



## An evolutionary explanation for risk aversion



Moshe Levy\*

School of Business Administration, The Hebrew University, Jerusalem 91905, Israel

### ARTICLE INFO

*Article history:*

Received 4 July 2013

Received in revised form 7 August 2014

Accepted 12 December 2014

Available online 20 December 2014

*JEL classification:*

D81

D03

*PsycINFO classification:*

2340

2510

*Keywords:*

Risk aversion

Evolution

Extinction

Having descendants forever

CRRA preference

### ABSTRACT

Recent models of the evolution of preferences have provided profound new insights into the origins of risk attitudes. In most of these models the evolutionary “objective function” is the maximization of the expected number of offspring, or alternatively, the maximization of the geometric-mean growth rate. We suggest that careful consideration should also be given to the objective of maximizing the probability of Having Descendants Forever,  $p(\text{HDF})$ . We show that the  $p(\text{HDF})$  criterion implies risk aversion. Moreover, it leads to preferences that are very closely approximated by the constant relative risk aversion preferences. Thus, constant relative risk aversion can be viewed as an evolutionary-developed heuristic aimed to maximize the probability of having descendants forever.

© 2014 Elsevier B.V. All rights reserved.

### 1. Introduction

Most economic models take preferences as exogenously given. A large body of economic and psychological literature is devoted to the experimental and empirical estimation of preferences. However, until recently much less attention has been given to the question of *why* preferences are what they are. This question is interesting and important not only because it yields insights into understanding why we behave as we do, but also because it provides a theoretical foundation for the experimentally/empirically focused investigation of preferences.

Attitudes toward risk are most likely affected by education, age and life experience. However, more and more evidence is accumulating about the central role of genetics in determining preferences. Empirical studies have shown that the asset allocation of identical twins are much more correlated than those of twins who are not identical. Furthermore, the asset allocations of identical twins who were raised apart are also highly correlated (see Barnea, Cronqvist, & Siegel, 2010; Cesarini, Dawes, Johannesson, Lichtenstein, & Wallace, 2009; Cesarini, Johannesson, Lichtenstein, Sandewall, & Wallace, 2010). In

\* Tel.: +972 25883219.

E-mail address: [msلم@huji.ac.il](mailto:mسلم@huji.ac.il)

recent years biologists and economists have identified specific “risk-attitude” genes (see [Kuhnen & Chiao, 2009](#); [Zhong, Israel, Xue, Ebstein, & Chew, 2009](#)). If preferences are (at least partially) genetically determined, one can view preferences as the result of an evolutionary process selecting for the evolutionary most advantageous risk attitude. This is the approach taken by several studies that have yielded profound insights into the evolution of preferences (see, for example, [Meginniss \(1977\)](#), [Sinn and Weichenrieder \(1993\)](#), [Rogers \(1994\)](#), [Robson \(1996, 2001a, 2001b\)](#), [Samuelson \(2001\)](#), [Curry \(2001\)](#), [Sinn \(2003\)](#), [Schlesinger \(2003\)](#), [Robson and Samuelson \(2007, 2010\)](#), [Rayo and Becker \(2007\)](#) and [Lakshminarayanan, Chen, and Santos \(2011\)](#)). The present paper adopts the same approach.

In an evolutionary context, organisms can be viewed as vessels for carrying their genes ([Dawkins, 1989](#)). Genes are “successful” if they manage to perpetuate from one generation to the next. Thus, one possible evolutionary “objective function” that can be considered is the maximization of the expected number of offspring – the more offspring, the more copies of the organism’s genes are transmitted to the next generation. While this is a simple and intuitively appealing objective function, it may lead to unreasonable results. To illustrate, consider the following simplified example. Suppose that there are only two possible reproduction prospects or “gambles” to choose from. Gamble A yields 0 offspring with probability 0.3 and 2 offspring with probability 0.7. Gamble B yields 0 offspring with probability 0.8 and 9 offspring with probability 0.2. Suppose also that there are two types of preference genes: gene A that implies the preference of gamble A, and gene B that implies the preference of gamble B.<sup>1</sup> Assume that the gamble realizations are independent across individuals. Then, after  $T$  generations the expected number of individuals with gene A will be  $(0.3 \cdot 0 + 0.7 \cdot 2)^T = 1.4^T$ , while the expected number of individuals with gene B will be  $1.8^T$ . Clearly, after some time the expected number of individuals with gene B becomes much larger than that of gene A, and the ratio of the expected numbers goes to infinity as  $T \rightarrow \infty$ . This may be interpreted as “B dominates the population in the long run”, and it is the motivation for the expected number of offspring criterion.

However, it is far from obvious that this criterion is evolutionary advantageous. Note that in the above example population B has a much larger probability than population A of becoming completely extinct. Let us elaborate. A direct calculation of the probability that A’s line eventually becomes extinct is quite cumbersome, because there are infinitely many possible realizations that lead to extinction.<sup>2</sup> Fortunately, it is much easier to solve this problem recursively. Let us denote the probability that the line of descendants of an individual with gene A will eventually become extinct by  $x_A$ . It is possible, with probability 0.3, that the initial individual will have no offspring, and this will imply the end of his line of descendants. However, even if he survives to have 2 offspring, (and this occurs with probability 0.7), it is possible that the lines of both of these offspring will eventually become extinct. As the offspring carry gene A, for each one of them the probability that his line of descendants will eventually become extinct is also by definition  $x_A$ . This is a key feature of the analysis. As the gambles are assumed to be independent, the extinction of one offspring is independent of the extinction of the other, and therefore the probability that both lines eventually become extinct is  $x_A^2$ . Thus,  $x_A$  is the solution to:

$$x_A = 0.3 + 0.7x_A^2, \quad (1)$$

which yields  $x_A = 0.428$ . This value captures all of the possible scenarios leading to eventual extinction. The probability of A Having Descendants Forever,  $p_A(\text{HDF})$ , is given by  $p_A(\text{HDF}) = 1 - x_A = 0.572$ . Similarly, the probability that individual B’s line of descendants eventually becomes extinct is given by the solution to:

$$x_B = 0.8 + 0.2x_B^9. \quad (2)$$

Solving Eq. (2) numerically yields  $x_B = 0.843$ , which implies  $p_B(\text{HDF}) = 1 - x_B = 0.157$ .<sup>3</sup> Thus, while the ratio of the expected population of A to the expected population of B converges to zero as  $T \rightarrow \infty$ , type A has a much higher probability of surviving forever. How can these two facts be reconciled? Note that as  $T$  becomes large the probability distribution of the number of B descendants becomes very skewed – there is a large probability that B will become extinct, but there is a small probability that B will have a very large number of descendants. This extreme low-probability event drives the high expected value of B descendants.

Extinction plays an obvious central role in the evolutionary dynamics. One may suspect, though, that once the population of a given type reaches a certain size, the probability of extinction in the i.i.d. reproduction framework is negligible. However, evolutionary biologists show that the  $p(\text{HDF})$  criterion may be very important even after the number of individuals in each

<sup>1</sup> As is typical in this simplified framework, reproduction is assumed to be asexual, i.e. the offspring have the same preferences as their parent.

<sup>2</sup> For example, one possible scenario for extinction is that the original parent has two offspring, each one of these offspring has two offspring, but in the third generation all four offspring die. Of course, there are infinitely many such scenarios leading to extinction, and the probability of extinction,  $x_A$ , is the sum of probabilities for all these events.

<sup>3</sup> Eqs. (2) and (3) are special cases of the general [Galton–Watson \(1875\)](#) equation for the probability of extinction of a family line, see Eq. (4).

Download English Version:

<https://daneshyari.com/en/article/884896>

Download Persian Version:

<https://daneshyari.com/article/884896>

[Daneshyari.com](https://daneshyari.com)