

WHAT WOULD DARWIN SAY ABOUT RATIONAL EXPECTATIONS?

by

Michael Waldman
Department of Economics
UCLA
Los Angeles, CA 90024

May 1988

UCLA Dept. of Economics
Working Paper #478

* I would like to thank Neil Bruce, David Butz, Harold Demsetz, John Haltiwanger, David Hirshleifer, Axel Leijonhufvud, Jane Murdoch, Ian Novos, Seonghwan Oh, Tim Opler, Harold Somers, and especially Ken Sokoloff for helpful comments on an earlier draft. Special thanks go to Jack Hirshleifer for introducing me to the evolutionary literature, and for the help he has provided me in my attempt to understand it.

ABSTRACT

An implicit assumption of the rational expectations approach is that individuals accurately estimate their own abilities (or more precisely there are no systematic errors). There is a wealth of evidence in the psychology literature, however, which clearly indicates that individuals systematically overestimate their own abilities. This paper provides an explanation for some of this evidence which is based on Darwin's theory of sexual selection. It then goes on to discuss the implications of the phenomenon for the following real world economic issues: (i) the existence of speculative bubbles in real world asset markets; (ii) the existence of a winner's curse in real world auctions; and (iii) the problem of career choice.

"The overweening conceit which the greater part of men have of their abilities is an ancient evil remarked by the philosophers and moralists of all ages..."

(Adam Smith, The Wealth of Nations, p. 209)

I. Introduction

In 1859 Charles Darwin published his famous book The Origin of Species, and in it he put forth the belief that through his work "...Much light will be thrown on the origin of man and his history." Although the work has had an immense impact, it is only recently that economists have paid significant attention to its implications for human behavior. This has occurred in a series of papers by important authors such as Becker, Hirshleifer and Frank, where evolutionary theory has been used to help in the understanding of a variety of economic issues.¹ The present paper also uses Darwin's ideas to look at an economic issue, but at one not previously considered from an evolutionary perspective. Specifically, this paper focuses on what evolutionary theory suggests concerning how humans form expectations.

The standard approach among economists who have worked in this area is to use evolutionary theory as a way of endogenizing preferences. That is, start with the axiom that individuals behave in a manner which maximizes utility. It then follows that the preferences which evolve must be those which equate utility maximization with the maximization of gene survival. Although I believe this approach has yielded numerous important insights, I feel it is

somewhat narrow.² Why should we take the axiom of utility maximization as given? In particular, suppose that, maybe for good evolutionary reasons, the preferences which evolve are not those which would equate utility maximization with the maximization of gene survival. What would that suggest? Well, it would seem to suggest that humans would then not be efficient at maximizing utility, but rather a bias would be exhibited which would move behavior away from utility maximization and towards gene survival maximization. In this paper I will argue that exactly this phenomenon may have occurred in our species as regards the formation of expectations. That is, the psychology literature indicates that human behavior is not consistent with rational expectations, and one of the reasons may be that rational expectations was not a successful strategy from an evolutionary perspective.

II. Some Background

A. Natural Selection and Sexual Selection

Darwin referred to two main ways in which organisms evolve: natural selection and sexual selection.³ Natural selection, or what Darwin also referred to as survival of the fittest, is what most people probably have in mind when they think of Darwin's theory. In the typical case more individuals are born than can possibly survive. Hence, the genes which are passed on to the next generation will on average be from individuals whose probability of survival is higher. The result is that over time the "successful" genes become more abundant in the gene pool, while those less successful wither away.⁴

The probability of passing on one's genes to the next generation, however, does not only depend on the probability of survival. It also depends

on the number and quality of mates which the individual can attract. This aspect of the evolutionary process leads to what is known as sexual selection. That is, it leads to the selection of traits which do not increase the probability of survival, but rather which allow the individual to acquire either more or higher quality mates.

The typical case in the animal kingdom is that it is the males who compete among themselves for the available females. One obvious reason being that a single male can impregnate many females, and hence, there is competition among males to not be left without a mate. Darwin (as well as many more recent authors) clearly felt that sexual selection among males was an important factor in the evolution of mankind. In particular, he felt that it was the cause of numerous male/female differences both in physical and mental characteristics (see Darwin, The Descent of Man, 1871).⁵

B. Estimating One's Own Abilities - Results from the Psychology Literature

An implicit assumption of the rational expectations approach is that individuals accurately estimate their own abilities (or more precisely there are no systematic errors). Is this a valid assumption? The psychology literature clearly indicates that the answer is no. That is, there is a wealth of evidence in that literature which states that, across a variety of settings, individuals systematically overestimate their own abilities.⁶ Examples include physicians being overconfident concerning their diagnoses, analysts being overconfident of their abilities to predict stock price movements, and males in particular being overconfident in predictions of their own future performances across a variety of tasks (see Kahneman, Slovic and Tversky (1982), Maccoby and Jacklin (1974), and Frieze et al (1978) for a

discussion of the evidence).

If these findings from the psychology literature are correct, then the assumption of rational expectations is clearly problematic. For example, a problem could arise if the expectation concerns the individual's performance at a future task (as would be the case when individuals make career choice decisions). Or, a problem could arise if an individual's expectation is partially based on information he himself has gathered, i.e., he might overestimate his own ability to gather accurate information (one could imagine such a problem arising in real world auctions).

One interesting aspect of the evidence is that, for some of the settings considered, it indicates a significant male/female difference. In particular, as discussed above, in an environment where individuals make predictions concerning their own future performances, it is only the males who systematically overestimate their own abilities.⁷

"Differential expectations for success and failure in males and females has been well documented...These results have been found for elementary-school children, who gave expectancy estimates for their performance at new intellectual tasks; for eighth-graders who were asked to state how well they expected to do at a matching task; for college students estimating their grades; and for college-aged people who guessed their performance at a geometric task. Consistently, males had generally higher initial expectancies than did females. Moreover, when objective ability estimates were available, males tended to overestimate their future successes relative to their ability level, while females tended to underestimate their future performances. Thus, both sexes were inaccurate but in different directions, although girls tended to be more accurate overall."

(Frieze et al, Women and Sex Roles, 1978, p. 242)

What I will show in the next section is that sexual selection can explain why males would systematically overestimate their own abilities when predicting their own future performances.

III. Sexual Selection and Estimating One's Own Abilities

The analysis in this section builds on the work of Manove (1988). What Manove shows is that from the standpoint of expected wealth, as opposed to expected utility, agents who overestimate their own abilities may actually do better than agents with more accurate estimations. Hence, if as seems likely firm survival is based on which firms have more wealth, market selection can actually favor those firms run by entrepreneurs who systematically overestimate their own abilities. What I do is take the basic insight of Manove, i.e., that agents who overestimate their own abilities may actually do better in terms of expected wealth, and consider its implications for the evolution of man as opposed to the evolution of firms.

A. A Simple Model of Sexual Selection

There are two aspects of the model to be employed which are worth highlighting. The first concerns the nature of the competition between males. One frequent suggestion concerning how sexual selection has worked in man is the accumulation of wealth. That is, females mate with the males who have accumulated the most wealth, and hence, males compete among themselves with the accumulation of wealth being the yardstick. From an evolutionary perspective, this is a logical way for females to choose among the available males, because access to more wealth should increase the probability that children survive to adulthood.

The second aspect concerns the manner in which wealth is accumulated. In contrast to the standard way wealth is accumulated in modern society, for most of our evolution the accumulation of wealth entailed some risk of death. For example, if one thinks of wealth being accumulated either through hunting

activities or the raiding of other villages, then an individual could only increase his expected wealth by increasing the probability he would die in the process.⁸

We can now proceed to the model. There is a continuum of N males in each generation, where a generation is alive during only one period (generations do not overlap). During each period the males alive at that date compete among themselves in terms of wealth accumulation – the outcome of the competition determining which "genes" are passed on to the next generation of males (all females are assumed to be identical).

Consider period t . At the beginning of t the N males alive at that date simultaneously choose effort levels. What is important here is that an individual's effort level determines the probability he dies prior to mating, and the wealth he accumulates if he lives. Let e_i be the effort level of male i . $\Pi(e_i)$ will denote the probability the individual dies prior to mating, where $\Pi' > 0$ and $\Pi'' \geq 0$.⁹ That is, an increase in effort increases the probability of dying, and the marginal change in the probability of dying is increasing in the effort level. The assumption concerning Π'' is consistent with the notion that individuals will undertake the safer activities first. W_i will denote the wealth accumulated by individual i if he lives, where $W_i = W^0 + e_i$.¹⁰

Expected utility, denoted EU, is given by equation (1).

$$(1) \quad EU = \Pi(e_i)U^D + (1 - \Pi(e_i))(U^L + f(W_i)) - g(e_i),$$

where $f' > 0$, $f'' \leq 0$, $g' \geq 0$, $g'' \geq 0$, and $(1 - \Pi(0))f'(W^0) + \Pi'(0)(U^D - U^L - f(W^0)) > g'(0)$.

$U^D - g(e_i)$ is the individual's utility if he dies prior to mating, while

$U^L + f(W_i) - g(e_i)$ is the utility if he lives ($U^L > U^D$). $g(e_i)$ is simply the

disutility the individual derives from effort, where the restriction $(1-\Pi(0))f'(W^0)+\Pi'(0)(U^D-U^L-f(W^0))>g'(0)$ guarantees that effort will be positive.¹¹

The next aspect of the model to be described is the nature of expectations. As indicated earlier, the key property of the model is that we allow the possibility that an agent will either overestimate or underestimate his own ability. W_i^E will denote agent i 's expectation concerning the wealth he accumulates if he lives, where $W_i^E=W^0+\theta_i e_i$. In this specification $\theta_i=1$ corresponds to the individual accurately estimating his own ability, while $\theta_i>1$ ($\theta_i<1$) means that the individual overestimates (underestimates) his own ability.¹²

The θ 's described above can be thought of as the "genes" which get passed on from one generation to the next. The final aspect of the model, therefore, concerns the determination of which θ 's get passed on. What is assumed is that the distribution of θ 's in any period $t+1$ is determined by the outcome of the wealth accumulation game in period t . In particular, the proportion of individuals in period $t+1$ with a specific value for θ will equal the proportion of the total wealth accumulated in period t which is held by males characterized by that value for θ . For example, suppose that at the outcome of the wealth accumulation game in period t , one-half the total wealth is held by males whose value for $\theta=2$. Then in period $t+1$, one-half of the total male population will be characterized by $\theta=2$.

B. Analysis

This section characterizes the distribution of θ 's which would evolve in the environment just described. In characterizing this distribution I will

employ two seemingly different approaches. The first is the approach used by biologists to analyze models of this sort, which is to look for the evolutionarily stable strategy, i.e., the ESS. The second is to employ a variant of the approach described in the Introduction. That is, I will look for the distribution of θ 's which equates utility maximization with the maximization of gene survival. The reason the two approaches are referred to as being only seemingly different is that, as will be demonstrated, for the model under consideration the approaches are in fact identical.

Although I have not been able to find a formal definition of an ESS for the exact type of game we are considering here, the appropriate conditions follow easily from the verbal definition.

"...An ESS is a strategy such that, if all members of a population adopt it, then no mutant strategy could invade the population under the influence of natural selection..."

(Maynard Smith, Evolution and the Theory of Games, 1982, p. 10)

For application to the current model, this will be taken to mean the following. Suppose that $N-\delta$ of the males in period t are characterized by $\theta=\hat{\theta}$, while the remaining δ males are characterized by $\theta=\theta'$, $\theta' \neq \hat{\theta}$. $\hat{\theta}$ will be an ESS if for all (θ', δ) pairs, where δ is "small", the number of males characterized by $\theta=\theta'$ in period $t+1$ must be smaller than δ (note: θ' can represent a mixed strategy, but for ease of exposition we restrict $\hat{\theta}$ to be a pure strategy). That is, if all males are initially employing an ESS, then an injection of mutants into the population will be followed by the number of males characterized by the mutant strategy strictly falling over time. Given this definition, we can now proceed to the first proposition.

Proposition 1:

- i) If an ESS exists, then it corresponds to agents overestimating their own abilities ($\theta > 1$).
- ii) If agents are risk neutral ($f'' = 0$), then an ESS exists and it is unique.

Proof: See the Appendix.

Proposition 1 tells us that Darwin's theory of sexual selection can indeed explain why males - and only males - would overestimate their own abilities when predicting future performance. The logic behind the result is simple. In a world characterized by sexual selection, i.e., one in which males compete among themselves for the available females, competition is likely to be in terms of accumulated wealth and not in terms of the maximization of utility. We also know that as regards expected wealth, agents who overestimate their own abilities in predicting future performance may actually do better than agents with more accurate estimations. Combining these two points we get the result found in Proposition 1, i.e., the evolutionary process may actually favor males who systematically overestimate their own abilities.

Some of the readers may be uncomfortable with the above approach because they are unfamiliar with the concept of an ESS. I will therefore end the section by investigating an approach which may seem a little more natural to economists.

The standard approach among economists who have worked in the area of evolutionary theory is to assume that the preferences which evolve are those which equate utility maximization with the maximization of gene survival. This approach is not directly applicable to the model under consideration

because in the current model preferences are taken as fixed, and it is instead expectations which are allowed to evolve. However, there is clearly a slight variation of the standard approach which is applicable. In particular, in Proposition 2 we consider how expectations must evolve such that utility maximization will be equivalent to the maximization of gene survival.

Proposition 2: Utility maximization is equivalent to gene survival maximization if and only if

- i) an ESS exists
- ii) all males are characterized by a value for θ which is an ESS.

Proof: See the Appendix.

Proposition 2 tells us that equating utility maximization with the maximization of gene survival yields exactly the same distribution of θ 's one finds when focusing on the ESS. In other words, we again have that Darwin's theory of sexual selection can explain why males (and not females) would overestimate their own abilities when predicting future performance.

C. Why Overestimation of Abilities?

In the previous section I demonstrated that sexual selection among males can result in evolutionary pressure for males to overestimate their own abilities when predicting future performance. One might object, however, that evolutionary pressure could as easily be relieved through the transformation of preferences as through the transformation of expectations. For example, Rubin and Paul (1979) also consider the implications of sexual selection among males. They assume that males accurately estimate their own abilities, and argue that because of sexual selection the evolutionary process may favor

males who are risk loving. In other words, Rubin and Paul's work suggests that risk loving preferences and the overestimation of abilities are two alternative paths evolution could take in response to the presence of sexual selection.^{13,14} The question which remains, therefore, is, what reasons are there to think that evolution took the path of having males systematically overestimate their own abilities?

The main reason is the psychology literature discussed in Section II.B. As stated there, the literature contains a wealth of evidence that individuals systematically overestimate their own abilities. Even more important than the existence of the evidence, however, is the nature of the evidence. It indicates that individuals systematically overestimate their own abilities in a number of different ways. First, individuals overestimate their own abilities when evaluating performance on a previously completed task. For example, after having made a diagnosis, a physician will typically place an overly high probability on the diagnosis being correct. Second, when performance of the task itself requires the individual to first estimate his own ability, the task is typically performed in a manner which indicates overestimation. That is, suppose an individual is posed a question which has a numerical answer, and is then asked to provide an interval which will contain the correct answer with probability .5. The typical response is to provide an interval which is too small, i.e., if given a series of such questions, on average the true answers will fall in the intervals offered less than half the time. Third, individuals may overestimate their own abilities when predicting future performances. For example, there is evidence that stock market analysts overestimate their abilities to predict stock price movements.

The theory presented in the previous section is only an explanation of why there would be overestimation of abilities in the third case, and further, it predicts that in this third case there will only be overestimation by males. And what is of real interest is that, of the three cases, it is only the last case where the evidence indicates a significant male/female difference.

There is a second reason why we might think that evolutionary pressure would have manifested itself in terms of the overestimation of abilities - but it is somewhat speculative. In their paper on sexual selection, Rubin and Paul argue that sexual selection in man was actually a two stage process. In the first stage young males compete among themselves to enter the "breeding hierarchy". In this stage there would have been an incentive for males to act in a risk loving fashion, since only a fraction of the males could succeed. The second stage concerns older males who are already in the hierarchy. Here the incentive for males to act in a risk loving fashion would be much less, since being unsuccessful at this point could lead to the demise of the male's current family. The overall result, as claimed by Rubin and Paul, is that this two stage process has led males to have risk loving preferences when young, and risk averse preferences when old.¹⁵

In the beginning of this section it was argued that risk loving preferences and overestimating one's own abilities are two alternative paths evolution could take in response to the presence of sexual selection. Given this, suppose that Rubin and Paul's view of sexual selection as a two stage process is accurate. In other words, that what is required is for young males to either exhibit risk loving preferences or overestimate their own abilities, while older males should exhibit neither trait. The question which arises is,

which avenue would evolution have taken to induce such a change. Although only speculation, one might argue that the path taken would more likely have been to have young males overestimate their own abilities. The reason is the ease with which such a trait could be made to disappear as males age. That is, if young males overestimated their own abilities, the trait would naturally diminish with age as the males learned over time what their true abilities were.

D. What About Learning?

At this point a word seems in order concerning what we know about overestimating one's own abilities and learning. There has been substantial psychological research on this issue, and although the evidence is somewhat mixed, it does seem to suggest that the tendency to overestimate one's own abilities can be eliminated through a learning process. Hence, the type of age related change required by Rubin and Paul's analysis does seem consistent with the overestimation of abilities by young males, and the learning of actual abilities as aging occurs.

It is of interest to note, however, that the literature indicates that learning is somewhat limited in its effectiveness. First, learning only works well when the individual is given clear and unambiguous feedback concerning what true performance was. Second, learning is only partially transferable across tasks. In particular, suppose an individual is given clear feedback concerning his performance at a specific task, such that he no longer overestimates his abilities at that task. Evidence indicates this may have an effect on how much he overestimates his abilities at other tasks, but it does not indicate that it will completely eliminate such overestimation.¹⁶

IV. Applications

There is a wealth of evidence in the psychology literature which indicates that individuals systematically overestimate their own abilities. In the previous section I provided an explanation for some of this evidence which is based on Darwin's theory of sexual selection. I will now take the phenomenon as given, and show how it can be applied to the analysis of a number of important economic issues.¹⁷

A. Speculative Bubbles

Casual empiricism, as well as more formal econometric and experimental evidence, suggests that speculative bubbles do sometimes come into existence.¹⁸ The rational expectations approach, however, is either inconsistent with the formation of speculative bubbles, or at the very least it has great difficulty explaining how such a phenomenon could occur.¹⁹ Of course, one could get around the problem by simply concluding that agents do not behave rationally. I believe such a drastic conclusion is not warranted. Rather, here it will be argued that agents are rational - but simply do not satisfy a rational expectations assumption. In particular, speculative bubbles exist because agents systematically overestimate their own abilities.

To understand the reasoning for my claim, let us begin with why the rational expectations approach has difficulty explaining the existence of speculative bubbles. Suppose all agents share a common belief concerning the fundamental valuation of a commodity - let it equal 100 - and suppose all agents realize that at some date the price of the commodity will return to this fundamental valuation. The existence of a speculative bubble would simply mean that at some earlier date the price of the commodity would be

greater than 100. Why is this inconsistent with rational expectations? The reasoning is simple. Agents holding the commodity at this earlier date would realize that on average they will lose money.²⁰ Given a rational expectations assumption, each agent would be unwilling to hold the commodity under such a circumstance. Hence, rational expectations suggests that speculative bubbles cannot exist.

Now let us consider whether the existence of speculative bubbles is inconsistent with the assumption of rationality. Again, suppose all agents believe the fundamental valuation of a particular commodity equals 100, and that at some date the price of the commodity will return to this fundamental valuation. Could it be rational for agents at some earlier date to hold the commodity if the price is greater than 100? The answer is yes. Agents could rationally hold the commodity if they believed the price would rise even further before it returned to the fundamental valuation.

This then explains how a speculative bubble could be formed if agents systematically overestimate their own abilities. Suppose that initially the price of a commodity equals its fundamental valuation. If all agents believe that the price will first increase and then return to the fundamental valuation, this could be a self-fulfilling prophecy. The logic is as follows. It is true that agents who hold the commodity during the price increase phase will on average lose money. However, if each agent overestimates his own ability to predict when the price will return to the fundamental valuation, each agent who holds the commodity during the price increase phase may be "expecting" a positive net return. Hence, even though participation during the price increase phase is a negative sum activity, if agents systematically overestimate their own abilities, then participation can be a "rational"

activity.^{21,22}

A final point is that, if overestimation of abilities is really the driving force, then one might argue that a learning process should eliminate speculative bubbles in asset markets. Such a perspective, however, places too much reliance on the effectiveness of learning. As discussed in Section III.C, learning only works well when there is clear and unambiguous feedback concerning performance, and the nature of asset markets makes such feedback unlikely. That is, even when losses are due to a poor trading strategy, it is frequently easy for an asset market trader to attribute his losses to bad luck. My conjecture, however, is that even though learning does not completely eliminate the existence of speculative bubbles, it does play an important role in their occurrence. In particular, my guess is that there is sufficient learning in response to the bursting of a large speculative bubble that such bubbles will not occur close together in time (see Kindleberger (1978) for supporting historical evidence on this point, and Smith et al (1987) for experimental evidence which is consistent with this view).

B. The Winner's Curse

It has frequently been suggested that real world auction markets are characterized by what is termed the winner's curse. By the winner's curse is meant the idea that an individual who wins an auction will on average lose money. The standard explanation for why a winner's curse might exist is as follows. The winning bidder will typically be the bidder whose information concerning the property being bid on is most positive. Hence, if each bidder does not properly take into account that he only wins when in some sense he overvalues the property, the result will be that the winner will on average

lose money.

Hendricks et al (1986) recently did a detailed study of federal auctions for oil and gas leases on the Outer Continental Shelf which were held between 1954 and 1969. They found two results consistent with the existence of a winner's curse. First, most firms could have significantly increased their profits by using a strategy of bidding less than their actual bids. Second, when the number of bidders was quite large, winning bidders on average did lose money. These results suggest that the existence of a winner's curse may not be a myth, but may actually be a phenomenon in need of serious study.²³

As presented above, the standard explanation for the existence of a winner's curse depends on bidders being naive concerning how auctions work. An alternative explanation is that bidders are not naive in this fashion, but rather simply overestimate their own abilities. The logic is as follows. Consider an auction where bidders accumulate information concerning the value of the property being bid on (this was a characteristic of the auctions investigated by Hendricks et al). Suppose further that each bidder overestimates his own ability to gather accurate information. What would we then expect? It would still be the case that the winning bidder would typically be the bidder whose information concerning the property being bid on was most positive. As opposed to the standard story, however, each bidder would now correctly realize that he would only win when the information gathered by other bidders was less positive. Nevertheless, because each bidder overestimates his own ability to gather accurate information, the fact that other bidders have gathered less positive information will be inadequately reflected in the bid. The subsequent result, therefore, would be the existence of a winner's curse, i.e., the winning bidder would on average

lose money.^{24,25}

One might ask whether there is some way to distinguish empirically between the standard explanation of the winner's curse, and the explanation presented here. One possibility suggests itself. If individuals overestimate their own abilities to gather accurate information, bids might not only inadequately reflect information gathered by other bidders, but might also inadequately reflect public information concerning the value of the property. That is, consider the difference between the winning bid and the value of the property suggested by the public information available. A prediction derived from this alternative explanation of the winner's curse, but not from the standard explanation, is that the magnitude of the winner's curse should be positively related to this difference.²⁶

In ending this section I would like to point out the implications of the current analysis for the pricing of securities. The argument above should apply equally well to the sale of a security with an uncertain return, as it does to the auctioning of oil and gas leases by the federal government. In both cases potential purchasers gather information concerning the value of the asset, and the individuals who actually purchase will be those whose information concerning the asset is most positive. Hence, if as argued above individuals systematically overestimate their own abilities to gather accurate information, the subsequent result is that securities characterized by uncertain returns will be systematically overpriced.

One might ask what the relationship is between this argument and that of Miller (1977), who also puts forth a theory which suggests that securities characterized by uncertain returns should be systematically overpriced. Miller's reasoning is analogous to that of the standard explanation of the

winner's curse presented at the beginning of this section. That is, if each bidder does not properly take into account that he only purchases the asset when in some sense he overvalues it, the result will be that purchasers will on average lose money. In other words, the relationship between the two arguments is that Miller relies on investors being naive concerning the process by which securities are priced, while my argument is that investors simply overestimate their own abilities.

One interesting aspect of the relationship between the papers is that much of the evidence Miller puts forth in support of his own theory is also consistent with mine. For example, Miller argues that there is positive correlation between systematic risk and the uncertainty of a security's returns. Hence, using his logic, the extent of the overpricing should be positively related to the systematic risk of the asset. This would also be a prediction of my theory if systematic risk served as a proxy for the variance of the error component in the information gathering process.²⁷ Further, as Miller points out, there is evidence that the riskiest stocks are systematically overpriced, i.e., that their yield is below the capital market line connecting the risk free interest rate and the market portfolio (see for example Friend and Blume (1970), and Fama and MacBeth (1973)).

C. Career Choice

"The contempt of risk and the presumptuous hope of success are in no period of life more active than at the age at which young people choose their professions...."
(Adam Smith, The Wealth of Nations, p. 211)

"...young men of an adventurous disposition are more attracted by the prospects of a great success than they are deterred by the fear of failure..."
(Alfred Marshall, Principles of Economics, p. 554)

In Section III.B it was argued that one possible outcome of sexual selection in man is that young males systematically overestimate their own abilities when predicting future performance, while old males have much more accurate estimations. On the other hand, no similar type of pattern was suggested for females. One obvious place where these ideas can be applied is to the issue of career choice. In particular, consistent with the quotes from Smith and Marshall above, the overestimation of abilities by young males should lead them to choose risky professions, i.e., they should be willing to choose jobs which hold out the promise of a very large return to those of exceptional ability.²⁸

Both Becker (1962) and Miller (1984) have claimed that this prediction can also be derived within a more standard framework. Becker argues as follows. The return to an individual entering a risky profession is the possibility he becomes a success, and earns a high wage for the remainder of his career. Hence, since young workers would earn this high wage for a longer period of time, we again have the prediction that young workers will choose risky professions. On the other hand, Miller derives the prediction by relying on the fact that young workers are more likely to be uncertain of their abilities, and that the incentive to gather information (take a risky

job) will typically increase with the level of uncertainty.

The careful reader should by this point have noticed that, contrary to the claims of Becker and Miller, the prediction from their more standard stories do not exactly match the prediction of Smith and Marshall. Smith and Marshall (and myself) make a prediction concerning young males, while Becker and Miller make a prediction concerning all young workers.²⁹ Hence, an interesting empirical study might be to investigate whether the occupational choices of young males and females differ more than would be suggested by standard theoretical considerations. Of course, such an empirical investigation would be very difficult given inherent male/female differences concerning factors such as child bearing.

V. Traditional Defenses of the Rational Expectations Approach

In the previous section I applied the systematic overestimation of abilities by individuals to the analysis of a variety of economic issues. In this section I provide a brief discussion of traditional defenses frequently put forth to support the rational expectations approach.

Two such defenses are already dealt with in the paper, and will be given no further comment. These are that individuals must exhibit rational expectations because that would have been a successful strategy from an evolutionary perspective, and that individuals must exhibit rational expectations because learning would quickly eliminate any behavior not consistent with rational expectations.

A third defense frequently put forth is the claim that, if even just a small number of agents in a market exhibit rational expectations, then the rational expectations hypothesis will be a good predictor of aggregate

behavior. Recent papers by Conlisk (1980), Akerlof and Yellen (1985a,b), Haltiwanger and Waldman (1985, 1987), Russell and Thaler (1985), De Long et al (1987), and Manove (1988) have shown this claim to be incorrect. In particular, these papers find two results which make a defense of this sort especially suspect. First, there is an important class of environments where, given agents who vary in terms of their ability to form expectations, it is actually the agents who do not exhibit rational expectations who are disproportionately important in the resulting equilibrium (see Haltiwanger and Waldman (1985)).³⁰ Second, Akerlof and Yellen show that in some environments, even if the private cost of making a mistake is second order small, the aggregate social welfare loss due to such mistakes can be first order.

Another argument frequently put forth is an evolutionary one, but in this case the evolution is on the level of the firm rather than on the level of the individual. In other words, firms will behave in a manner consistent with rational expectations because those which behave otherwise do not survive (see Alchian (1950)). Even relative to the applications of the previous section to which this argument is applicable (A and B), this is a very thin reed on which to support the rational expectations approach. On the one hand, if large speculative bubbles in the stock market only occur once every fifteen or twenty years, survival pressure is unlikely to weed out those which behave inefficiently during such episodes. On the other, since bidding on oil and gas leases is only one small aspect of what large energy companies do, one could easily imagine such a firm continuously overbidding without falling prey to bankruptcy.

As regards this defense of the rational expectations approach, it should

also be pointed out that in some cases those firms which do not satisfy a rational expectations assumption can actually do better from the standpoint of expected returns. Hence, evolutionary considerations at the level of the firm can actually work against the survival of firms which satisfy a rational expectations assumption (see De Long et al (1987) and Manove (1988)). As discussed earlier, Manove shows just such a result for an economy which is initially characterized by a subset of firms run by entrepreneurs who systematically overestimate their own abilities.

The final argument to be considered is that of selection within the firm. That is, even though individuals on average may systematically overestimate their own abilities, one might argue that the selection process will result in the top managers of firms being individuals who have accurate estimations. There are two reasons why such an argument is suspect. First, if ability and effort are complementary, then the individuals who exert more effort will be those whose magnitude of overestimation is greatest. In other words, rather than top managers accurately estimating their own abilities, the selection process will likely choose individuals who systematically overestimate their own abilities.³¹ Second, individuals who are selected to be top managers are typically those who outperform their peers. Given this, suppose each individual starts out by overestimating his own ability. We would then expect top managers to also overestimate their own abilities, because they would have received little feedback to suggest that their initial estimations should have been scaled back.

VI. Conclusion

An implicit assumption of the rational expectations approach is that individuals accurately estimate their own abilities (or more precisely there are no systematic errors). Evidence from the psychology literature, however, clearly indicates that individuals systematically overestimate their own abilities. Examples include physicians being overconfident concerning their diagnoses, and analysts being overconfident of their abilities to predict stock price movements. One interesting aspect of this literature is that, for some of the settings considered, there is clear evidence of a significant male/female difference. That is, in an environment where individuals make predictions concerning their own future performances, it is only the males who systematically overestimate their own abilities. The first goal of this paper has been to show that this aspect of the evidence can be explained through Darwin's theory of sexual selection. The logic is that in an environment where males compete among themselves for the available females, competition is likely to be in terms of accumulated wealth and not in terms of the maximization of utility. Hence, since in terms of expected wealth agents who overestimate their own abilities may actually do better than agents with more accurate estimations, it is quite possible that the evolutionary process has favored males who systematically overestimate.

Of course, an alternative explanation for this male/female difference is that it is due to differences in socialization. With respect to this alternative explanation I would like to make two points. First, the evidence that differential socialization is the cause of many male/female differences in behavior is somewhat mixed (see Maccoby and Jacklin (1974), ch. 9). Second, it is of interest to note that the direct cause of a male/female

difference can be differential socialization, when on an indirect level it is really biology or evolutionary pressure which is the driving force. For example, Moss (1967) finds that male infants are on average more irritable than female infants, and that this in turn affects the interaction between mother and child. If this difference in the interaction was then the cause of later male/female differences in behavior, it could easily be evolutionary pressure which is the true root cause of these later male/female differences. (That is, evolution causes the difference in irritability in order to induce these later male/female differences in behavior.)

Finally, I would like to end by briefly discussing the second goal of the paper. This goal was to apply the idea that individuals systematically overestimate their own abilities to the analysis of a variety of important economic issues. In doing so I was able to demonstrate that the overestimation of abilities can explain a number of phenomena which are puzzling in the context of a rational expectations approach (e.g., speculative bubbles, the winner's curse). From the standpoint of what is important for economists, it is really this second aspect of the paper which is most important. That is, there is a wealth of evidence that individuals systematically overestimate their own abilities, and, as just stated, this idea can explain a number of otherwise puzzling phenomena. Hence, independent of whether you find my evolutionary argument persuasive, I think serious attention must be given to the possibility that the overestimation of abilities is an important factor in economic behavior.

Appendix

Proof of Proposition 1: Let $e^* = \arg \max_e (1 - \Pi(e))(W^0 + e)$. Note that e^* is uniquely defined given $\Pi' > 0$ and $\Pi'' \geq 0$. Suppose that in period t , $N - \delta$ of the males choose $e = e^*$ and the remaining δ males choose $e = e'$, $e' \neq e^*$ (e' may represent a mixed strategy). Let \hat{W} denote the total wealth accumulated. Given $e' \neq e^*$ and the definition of e^* , we know $\hat{W} < N(1 - \Pi(e^*))(W^0 + e^*)$. Let λ denote the proportion of the total wealth held in period t by males characterized by $e = e^*$. We have $\lambda = (N - \delta)(1 - \Pi(e^*))(W^0 + e^*) / \hat{W}$, or $\lambda > (N - \delta) / N$. Suppose now that all the males choosing e^* were characterized by the same value for θ , denoted θ^* , and that all those choosing e' were characterized by a different value for θ , denoted θ' (where θ' could represent a mixed strategy). The above implies that in period $t + 1$ more than $N - \delta$ of the males will be characterized by θ^* , and less than δ will be characterized by θ' . Hence, if we could find such a value θ^* , it would be an ESS. Note, in addition, by reversing the argument, i.e., supposing that in period t $N - \delta$ of the males choose $e = e'$ and the remaining δ males choose $e = e^*$, we get that there cannot be an ESS which is not a value θ^* .

The first order condition which defines e^* is given by

$$(A1) \quad -\Pi'(e^*)(W^0 + e^*) + (1 - \Pi(e^*)) = 0.$$

For the individual to choose $e = e^*$, the first order condition for utility maximization must be

$$(A2) \quad \Pi'(e^*)U^D - \Pi'(e^*)(U^L + f(W^0 + \theta e^*)) + (1 - \Pi(e^*))\theta f'(W^0 + \theta e^*) - g'(e^*) = 0.$$

In addition, given the restrictions on Π'' , f'' and g'' , if (A2) holds then e^* must be chosen.

Because $f'' \leq 0$, we know that $f(W^0 + \theta e^*) \geq (W^0 + \theta e^*) f'(W^0 + \theta e^*)$. Thus, (A2) reduces to

$$(A3) \quad \Pi'(e^*)(U^D - U^L) - g'(e^*) + f'(W^0 + \theta e^*) [\theta(1 - \Pi(e^*)) - \Pi'(e^*)(W^0 + \theta e^*)] \geq 0.$$

Given (A1), if $\theta \leq 1$, then $\theta(1 - \Pi(e^*)) - \Pi'(e^*)(W^0 + \theta e^*) \leq 0$. Hence, for (A3) to be satisfied we need $\theta > 1$. This proves i).

Now go back to (A2) and assume $f'' = 0$. This yields

$$(A4) \quad \Pi'(e^*)(U^D - U^L) - g'(e^*) - \Pi'(e^*)(W^0 + \theta e^*) f' + (1 - \Pi(e^*)) \theta f' = 0.$$

Take the derivative of the LHS of (A4) with respect to θ , and you get $-\Pi'(e^*) e^* f' + (1 - \Pi(e^*)) f'$. Given (A1), the previous expression is strictly positive. Hence, there exists a unique value for θ which satisfies (A4). This proves ii).

Proof of Proposition 2: It is a little difficult to talk about how an individual should behave to maximize gene survival when there is a continuum of agents. The reason is that, given a continuum of agents, the behavior of a single individual in one period has no effect on the distribution of θ 's in the following period. To get around this problem we assume a set ϵ of agents all choose the same effort level with the goal being the maximization of gene survival, and then look at what happens in the limit as ϵ approaches zero. Note, because we want to find the behavior which actually does maximize gene survival (and not just the one which is perceived to maximize gene survival), we assume that this set ϵ of agents accurately estimate their own abilities.

Consider a set ϵ of agents who all choose the same effort level \hat{e} in an

attempt to maximize gene survival. Given the simultaneous manner in which effort choices are made, these agents should take the other $N-\epsilon$ agents' wealth accumulation (effort levels) as fixed in choosing \hat{e} . Let \hat{W} denote the wealth accumulation of the other $N-\epsilon$ agents. Our set ϵ of agents will want to maximize the proportion of the total wealth accumulated that they themselves hold. That is, $\hat{e} = \arg \max_e \frac{\epsilon(1-\Pi(\hat{e}))(W^0 + \hat{e})}{\epsilon(1-\Pi(\hat{e}))(W^0 + \hat{e}) + \hat{W}}$. The first order condition for \hat{e} is given by

$$(A5) \quad \frac{\epsilon[-\Pi(\hat{e})(W^0 + \hat{e}) + (1-\Pi(\hat{e}))]}{\epsilon(1-\Pi(\hat{e}))(W^0 + \hat{e}) + \hat{W}} + \frac{-\epsilon^2(1-\Pi(\hat{e}))(W^0 + \hat{e})[-\Pi'(\hat{e})(W^0 + \hat{e}) + (1-\Pi(\hat{e}))]}{(\epsilon(1-\Pi(\hat{e}))(W^0 + \hat{e}) + \hat{W})^2} = 0.$$

As ϵ approaches zero, the second expression becomes insignificant relative to the first expression because the second expression has an ϵ^2 term in the numerator. Hence, as ϵ approaches zero, (A5) reduces to

$$(A6) \quad \frac{\epsilon[-\Pi(\hat{e})(W^0 + \hat{e}) + (1-\Pi(\hat{e}))]}{\epsilon(1-\Pi(\hat{e}))(W^0 + \hat{e}) + \hat{W}} = 0.$$

A comparison of (A1) and (A6) implies that in the limit as ϵ approaches zero, $\hat{e} = e^*$. Given this, i) and ii) now follow from the proof of Proposition 1.

Footnotes

¹Papers by economists which have employed an evolutionary approach include Becker (1976), Hirshleifer (1977, 1982, 1984), Hirshleifer and Coll (1987), Rubin and Paul (1979), and Frank (1987). See Wilson (1975) and Dawkins (1976) for statements by biologists of the evolutionary perspective.

²One previous paper which begins to move away from the approach just described is that of Hirshleifer (1984). He begins by noting that emotions will in many cases cause the individual to not achieve short run utility maximization. He then argues that the existence of emotions can make sense in an evolutionary framework because their existence allows the individual to avoid problems of time inconsistency.

³For a fuller discussion of the relationship between natural selection and sexual selection than appears here, see either Darwin (1859, 1871) or Arnold (1983).

⁴This description of natural selection is somewhat imprecise in that selection actually takes place at the level of the gene, and not that of the individual. This is important in the study of altruism among kin (see Hamilton (1964), Trivers (1972), and Dawkins (1976)).

⁵See Leakey and Lewin (1979) for a discussion of what is presently known concerning early man and the importance of sexual selection.

⁶One might argue whether the systematic overestimation of abilities is inconsistent with Muth's initial discussion concerning rational expectations.

"The hypothesis can be rephrased a little more precisely as follows: that expectations of firms (or, more generally, the subjective probability distribution of outcomes) tend to be distributed, for the same information set, about the predictions of the theory (or the "objective" probability distribution of outcomes).
(Muth 1961, p. 316)

However, the systematic overestimation of abilities is clearly inconsistent with how rational expectations has been applied in practice. See, for example, Tirole (1982).

⁷See Maccoby and Jacklin (1974), pp. 154-155, for a further discussion of this point.

⁸For this model one need not think of accumulated wealth as only referring to either money or durable assets, but rather one could also think in terms of reputation as a hunter/warrior, status in the group, etc.

⁹To be precise, the probability of an individual dying prior to mating equals $\min(\Pi(e_i), 1)$.

¹⁰Assuming that $W_i = W^0 + h(e_i)$, $h' > 0$, would not add any generality, since effort could always be rescaled such that $W_i = W^0 + e_i$.

¹¹An alternative specification would be to assume that disutility from effort is only lost if the individual does not die prior to mating. Such a change would have no effect on the results.

¹²Because of the structure of the model, it is not necessary to specify whether each agent has accurate expectations concerning how other agents' effort levels get translated into wealth, or whether each agent knows how much other agents either overestimate or underestimate their own abilities. Note, further, that an alternative way of allowing agents to either overestimate or underestimate their own abilities would be to let them have incorrect expectations concerning the function Π , and that modeling incorrect expectations in this alternative fashion would lead to no substantive change in the results.

¹³In fact, this point can be demonstrated formally using the model of the previous section.

¹⁴In a private correspondence Jack Hirshleifer has pointed out to me a third possible path evolution could take. In particular, he suggests that sexual selection could result in males having a higher variance of abilities than females - and possibly a lower mean ability.

"Here's a simple example. Assume the contest is such that only a single male mates, namely, the one with the highest ability. Suppose all male abilities are initially drawn from the same two-valued distribution: (+1,-1;.5,.5). If the male population size is N, each male has a 1/N chance of winning (assuming a random tie-breaking rule). Now think in terms of parents, each of whom produces a single male offspring. Here the parent would opt for higher variance of the probability distribution of talent for its male offspring. In evolutionary terms, suppose a mutation arises in a single parent changing its male offspring's talent distribution to one with lower mean but higher variance, for example to (+2,-3;.5,.5), while all the other parents retain the initial distribution. If N=2 (there is one mutant and one normal parent), the deviant parent would still have only a 50% chance of its offspring winning the contest, so here there's been no improvement from shifting to a high-variance strategy. But suppose N=3. Then the deviant increases his probability of success from 1/3 to 1/2, and the improvement factor will rise further as population size increases. The specific solution will depend upon the parameters of the trade-off, but we can expect that in equilibrium males will end up quite variable in abilities -- and possibly would even have lower mean ability than females. I have the impression that this implication is broadly consistent with the evidence: there are more male geniuses, but also more male idiots!"

(private correspondence from Jack Hirshleifer, January 1988)

¹⁵As pointed out by Rubin and Paul, there is evidence that systematic changes of this type do occur in nature (see Gadgil and Bossert (1970), and Hrdy (1977)).

¹⁶See Alpert and Raiffa (1982), Fischhoff (1982) and Lichtenstein et al (1982) for discussions of how learning can affect the systematic overestimation of abilities.

¹⁷The first and third applications are consistent with the type of overestimation of abilities predicted by my theory, while the second

application is consistent with the psychological evidence — but would not be predicted by my theory.

¹⁸See West (1986) for a recent econometric study which provides evidence that speculative bubbles do occur, and Smith et al (1987) for a recent experimental study which supports the existence of bubbles.

¹⁹Tirole (1982) considers an economy with a finite number of infinitely lived traders, and demonstrates that rational expectations is inconsistent with the formation of speculative bubbles (see also Obstfeld and Rogoff (1986)). Tirole (1985) shows that in an overlapping generations economy speculative bubbles can exist. However, he does not demonstrate the existence of a bubble which seems consistent, for example, with the recent stock market crash. That is, he does not demonstrate the existence of a bubble whose bursting both is a surprise to most traders, and is very costly to most traders.

²⁰I am implicitly assuming here that no new traders would enter the market before the "bubble bursts". If we allowed for the entry of new traders then the argument would become somewhat more complex, but the conclusion would remain unchanged.

²¹This perspective on speculative bubbles might be useful for explaining the results of Shiller (1979, 1981) and LeRoy and Porter (1981) concerning the excess volatility of speculative assets. Note, however, that at least prior to the recent stock market crash, the evidence on this point was somewhat ambiguous (see Kleidon (1986)). Another potential use for this perspective is to explain why the recent stock market crash was so severe. The argument is as follows. One type of program trading is what is called portfolio insurance. Portfolio insurance is basically a trading scheme

designed to protect investors against large drops in the value of their holdings. Of course, when the crash occurred these insurance schemes did not work.

Why should the existence of portfolio insurance affect the severity of the crash? In the scenario sketched above, investors must weigh expected future stock price increases with the penalty of being caught in the market when the crash occurs. If investors believe that the penalty is small because they are insured against a crash, then in some sense they should be willing to stay in the market longer. In other words, once one allows agents to overestimate their own abilities, then the fact that investors think they are insured against a fall can cause the actual fall to be greater when it eventually does occur.

²²A similar logic can also help explain a paradoxical result in asset markets which is discussed by Arrow (1982). He suggests that the findings of Stewart (1949) are evidence of irrationality in asset markets. Stewart looked at returns to trading in grain futures markets. He found that professional speculators earned positive profits, while large hedgers and non-professional speculators lost money. Arrow interpreted the fact that non-professional speculators lost money as a sign of irrationality. Using logic similar to that above, I would interpret Stewart's results as evidence against rational expectations, but not as evidence against rationality.

²³See also the earlier studies of Capan et al (1971), and Dougherty and Lohrenz (1976).

²⁴As for the previous application, one might argue that a learning process should eliminate this problem. Again, however, one must remember that learning only works well when there is clear and unambiguous feedback

concerning actual performance. The nature of oil and gas lease auctions is such that the true value of the property may not become known until substantially after the bidding takes place, and even then the firm only learns the actual valuation and not what the correct bid would have been. Hence, learning may not eliminate the winner's curse in this case, because the feedback is not clear enough.

²⁵Roll (1986) contains a very short discussion of the winner's curse which is somewhat suggestive of the argument above (see p. 200). More generally, using an argument related to that above, he discusses how the overestimation of abilities can be important from the standpoint of corporate takeovers.

²⁶There are experimental results which find the winner's curse in settings where bidders cannot affect the accuracy of the information received (see, for example, Kagel and Levin (1986)). One might take this as evidence against my explanation. But note that the two explanations for the winner's curse discussed in this paper are not mutually exclusive, and hence, such evidence could be consistent with my explanation playing a partial role.

²⁷Let V_i be the information concerning the value of the asset received by potential purchaser i , and let V^* be the true value of the asset. What I have in mind is that for each agent i , $V_i = V^* + (\epsilon/A_i)$, where ϵ is an error term and A_i is agent i 's ability.

²⁸Although Smith's quote does not specifically mention males, given the nature of the surrounding passages and the nature of his times, it is clear that he must have been referring to males.

²⁹Of course, if one combines either the Becker or Miller argument with the argument of Rubín and Paul (see Section III.B), then the predictions are

identical.

³⁰The class of environments are those which exhibit what Haltiwanger and Waldman term synergism, and others have termed strategic complements, increasing returns and network externalities.

³¹I would like to thank Joe Ostroy for pointing out this argument to me. Note that the psychology literature provides evidence in support of this view, i.e., there is evidence which indicates that expectations of success can have a positive effect on performance (see Battle (1965) and Feather (1966)).

References

- Akerlof, George A., and Janet L. Yellen (1985a), "Can Small Deviations From Rationality Make Significant Differences to Economic Equilibria?," American Economic Review, 75, September 1985, 708-720.
- _____, and _____ (1985b); "The Macroeconomic Consequences of Near-Rational Rule-of-Thumb Behavior," Quarterly Journal of Economics, 100, Supplement 1985, 823-838.
- Alchian, Armen A., "Uncertainty, Evolution and Economic Theory," Journal of Political Economy, 58, June 1950, 211-221.
- Alpert, Marc, and Howard Raiffa, "A Progress Report on the Training of Probability Assessors," in Daniel Kahneman, Paul Slovic, and Amos Tversky (eds.), Judgement Under Uncertainty: Heuristics and Biases, Cambridge: Cambridge University Press, 1982, 294-305.
- Arnold, Steven J., "Sexual Selection: The Interface of Theory and Empiricism," in Patrick Bateson (ed.), Mate Choice, New York: Cambridge University Press, 1983, 67-107.
- Arrow, Kenneth J., "Risk Perception in Psychology and Economics," Economic Inquiry, 20, January 1982, 1-9.
- Battle, E. S., "Motivational Determinants of Academic Task Persistence," Journal of Personality and Social Psychology, 2, 1965, 209-218.
- Becker, Gary S., "Investment in Human Capital: A Theoretical Analysis," Journal of Political Economy, 70, October 1962, 9-49.
- _____, "Altruism, Egoism, and Genetic Fitness: Economics and Sociobiology," Journal of Economic Literature, 14, September 1976, 817-826.
- Capan, E. C., R. V. Clapp, and W. M. Campbell, "Competitive Bidding in High

- Risk Situations," Journal of Petroleum Technology, 23, June 1971, 641-653.
- Conlisk, John, "Costly Optimizers Versus Cheap Imitators," Journal of Economic Behavior and Organization, 1, 1980, 275-293.
- Darwin, Charles R., The Origin of Species, London: John Murray, 1859.
- _____, The Descent of Man, London: John Murray, 1871.
- Dawkins, Richard, The Selfish Gene, New York: Oxford University Press, 1976.
- De Long, J. Bradford, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldmann, "The Economic Consequences of Noise Traders," NBER Working Paper No. 2395, October 1987.
- Dougherty, F. L., and J. Lohrenz, "Statistical Analysis of Bids for Federal Offshore Leases," Journal of Petroleum Technology, 28, November 1976, 1377-1390.
- Fama, Eugene F., and James D. MacBeth, "Risk, Return, and Equilibrium: Empirical Tests," Journal of Political Economy, 81, May/June 1973, 606-636.
- Feather, N. T., "Effects of Prior Success and Failure on Expectations of Success and Subsequent Performance," Journal of Personality and Social Psychology, 3, 1966, 287-298.
- Fischhoff, Baruch, "Debiasing," in Daniel Kahneman, Paul Slovic, and Amos Tversky (eds.), Judgement Under Uncertainty: Heuristics and Biases, Cambridge: Cambridge University Press, 1982, 422-444.
- Frank, Robert H., "If *Homo Economicus* Could Choose His Own Utility Function, Would He Want One With a Conscience?," American Economic Review, 77, September 1987, 593-604.
- Friend, Irwin, and Marshall Blume, "Measurement of Portfolio Insurance Under Uncertainty," American Economic Review, 60, September 1970, 561-576.

Frieze, Irene H., Jacquelynne E. Parsons, Paula B. Johnson, Diane N. Ruble,
and Gail L. Zellman, Women and Sex Roles, New York: W. W. Norton, 1978.

Gadgil, Madhav, and William H. Bossert, "Life Historical Consequences of
Natural Selection," The American Naturalist, 104, January 1970, 1-24.

Haltiwanger, John, and Michael Waldman, "Rational Expectations and the Limits
of Rationality: An Analysis of Heterogeneity," American Economic Review,
75, June 1985, 326-340.

_____, and _____, "Responders Versus Nonresponders: A
New Perspective on Heterogeneity," UCLA Working Paper No. 436, February
1987.

Hamilton, W. D., "The Genetical Theory of Social Behaviour," (I and II),
Journal of Theoretical Biology, 7, 1964, 1-16, 17-32.

Hendricks, Kenneth, Robert H. Porter, and Bryan Boudreau, "Information,
Returns, and Bidding Behavior in OCS Auctions: 1954-1969," Working Paper
E-86-71, Hoover, December 1986.

Hirshleifer, Jack, "Economics From a Biological Viewpoint," Journal of Law
and Economics, 20, April 1977, 1-52.

_____, "Evolutionary Models in Economics and Law: Cooperation
Versus Conflict Strategies," Research in Law and Economics, 4, 1982,
1-60.

_____, "On the Emotions as Guarantors of Threats and Promises,"
UCLA Working Paper No. 337A, August 1984.

_____, and Juan Carlos Martiniz Coll, "What Strategies Can Support
the Evolutionary Emergence of Cooperation?," CISA Working Paper No. 58,
UCLA, February 1987.

Hrdy, Sarah B., The Langurs of Abu, Cambridge: Harvard University Press, 1977.

- Kagel, John H., and Dan Levin, "The Winner's Curse and Public Information in Common Value Auctions," American Economic Review, 76, December 1986, 894-920.
- Kahneman, Daniel, Paul Slovic, and Amos Tversky (eds.), Judgement Under Uncertainty: Heuristics and Biases, Cambridge: Cambridge University Press, 1982.
- Kindleberger, Charles P., Manias, Panics, and Crashes, New York: Basic Books, 1978.
- Kleidon, Allan W., "Anomalies in Financial Economics: Blueprint for Change," Journal of Business, 59, Supplement October 1986, S469-S499.
- Leakey, Richard E., and Roger Lewin, People of the Lake, New York: Avon Books, 1978.
- LeRoy, S. F., and R. D. Porter, "The Present-Value Relation: Tests Based on Implied Variance Bounds," Econometrica, 49, 1981, 555-574.
- Lichtenstein, Sarah, Baruch Fischhoff, and Lawrence D. Phillips, "Calibration of Probabilities: The State of the Art to 1980," in Daniel Kahneman, Paul Slovic, and Amos Tversky (eds.), Judgement Under Uncertainty: Heuristics and Biases, Cambridge: Cambridge University Press, 1982, 306-334.
- Maccoby, Eleanor Emmons, and Carol Nagy Jacklin, The Psychology of Sex Differences, Stanford, CA: Stanford University Press, 1974.
- Manove, Michael, "Overoptimistic Entrepreneurs," mimeo, Boston University, March 1988.
- Marshall, Alfred, Principles of Economics, 8th ed., New York: Macmillan, 1948.
- Maynard Smith, John, Evolution and the Theory of Games, Cambridge: Cambridge University Press, 1982.
- Miller, Edward M., "Risk, Uncertainty, and Divergence of Opinion," Journal of

Finance, 32, September 1977, 1151-1168.

Miller, Robert A., "Job Matching and Occupational Choice," Journal of Political Economy, 92, December 1984, 1086-1120.

Moss, H. A., "Sex, Age, and State as Determinants of Mother-Infant Interaction," Merrill-Palmer Quarterly, 13, 1967, 19-36.

Muth, John F., "Rational Expectations and the Theory of Price Movements," Econometrica, 29, July 1961, 315-335.

Obstfeld, Maurice, and Kenneth Rogoff, "Ruling Out Divergent Speculative Bubbles," Journal of Monetary Economics, 17, 1986, 349-362.

Roll, R., "The Hubris Hypothesis of Corporate Takeovers," Journal of Business, 59, 1986, 197-216.

Rubin, Paul H., and Chris W. Paul II, "An Evolutionary Model of Taste for Risk," Economic Inquiry, 17, October 1979, 585-596.

Russell, Thomas, and Richard Thaler, "The Relevance of Quasi Rationality in Competitive Markets," American Economic Review, 75, December 1985, 1071-1082.

Shiller, Robert J., "The Volatility of Long-Term Interest Rates and Expectations Models of the Term Structure," Journal of Political Economy, 87, December 1979, 1190-1219.

_____, "The Use of Volatility Measures in Assessing Market Efficiency," Journal of Finance, 36, May 1981, 291-304.

Smith, Adam, The Wealth of Nations, (Books I-III), New York: Penguin Books, 1986.

Smith, Vernon L., Gerry L. Suchanek, and Arlington W. Williams, "Bubbles, Crashes and Endogenous Expectations in Experimental Spot Asset Markets," mimeo, May 1987, Forthcoming Econometrica.

Stewart, B., "An Analysis of Speculative Trading in Grain Futures," U.S.

Department of Agriculture Technical Bulletin No. 1001, 1949.

Tirole, Jean, "On the Possibility of Speculation Under Rational Expectations,"

Econometrica, 50, 1982, 1163-1181.

_____, "Asset Bubbles and Overlapping Generations," Econometrica, 53,

September 1985, 1071-1100.

Trivers, Robert L., "Parental Investment and Sexual Selection," in B. Campbell

(ed.), Sexual Selection and the Descent of Man, Chicago: Aldine, 1972.

West, Kenneth D., "A Specification Test for Speculative Bubbles," Working

Paper E-86-35, Hoover, July 1986.

Wilson, Edward O., Sociobiology: The New Synthesis, Cambridge, MA: Harvard

University Press, 1975.