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The evolution of hyperbolic discounting: Implications for truly social valuation of the future

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ABSTRACT

We explore the standard expected utility model and alternatives to it. We then examine the behavioral and neurological evidence for hyperbolic discounting. We discuss evidence related to the neurological and behavioral evolution of discounting in non-human animals and in humans. We explore new findings about the importance of sociality in human behavior and the implications for truly social time preference. Finally, we discuss the implications of the neurological evidence on discounting for social environmental valuation, in particular the implications for very long-run decisions such as those involved in climate change mitigation and biodiversity preservation.

1. The basic economics of discounting

Evaluating the impacts of present activities on those living in the future is one of the most critical areas of uncertainty in environmental policy. The debate surrounding discounting is not only important to the numerical valuation of the costs and benefits of environmental policies (social benefits/costs and optimal path calculations), it is also central to designing policies that are incentive compatible with observed human behavior and evolved neurological structures and pathways. In the standard economic model—here referred to as the discounted utility (DU) model—the debate about responsibility to future generations is reduced to the choice of a social discount rate (Dasgupta and Heal, 1974; Hepburn et al., 2009; Pearce et al., 2003). Discounted utility refers to the discounted value of the flow of services from consumer goods over time (Ramsey, 1928; Samuelson, 1937).[1] DU assumes a strict equivalence between benefits and the utility derived from those benefits. It is essentially a financial investment model showing how a perfectly rational individual should allocate investments so as to maximize expected present value of those investments. The standard DU model of environmental valuation assumes that

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[1] The DU model, referred to variously as "discounted utilitarianism", the "Ramsey model" or the "Ramsey–Cass–Koopmans" model is perhaps the most widely used deterministic model in general equilibrium economics. A variation is the dynamic stochastic general equilibrium model (DSGE) which is a specific application in macroeconomic models allowing for uncertainty.

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social decision makers, like an individual making private investments, should seek to maximize the sum of present and discounted future economic welfare. In the DU framework, issues of intergenerational fairness are tied to the discount rate by both the pure rate time preference and the elasticity of marginal utility. The social discount rate is typically the private rate adjusted for external effects, and determining the scope of these effects is fraught with difficulties (Graaff, 1987). In the DU model, the value of future welfare is usually discounted at constant percent per year reflecting among other things society's impatience, or the preference for receiving benefits in the short run while deferring costs to the future.

In a continuous-time setting with constant population and a single consumption good, the DU approach employs the mathematics of constrained optimization to maximize the social welfare functional:

$$W(t) = \int U[C(t)] \left[\frac{1}{(1+r)^{\alpha(t)}} \right] dt \tag{1}$$

In this form, U is instantaneous utility, C is the flow of consumption goods and $[1/(1+r)^{\alpha(t)}]$ is the discount weight. Using a constant discount rate reduces the weighting factor used in Eq. (1) to $[1/(1+r)^t]$, where $\alpha(t) = t$ (Albrecht and Weber, 1995; Caines and van der Pol, 2000). Eq. (1) is a general formula that can be converted into an exponential or hyperbolic function.

We must note that in the standard approach, this discount rate r is based on more fundamental elements, drawing on arguments of Ramsey (1928), Cass (1965), and Koopmans (1965). This formulation has the appropriate discount rate to be used to be the sum of a pure rate of time preference, ρ, and the curvature of the utility of income, θ, times the expected growth rate of output, g, that is,

$$r = \rho + \theta g, \tag{2}$$

where,

$$\theta = \frac{u''(c)c}{u'(c)}, \tag{3}$$

which is generally thought to lie between zero and one.

Even before getting into the issues of main interest for this paper, this formulation raises some issues. The first involves the fact that this formulation assumes that the economy is a single agent. That is problematic in itself. The next involves the determination of ρ, the social rate of time preference. Famously Ramsey himself declared that this should be zero on moral grounds, calling positive time preference rates to be "telescopic myopia." However, even if Ramsey's wish is followed through on, this formula will still deliver a positive discount rate to be used in (1) as long as future growth is expected to be continued and to be valued. Ironically, if there is a failure to adequately deal with global environmental problems, this expected g could possibly become negative, which could potentially lead to a negative r, although such a prospect is rarely taken seriously.

In spite of sustained criticism (Bromley, 1990; Frederick et al., 2002; Howarth, 2009; Ludwig et al., 2005) the DU model still dominates econometric work in environmental valuation including discussions of whether or not economies are sustainable (Arrow et al., 2004). Discussion of the proper discount rate was central to the controversies surrounding the *Stern Review* (Cole, 2008; Quiggin, 2008; Stern, 2007) on the economics of climate change and The Economics of Ecosystems and Biodiversity (TEEB) initiative on the economics of biodiversity loss (Gowdy et al., 2010). The upshot of these discussions is that there is no purely economic justification for choosing a particular discount rate. Econometric studies offer little guidance since even with fairly short-lived choices people employ a wide range of discount rates depending on framing, the nature of the product, income, and numerous other factors. For example, estimates of the discount rate for the adoption of energy saving appliances show inconsistent and widely varying time horizons. Hausman (1979) found that air conditioner purchases showed a discount rate of 25 percent and that the rate varied between 5 percent for high income households and 89 percent for low income households. Train (1985) found that discount rates varied considerably depending on the kind of appliance.

Hausman's results indicate that households discount the future benefits of energy appliances at rates far higher than the risk adjusted market rate of return. There are several ways to interpret this. One possibility is that people have different rates of return for different kinds of investments, a result widely at odds with the DU model (see Frederick et al., 2002). Another possibility is that people are not maximizing the present value of their investments which means that preferences cannot be described in terms of discount rates (Howarth and Sanstad, 2005). Hausman's (1979) and other similar studies calculate internal rates of return on particular investments assuming rational, maximizing behavior and their assumptions seem questionable given the findings. Howarth and Sanstad, 2005 argue that the extremely high discount rates for energy efficient appliances arise from asymmetric information, bounded rationality and transaction costs. It should also be mentioned that discounted utility models have played a key role in the analysis of investment behavior under uncertainty, particularly the debate over the equity premium puzzle (Ding et al., 2012).

Discounting is particularly problematic when dealing with extremely long-lived environmental problems like biodiversity loss, climate change and the risks associated with nuclear power (Carson and Roth Tran, 2009; Gowdy, 1997). Earlier it was sometimes argued that the discount rate should be based on the after-tax marginal rate of return on private investment as the best measure of the opportunity cost of capital, although that view has since been superseded by the view that a broader social consideration should dominate (Baumol, 1968; Marglin, 1963). The earlier view underlay the effort in 1970 by the Nixon Administration to impose a government-wide 10 percent discount rate for use in all cost–benefit analysis (based