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Eliciting discount functions when baseline consumption changes over time☆

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ABSTRACT

Many empirical studies on intertemporal choice report preference reversals in the sense that a preference between a small reward to be received soon and a larger reward to be received later reverses as both rewards are equally delayed. Such preference reversals are commonly interpreted as contradicting constant discounting. This interpretation is correct only if baseline consumption to which the outcomes are added, remains constant over time. The difficulty with measuring discounting when baseline consumption changes over time, is that delaying an outcome has two effects: (1) due to the change in baseline consumption, it changes the utility from receiving the outcome, and (2) it changes the factor by which this utility is discounted. In this paper we propose a way to disentangle the two effects, which allows us to draw conclusions about discounting even when baseline consumption changes over time.

1. Introduction

Many empirical studies show that people's choice behavior is time inconsistent in the sense that a preference between a small reward to be received soon and a larger reward to be received later, reverses as both rewards are equally delayed. This preference reversal is commonly interpreted as contradicting Samuelson's (1937) constant discounting and as evidence for hyperbolic discounting (Frederick et al., 2002). We show that this interpretation is not justified if the decision maker adds rewards to a baseline consumption level which may change over time in a manner unknown to the experimenter. Noor (2009) showed that another common approach to falsify constant discounting, which relies on the money discount function, only works if baseline consumption is constant over time. This is bad news. Unless we know that baseline consumption remains unchanged over time, we cannot draw clear conclusions about the discount function from the usual intertemporal choices that are observed in the literature.

This paper proposes an approach to derive properties of the discount function when it is unknown how baseline consumption may change over time. We provide conditions under which one can conclude that choice behavior is inconsistent with constant discounting, even when one does not know how baseline consumption changes over time.

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The difficulty with measuring discounting when baseline consumption changes over time, is that delaying an outcome has two effects: (1) due to the change in baseline consumption, it changes the extra utility from receiving the outcome, and (2) it changes the factor by which this extra utility is discounted. In order to draw conclusions about discounting one needs to disentangle these two effects, which seems impossible at first sight. The main contribution of this paper is to provide a method for disentangling the two effects.

Key to our approach is to extend the domain of preferences from dated outcomes $(t : x)$ that yield outcome x for sure at date t, to risky dated outcomes $(t : p : x)$ that yield outcome x with probability p at date t. We consider tradeoffs between delaying an outcome and making the outcome more risky by determining probability equivalents of delays. Imagine we start with the receipt of an outcome x at date 0 and we delay it to date t. Then we determine the probability p that would make 'receiving the outcome at date t for sure' equivalent to 'receiving the outcome at date 0 with probability p'. There are only few studies (Keren and Roelofsma, 1995; Baucells and Heukamp, 2012; Gerber and Rohde, 2014) that analyze the tradeoff between probability and delay. Our results show that analyzing this tradeoff by extending the preference domain to risky dated outcomes, may prove helpful when preferences over dated outcomes alone are not sufficient to draw conclusions about the discount function.

2. Baseline consumption and impatience

Let $\mathcal{T} = \{0, 1, \ldots, T\}$ be the set of dates, where date 0 represents today and date $T \in \mathbb{N}$ is the decision maker's time horizon.[1] The decision maker (DM) evaluates *risky dated outcomes* $(t : p : x)$, which give *outcome* $x \in \mathbb{R}_+$ with *probability* $p \in [0, 1]$ at *date* $t \in \mathcal{T}$ and nothing otherwise. We assume that the DM's preference relation $\succcurlyeq$ over risky dated outcomes $\mathcal{D} = \mathcal{T} \times [0, 1] \times \mathbb{R}_+$ can be represented by the utility function $V : \mathcal{D} \rightarrow \mathbb{R}$ with

$$V(t : p : x) = p\delta(t)\left[u(b_t + x) - u(b_t)\right], \tag{1}$$

where $u : \mathbb{R}_+ \rightarrow \mathbb{R}$ is a strictly increasing, strictly concave, and twice continuously differentiable *utility function,* where $\delta : \mathcal{T} \rightarrow (0, 1]$ is a strictly decreasing *discount function* with $\delta(0) = 1$, and where $b_t \in \mathbb{R}_+$ is the DM's *baseline consumption* at date t.[2] Hence, whenever the DM receives an outcome x at date t, he adds it to his baseline consumption and consumes the sum of both, which yields utility $u(b_t + x)$. If x is received with probability p at date t, the increase in expected utility at date t therefore is $p[u(b_t + x) - u(b_t)]$, which is equivalent to an increase in expected utility of $\delta(t)p[u(b_t + x) - u(b_t)]$ at date 0. Thus, baseline consumption affects the extra utility generated by the receipt of an outcome x.

We assume that an outcome is consumed at the date of receipt. This is a common assumption in the literature, which can, at least partly, be justified by the large monetary discount rates implied by the choices of subjects in experiments (Frederick et al., 2002). If individuals would face no liquidity constraints, and would use their experimental receipts to maximize the present values of their lifetime incomes, their choices would follow the market interest rates. Thus, their monetary discount rates would be much lower than commonly observed. Even though recent studies, using novel experimental methodologies, obtained lower estimates of these monetary discount rates (Andreoni and Sprenger, 2012), they are still much higher than the market interest rates.

Our model is a special case of the model we characterized in Gerber and Rohde (2014) with weighting function $w(p, t) = p\delta(t)$.[3,4] We assume that baseline consumption is riskless, but, as in Noor (2009), it can be viewed as a "stand-in" for any other factors that possibly affect marginal utility.

The DM has *decreasing (constant, increasing) absolute risk aversion* if $-u''(x)/u'(x)$ is strictly decreasing (constant, strictly increasing) in x.

A preference reversal typically observed in empirical studies is

$$(0 : 1 : x) \succcurlyeq (\tau : 1 : y) \quad \text{and} \quad (t : 1 : x) \prec (t + \tau : 1 : y) \tag{2}$$

with $y > x > 0$, and $\tau, t > 0$, i.e. the DM weakly prefers receiving x with probability 1 at date 0 to receiving the larger payoff y with probability 1 at date τ, but he strictly prefers to wait for the larger payoff y if both rewards are delayed by t. Based on this preference reversal it is commonly concluded that the discount function cannot be the exponential $\delta(t) = e^{-rt}$. We will show, though, that this conclusion is only justified if baseline consumption is constant over time.

In line with Prelec (1989, 2004) we say that decreasing impatience holds when the near future is discounted at a higher rate than the far future.

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[1] In order to avoid technicalities we assume T to be finite.

[2] This representation of a preference relation over $\mathcal{D}$ is obtained if the DM's preference relation $\succsim$ over consumption streams $(\tilde{c}_0, \tilde{c}_1, \ldots, \tilde{c}_T)$, where $\tilde{c}_t$ is a random variable with realizations in $\mathbb{R}_+$, is represented by a discounted expected utility function, i.e. $(\tilde{c}_0, \ldots, \tilde{c}_T) \succsim (\tilde{c}'_0, \ldots, \tilde{c}'_T) \Leftrightarrow \sum_t \delta(t)EU(\tilde{c}_t) \geq \sum_t \delta(t)EU(\tilde{c}'_t)$, where $EU(\cdot)$ is expected utility taken with respect to some von Neumann–Morgenstern utility function u.

[3] In Gerber and Rohde (2014) we let $\mathcal{T} = \mathbb{R}_+$.

[4] All results in Sections 2 and 3 remain valid if we would have $V(t : p : x) = w(p)\delta(t)[u(b_t + x) - u(b_t)]$ instead, with w increasing, non-linear, and $w(0) = 0$ & $w(1) = 1$.