Inferring discount rates from time-preference experiments

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**HIGHLIGHTS**
- Inferred discount rates in time-preference experiments depend on payment spreading.
- We calculate optimal spreading for a given set of behavioral and design parameters.
- Inferred discount rates are near risk-neutral rates under optimal spreading.
- Estimated discount rates mostly reflect pure rates of time preference.

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**ABSTRACT**

We observe that identification of the discount rate from experimental data requires an assumption about the consumption period, the length of time over which a payment will be turned into utility-providing consumption. We show that the optimal consumption period is substantially longer than assumed in previous studies. When the consumption period is allowed to take on more reasonable values, the discount rates implied by experimental choices are unreasonably large and relatively insensitive to assumptions about utility curvature.

**1. Introduction**

A time preference experiment is one that asks individuals to choose between \(X\) now and a larger amount of \(Y\) in the future. As pointed out by researchers, these experiments elicit a combined discount rate/utility curvature parameter (e.g. Frederick et al., 2002 and Andersen et al., 2008). If utility is linear, i.e. zero utility-curvature, the implied discount rates from these experiments are often quite high, a finding that has broad implications. If researchers instead allow for risk aversion, typically inferred from a separate or related set of experiments, the implied discount rates are smaller and have less drastic implications.

\(^\dagger\) Laury et al. (2012) use a novel experimental design that attempts to eliminate the influence of utility curvature by having individuals make choices over time-delineated probabilistic payments. The researchers estimate discount rates of 11%–12% in two experiments.

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2. Optimal spreading and implied discount rates

We explore the inference of discount rates in the context of a time-preference experiment in which an individual chooses between an early payment, $M_0$, received at day $t_0$ and a later but larger payment, $M_1$ received at day $t_1 > t_0$. Present discounted utility of the early payment under exponential discounting and additively-separable per-period utility is:

$$PDU_0 = \sum_{i=0}^{t_0-1} \left( \frac{1}{1 + \delta} \right) \frac{\omega}{\lambda_0} U(\omega) + \sum_{i=t_0+\lambda}^{T-1} \left( \frac{1}{1 + \delta} \right) \frac{\omega}{\lambda_0} U(\omega),$$

where $\delta$ is the individual’s annual discount rate, $\omega$ is background consumption, $T$ is the time horizon, and $U(\omega)$ is the instantaneous utility of consumption. Following Andersen et al. (2008), the individual spreads consumption of the payment evenly over $\lambda_0$ days and thus consumes $M_0/\lambda_0$ per day over that period. Define in a similar fashion the present discounted utility, $PDU_1$, under the later payment, $M_1$, and consumption period, $\lambda_1$. Similarly to other studies, we assume that background consumption is constant over time.

An individual’s preferred spreading period is motivated by the two basic behavioral parameters of our model: the discount rate and risk-aversion. Risk-averse individuals will want to spread consumption over multiple days to increase the marginal value of instantaneous utility in each period, and therefore their total utility. This utility increase is offset by the additional discounting of utility that occurs for consumption on days further into the future from the present time. Our model suggests, for example, that risk-neutral individuals would choose not to spread at all.

Without good data or experimental evidence on the time path of consumption flows, most experimental studies eliciting discount rates have assumed individuals consume their payments in one day (e.g., Andersen et al., 2008, Tanaka et al., 2010, Andreoni and Sprenger, 2012 and Meier and Sprenger, 2012). We show that this consumption period is woefully sub-optimal given the other parameters estimated or assumed in these studies. Suppose the individual has CRRA utility, $U(c) = c^{1-\rho}/(1-\rho)$ and suppose the individual chooses the period over which to consume $M_0$ (or $M_1$) given discount rate $\delta$ and utility curvature $\rho$. Fig. 1 shows the value of $\lambda$ that maximizes (1) for a range of $[\delta, \rho]$ values given background consumption of $\omega$ and an early payment of $\$405$, denoted $\lambda^*$. For comparison to previous work, we examine $\delta = 0.1$ and $\rho = 0.75$, which are approximately the values estimated by Andersen et al. under the assumption of $\lambda = 1$ for the Danish population. For this $[\delta, \rho]$ pair, we find the optimal spreading period, $\lambda^*$, is 234 days.

Time-preference experiments attempt to infer $\delta$ from individuals’ choices between the earlier $(M_0)$ and later $(M_1)$ payments, based on some other knowledge of (or assumption about) $\rho$. To see the implications of optimal spreading for this inference, we look at the set of $[\delta, \rho]$ that would be consistent with an individual being indifferent between an earlier payment of $M_0 = \$405$ at $t_0 = 14$ and a later payment of $M_1 = \$515$ at $t_1 = 270$, assuming $\omega = \$20$ and setting $\lambda_0 = \lambda_0^*$ and $\lambda_1 = \lambda_1^*$. Results are in Fig. 2. A risk-neutral individual who was indifferent between these two payments would have a discount rate of $\delta \approx 0.41$. Higher $\rho$’s are, of course, associated with lower $\delta$’s, but the extent to which the inferred $\delta$ varies is quite small when $\lambda$ is chosen optimally. As Fig. 2 shows, an individual with risk aversion $\rho = 0.75$ would need a discount rate only slightly below the risk-neutral individual’s, 0.38, to be indifferent between the two payments.

Fig. 2 shows for comparison the same curve when $\lambda$ is constrained to equal 1. This curve is the set of $[\delta, \rho]$ that would be consistent with the individual being indifferent between our early and late payments conditional on $\lambda = 1$. Here, an individual with risk aversion $\rho = 0.75$ who was indifferent between the two payments would have an inferred discount rate $\delta = 0.16$. This inferred rate is substantially lower than implied by optimal consumption spreading. Studies which adjust inferred discount rates so as to account for utility-curvature may be finding much lower estimates of $\delta$ than are truly representative of individuals’ time preferences because these studies do not allow for optimal (or even reasonable) consumption spreading.

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2 Andersen et al. (2008) examine periods of greater than one day but their main results are based on a consumption period of one day since this one day period maximized the log-likelihood of their estimates; their log-likelihood is quite flat in this dimension, however. Andersen et al. further assumed the spreading period to be the same for the early and late payment.

3 Our figures show values for a relative risk-aversion parameter between 0 and 0.8. The patterns we find apply at all levels of $\rho$: higher $\rho$ implies a lower discount rate and more consumption spreading, all else equal. The lack of capital markets in our model constrains spreading to being non-negative.

4 Our comparison to Andersen et al. (2008) is not exact because they use a slightly larger payment amount of $458 for their early payment. Higher payments sizes, however, will only increase the optimal spreading period. Our choice of $405$ in 14 days is based on a time preference experiment we conducted with a sample of 208 US farmers (Duquette et al., 2012).

5 In Duquette et al. (2012), we estimated an average discount rate of 0.34 under continuous compounding and risk neutrality. Our choice of a risk-neutral rate of 0.41 here is based upon estimates using daily compounding, which makes for easier comparison to other estimates in the literature.
3. Quasi-optimal rates

Optimal consumption spreading is a strong assumption in these models. As Horowitz (1991), Andersen et al., and others have pointed out, individuals who fully optimize background consumption and consumption spreading given a market rate of return for borrowing or saving would have inferred risk-neutral discount rates equal to the market rate of return (e.g., Fuchs, 1982; Lowenstein, 1987; Horowitz, 1991 and Pender, 1996). In such a case, experimental choices would reveal nothing about utility parameters. Much of the experimental literature has found individual behavior to be inconsistent with these obviously strong assumptions (e.g., Coller and Williams, 1999). We therefore examine discount rate inferences under two versions of quasi-optimal spreading, which we called (i) fixed and (ii) proportional spreading.

Results are shown in Fig. 3. The dot–dash line in Fig. 3 shows the set of \( \{ \delta, \rho \} \) consistent with an individual being indifferent between the early and late payments when the individual is assumed to have a consumption period \( \lambda = 50 \) longer than assumed by previous studies but fixed across individuals (i.e., \( \lambda \) is not allowed to depend on \( \delta \) and \( \rho \)). Alternatively, the dotted line in Fig. 3 shows the curve when \( \lambda = 0.1 \lambda^* \). For this case, consumption spreading is allowed to vary with \( \delta \) and \( \rho \), such that more risk averse or more patient individuals will have longer consumption spreading (consistent with Fig. 1), but the individual is constrained to have shorter-than-desired spreading. Since \( \lambda^* \) varies from 10 (for the early payment when \( \delta = 0.41 \) and \( \rho = 0.01 \)) to 144 days (for the late payment when \( \delta = 0.38 \) and \( \rho = 0.8 \)), this curve shows preferences for \( \lambda \) ranging from 1 to 14 days; in other words, closer to the spreading periods assumed under previous analysis, but varying across individuals.

In both of these quasi-optimal cases, inferred discount rates are relatively insensitive to assumptions about \( \rho \) and are much higher than under the typical assumption of \( \lambda = 1 \). For example, when \( \rho = 0.75 \), the discount rate that is consistent with indifference between the early and late payments is 0.35 when \( \lambda = 50 \) and 0.34 when \( \lambda = 0.1 \lambda^* \). These discount rate values are much closer to the risk-neutral rate than the inferred 0.16 discount rate when \( \lambda \) is fixed at 1 day.

4. Discussion

Starting with Thaler (1981), economists have found discount rates measured in time preference experiments to be extremely high, in the range of 20% or higher, and discounting behavior has varied widely across studies, with no particular pattern that hints at convergence (Frederick et al., 2002). Recent authors have noted that these experiments measure a combined discount rate/risk aversion parameter and that when care is taken to separate out risk aversion, the inferred discount rates are lower, although still somewhat high compared to values used in, say, most macro simulations.

Risk aversion is perceived to be important in these experiments not because payments are uncertain (experimenterstypically take pains to reassure subjects that payments are very certain) but because payments are lumpy. Individuals who receive a later payment – and who consume that payment in one fell swoop – receive little additional utility from the higher payment if they are risk averse and therefore are more likely to take an earlier payment. If researchers did not account for risk aversion, this behavior would appear to show a high discount rate.

The forces that lead the individual to devalue the lumpy payment would also lead her to spread the payment over multiple periods, however. As this paper has shown, once we allow individuals even a slight bit of consumption spreading, their choice behavior depends primarily on the discount rate. This occurs both because nearly all individuals want to spread consumption over more than a single day and because more risk averse individuals want to spread consumption more than less risk averse individuals. Relaxing either one of these assumptions about spreading leads inferred discount rates to be higher and much closer to the risk neutral rate.

There are at least two future research paths suggested by this research. First, researchers could attempt to estimate individuals’ consumption periods. Second, there are a number of experimental studies that allow individuals to have time-inconsistent behavior, which can be represented with more general forms for discounting (e.g., Benhabib et al., 2010). It would be worthwhile to examine whether longer spreading periods affect discounting parameters under these other forms of discounting.

References


