Rational Markets: Yes or No? The Affirmative Case

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Abstract

With the recent flurry of articles declaiming the death of the rational market hypothesis, it is well to pause and recall the very sound reasons this hypothesis was once so widely accepted, at least in academic circles. Although academic models often assume that all investors are rational, this assumption is clearly an expository device, not to be taken seriously. What is in contention is whether markets are "rational" in the sense that prices are set as if *all investors are rational. Even if markets are not rational in this sense, abnormal profit opportunities still may not exist. In that case, markets may be said to be "minimally rational." I maintain that not only are developed financial markets minimally rational, they are, with two qualifications, rational. I contend that, realistically, market rationality needs to be defined so as to allow investors to be uncertain about the characteristics of other investors in the market. I also argue that investor irrationality, to the extent that it affects prices, is particularly likely to be manifest through overconfidence, which in turn, is likely to make the market hyper-rational. To illustrate, the article reexamines some of the most serious historical evidence against market rationality.*

In November 1999, at a program put on by the Berkeley Program in Finance at the Silvarado Country Club in California's Napa Valley, I was charged with debating Richard Thaler, one of the founders of behavioral finance. The issue was "Rational Markets: Yes or No?" It struck me then, as I tried to marshal the arguments in the affirmative, how far modern financial economics has come unstuck from its roots. Ever since research supporting market irrationality became respectable, perhaps dating from the June/September 1978 issue of the *Journal of Financial Economics*, our profession has forgotten the good reasons the affirmative proposition was once so widely believed. Seemingly every day, some new "anomaly" is reported that drives yet another nail into the coffin of the rational market hypothesis. The weight of paper in academic journals supporting anomalies is now much heavier than evidence to the contrary. Old enough to remember and respect the "old school," I was asked to present this forgotten case.

Thaler and I agreed to interpret "rational" to mean that investors follow the Savage (1954) axioms (a set of rational precepts such as the transitivity principle—that is, "if A is preferred to B and B to C, then A will be preferred to C"). These axioms imply that investors act as though they maximize expected utility using subjective probabilities.[1] In addition, rationality

[1] Savage's axioms are an extension of the better-known Von Neumann–Morgenstern axioms justifying expected utility. Essentially, Savage's contribution was to justify the use of subjective probabilities in calculating expected utility.

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requires that these subjective probabilities be unbiased. I confess to finding this definition of rationality somewhat vague, but I take it to mean that if we were able to run the economy over and over again, asset returns would trace out a realized frequency distribution and an investor's subjective probabilities are "unbiased" if they are the same as these frequencies.

On the one hand, this definition of rationality is even more restrictive than is sometimes meant because it insists on more than rational means; using it, rather, implies an entire rational probability distribution. These days, any good derivatives theorist knows that unbiased means are not sufficient for rationality because options can be used to profit from even the slightest mistakes in assessing probabilities.[2] On the other hand, I do not want to define rational so narrowly as to say that it precludes unresolved differences of opinion or that it precludes investors from being uncertain about what other investors are like. Rationality means "know thyself" but not necessarily knowing others.

Types of Market Rationality

Let me suggest the following categorization as a convenient way of thinking about what will be meant here by "rationality in markets":

Maximally rational markets. I define markets as "maximally rational" if all investors are rational. If markets were maximally rational, investors would probably trade relatively infrequently and would make intensive use index funds. Although most academic models in finance are based on this assumption, I believe financial economists do not take it seriously. Indeed, they need only talk to their spouses or to their brokers to know it cannot be true.

Rational markets. What is in contention, however, is whether markets are simply "rational," in the sense that asset prices are set *as if* all investors are rational. Clearly, markets

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[2] The definition I have given of unbiased subjective probabilities is somewhat vague because the probabilities will depend on the information assumed in the model to be available to investors. An extreme (but popular) version of this approach assumes that investors know how equilibrium prices are set. For example, they know enough about the distribution of endowments and preferences across the economy to know how investors determine future equilibrium prices. I find this assumption an extreme and counterfactual requirement for equilibrium that has nothing to do with rational decision making—not to mention that it is a substitute for one of the major purposes of prices, which is precisely to convey in compact form what is most important about other investors' demands. In any event, we are left with defining market rationality relative to the information set possessed by all investors. In a more satisfactory model, we would want this information set to be endogenously determined; in particular, we would want to incorporate the research efforts of active investors. Presumably, God could do better. Indeed, God's subjective probability distribution for future asset prices may have point mass. So at bottom, a rational market must have the property that individual investors are sufficiently equal in their ability to process and gather information that none of them can find abnormal profit opportunities in the market. Some investors may be much

can be rational even if not all investors are actually rational. So, in a rational (but not maximally rational) market, investors may trade too much or fail to diversify enough for their own good. These matters are not in contention here, and in fact, I do not dispute them. In rational markets, money managers acting in the interests of their clients should work to correct their own and their clients' irrational investment choices.

Minimally rational markets. Even if we decide markets are not rational, they may still fail to supply opportunities for abnormal profits. For example, if you tell me that markets are irrational because prices are too volatile relative to fundamentals or that closed-end funds sell at discounts, there may be no way I can use that information to make profits. If you tell me such-and-such a stock is overpriced but there are significant obstacles to short selling or significant costs to trading the stock, again I may not be able to do much about the opportunity.

In these cases, I say that although markets are not perfectly rational, they are at least "minimally rational"; that is, although prices are not set as if all investors are rational, nevertheless, no abnormal profit opportunities exist for the investors who are rational. If markets are only minimally rational, investors will be more easily misled into thinking they can beat the market, and it then becomes even more important for money managers to give sound advice.

As I discuss various anomalies, I will address what kind of market rationality they contradict. Clearly, the most interesting anomalies will be those that show the market is not even minimally rational.

The Prime Directive

When I went to financial economist training school, I was taught "The Prime Directive":

> *Explain asset prices by rational models. Only if all attempts fail, resort to irrational investor behavior.*

That is, as a trained financial economist, with the special knowledge about financial markets and statistics that I had gained and aided by the new high-tech computers, databases, and software, I must be careful how I used my power. Whatever else I do, I should follow the Prime Directive.

The burgeoning behavioralist literature indicates that many behavioral finance economists have lost all the constraints of this directive—that whatever anomalies are discovered, illusory or not, behavioralists will come up with an explanation grounded in

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smarter in a conventional sense than others, but in a rational market, this superiority (which in other circumstances would prove quite valuable) is rendered useless.

systematic irrational investor behavior.[3] But this approach is too easy. For example, if we discover that asset prices exhibit reversals (surprise of surprises) the behavioralists say the cause is the documented tendency of individuals to overreact to recent events. Of course, that explanation could be true, but to believe it requires that we extrapolate from studies of *individual* decision making done in narrow and restricted conditions to the complex and subtle environment of the security markets. The explanation also smacks too much of being concocted to explain *ex post* observations—much like medievalists used to suppose that a different angel provided the motive power for each planet. And then, when we discover that price reversals occur in the short run, momentum in the intermediate term, and price reversals again in the long run, behavioralists find some more convoluted way to explain that pattern based on irrational behavior (reminding me of Ptolemaic epicycles).

In short, the behavioral cure may be worse than the disease. Exhibit 1 is a litany of explanations drawn from the burgeoning, clearly undisciplined, and unparsimonious behavioral literature. Many of these errors in human reasoning are no doubt systematic across individuals and time, just as behavioralists argue, but for many reasons, as I argue, they are unlikely to aggregate so as to affect market prices. We do not know enough to fall back to what should be the last line of defense, market irrationality, to explain asset prices. With patience, we will find that the anomalies that appear puzzling today will either be shown to be empirical illusions or be explained by further model generalization in the context of rationality.

Two Qualifications. I must qualify my view supporting market rationality in two ways. First, a small group of irrational investors can occasionally determine asset prices and the large body of investors will not be able to do anything about it. For example, the finding in mergers that acquiring companies overpay is inconsistent with rational markets as I have defined that term but is surely something that occasionally happens. Even though the market price of the acquired company is set irrationally, however, as long as the market participants cannot anticipate the merger announcement or consummation, no abnormal profit opportunities arise. In the terminology established here, therefore, the market is not rational

[3] For example, Thaler (1991, p. 162) wrote, "While the power of economic theory is surely unsurpassed in social science, I believe that in some cases this tool becomes a handicap, weighting economists down rather than giving them an edge. The tool becomes a handicap when economists restrict their investigations to those explanations consistent with the paradigm, to the exclusion of simpler and more reasonable hypotheses. For example, in commenting on the size effect anomaly in financial markets (small firms appear to earn excess returns, most of which occur in the first week in January), an editor of the *Journal of Financial Economics* commented: 'To successfully explain the size effect, new theory must be developed that is consistent with rational maximizing behavior on the part of all actors in the model' (Schwert 1983). Isn't it possible that the explanation for the excess return to small firms in January is based, at least in part, on some of the agents behaving less than fully rationally?"

but it remains minimally rational. In any event, such deviations from market rationality, even if they are highly visible and publicized, are relatively unimportant and infrequent in the scope of the totality of market transactions.

Second, I have for a long time believed investors are overconfident.[4] Surely, the average investor believes he is smarter than the average investor. This misconception leads to such sins as excess trading volume, active money management, under-diversification, excessively high prices paid in corporate takeovers, and the disposition effect (the tendency to hold on to losers and sell winners).[5] Overconfidence, as I shall argue, creates a violation of the Prime Directive because it is a systematic investor irrationality that affects prices in important ways.

Philosophical Basis for Rational Markets

It is a mistake to think, as behavioralists have argued, that financial economists are wedded to the idea of rational markets because they would not know what to do without the assumption of rational markets, that carefully modeling markets without the assumption is "too hard," or that modeling without it would not be mathematically tractable and would not produce their overvalued "closed-form results." Rather, the belief in rational markets stems from a long cultural and scientific heritage probably dating back to the ancient Greeks who elevated "reason" as the guide to life.[6] But the belief that man is by nature rational seems first to have taken hold during the Enlightenment, when Descartes, the French mathematician and philosopher provided one of its most forceful expositions in his *Discourse on the Method of Rightly Conducting the Reason* (1637)*:*

> Good sense is, of all things in the world, the most equally distributed, for everybody thinks of himself so abundantly provided with it, that even those most difficult to please in all other matters do not commonly desire more of it than they already possess. It is unlikely that this is an error on their part; it seems rather to be evidence in support of the view that the power of forming a good judgment and of distinguishing the true from the false, which is properly

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[4] The idea that individuals are overconfident is not new. According to Adam Smith in *The Wealth of Nations* published in 1776: "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" (p. 209).

[5] Barber and Odean (1999) discusses the disposition effect.

[6] In a much later century, Bishop Joseph Butler, England's foremost moral philosopher, wrote in his *Analogy of Religion*, ". . . probability is the very guide to life."

> speaking called Good Sense or Reason, is by nature equal in all men. Hence, too, it will show that the diversity of our opinions does not proceed from some men being more rational than others, but solely from the fact that our thoughts pass through diverse channels and the same objects are not considered by all. (p. 69)

Later Darwin answered in *The Descent of Man* (1871) the question of why man turned out to be rational:

> These faculties (moral and intellectual) are variable; and we have every reason to believe that the variations tend to be inherited. . . . Of the high importance of the intellectual facilities there can be no doubt, for man mainly owes to them his predominant position in the world. We can see that in the rudest state of society the individuals who were the most sagacious, who invented and used the best traps, and were best able to defend themselves, would rear the greatest number of offspring. The tribes that included the largest number of men thus endowed would increase in number and supplant other tribes. (p. 122)

One might be tempted to apply Darwinian natural selection more directly to markets and claim that, because only the fittest (i.e., the most rational) survive, the market must be principally populated by highly rational investors. But this ground is dangerous. *Ex post*, one can surprisingly easily justify many forms of contradictory behavior from natural selection arguments, as witness the amusingly contradictory conclusions reached in Morris's *The Naked Ape* and Morgan's *The Descent of Woman*.[7] In addition, nature, as it works out the prerogatives of natural selection, necessarily compromises, since nature must optimize under constraints. As a result, successfully adaptive behavior always leaves open some weakness. Moreover, natural selection may work so slowly that, even as the environment changes, the older (and now maladaptive) behavior may persist for some time.[8]

Specifically, behavioralists have argued that irrationally overconfident investors have an advantage, in a sense, over their rational counterparts for a number of reasons. Overconfidence encourages them to take excessive risk by holding securities with high expected returns; these

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[7] Desmond Morris, *The Naked Ape: A Zoologist's Study of the Human Animal* (New York: McGraw-Hill, 1967); Elaine Morgan, *The Descent of Woman* (New York: Stein and Day, 1972).

[8] I received a comment that estate taxes may erode natural selection by forcing transfers from successful rational investors to irrational investors and that death may play a similar role within families—to the extent that lineage does not guarantee rationality (despite the views held in ancient Republican Rome).

securities, in turn, will tend to make overconfident investors richer and, therefore, increase their influence over prices. Moreover, to the extent that overconfidence takes the form of biased self-attribution, irrational investors who have merely gotten rich through luck will mistakenly attribute their good fortune to their own skill and will be overconfident about subsequent investments. Irrational overconfidence could just as well, however, lead to foolhardy, life-threatening behavior (smoking, mountain climbing, etc.) that would diminish the ranks of the irrational. In short, Darwinian speculation along these lines is capricious.

Adam Smith implicitly relied on rational behavior for the effectiveness of his "invisible hand." Empirical proof of the basic rationality of man as expressed in markets is shown by the success over the past two centuries of competitive and democratic economies, which set up a framework in which the invisible hand can function. Indeed, particularly as the 20th century drew to a close, the apparent allocative efficiency of the U.S. economy was hard to reconcile with pervasive irrational behavior.

Perhaps unconsciously, these arguments underlie the intuitive a priori idea that many financial economists have that markets are rational. A more consciously held position, given full voice by Hayek (1945), is that the prices produced in competitive and reasonably liquid markets aggregate the information potentially known by millions of diverse investors drawn from all corners of the earth**:**

> The peculiar character of the problem of rational economic order is determined precisely by the fact that the knowledge of the circumstances of which we must make use never exists in concentrate or integrated form, but solely as dispersed bits of incomplete and frequently contradictory knowledge which all the separate individuals possess. The economic problem of society is thus a problem of the utilization of knowledge not given to anyone in its totality. The most significant fact about the [price] system is the economy of knowledge with which it operates, or how little the individual participants need to know in order to be able to take the right action. In abbreviated form, by a kind of symbol, only the most essential information is passed on and passed on only to those concerned. (p. 525)

Each investor, using the market to serve his or her own self-interest, unwittingly makes prices reflect that investor's information and analysis. It is as if the market were a huge, relatively low-cost continuous polling mechanism that records the updated votes of millions of investors in continuously changing current prices. In light of this mechanism, for a single investor (in the absence of inside information) to believe that prices are significantly in error is almost always folly. Public information should already

be embedded in prices. Indeed, stocks are highly responsive to news that clearly relates to them. Even if an investor is fortunate enough to be possessed of nonpublic but not inside information, it may do her more harm than good if she is tempted to take a position based on the information, for the price may already reflect other nonpublic information known to other investors that may nullify the effect of her information. So one of the lessons of modern financial economics is that an investor must take care to consider the vast amount of information already impounded in a price before making a bet based on information.

The securities market is not the only example for which the aggregation of information across individuals leads to the truth. At 3:15 p.m. on May 27, 1968, the submarine USS Scorpion was officially declared missing with all 99 men aboard. She was somewhere within a 20-mile-wide circle in the Atlantic Ocean, far below implosion depth. Five months later, after extensive search efforts, her location within that circle was still undetermined. John Craven, the Navy's top deep-water scientist, had all but given up. As a last gasp, he asked a group of submarine and salvage experts to bet on the probabilities of different scenarios that could have occurred. Averaging their responses, he pinpointed the exact location (within 220 yards) of the missing sub.[9]

The information-aggregation function of markets is almost certainly better at the dawn of the 21st century than in prior times. The Friedmans argued in *Free to Choose*, which was written even before the development of the Internet and laptop computers, that advances in technology and organized markets have increased the speed with which information is reflected in prices:

> The transmission of information through prices is enormously facilitated these days by organized markets and by specialized communication facilities. It is a fascinating exercise to look through the price quotations in the *Wall Street Journal*. . . . These prices mirror almost instantly what is happening all over the world. There is a revolution in some remote country that is a major producer of copper, or there is a disruption of copper production for some other reason. The current price of copper will shoot up at once. To find out how long knowledgeable people expect the supplies of copper to be affected, you need merely examine the prices for future delivery on the same page. (p. 16)

In a rational market, the prices of assets convey much of what an investor needs to know to act intelligently. In particular, except in very unusual circumstances, today's price is a

[9] This episode is described in Sontag and Drew (1998).

good approximation of tomorrow's expected price, although today's price by itself says little about the full range of tomorrow's possible outcomes and their probabilities. In the waning days of the 20th century, however, even this information began to be aggregated across investors and compactly conveyed—in the form of the prices of options.[10] Open interest and trading volume in derivatives, domestic or international, now eclipse outstanding units and trading volume in underlying assets. I estimate that the trading volume in derivatives around the world, measured in terms of the value to which a derivative is a right, is greater than $1 quadrillion a year (Rubinstein 1999). So, the securities market today probably does a better job than ever before of aggregating the wisdom of those that trade in it.

Basis for Minimally Rational Markets

Financial economists have even better reasons than those discussed so far to believe that markets are at least minimally rational. Most basic is the idea that profitable trading strategies self-destruct. In practice, their profitability is limited by their tendency to move prices against themselves as they are exploited; eventually, the strategies are discovered by other investors, and the profitability is eliminated through overuse.

Another (but much weaker) argument is that irrational investors self-destruct, leaving the field open to those who are rational. For example, irrational investors can destroy themselves by trading too actively and thereby running up significant trading costs. Whether one can extend this line of reasoning by supposing that irrational investors become poor and thus can have little influence on market prices is, however, quite sensitive to the assumed set-up. At one extreme, Alchian (1950) argued that even if all investors are irrational, aggregate market forces can result in market rationality. At the other extreme, Thaler argued in our debate that irrational investors get richer, not poorer.

A somewhat stronger survivalist argument relates to money managers, namely, that irrational money managers will tend to be eventually exposed and weeded out (particularly if academic financial economists do their job and develop good ways to measure performance!). An important prediction of minimally rational markets is that, in practice, this mechanism operates weakly. If markets are rational, irrational money managers cannot do their clients much harm (other than trading too much, failing to diversify, or overcharging for their services), so they may be hard to detect.

Another force maintaining the minimal rationality of markets is that the trading of irrational investors, if not expressed in a consistent manner cross-sectionally, may be self-canceling, which would leave the determination of prices in the hands of the rational investors.

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[10] A discussion of methods for extracting probability distributions from the prices of derivatives can be found in my 1994 *Journal of Finance* article.

In this instance, even the most market-savvy investors will earn only average returns because they will view all asset prices as correctly determined. Behavioralists have been quick to reply that this argument does not apply to their findings, which are based on *systematic* irrational behavior. In other words, behavioralists believe they can identify situations in which irrational investors will be systematically optimistic or systematically pessimistic. Even if this belief were true on occasion, the potential for self-cancellation shows why the game of investing is so different from, for example, chess, in which even a seemingly small advantage can lead to consistent victories. Humans are accustomed to thinking of games—and, by extension, life—as won by the person with a slight edge. I believe that attitude is a key reason it is so hard to persuade lay investors that markets are minimally rational: The investors implicitly lump the market with other arenas of competition in their experience.

Overconfidence and Minimally Rational Markets. The most telling reason markets should be considered at least minimally rational comes from behavioralist thinking itself (although behavioralists have apparently not drawn the same implication of overconfidence that I have): Overconfidence leads investors to believe they can beat the market. For example, a money manager may be overconfident about his abilities, or in an effort to convince his clients about his superior abilities, he may develop a facade of overconfidence. While overconfidence can express itself in other ways, surely it causes many investors to spend too much on research and causes many to trade too quickly on the basis of their information without recovering in benefits what they pay in trading costs.

The market can be likened to an almost exhausted gold mine. A few nuggets remain and are occasionally found, which encourages further efforts by the overconfident, but no miner can reasonably expect continued mining to be worthwhile. As a result, there is a sense in which asset prices become hyper-rational; that is, they reflect not only the information that was cost-effective to learn and impound into prices but also information that was not worthwhile to gather and impound. Overspending on research is not in one's self-interest, but it does create a positive externality for passive investors who now find that prices embed more information and markets are deeper than they should be.

Remember the chestnut about the professor and his student. On one of their walks, the student spies a $100 bill lying in the open on the ground. The professor assures the student that the bill cannot be there because if it were, someone would already have picked it up. To this attempt to illustrate the stupidity of believing in rational markets, my colleague Jonathan Berk asks: How many times have you found such a hundred dollar bill? He implies, of course, that such a discovery is so rare that the professor is right in a deeper sense: It does not pay to go out looking for money lying around.

Evidence of Minimal Rationality. For empirical evidence that investors overspend on research and transact too quickly based on their information, one need look only to the long history of mutual fund performance—by far the most widely studied database of the results of professional investing. Jensen's 1968 and 1969 studies of mutual funds almost single-handedly convinced me that large-cap equity markets are, for practical purposes, at least minimally rational. He showed that the average actively managed mutual fund does not outperform a market index. Indeed, the average fund underperforms by about the size of its fees and trading costs. In his comments following the debate with Thaler, Richard Roll argued that this fact, by itself, is no proof that markets are minimally rational: Simply put, whether or not markets are rational, if mutual funds are average investors, then tautologically, they must necessarily have average performance—the index minus their costs. But actively managed mutual funds are surely above-average investors, in the sense that they spend considerably more on research, trade more than the average investor, and have potentially large advantages from economies of scale.[11] If the market were not minimally rational, this extra cost would surely be worth the effort.

Of course, some mutual funds in Jensen's sample did have better returns than the market index—even after adjustment for capital asset pricing model (CAPM) risk. Jensen argued, however, that he found no evidence that any one mutual fund outperformed the index more than would have occurred by chance. That is, the dispersion of performance that would have naturally occurred had all his funds selected stocks by throwing darts was the same as the dispersion actually observed.[12] Now, 30 years after Jensen's work, the evidence is even stronger. The continuing performance of mutual funds, as well as the broad consensus of the substantial research into this issue that has occurred since the 1960s, lends support to Jensen's results. This is a step on which those that affirm the irrationality of markets must fall down, or else o'erleap, for in their way it lies. It should not simply be put on one side of the ledger and given equal weight with any market anomaly on the other side. In fact, just to pile on the metaphors, the behavioralists have nothing in their arsenal to match it; it is a nuclear bomb against their puny sticks.

First, unlike almost all their anomalies that seem to reject minimal rationality, mutual fund performance is based on actual, not paper, losses. We can argue as long as we like about

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[11] If you manage hundreds of millions of dollars, you can easily afford to hire a smart analyst who spends every day thinking about copper, for example.

[12] I became so convinced of the truth of Jensen's findings that my consistent response to inquiries about what stocks to buy after the Vanguard S&P 500 Index fund became available in 1976 was to buy the Vanguard fund (now, perhaps I would recommend a more broadly based index fund). Also motivating my advice was the fear that even if one of the many mutual funds were able to beat Vanguard by skill, it would be impossible to identify that fund in advance.

whether various anomalous strategies can actually be implemented; we will never know until they are. We can argue as long as we like about whether an anomaly is the result of data mining, and we will never really know. We can argue as long as we like about whether a legitimate successful strategy should have been discovered in a rational market, given the costs of research and the technology then existing, and we will not know. But we can look at the results of 50 years of investing by thousands of smart and highly compensated individuals who spent most of their waking hours studying markets and conclude that they, at least, could not find successful anomalous strategies. Even if with the unfair advantage of hindsight we say such strategies existed, those fund managers were not clever enough to discover them. For me, unless and until those who believe in market irrationality can directly counter this evidence with evidence from actual profits and losses, the game is over.[13]

I report the results of my own (admittedly casual) study of stock-picking ability by mutual funds in Table 1.[14] To isolate stock-picking ability, I compared the performance of the Vanguard index fund with the other funds in its Morningstar category (Domestic Equity/Large Blend) as of the end of July 1999. In this category were 79 funds with 15-year track records. Note that Vanguard's reinvested rate of return per year before taxes was 17.94 percent, the sixth best fund over this period. As expected in a minimally rational market modified by overconfidence, the median fund return is about 2.5 percent less than the index fund. This weaker performance indicates that the average fund simply wasted about that amount in research, trading costs, and perhaps inefficient administration.[15]

A problem with these results is survivorship bias. Carhart (1997), in an exhaustive 1962–93 study, found that about 3.5 percent of funds drop out every year, presumably because of poor performance. This would suggest that about one-third of the funds in existence 15 years ago may have dropped out by the time of my study. If so, a crude correction for survivorship bias would mean that Vanguard was probably the sixth best performing fund out of about 120, placing it in the fifth percentile. The Vanguard index fund was not the best performing fund—five others did better—but even the best performing fund (which was Fidelity

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[13] These conclusions would no doubt be greatly strengthened if an after-tax analysis were used. Arnott, Berken, and Ye (2000) examined the universe of large ($100+ million) equity mutual funds with 10-, 15-, and 20-year results for 1979–1998. The marginal impact of realized capital gains and dividends for Vanguard shareholders for all three time horizons would have been less unfavorable than 90 percent of the 355 funds in the universe.

[14] I wanted to see how good my 1976 advice was to buy the Vanguard S&P 500 fund.

[15] Indeed, the average fund may have received no benefit whatsoever from its research (Carhart 1997) estimated that the typical fund has 1.17 percent in expenses and 0.78 percent in trading costs).

Magellan) outperformed Vanguard by less than 2 percent a year. One would have to calculate the statistics, but it seems to me that this mutual fund performance record is probably worse than should have occurred by chance. Some funds had to be lucky, and those five were the lucky ones.

A less ambiguous measure of Vanguard's success comes from examining only the last five years (July 1994 – July 1999) and restricting the universe to those funds still existing that started prior to Vanguard (because it is unlikely that any fund that started before August 1976 and still existed five years ago has dropped out since then). Of the 60 funds in this restricted sample, Vanguard was the #1 performing fund. In this case, we do not even have to use chance to justify minimal market rationality by claiming that the better performing funds were lucky because there weren't any![16]

These findings strongly suggest that mutual fund managers and/or their clients are overconfident. This attitude persuades them to overinvest in research (and to be too quick to trade on information to overcome trading costs). Some of their research may reveal that some stocks are mispriced, and the funds take advantage of that information; on the whole, however, the research is wasted. For every dollar invested in research, perhaps only a nickel of benefit is received (see Carhart). What makes matters even worse for these funds is that their joint activity and that of other overconfident investors makes the market hyper-rational. Thus, investing with active money management is even less attractive than it would be in a purely rational market.

Psychology in Rational Markets

Behavioralists sometimes talk as if they have brought the benefits of psychology to the study of financial markets. In fact, classical finance models have long included assumptions about investor behavior that go beyond (but nonetheless are consistent with) the mere requirement of rational decision making. The basic assumption behind all finance models is *avarice*: Other things being equal, more wealth (or more consumption) is better than less. This tenet is so universally believed that we can easily forget that it is an important statement about human psychology.

The second assumption that relates to investor behavior is the assumption that investors are, by and large, risk averse. *Risk aversion* may not apply at all times and places, but it is generally believed to be a pervasive aspect of human behavior. The assumption of risk

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[16] Related evidence was presented by Barber, Lehavy, McNichols and Trueman (2001). Investigating brokerage house stock recommendations for the 1985–96 period, they found no reliable evidence of performance persistence or statistically significant differences in the abnormal returns of the best and worst brokerage houses.

aversion is supported by a long history of evidence drawn from many diverse situations. Finance models often become quite specific about risk aversion; they may assume, for example, that (all else being equal) as an investor's wealth increases, the investor is willing to invest more money in risky assets.[17]

Next on the list is *impatience*—the tendency of people to value consumption more today than consumption tomorrow. Behavioralists pejoratively refer to this behavior as low self-control, but it is entirely consistent with the Savage axioms.

Finally, the idea of *habit formation* in economics should be mentioned. Financial economists have long had the bad habit of modeling rational choice in terms of time-additive utility functions (I plead guilty as well). These utility functions imply that how much one consumes today has no effect on the utility of consumption tomorrow. An elaborately staged behavioral experiment is not needed to know that this assumption cannot be right. Financial economists need to allow for habit formation; doing so may be analytically difficult, but it is completely consistent with rationality. One of the most distinctive features of prospect theory (a behavioral favorite) involves reference points, which is quite similar to the older idea of habit formation in economics. For many results in finance, habit formation is of no importance, but for many so-called anomalous observations, it is. Because time additivity is clearly counterfactual, we should not be surprised to find that it leads to the wrong conclusions in some situations. I realized this possibility in 1976. In a paper I published that year, I assumed intertemporally additive utility functions in consumption with constant relative risk aversion. I reached the conclusion that the rate of return on the market portfolio and the rate of growth of aggregate consumption were perfectly positively correlated and that the logarithmic standard deviations of these rates were the same—a result that later became subsumed in the equity premium puzzle. Did I then throw in the towel and blame this predictive failure on the assumption of rationality? No, I followed the Prime Directive and looked elsewhere. At the time, I was betting on the model's failure to consider habit formation.

Accounting for Anomalies

What do good financial economists do when confronted with mounting anomalous evidence? First, we point out that simply to be realistic, rational markets must not be interpreted too strictly. In particular, if someone smart spends a lot of time studying the market, he or she

[17] This assumption is also well supported by evidence. Work, however (by behavioral economists), indicates that in many circumstances, the assumption of risk aversion needs to be amended to "loss aversion"—that is, strong aversion to wealth falling below current wealth [see Kahneman and Tversky 1979). Of course, this aversion is perfectly consistent with individual rationality.

might well come up with something useful, but the odds are that, even so, the idea will not be worth much when implemented. Moreover, *ex ante*, the idea should certainly not be expected to produce profits that do more than cover the costs. Therefore, even in a minimally rational market, a real anomaly could exist and someone could luck into finding it, but *ex ante* the expected profits are zero—or, with overconfidence affecting prices, actually negative.

Second, we note that many so-called anomalies are empirical illusions created by data mining, survivorship bias, selection bias, short-shot bias (a term for the failure to appreciate the possibility of rare negative events that are not in an historical sample), trading costs (particularly the invisible market impact costs that can destroy paper profits), and the high variance of sample means (which imply that luck can play a big role in realized returns). I will discuss these illusions in the context of particular anomalies.

Finally, good financial economists do not blame their failure to explain non-illusory anomalous evidence on irrationality. They look elsewhere. The problem may lie in models that are single period or models that are multiperiod but assume stationarity or a random walk.[18] Or maybe, as I had, the economists have not considered habit formation, which may simply take the form of costly revision of consumption patterns. Even relatively small adjustment costs in changing consumption can have significant effects on asset-price patterns. Perfect markets could be another culprit; in particular, market liquidity may not be constant, and constraints on short sales may show up in prices.

For the most part, financial economists take the stochastic process of stock prices, or the value of the firm, or dividend payments as primitive. But to explain some anomalies, we may need to look deeper into the guts of corporate decision making to derive what the processes are. Many finance models assume homogenous beliefs, which is clearly a severe counterfactual limitation for some purposes.

Perhaps the most important missing generalization in almost all work on asset prices thus far is uncertainty about the demand curves (via uncertainty about endowments or

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[18] Despite rumors to the contrary, nothing about market rationality forces asset prices to follow a random walk. In my 1976 paper, I asked under what conditions a random walk (by that I meant serially uncorrelated market portfolio returns) would arise naturally in equilibrium. In the context of a market populated by investors with additive logarithmic utility functions in consumption, the rate of growth of aggregate consumption is perfectly positively correlated with the return of the market portfolio. Therefore, a necessary and sufficient condition for a random walk is that the rate of growth of aggregate consumption (exogenously determined in the model) be serially uncorrelated. Per capita consumption growth, affected as it is by technological change and changing population characteristics, such as Baby Booms, need hardly be serially uncorrelated. Therefore, a random walk should not generally be a feature of equilibrium, even in rational markets. So, the finding that stock prices exhibit reversals in the short run and long run and momentum in the intermediate run, even if true, is not prima facie evidence of market irrationality.

preferences) of other investors. This uncertainty injects a form of "endogenous uncertainty" into the economy that may be on a par with exogenous uncertainty about fundamentals.

To survey critically the entire anomaly literature would require more than one issue of this journal. Instead, I will briefly examine six of the most serious anomalies that are often used as evidence of market irrationality.

Excess Volatility. Believers in this anomaly assert that asset prices vary far too much relative to fundamentals. Even if true, this observation, which was popularized by Shiller (1981), has a good explanation that is consistent with rational markets: Much of the volatility in prices derives from changes in beliefs about the demand curves of other investors, a form of endogenous uncertainty.[19] This added source of risk makes asset prices more volatile than the fundamentals alone would imply. Even in a rational market, investors may be quite uncertain and at times mistaken about the views and positions of other investors.[20] They are not mistaken on average, of course, but frequently turn out after the fact to have been optimistic or pessimistic. In practice, the current price, past price changes, and volume provide only a noisy signal about future investor intentions. For example, investors may be expecting relatively pessimistic investors to buy in if stock prices fall by X percent. If the investors do not buy in, other investors may infer that their information is even more negative than they had originally believed. Then, even investors who were previously optimistic based on their own fundamental information may revise their estimates downward, and prices could fall much farther than would otherwise have been the case.

This endogenous uncertainty may also explain why prices change even in the seeming absence of news. In these cases, stock prices are reacting to information about the characteristics of other investors. Further evidence of the importance of this type of uncertainty

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[19] The economist Paul Krugman appears to be a recent convert to this belief. In a regular editorial column in January 2000, he wrote, "But while it may be very hard to tell whether the market is overvalued or undervalued, one thing is for sure: It fluctuates more than it should. That is, instead of rising and falling only when there is real news about the future, stocks surge and plunge for no good reason."

[20] The sources of uncertainty about other investors may be broken into two types: Type 1 is uncertainty about the positions and preferences of other investors; Type 2 is uncertainty about the fundamental beliefs of other investors concerning expected cash flows. A somewhat oversimplified description is that the first can lead to time-varying discount rates (the denominator of present value calculations), and the second, to time-varying expected cash flows (the numerator of present value calculations). For example, if investors generally overestimate the risk aversion of other investors, they will believe expected returns are too high and perhaps overinvest in risky securities. When they learn, perhaps through observing future trading volume and price changes, that other investors are less risk averse than they had thought, prices will fall as they reduce their holdings. The result is extra volatility deriving from Type 1 uncertainty.

comes from the observation that excess volatility relative to fundamentals is much greater when the market is open for trading then when it is closed—overnight, over the weekend, or during a holiday (see French and Roll 1986). When the market is open, price/volume changes are clearly visible to all participants, and they convey information about the preferences, trading positions, and beliefs of other investors.

Until recently, the effect of this form of endogenous uncertainty on asset prices was largely unexplored, so it is too early to tell if it explains the magnitude of excess volatility relative to fundamentals.[21]

Risk-Premium Puzzle. The second anomaly is that aggregate consumption is not sufficiently variable to justify the high realized return premiums (about 7+ percent) from investing in stocks in the United States. The first anomaly concerned excessive volatility; the second concerns excessive excess returns (market index returns minus the riskless return), again relative to the volatility of aggregate consumption. When the two anomalies are juxtaposed in this way, the two may be seen to be really the same anomaly: Excess returns have not been surprisingly high relative to the volatility of stock returns. The real question behind the risk-premium puzzle may not be why are risk premiums so large but, rather, why the volatility of stock returns is so large, and a potential answer has just been discussed.

In addition, anything that can break the link between the rate of growth of aggregate consumption and the rate of return of the market portfolio could help explain the puzzle. Originally, the risk-premium puzzle appeared in equilibrium models that assumed additive utility of consumption over time, which excluded habit formation in consumption. Generalized models that allow for habit formation imply that consumption paths will be smoothed relative to wealth paths, so the volatility of wealth can exceed the volatility of consumption (see, for example, Campbell and Cochrane 1999).

Another line of argument is suggested by recent work on inferring risk-neutral probabilities from index option prices. Since the 1987 crash, the prices of deep out-of-the-money puts in stock markets around the world have been very high relative to the predictions derived from lognormal risk-neutral distributions (i.e., the Black–Scholes formula). These prices may be high simply because investors are extremely risk averse toward extreme downside market outcomes and are, therefore, willing to pay a very high price for securities that provide insurance against them. Such extreme risk aversion may justify high realized risk premiums. Moreover, extreme declines in stock prices are also rare events and may have

[21] Papers exploring this issue include Kraus and Smith (1996), Barbaris, Huang, and Santos (1999) and Kurz and Motolese (1999).

occurred with much less frequency than the aggregate market apparently believes. So, in short, the U.S. stock market may have performed much better than the market expected.

This phenomenon is not itself good evidence of market irrationality because even assuming a lognormal distribution, the standard error of the realized market return for as long as 50 years is several percent; so, a relatively high realized return could easily have happened by chance. If there were some way to enlarge the sample size by looking over a much longer time period—say, several hundred years—the large standard error of the realized market return might shrink significantly. Unfortunately, we cannot test this idea by rerunning U.S. market history to see what would have happened along other sample paths. We can, however, look at other stock markets. To the extent that their returns are independent, they are a good substitute for the apparent impossibility of time travel. Jorion and Goetzmann (1999) performed just this experiment. They examined the 20th century returns of 39 stock markets around the world, including several with experiences vastly different from the U.S. market, such as Russia (which had a little problem in 1917) and Germany and Japan (which experienced discontinuities at the end of World War II). Perhaps not surprisingly, the authors reported that the U.S. market was the best performing of all 39 markets. In brief, the widely touted risk-premium puzzle could be no more than an extreme example of survivorship bias.

Book-to-Market Ratio, Value versus Growth, and Size. The CAPM says that only the return on the market portfolio should be priced, but empirical work indicates that the book-to-market ratio and size are priced in U.S. and international markets. Related to this anomaly is the general tendency over long periods of time for value-based stocks to have higher returns than growth-based stocks. A few years ago, in a conference at UCLA, Eugene Fama defended market rationality against criticism made by Thaler by arguing that, although beta (hence, the CAPM) did not seem to be much help in predicting cross-sectional realized returns, book-to-market and size were. The joint verbal response of Thaler, Titman, and Lakonishok was that no one had a convincing rationality-based explanation of why book-to-market and size should have anything to do with expected returns because how these factors could reflect risk is hardly obvious. Thaler further argued that the importance of these factors is evidence of market irrationality.

These extra-market factors and other value versus growth measures, such as P/Es and dividend yield, seem intuitively similar; in particular, they all involve the stock price itself. This aspect should make one immediately suspicious that they are at root the same effect and that the effect has something to do with the stock price. Indeed, as Berk (2001) reported, purely accounting (non-stock-price) variables used in place of size, such as revenue or number of employees, have no relation to expected returns.

Moreover, Berk made the following syllogistic argument: Consider a group of companies that all have equal expected cash flows but some have higher expected returns than others for *any* reason (perhaps because they are riskier):

- The companies with the higher expected returns must be worth less to investors.
- Companies that are worth less to investors tend to be small (in terms of aggregate market value).
- Therefore, companies with higher expected returns are small.

So, the mere finding that companies with high expected returns are small has nothing to do with size serving as a proxy for risk. It is evidence neither for nor against market rationality; it simply must be true. Therefore, it should come as no surprise that the size effect, first discovered for post-World War II U.S. stocks, was later shown to be true for stock markets around the world and for pre-World War II U.S. stocks. The confirming results of these so-called out-of-sample tests may simply follow from a tautology. Similarly, book-to-market and other price-dependent factors are also tautologically related to expected returns.

Closed-End Fund Discounts. Closed-end funds often sell at significant discounts to net asset value (NAV, the value of the fund if liquidated at current market prices). This anomaly is potentially serious. It suggests a fundamental mispricing of individual stocks (because a company can be interpreted as a "closed-end" fund of investment projects that is more complex than a true closed-end fund because of synergies among the projects). If the market cannot get the pricing of closed-end funds correct, how can it be expected to correctly price individual stocks?

Closed-end fund discounts appear damaging to the hypothesis of market rationality, but they are not as damaging as they at first seem. In principle, discounts can be reconciled with market rationality by noting the drawbacks of such funds to an investor: excessive trading costs and management fees, poor managerial performance arising from incentive-incompatible fee structures, hidden accumulated capital gains tax liabilities, and loss of the tax-timing option available to investors who own the same portfolio as the fund but have the option of deciding for themselves when to realize capital gains and losses. [22]

Much harder to argue is that closed-end fund discounts are inconsistent with *minimal* market rationality. One way to profit from mispricing is to buy enough of the shares of a closed-end fund to force it open and then sell out at the NAV. In practice, however, enough shareholders demand premiums if they are to be convinced to sell that takeover is risky and usually unprofitable.

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[22] See Bierman and Swaminathan (2000) for an analysis showing that "a well-managed mature closed-end fund with unrealized capital gains should have a large discount." (p. 50)

Most striking for the coexistence of the discount and minimal market rationality is the evidence on the temporal behavior of closed-end fund discounts. Chay and Trzcinka (1999), examining 94 closed-end equity funds during the 1966–93 period, showed that discounts on equity closed-end funds change in a way that tends to correctly anticipate subsequent closed-end fund performance. That is, funds with high discounts tend subsequently to have poorer performance than funds with low discounts over the next year or two. This phenomenon is truly a *tour de force* of market rationality; it stands the closed-end fund discount anomaly on its head by enlisting it as an argument for market rationality!

Calendar Effects. The Monday effect is the strongest of the calendar anomalies. Although the U.S. stock market has risen at about 10 percent a year since 1928, the Friday close–Monday close three-day return has been negative. This anomaly is even stronger than the literature suggests: The 1928–87 period encompassed 12 nonoverlapping five-year periods, and in every one, Monday was not only negative but it was also the worst day of the week. Given the hypothesis that Monday is just as likely as any other day to be the worst day of the week, the probability of this finding (ignoring the fact that in a few years the market was open six days) is $(1/5)^{12}$ or less than 0.00000001. Furthermore, of the 55 overlapping five-year periods in the 1928–87 period, Monday was always negative and, in all but one, was the worst day of the week. How could a rational market permit such an obvious and simple anomaly to go unchecked for more than half a century?

Despite its persistence, the Monday effect is not large enough to support a profitable trading strategy if one assumes realistic trading costs.[23] Sullivan, Timmerman, and White (1999) showed that the effect could easily be the result of data mining. They examined a large universe of potential calendar effects and argued that even an effect as strong as the Monday effect could easily occur by chance. Dumping more water on the calendar fire (and perhaps quenching it) is the fact that after 1987, the Monday effect disappeared. Indeed, for 1989–1998, not only have Monday returns been positive, but Monday has been the *best* day of the week.

Fans of calendar effects should not despair, however, since a new effect has been inaugurated, the "Thursday effect," with negative returns over this recent 10-year period.

1987 Stock Market Crash. On October 19, 1987, the stocks on the NYSE, apparently in the absence of any significant fundamental news, fell approximately 29 percent in a single day. The reported decline in the S&P 500 Index for October 19, 1987, was 20 percent, but because many large stocks were inactively traded for long time periods and orders were backed

up, this report undoubtedly understates the decline. The S&P 500 futures market, which was actively trading even at the end of the day, thus providing a better indication of the true magnitude of the crash, experienced a decline of 29 percent.

A number of forces could have converged, even in a rational market, to create this crash. First, prior to the crash date, the volatility of the market significantly increased. In fact, the three days of October 14–16, 1987, saw the largest three-day percentage decline in the S&P 500 Index since 1940. Because the daily mean is near zero and variance is squared returns, this decline translated into a sudden extremely large upward shift in volatility that may have convinced the most risk-sensitive investors to exit the market on Monday. As they left and the market became chaotic, two of the usual protections that investors rely on to reduce their risk exposure—liquidity and diversification—failed. This failure prompted less sensitive but still risk-averse investors to exit the market as quickly as possible. Stocks stopped trading, exchange printers were backed up, market orders could take hours to be filled. As the day wore on, the fear arose that a domino effect of massive bankruptcies in financial services firms and organizations would cripple the market. To make matters worse, almost all stocks around the world fell together, thus wiping out the normal refuge of international diversification.

In addition, the trades of portfolio insurers (who had no fundamental information but whose strategy required selling as prices fell) may have been misinterpreted by other investors as signs of a fundamental deterioration of market prices. Many investors would have had no way to know that these trades were not motivated by fundamentals. This situation also supports the idea that price changes derive from changing beliefs about the demand curves of other investors.

Other evidence supporting this idea comes from the work of Hong and Stein (1999). Their paper can be interpreted as providing a rational basis for the fact that since World War II, the S&P 500 Index has had many more significant one-day declines than significant one-day rises. They argued that the information of pessimistic investors is largely hidden from other investors, particularly after a market rise, because of constraints on short sales. The market makes its best guess as to what this information is and prices stocks accordingly, but occasionally, a serious misestimation occurs. In the crash, when the market began to fall, these pessimistic investors failed to materialize as buyers. The market could then see that these investors were very pessimistic relative to the elevated prices, so even formerly optimistic investors did not buy in further as the market fell.

Final Thought

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[23] The Monday effect could, however, provide the basis for timing trades that an investor might make for other reasons.

Some adherents of behavioral finance begin sensibly enough with the results of convincing experiments that show human beings are irrational in certain specific systematic ways. But then comes the hand waving as they try to extend the results to the much more complex, long-lasting, repetitive, and subtle environment of the market. This extension requires a big leap of faith. The market, as we have seen, has many special features that protect it from aggregating the irrationalities of individuals into prices. Perhaps it is too soon to pronounce, as behavioralists are wont to do, the hypothesis of rational markets down for the count. To quote Thomas Kuhn from his book *The Structure of Scientific Revolutions* (1962):

> How, then, to return to the initial question, do scientists respond to the awareness of an anomaly in the fit between theory and nature? . . . There are always some discrepancies. Even the most stubborn ones usually respond at last to normal practice. Very often scientists are willing to wait, particularly if there are many problems available in other parts of the field. We have already noted, for example, that during the 60 years after Newton's original computation, the predicted motion of the moon's perigee remained only half of that observed. As Europe's best mathematical physicists continued to wrestle unsuccessfully with the well-known discrepancy, there were occasional proposals for a modification of Newton's inverse square law. But no one took these proposals very seriously, and in practice, this patience with a major anomaly proved justified. (p. 81)

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Exhibit 1. Behavioral Explanations for Market Phenomena

Reference points and loss aversion (not necessarily inconsistent with rationality)

Endowment effect: What you start with matters
Status quo bias: More to lose than to gain by departing from current situation
House money effect: Nouveau riche are not very risk averse

Overconfidence

Overconfidence about the precision of private information
Biased self-attribution (perhaps leading to overconfidence)
Illusion of knowledge: overconfidence arising from being given partial information
Disposition effect: tendency to hold losers but sell winners
Illusion of control: unfounded belief in being able to influence events

Statistical Errors

Gambler's fallacy: need to see patterns when, in fact, there are none
Very rare events assigned probabilities much too high or too low
Ellsberg paradox: perceiving differences between risk and uncertainty
Extrapolation bias: failure to correct for regression to the mean and sample size
Excessive weight given to personal or anecdotal experiences relative to large-sample statistics
Overreaction: excessive weight placed on recent relative to historical evidence
Failure to adjust probabilities for hindsight and selection bias

Miscellaneous Errors in Reasoning

Violations of basic Savage axioms, namely, the sure-thing principle, dominance, transitivity
Sunk costs influencing decisions
Preferences not independent of elicitation methods
Compartmentalization and mental accounting
"Magical" thinking: believing you can influence the outcome when you cannot
Dynamic inconsistency: negative discount rates, "debt aversion"
Tendency to gamble and take on unnecessary risks in some situations
Overpricing long shots
Selective attention and herding (as evidenced by fads and fashions)
Poor self-control
Selective recall
Anchoring and framing biases
Cognitive dissonance and minimizing regret (the "confirmation trap")
Disjunction effect: waiting for information even if it is not important to the decision
Time diversification
Tendency of experts to overweight the results of models and theories
Conjunction fallacy: probability of two things co-occurring believed more probable than a single one

And Why Not Add While We Are at It

Confusion of probabilities with preferences (religion, money management)
Freudian defense mechanisms: repression, displacement, reaction formation, isolation of affect, undoing, somatization, conversion
Kleinian defense mechanisms: splitting, projective identification, introjection, denial

Table 1. Mutual Fund Performance versus Vanguard S&P 500 Index Fund, as of July 31, 1999

Universe = Domestic Equity/Large Blended (Morningstar Category)

		Vanguard		**Morningstar Funds**	
Years	Number of Morningstar Funds[a]	Rank[a]	Return	Median Fund Return	Top Fund Return
last 5	357 (60)	13 (1)	25.02%	20.79%	29.86%
last 10	132 (60)	11 (3)	16.95	14.30	21.61
last 15	79 (60)	6 (4)	17.94	15.51	19.83

Note: Returns are the reinvested rate of return per year after fees but not considering loads or taxes, and they are not corrected for survivorship bias.

[a]Numbers in parentheses in the columns labeled "Sample Size" and "Vanguard Rank" are for the sub-universe of all Morningstar funds in existence since August 1976 (Vanguard's inception).