(1+\rho_S)^t}, \qquad (13)$$

where $v(S_t)$ is a function transforming social payments (or social improvements) into utility and ρ_C and ρ_S are utility discount rates for the consumption and social goods, respectively. This is similar to the model developed by Futagami and Hori (2010). In this new formulation, the indifference equation between personal payment X made at time t and personal payment Y made at time $t + \tau$ becomes

$$\frac{(\omega_{t,p} + X)^{1-\sigma}}{(1-\sigma)} + \frac{(\omega_{t,s})^{1-\sigma}}{(1-\sigma)} + \frac{(\omega_{t+\tau,p})^{1-\sigma}}{(1-\sigma)(1+\rho)^{\tau}} + \frac{(\omega_{t+\tau,s})^{1-\sigma}}{(1-\sigma)(1+\rho)^{\tau}} = \tag{4'}$$

$$\frac{(\omega_{t,p})^{1-\sigma}}{(1-\sigma)} + \frac{(\omega_{t,s})^{1-\sigma}}{(1-\sigma)} + \frac{(\omega_{t+\tau,p} + Y)^{1-\sigma}}{(1-\sigma)(1+\rho)^{\tau}} + \frac{(\omega_{t+\tau,s})^{1-\sigma}}{(1-\sigma)(1+\rho)^{\tau}}.$$

Here consumption of the personal (social) good in period t, C_t (S_t), is the combination of background consumption and any payments made at that time, $\omega_t + X$. Equation (4') illustrates an important point. If the payment options being considered are entirely personal, the indifference equation allows for all social inputs into the welfare function to cancel, leaving an indifference equation identical to the CRRA utility model with only 1 good. This is also true if all payments are social in nature.

Varying the level of background consumption into which subjects will integrate their winnings will influence the elicited levels of risk aversion and time preference (Andersen *et al*. 2008, Howard 2012). The next section generates estimates using two different assumptions regarding background consumption. First, following Laury *et al*. (2010), I assume zero background consumption. This assumption carries the implication that subjects do not integrate winnings into their consumption decisions. Second, following Andersen *et al*. (2008), I set background consumption equal to the average daily consumption level of the population. As the sample population is comprised entirely of undergraduates, and as such is not representative of the general population regarding income and consumption levels, the average daily consumption level for the sample is derived using data obtained in the experiment regarding subjects' income levels. Subjects on average claimed $900 per month in income, from which average daily consumption was set to $30. As can be seen in next section, the results are largely the same in each case, demonstrating that the main result of this paper is robust to variation in background consumption specification.

It is perhaps less obvious how one should construct background consumption for charitable contributions. In 11 of 12 sessions, I attempted to anchor background consumption using the following statement, "It is our belief that the charities listed are typically capable of utilizing donations within a week of receiving them, and that they receive about $5,000 dollars per week in donations." However, it is clear from the data that subjects did not use this figure as their background consumption for social decisions, as doing so yields large negative discount rates for charitable contributions.

There are two methods subjects could use for generating background consumption values. First, they could determine a background consumption figure using the knowledge available to them. Second, in an effort to decrease cognitive load, they may associate background consumption for social payments with a background consumption that is more salient, like the background consumption for personal payments. If they chose to use the first method, subjects would almost surely tie the social background consumption to the anchor provided, as it is highly unlikely for students to have much, if any, knowledge regarding the financial details of the charities presented to them. Since this did not happen, subjects most likely used the same basic background consumption figure utilized for personal payments and applied it to social payments as well. This is the assumption I make in my estimation. I also check the robustness of my results by allowing background consumption applied to social payments to be a parameter determined in the maximum likelihood regression. In doing so, the basic qualitative results still hold, namely the discount rate applied to social payments is significantly lower (in this case, about 20% lower[6]) than the discount rate applied to personal payments.

Results

Figures 4 and 5 provide an analysis of the raw data. Figure 4 compares CDFs for the social and personal risk tasks. The x-axis details the total number of safe lottery choices made by subjects. In this way, a value of 0.1 at choice 5 is interpreted as 10% of subjects choosing a total of 5 safe choices or fewer. Should one CDF dominate the other, the dominant CDF would have a greater percentage of subjects switching from safe lotteries to risky lotteries at each choice row, suggesting that subjects were less risk averse in this task. The CDFs in Figure 4 are largely indistinguishable, with the personal CDF being slightly higher than the social CDF at some points. This suggests that any difference in risk preferences is likely to be small, with a tendency for subjects to exhibit greater risk aversion in social tasks. Figure 5 compares CDFs for the social and personal discounting tasks. The x-axis details the total number of early payment options preferred by respondents. Again, a value of 0.1 at choice 5 is interpreted as 10% of subjects choosing a total of 5 early payments or fewer. A dominant CDF in this case would suggest greater patience and lower discount rate. The CDF for the social discounting task dominates the CDF for personal discounting, suggesting that subjects discount social payments at a lower rate than personal payments.

Maximum likelihood estimation results are presented in Tables 1, 2 and 3. Table 1 provides point estimates for each model of interest. Table 2 presents detailed estimation results

[6] The estimated discount rate for charitable contributions is 32% and the estimated discount rate for personal payments is 42%. The social dummy variable has a p-value of 0.035.

with an assumption of zero background consumption, while Table 3 presents detailed estimation results with an assumption of $30 background consumption. Model I of each table estimates the four model parameters alone. Model II provides these estimates, but in addition the discount rate and CRRA coefficient are allowed to differ for social and personal payments. This is done by including a dummy variable in the estimation of each parameter (called "Social") equal to 1 if the task pertains to charitable contributions and 0 if the task pertains to personal payments. In this way, the discount rate associated with personal payments is captured by the constant term, while the discount rate associated with charitable contributions is captured by the sum of the constant term and the coefficient of the social dummy variable. Model III is identical to Model II but with additional controls added. These controls capture session effects, format effects, incentive effects, order effects, and dummy variables controlling for sex and high GPA students. Model IV is identical to Model III, but the behavioral noise terms are additionally allowed to differ for social and personal payments. For Models III and IV, the point estimates in Table 1 are calculated using the summation of the mean value for each independent variable multiplied by the independent variable's coefficient.

Previous work using this estimation method and university student populations report CRRA parameters of around 0.7 and discount rates between 10% and 14%. Similar estimations using the current dataset yield much lower levels of risk aversion (0.2-0.4 vs. 0.7) and much higher discount rates (20-41% vs. 10-14%). However, it is likely that the higher discount rates herein are driven mostly or entirely by the greater risk tolerance of this dataset. When estimating the discount rate alone and imposing a CRRA coefficient of 0.7, the data yields a discount rate of 11.6%, which is within the range of the previous literature. This suggests that subject responses were, on aggregate, similar in this experiment to previous experiments regarding the time preference task. However, subject responses in this study displayed much more risk tolerance than in the previous literature.

I find the behavioral noise term is much larger for risk preference tasks than for time preference tasks. This is consistent with previous literature, and is likely due to the higher cognitive burden of risk preference tasks. Time preference questions involve choosing between two certain payments, a fairly simple task. Risk preference tasks, however, require subjects to choose between two uncertain lotteries. As the value of certain payments are more easily understood that those of uncertain lotteries, the finding that responses for risk preference task are noisier is both expected and with precedent.

The most important result of this paper pertains to dual-rate discounting. I find that discount rates applied to charitable contributions are significantly lower than discount rates applied to personal payments. The difference between social and personal discounting is significant at the 1% level in every model. In addition, the difference between the two discount rates elicited is fairly large, with the discount rate for charitable donations being 12.3-17.6 percentage points lower, which equates to between 33% and 47% lower than the discount rate for personal payments.

While it is not the focus of the paper, I also find evidence that subjects exhibit greater risk aversion for charitable contributions than for personal payments. With both background consumption models, subjects are more risk averse in social tasks than in personal tasks. This finding persists in Model III, when controls are added, but disappears in Model IV when noise terms are allowed to vary by task type. The data supports the notion that subjects are not as willing to take risks regarding social benefits as they are with personal payments, although the evidence for this assertion is not as strong as the evidence for dual rate discounting. In the area of comparing personal and social risk preferences, Harrison et al. (2010) found that social risk attitudes closely approximate individual risk attitudes. Shupp and Williams (2008) find that, compared to individuals, groups are more risk averse in high-risk situations and less risk averse in low-risk situations. Masclet *et al*. (2009) finds that groups are more risk averse than individuals. The analysis of risk attitudes in the current study differs from previous work by capturing social risk in lotteries over charitable contributions (from which the subject is not likely to benefit at all) instead of lotteries that pay a group, of which the subject is a member.

One might be tempted to argue that the discounting results are an artifact of a sample that has been shown to behave differently, at least regarding risk preference, than subjects from previous studies. While it is true that subjects in this dataset are more risk tolerant than in previous work, they have been shown to give similar time preference responses, and these are the responses that yield significant and interesting results. Additionally, even accepting that the subjects in this study are more risk tolerant, this could only be driving the differential discounting result if subjects demonstrated much greater risk aversion in their charity decisions than in their personal decisions. While some estimations report this, particularly Models II and III, Model IV finds no significant difference in risk aversion but still returns lower social rates of discounting. This suggests that any difference in time preference based on the payment type cannot be driven entirely by differences in risk preference, and so are not attributable to some unusual artifact of the study population.

Reduced payment salience could also explain these findings. It is possible that social payments are less salient to subjects, and that subjects may simply apply a lower discount rate to less salient payments. I have no direct test for the salience of payments, but I postulate that less salient payments would receive less focus and cognitive effort from subjects. This would likely have two effects that are testable using the data available. First, putting forth less cognitive effort is likely to result in noisier responses. I find no effect of payment type on the behavioral noise term, meaning a hypothesis that subjects gave noisier responses to charitable contribution questions is not supported by the data. Second, it is also probable that format effects will be more pronounced in tasks for which subjects are putting forth less focus and cognitive effort[7]. Again, the data does not support the salience argument based on this criterion. As can be seen in Table A2, which presents the complete results from Models III and IV, format effects are present and significant in the risk task, but are almost identical by payment type. For the discounting task, no significant format effects are present for either personal or social payments. These results confirm that a lack of salience in the charitable contribution tasks is unlikely to be the driver of the discount rate disparity found in the data.

Why are risk preference estimates lower in this sample than in the previous literature? The major difference in risk task structure between this study and those by Andersen *et al*. (2008) relates to payment structure. First, lotteries in the current experiment had lower payouts, ranging from $20-$300 compared to $15-$587 (calculated using the exchange rate provided in the paper) in Andersen *et al*. Additionally, every subject received a payment based on the resolution of one task in the Andersen *et al*. experiment, while only 1 in 12 subjects received such a payment in this experiment. Studies have shown both that subjects exhibit greater risk aversion when payments are real and that risk aversion increases with payment size (Holt and Laury 2002, Harrison 2007, Harrison and Rutstrom 2008). Taking the differences in payment

[7] To control for format effects, subjects were randomly given one of two versions of each task. The MPL for one version skewed high, while the other skewed low. Subjects who were paying less attention would be more prone to switching options in the middle of the table, a tendency that would produce higher discount rates and greater risk aversion in the skew high table than in the skew low table. Figure 3 provides an example of the two tables that would be used to control for format effects.

structure into account, subjects in this study are likely acting in a similar fashion to those in previous work.[8]

Discussion and Conclusion

This paper presents experimental evidence of dual-rate or differential discounting among college undergraduates regarding personal payments and charitable contributions. I find evidence that subjects discount personal payments at a significantly higher rate than charitable contributions. Charitable contributions are intended to act as an example of a social good, a good that benefits others or society in general. Many environmental amenities and values could also be lumped into this general category of social goods. For example, cleaner air in your neighborhood benefits everyone in the neighborhood, not just you. Further, cleaner air in an adjacent state does not benefit you directly, but yields benefits to many other people. Despite having no direct impact on the agent, this type of good may still increase her utility simply by improving social welfare, provided the agent exhibits some altruism. In this way, I posit through the results of this paper that individuals may discount social goods at a lower rate than personal goods.

While the results of this experiment are not grounds for scrapping our current methods of evaluating public projects, it raises important questions about the circumstances under which dual-rate discounting may be appropriate. Even accepting that individuals tend to discount social

[8] As a numeric example, Table 3.3 in Harrison (2007) provides an estimate of hypothetical bias using an interval estimation technique. In this estimation, the coefficient for hypothetical estimates is -0.208, while the constant term is 0.568, suggesting that CRRA parameters generated from hypothetical responses are about 37% lower than those from incentivized responses. This is admittedly a back-of-the-envelope calculation. A better point estimate would evaluate at the mean for each independent variable in the estimation, but lacking information on means this is a rough approximation. By comparison, the CRRA estimates in this study are 29-57% lower than in the previous literature (0.2-0.4 compared with 0.7).

Thus, the actions of subjects in this study are comparable to the findings of previous studies when one accounts for the possibility that each subject will not be paid based on their responses. It should also be noted that this same behavior is seen only in the risk parameter, while the time preference parameter values are in line with previous work when subjects were guaranteed payment, once differences in risk preferences were controlled for.

goods at a lower rate, it does not necessarily follow that these divergent discount rates should be reflected in CBA. If such decisions are not driven by some reasonable impetus, but are instead the result of irrational behavior, it would be foolish to reflect such actions in CBA. This would be akin to requiring policies to be time inconsistent merely because time inconsistent decisions have been regularly found in experiments. If, however, the dual-rate discounting we find in individuals derives from a reasonable source and can be rationally explained, there may be grounds for adapting CBA discounting practices.

One potential explanation for the dual rate discounting found in the data lies in the hazard rate. Recall that the hazard rate is, roughly speaking, the rate at which an agent discounts future value because there is a possibility she will not survive to enjoy it. Personal value streams may only provide utility to an agent if she personally enjoys them. In this case a hazard rate that produces negligible present value of receiving the good in 100 years is clearly justified, since the likelihood on any current adult being alive in 100 years is negligible. For social value streams, which need only be enjoyed by society to generate utility for an agent, the hazard rate can be acceptably lower, as the chances of society collapsing in 100 years are markedly less than the chances of any individual's demise. This difference in hazard rates could lead to different total utility discount rates, and is by no means the only avenue through which such a wedge may develop. One may argue that bequests to children or grandchildren ensure that personal payments can be enjoyed even 100 years hence, but it is unclear whether payments to progeny are discounted like personal or social payments. This explanation is unlikely to justify the differences identified in the current experiment, but could be a fruitful area of future research.

Two interrelated issues may also justify dual rate discounting regarding environmental and consumption goods, as noted by Weikard and Zhu (2005) and Hoel and Sterner (2007). They arise from limits to substitutability between environmental and consumption goods and problems with future pricing of environmental goods. Limited substitutability can occur from both the production and consumption elements of the economy. From the production side, certain environmental amenities (e.g. clean air, water, and nonrenewable commodities) may be vital to some production process. For example, no amount of feed can substitute for a lack of clean water in livestock production. Similarly, greatly reducing the earth's biodiversity may hamper biomedical research in a way that cannot be adequately compensated. The same basic logic holds for the consumption side as well. No amount of consumption goods can atone for a lack of clean water or air. Perhaps more to the point, if the level of consumption goods per capita continues to rise for the next century, but the level of environmental goods per capita stays constant or declines, their ratio may become skewed to the point that people begin to view increased consumption as a poor substitute for further damage to the stock of environmental amenities.

Problems with future pricing of environmental goods could potentially arise in several different ways, but they boil down to the assertion that markets may get things wrong. This can be due to numerous issues, but I will highlight two in particular. First we consider the case of negative externalities. For a particular good, the existence of negative externalities results in a market price that is lower than optimal. If environmental/social goods are associated with greater negative externalities than personal goods, the result would be a greater undervaluation of environmental/social goods than their personal counterparts.

As a second example, suppose the market for some environmental amenity has an outlook, and projects prices, N years into the future. It is possible that the level of substitutability between this environmental amenity and consumption goods may be relatively high over the next N years but decreases beyond N years. If this is the case, policy makers will likely assume high substitutability well into the future and the long term price path of the environmental amenity, extrapolated from the data markets have provided over N years, will be set lower than if markets accurately recognized the long-term substitutability problems facing the amenity. In this way, there is a problem with the market estimates of future prices for such a good.

As Tol (2009, 2003) correctly points out, adjusting discount rates to address this is an imperfect and in theory unnecessary fix to the problem. If we know enough about the pricing bias to choose an optimal dual-rate discounting regime, we should know enough to simply amend the price path (or, in integrated assessment models for climate change, the impact function), rendering dual-rate discounting unnecessary. However, researchers are unlikely to know precisely what changes need to be made. They will more likely have a rough understanding of the problem without knowing the problem's full extent. In this case, opting for a dual-rate discounting regime has one potential advantage over adjusting future price paths, and that is the ability of economic modelers to obtain estimates of the proper discount rate for social/environmental policies via the descriptive approach. Economists should be able to find evidence, both in markets and in the observed actions of individuals, to guide our estimates of the proper social/environmental discount rate, just as they use market rates to guide their estimates of the unitary discount rate currently used in CBA. I know of no comparable method through which future price or impact function biases can be estimated.

This line of research would benefit from numerous extensions. First, it is possible that this study lacks a degree of construct validity. Agents may treat charitable donations, even those that are given to environmental advocacy groups, very differently than environmental quality improvements and other direct social benefits. These environmental quality improvements are likely to differ from charitable donations in several meaningful ways, and as such this line of research would profit from further comparison of different value streams beyond monetary payments and charitable contributions. They could include different social value streams like improvements to environmental quality or reductions in public debt, as well as other personal values streams that are narrower in their potential uses, like gift cards. A similar study utilizing a representative sample would test whether the results presented here hold for the population as a whole. In addition, further work could be aimed at gaining a more detailed and nuanced understanding of the discounting differences highlighted here. For instance, one could investigate whether subjects are more likely to hyperbolically discount one type of payment, while exponentially discounting another.

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Appendix

I. Maximum Likelihood Estimations with Controls

[Tables A1 and A2 Here]

Figure 1: Risk Preference Task Example

Lottery A				Lottery B				(5)
(1A) Prob. Of High Payout	(2A) High Payout	(3A) Prob. Of Low Payout	(4A) Low Payout	(1B) Prob. Of High Payout	(2B) High Payout	(3B) Prob. Of Low Payout	(4B) Low Payout	Preferred Lottery
10%	$180	90%	$160	10%	$300	90%	$20	A I B
20%	$180	80%	$160	20%	$300	80%	$20	A I B
30%	$180	70%	$160	30%	$300	70%	$20	A I B
40%	$180	60%	$160	40%	$300	60%	$20	A I B
50%	$180	50%	$160	50%	$300	50%	$20	A I B
60%	$180	40%	$160	60%	$300	40%	$20	A I B
65%	$180	35%	$160	65%	$300	35%	$20	A I B
70%	$180	30%	$160	70%	$300	30%	$20	A I B
75%	$180	25%	$160	75%	$300	25%	$20	A I B
80%	$180	20%	$160	80%	$300	20%	$20	A I B
85%	$180	15%	$160	85%	$300	15%	$20	A I B
90%	$180	10%	$160	90%	$300	10%	$20	A I B
95%	$180	5%	$160	95%	$300	5%	$20	A I B
100%	$180	0%	$160	100%	$300	0%	$20	A I B

Figure 2: Time Preference Task Example

(1) Payment Alternative	(2) Payment Option A (Pays amount below in 1 week)	(3) Payment Option B (Pays amount below in 14 weeks)	(4) Annual Interest Rate (In percent)	(5) Annual Effective Interest Rate (In percent)	(6) Preferred Payment Option
1	$100	$100	0	0	A I B
2	$100	$100.75	3	3.03	A I B
3	$100	$102	8	8.24	A I B
4	$100	$103.75	15	15.87	A I B
5	$100	$105	20	21.55	A I B
6	$100	$110	40	46.41	A I B
7	$100	$112.50	50	60.18	A I B
8	$100	$117.50	70	90.61	A I B
9	$100	$122.50	90	125.19	A I B
10	$100	$125	100	144.14	A I B
11	$100	$127.50	110	164.27	A I B
12	$100	$128.75	115	174.78	A I B
13	$100	$130.50	122	190.03	A I B
14	$100	$131.25	125	196.75	A I B
15	$100	$131.75	127	201.30	A I B
16	$100	$132.50	130	208.22	A I B

Figure 3: Differences in "Skew High" and "Skew Low" Tables to Capture Format Effects

Payment Alternative	Payment Option A	Payment Option B Skew High	Payment Option B Skew Low
1	$100	$100	$100
2	$100	$100.75	$100.25
3	$100	$102	$100.75
4	$100	$103.75	$101.25
5	$100	$105	$102.50
6	$100	$110	$103.75
7	$100	$112.50	$105
8	$100	$117.50	$107.50
9	$100	$122.50	$110
10	$100	$125	$115
11	$100	$127.50	$117.50
12	$100	$128.75	$122.50
13	$100	$130.50	$127.50
14	$100	$131.25	$130
15	$100	$131.75	$131.75
16	$100	$132.50	$132.50

Figure 4: CDF for Safe Lottery Choices in Risk Tasks

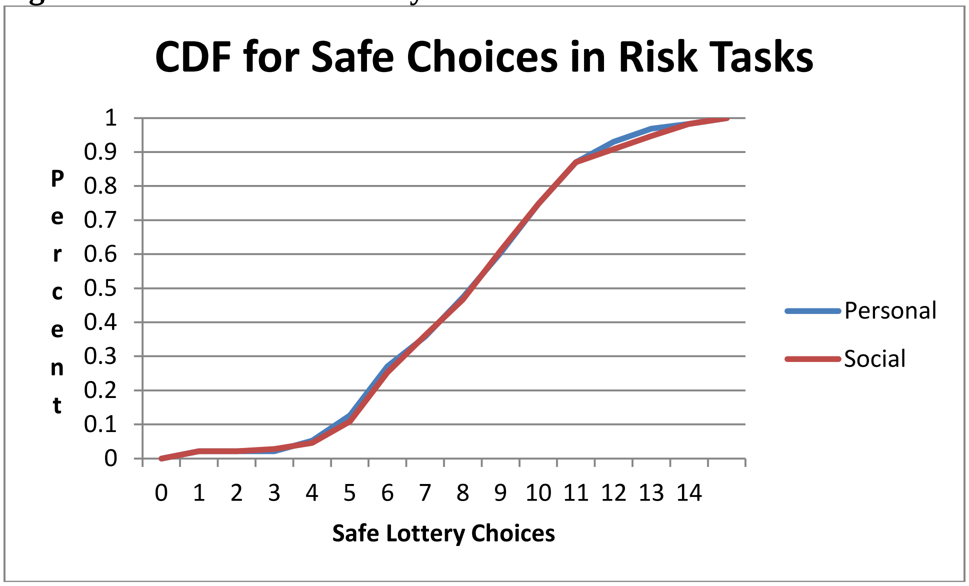

Figure 5: CDF for Proximate Payment Choices in Discounting Tasks

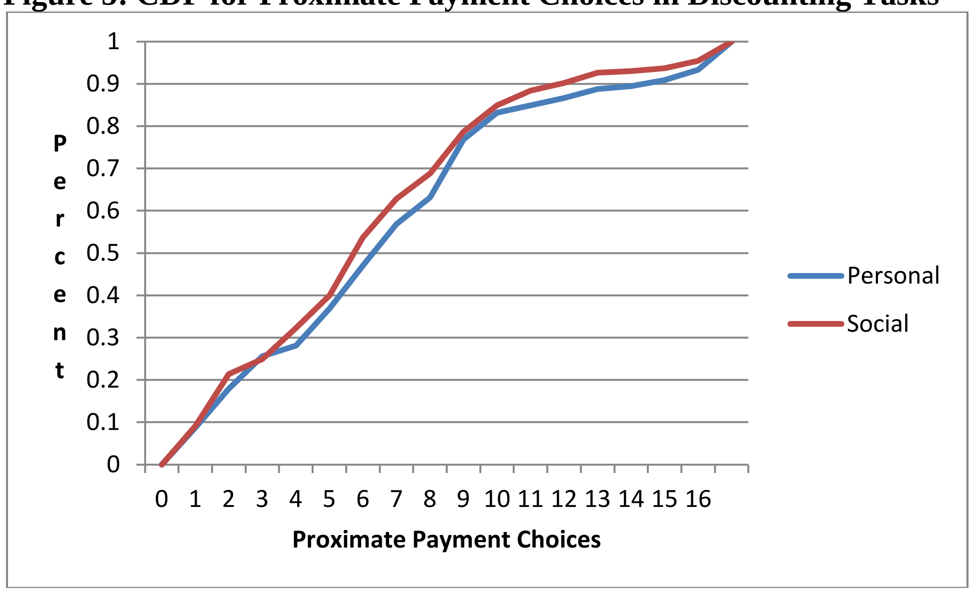

Table 1: CRRA and Time Preference Point Estimates

	Zero Background Consumption		**$30 Background Consumption**	
	CRRA	Time Preference	CRRA	Time Preference
I (Pooled)	0.299	0.288	0.422	0.328
II (Personal/Social)	0.260/0.367***	0.375/0.199***	0.388/0.482***	0.413/0.239***
III (Personal/Social)	0.218/0.318**	0.348/0.190***	0.413/0.483*	0.394/0.236***
IV (Personal/Social)	0.325/0.371	0.377/0.254***	0.432/0.448	0.381/0.240***

Notes: *, **, and *** indicate the personal and social parameter estimates are significantly different from each other at the 10%, 5%, and 1% levels, respectively. For model II, which lacks controls, the personal discount rate is the constant term and the social discount rate is the sum of the constant and coefficient for the social dummy. For models III and IV, the personal discount rate is the sum of the constant and the coefficients for all controls multiplied by the mean value of these controls in the sample. The social discount rate is the sum of the personal point estimate and the coefficient for the social dummy.

Table 2: Maximum Likelihood Estimates: Zero Background Consumption

Parameter	Variable	I	II	III	IV
CRRA Coefficient (σ)	Constant	0.299*** (0.055)	0.260*** (0.058)	0.242 (0.192)	0.270 (0.291)
	Social	—	0.107** (0.050)	0.100** (0.048)	0.016 (0.089)
	Controls?	No	No	Yes	Yes
	Test Social Point Estimate = 0	NA	< 0.001	< 0.001	< 0.001
Time Preference Parameter (ρ)	Constant	0.288*** (0.038)	0.375*** (0.049)	0.232*** (0.100)	0.220** (0.100)
	Social	—	-0.176*** (0.041)	-0.158*** (0.037)	-0.123*** (0.047)
	Controls?	No	No	Yes	Yes
	Test Social Point Estimate = 0	NA	< 0.001	< 0.001	< 0.001
Risk Task Noise Term (μ_R)	Constant	0.188*** (0.021)	0.186*** (0.020)	0.160*** (0.017)	0.142*** (0.020)
	Social	—	—	—	0.041 (0.034)
Discounting Task Noise Term (μ_D)	Constant	0.059*** (0.007)	0.057*** (0.006)	0.051*** (0.007)	0.049*** (0.006)
	Social	—	—	—	0.007 (0.009)

Notes: Standard errors presented in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Table A1 contains variable definitions and Table A2 provides the full estimation results with controls for Columns III and IV. The "Test Social Point Estimate = 0" rows report p-values for a test in which the null hypothesis is that the mean point estimate for social payments is equal to zero.

Table 3: Maximum Likelihood Estimates: $30 Background Consumption

Parameter	Variable	I	II	III	IV
CRRA Coefficient (σ)	Constant	0.422*** (0.070)	0.388*** (0.075)	0.292* (0.152)	0.316** (0.149)
	Social	—	0.094*** (0.037)	0.070* (0.038)	0.016 (0.040)
	Controls?	No	No	Yes	Yes
	Test Social Point Estimate = 0	NA	< 0.001	< 0.001	< 0.001
Time Preference Parameter (ρ)	Constant	0.328*** (0.038)	0.413*** (0.123)	0.224* (0.100)	0.216* (0.123)
	Social	—	-0.174*** (0.044)	-0.158*** (0.043)	-0.141*** (0.044)
	Controls?	No	No	Yes	Yes
	Test Social Point Estimate = 0	NA	< 0.001	< 0.001	< 0.001
Risk Task Noise Term (μ_R)	Constant	0.125*** (0.014)	0.122*** (0.014)	0.107*** (0.013)	0.100*** (0.014)
	Social	—	—	—	0.026 (0.019)
Discounting Task Noise Term (μ_D)	Constant	0.027*** (0.005)	0.026*** (0.004)	0.024*** (0.004)	0.023*** (0.004)
	Social	—	—	—	0.003 (0.004)

Notes: Standard errors presented in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Table A1 contains variable definitions and Table A2 provides the full estimation results with controls for Columns III and IV. The "Test Social Point Estimate = 0" rows report p-values for a test in which the null hypothesis is that the mean point estimate for social payments is equal to zero.

Table A1: Variable Definitions

Variable	Description
Constant	Estimate of parameter when all dummy variables are 0
Social	Dummy equal to 1 if response pertained to charitable contribution
SR_Hi	Dummy equal to 1 if subject received skew high table social risk preference task
PR_Hi	Dummy equal to 1 if subject received skew high table personal risk preference task
SD_Hi	Dummy equal to 1 if subject received skew high table social time preference task
PD_Hi	Dummy equal to 1 if subject received skew high table personal time preference task
Social_First	Dummy equal to 1 if subject answered social tasks before personal tasks
P_DFirst	Dummy equal to 1 if time preference task was before risk preference task (personal)
S_DFirst	Dummy equal to 1 if time preference task was before risk preference task (social)
Female	Dummy equal to 1 if subject was female
GPA3	Dummy equal to 1 if subject's GPA is 3 or greater
SessionX	Dummy equal to 1 if response is from Session X

Table A2: Maximum Likelihood Estimates with Controls Reported

Parameter	Zero Background Consumption				$30 Background Consumption			
	III		IV		III		IV	
CRRA Parameter (σ)								
Constant	0.242	(0.192)	0.270	(0.191)	0.292*	(0.152)	0.316**	(0.149)
Social	0.100**	(0.048)	0.016	(0.089)	0.070*	(0.038)	0.016	(0.040)
SR_Hi	0.101	(0.069)	0.100	(0.069)	0.122**	(0.063)	0.120*	(0.064)
PR_Hi	0.077	(0.070)	0.086	(0.070)	0.106*	(0.056)	0.109*	(0.057)
Social_First	0.032	(0.192)	0.021	(0.200)	0.075	(0.138)	0.072	(0.139)
P_DFirst	0.038	(0.240)	0.044	(0.239)	0.044	(0.183)	0.047	(0.185)
S_DFirst	-0.214	(0.158)	-0.043	(0.150)	-0.024	(0.114)	-0.037	(0.114)
Female	0.105	(0.085)	0.101	(0.084)	0.083	(0.069)	0.081	(0.068)
GPA3	0.031	(0.108)	0.030	(0.104)	-0.004	(0.070)	-0.004	(0.061)
Session1	0.327	(0.302)	0.376	(0.298)	0.306	(0.221)	0.341	(0.220)
Session2	-0.415	(0.253)	-0.391	(0.247)	-0.325	(0.202)	-0.314	(0.203)
Session4	-0.068	(0.260)	-0.055	(0.267)	0.048	(0.182)	0.054	(0.185)
Session7	-0.314	(0.416)	-0.327	(0.405)	-0.163	(0.312)	-0.185	(0.307)
Session8	-0.171	(0.191)	-0.178	(0.194)	-0.120	(0.162)	-0.128	(0.166)
Session9	-0.167	(0.208)	-0.154	(0.205)	-0.124	(0.161)	-0.122	(0.161)
Session10	-0.160	(0.212)	-0.155	(0.211)	-0.045	(0.162)	-0.045	(0.162)
Session11	-0.347	(0.289)	-0.320	(0.285)	-0.239	(0.232)	-0.235	(0.230)
Time Preference Parameter (ρ)								
Constant	0.232**	(0.100)	0.220**	(0.100)	0.224*	(0.123)	0.216*	(0.123)
Social	-0.158***	(0.037)	-0.123***	(0.047)	-0.158***	(0.043)	-0.14***	(0.044)
SD_Hi	0.061	(0.054)	0.064	(0.056)	0.072	(0.068)	0.073	(0.069)
PD_Hi	-0.044	(0.058)	-0.050	(0.060)	-0.051	(0.073)	-0.055	(0.074)
Social_First	0.233*	(0.131)	0.242	(0.132)	0.398**	(0.159)	0.399**	(0.160)
P_DFirst	0.018	(0.101)	0.112	(0.103)	0.062	(0.106)	0.058	(0.108)
S_DFirst	-0.016	(0.160)	0.006	(0.165)	-0.046	(0.191)	-0.047	(0.190)
Female	0.027	(0.063)	0.027	(0.064)	0.079	(0.070)	0.081	(0.070)
GPA3	-0.040	(0.077)	-0.041	(0.078)	0.012	(0.094)	0.012	(0.094)
Session1	-0.495*	(0.192)	-0.538***	(0.198)	-1.278***	(0.314)	-1.35***	(0.302)
Session2	0.259	(0.212)	0.237	(0.217)	0.192	(0.229)	0.195	(0.229)
Session4	0.189	(0.147)	0.179	(0.155)	0.149	(0.151)	0.145	(0.152)
Session7	-0.251	(0.211)	-0.263	(0.214)	-0.564**	(0.223)	-0.558**	(0.223)
Session8	0.013	(0.098)	0.015	(0.104)	-0.018	(0.117)	-0.016	(0.119)
Session9	-0.111	(0.143)	-0.126	(0.148)	-0.311	(0.170)	-0.315*	(0.170)
Session10	0.095	(0.132)	0.088	(0.135)	0.068	(0.155)	0.065	(0.156)
Session11	-0.011	(0.192)	-0.045	(0.202)	-0.257	(0.200)	-0.255	(0.200)

Notes: Standard errors presented in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Columns marked III allow for variation in payment type and adds controls for σ and ρ; Columns marked IV additionally allows for variation in payment type for the noise terms μ_R and μ_D. Because of collinearity issues between session and order variables, four of the session dummies have been dropped. The dummies dropped in this estimation are 3, 5, 6, and 12. Robustness checks, in which different session dummies were dropped, yielded similar qualitative results.