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The evolutionary theory of time preferences and intergenerational transfers

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ABSTRACT

At each age an organism produces energy by foraging and allocates this energy among reproduction, survival, growth, and intergenerational transfers. We characterize the optimal set of allocation decisions that maximizes fitness. Time preference (the discount rate) is derived from the marginal rate of substitution between energy obtained at two different times or ages, holding fitness constant. Time preference varies with age in different ways depending on whether an individual is immature or mature, and during the transition between these stages. We conclude that time preference and discount rates are likely to be U-shaped across age.

> Once upon a time, there was a monkey-keeper who fed the monkeys with acorns. When he said that he would give them three bushels of acorns in the morning and four bushels of acorns in the evening, all the monkeys were angry with his arrangement. However, when he said he would give them four bushels of acorns in the morning and three bushels of acorns in the evening, all the monkeys were pleased with his arrangement.

Zhuangzi, 1999 Qiwu lun 233B.C.

1. Background

Economists generally take the framework of the human life cycle as given: the age patterns of fertility and mortality; the low level of fertility relative to other species and the long period of child dependency; bodily growth limited to the first part of life and fertility limited to a later period; extended parental support of their children, and the rate of time preference. Arguably, however, these features were shaped by natural selection in our evolutionary past and may be at least

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partially understood in an optimization framework, one approach to what biologists call "life history theory". In the fable quoted above, even "ancient monkeys" had a time preference for (4,3) over (3,4). In this paper, we shall investigate how such preferences are shaped by evolution.

Robbins (1945, p. 16) famously defined economics as "the science which studies human behavior as a relationship between ends and scarce means which have alternative uses." In evolutionary theory, the end is clear: fitness, or the propagation of genes into the future. Here we use economic reasoning to analyze how humans have evolved to allocate the scarce resource, energy, among the alternative uses of fertility, survival, body growth, and transfers to others so as to maximize the propagation of genes into the future, and how time preference emerges from this process. Economic reasoning thus illuminates the evolutionary theory of life histories. But evolutionary theory, in turn, also sheds light on central problems in economics. Research in behavioral economics and neuroeconomics has found that intertemporal choices are governed by a set of disparate and conflicting emotions, cognitive processes, and neural functions (Frederick et al., 2002; Camerer et al., 2005). Evolutionary theory is a foundational approach to thinking about intertemporal choice in a unified way, leading to predictions about how this apparent hodgepodge of influences should lead to a coherent set of outcomes. For example, Sozou (1998) has shown how hyperbolic discounting and preference reversals may evolve through natural selection when discounting reflects risk.

1.1. Prior literature

Economics increasingly recognizes that the biological nature of humans shapes their development, health, emotions, reproduction, altruism and cognitive processes. Evolutionary theory provides a fundamental organizing theory for understanding the interrelations of such human traits, and economists have begun to use their tools to analyze the evolutionary processes that shaped them. This paper seeks to understand the evolution of time preference, and it joins a growing number of papers that have taken an economic approach to the evolution of the life cycle or life history (Hansson and Stuart, 1990; Rogers, 1994; Sozou, 1998; Sozou and Seymour, 2003; Kaplan and Robson, 2002; Robson and Kaplan, 2003; Lee, 2003; Galor and Moav, 2001, 2002; Chu and Lee, 2006; Lee, 2008; Robson and Szentes, 2008). They ask what patterns of these life history traits would maximize fitness, typically measured either by the steady state population growth rate or by the expected number of births over a lifetime. In this paper we focus on the evolution of time preferences, but we begin by analyzing the optimal life cycle. The general idea, as developed by Hansson and Stuart (1990), Rogers (1994), Sozou and Seymour (2003) and Kageyama (2009) is that time preferences should have evolved in the past so that the marginal rate of substitution (MRS) between a good received at two different ages should be the MRS in fitness. We assess the MRS in fitness by analyzing the optimal life history.

Of course, economists' concept of human time preference does not refer to fitness, but rather to the variation of utility that is associated with different sequences of consumption amounts. But one may argue that the association of utility with consumption sequences evolved to guide individual decision making so as to enhance fitness. It is in this sense that our analysis informs the evolution of time preference. As Camerer et al. (2005 p. 27) remind us, ". . . humans did not evolve to be happy, but to survive and reproduce". Economists typically represent the objective function for intertemporal choice as an atemporal utility function multiplied by an age-time discount factor derived from a cumulated rate of time preference. It is this latter that we seek to understand here. Of course, the level of energy use and consumption is vastly higher now than in our evolutionary past, but we believe that human discounting today has some biological commonality with our ancient relatives, and it is this that we attempt to characterize.

We analyze and discuss intertemporal tradeoffs in terms of energy, but the actual tradeoffs are between the things into which energy can be converted: fertility, survival, bodily growth, and transfers to others. By way of illustration, consider human hunter-gatherers who chose between immediate childbearing versus building up somatic reserves of self and earlier born children to raise the probability of longer term survival and future reproduction. That was a decision about long term intertemporal tradeoffs. Short birth intervals undermined the health of both the mother and her previously born child, so these decisions were pervasive for humans in our evolutionary past. Consider individual members of some species of birds that must choose as yearlings whether to disperse, risking mortality from predation but gaining a shot at reproducing during the current breeding season, versus staying as "helpers at the nest" to assist their parents to raise new generations of siblings, and thereby to raise their inclusive fitness. Staying reduces their mortality risk while allowing them to gain experience before dispersing the following year and keeping them in the running to inherit the breeding site if their parents die. These kinds of decisions involve intertemporal tradeoffs.

Hansson and Stuart (1990) considered individuals living a single period and investing in their offspring through intergenerational transfers in order to maximize their steady state population growth rate. They showed that such individuals would optimally discount the future at that maximum rate. We can view the saving and capital accumulation in the Hansson–Stuart model as investment in the body and particularly the brain of the developing offspring (Robson and Kaplan, 2003). Other kinds of investment such as heritable dwellings, storage facilities, dams, and food stocks occur in some non-human species but do not seem relevant for most human hunter-gatherers in the evolutionary past. Because individuals lived only one period in Hansson and Stuart's analysis, generations did not overlap and variations within the individual life cycle were not considered.

By contrast, pioneering papers by Rogers (1994, 1997) calculated the fitness preserving MRS for demographic outcomes at different ages, where fitness tradeoffs were assessed through analysis of demographic accounting identities. Rogers also