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Rational Markets: Yes or No?
The Affirmative Case

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ABSTRACT

This paper presents the logic behind the increasingly neglected proposition that prices set in developed financial markets are determined as if all investors are rational. It contends 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. It also argues that investor irrationality, to the extent it affects prices, is particularly likely to be manifest through overconfidence, which in turn is likely to make the market in an important sense too efficient, rather than less efficient, in reflecting information. To illustrate, the paper ends by re-examining some of the most serious evidence against market rationality: excess volatility, the risk premium puzzle, the size anomaly, calendar effects and the 1987 stock market crash.

This paper is available on-line at: http://haas.berkeley.edu/finance/WP/rpflist.html

In November, 1999, at the 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 has become respectable, perhaps dating from the June/September 1978 issue of the *Journal of Financial Economics*, our profession has forgotten the very good reasons that the affirmative proposition was once so widely believed. It seems a daily occurrence that some new "anomaly" is reported that drives yet another nail into the coffin of rational markets. The weight of paper in academic journals supporting anomalies is now much heavier than evidence to the contrary. So old enough to remember and respect the "old school", I was asked to present this forgotten case.

Richard and I agreed to interpret "rational" to mean that investors follow the Savage axioms (which are rational precepts like "if A is preferred to B and B to C, then A will be preferred to C"). These imply that investors act as if they maximize expected utility using subjective probabilities.[1] In addition, rationality requires that these subjective probabilities be unbiased. I confess to find this a little vague, but I take it that this means that if we were able to run the economy over and over again, asset returns would trace out a realized frequency distribution. We say an investor's subjective probabilities are unbiased if they are the same as these frequencies. This is even more restrictive than sometimes is meant because I am here insisting on more than rational means, but on an entire rational probability distribution. These days, any good derivatives theorist knows that unbiased means are not enough since options can be used to profit from even the slightest mistakes in assessing probabilities.[2] On the other hand, I do not want to

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[1] See Leonard J. Savage, *The Foundations of Statistics*, Dover, 1954. His 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.

[2] I find the definition I have given of unbiased subjective probabilities somewhat vague since the probabilities will depend on the information we assume is available to investors in the model. An extreme, but popular, version of this 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 these determine future equilibrium prices. I have always found this an extreme and counterfactual requirement for equilibrium having nothing to do with rational decision making, not to mention that it substitutes 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 defining market rationality, then, 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, his subjective probability distribution for

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 we are discussing.

> *I will say markets are <u>maximally rational</u> if <u>all</u> investors are rational.*

If markets were maximally rational, investors should probably trade relatively little and intensively use index funds.

Although most academic models in finance are based on this assumption, I don't think financial economists really take it seriously. Indeed, they need only talk to their spouses or to their brokers to know it cannot be true.

> *However, what is in contention is whether or not markets are simply <u>rational</u>, that is, asset prices are set <u>as if</u> all investors are rational.*

Clearly this can be true 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 are not matters of contention here, and in fact I don't dispute them. If markets were rational, money managers acting in the interests of their clients, should work to correct their own and their client's irrational investment choices.

But even if we decide markets are not rational that does not mean they supply profit opportunities. 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. Or if you tell me such-and-such a stock is overpriced,

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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 profit opportunities in the market. Some investors may be much smarter in a conventional sense than others, but in a rational market, for some reason, this superiority (which in other circumstances would have proven quite valuable) is rendered useless.*

but there are significant obstacles to short-selling or significant trading costs, again I may not be able to do much about it.

> *In these cases, I would like to say that although markets are not perfectly rational, they are at least <u>minimally rational</u>: although prices are not set as if all investors are rational, there are still no abnormal profit opportunities for the investors that are rational.*

If markets were only minimally rational, it will be even easier for investors to be misled into thinking they can beat the market, and it then becomes even more important for money managers to give sound advice.

As we encounter different anomalies, I think it will be useful to ask what kind of market rationality they contradict. Clearly, we will be most interested in anomalies 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*. That is, as a trained financial economist, with the special knowledge about financial markets and statistics that I had learned, enhanced with the new high-tech computers, databases and software, I would have to be careful how I used this power. Whatever else I would do, I should follow *The Prime Directive*:

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

One has the feeling from the burgeoning behavioralist literature that it has lost all the constraints of this directive – that whatever anomalies are discovered, illusory or not, behavioralists will come up with an explanation grounded in systematic irrational investor behavior.[3]   But this is

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[3] For example, hear the words of Richard Thaler: "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?" – "The Psychology of Choice and the Assumptions of Economics," reprinted in *Quasi-Rational Economics* (Russell Page Foundation, 1991), p. 162.

just too easy. For example, if we discover asset prices exhibit reversals, surprise of surprises, the behavioralists tell us this is due to the documented tendency of individuals to overreact to recent events. Of course that 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 more complex and subtle environment of the securities markets. The explanation also has too much of a flavor of being concocted to explain ex-post observations – much like the ancients used to suppose there were a different angel providing the motive power for each planet. And then when it is discovered that really price reversals occur in the short-run, momentum in the intermediate-term run, and price reversals in the long-run, sure enough, behavioralists will find some more convoluted way to explain that from irrational behavior (reminding me of Ptolemaic epicycles).

The behavioral cure may be worse than the disease. Here is a litany of cures drawn form the burgeoning and clearly undisciplined and unparsimonious behavioral literature:

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: want to hold losers but sell winners
       Illusion of control: unfounded belief of 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 antidotal experiences over large sample statistics
       Overreaction: excessive weight placed on recent over historical evidence
       Failure to adjust probabilities for hindsight and selection bias

Miscellaneous errors in reasoning:
       Violations of basic Savage axioms: sure-thing principle, dominance, transitivity
       Sunk costs influence decisions
       Preferences not independent of elicitation methods
       Compartmentalization and mental accounting
       "Magical" thinking: believing you can influence the outcome when you can't
       Dynamic inconsistency: negative discount rates, "debt aversion"
       Tendency to gamble and take on unnecessary risks
       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 ("confirmation trap")
Disjunction effect: wait for information even if not important to decision
Time-diversification
Tendency of experts to overweight the results of models and theories
Conjunction fallacy: probability of two co-occurring 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

It is my thesis that it is too soon to fall back to what should be the last line of defense, market irrationality, to explain asset prices. With patience, the anomalies that appear puzzling today will either be shown to be empirical illusions or explained by further model generalization in the context of rationality.

Two Qualifications

However, I have a slight confession. I must qualify my view supporting market rationality in two ways. First, occasionally a small group of irrational investors will be able to determine asset prices, and the larger body of investors will not be able to do anything about it. For example, the finding in mergers that acquiring firms overpay is inconsistent with rational markets as I have defined it, but surely something that occasionally happens. But these relatively unimportant deviations from perfect market rationality do not lead to profit opportunities and therefore are not proof that markets are not at least minimally rational.

Second, I have for a long time believed that investors are overconfident.[4] For example, surely the average investor believes he is smarter than the average investor. This 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 – although I learned about this last recently from Terry Odean). This is a violation of

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[4] The idea that individuals are overconfident is, of course, not new. For example, 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." (Penguin Edition, 1986, p. 209).

The Prime Directive because overconfidence is a type of systematic investor irrationality and will affect prices, as I shall argue later, in important ways.

Philosophical Basis for Rational Markets

It is a mistake to think, as behaviorialists have argued, that the reason financial economists seem so wedded to the idea of rational markets is that they wouldn't know what to do without that assumption, or that carefully modeling markets without it is "hard", or that modeling without it would not be mathematically tractable and 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 (in a much later century Bishop Joseph Butler, England's foremost moral philosopher, was to utter "… probability is the very guide to life."). But the belief that man is by nature rational seems first to have taken hold during the enlightenment when it was given one its most forceful expositions by René Descartes, the French mathematician and philosopher, in his *Discourse on the Method of Rightly Conducting Reason*:

> *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 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.*

Later Darwin in *The Descent of Man* answered the question 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 which included the largest number of men thus endowed would increase in number and supplant other tribes.*

One might be tempted to take this further and apply Darwinian natural selection more directly to markets and claim that since only the fittest (i.e. the most rational) survive, the market must be principally populated by highly rational investors. But this is dangerous ground. Ex-post it is surprisingly easy to justify many forms of contradictory behavior from natural selection

arguments, as witness the amusingly contradictory conclusions reached in *The Naked Ape* by Desmond Morris and *The Descent of Woman* by Elaine Morgan. Also nature, as it works out the prerogatives of natural selection, necessarily compromises since it too must optimize under constraints. As a result, successfully adaptive behavior always leaves open some weakness. Also, natural selection can work very slowly, so that as the environment changes the older now maladaptive behavior can persist for some time.

More specifically, behavioralists have ingeniously argued that irrational overconfident investors have an advantage in a sense over their rational counterparts. Overconfidence will encourage them to take excessive risk by holding high expected return securities which in turn will tend to make them richer and therefore increase their influence over prices. Moreover, to the extent overconfidence takes the form of biased self-attribution, irrational investors who have merely gotten rich through luck will mistakenly attribute that to their own skill and be overconfident about subsequent investments.

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

Perhaps unconsciously, the above arguments underlie the intuitive prior that many financial economists have that markets are rational. But a more consciously held position, given full voice by Nobel Laureate Friedrich Hayek,[5] 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 disbursed 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*

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[5] F. Hayek, "The Use of Knowledge in Society," *American Economic Review* (September 1945).

> *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.*

Each investor, using the market to serve his own self-interest, unwittingly makes prices reflect his 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 the continuously changing current price. In the face of this mechanism, it is almost always a folly for a single investor (in the absence of inside information) to believe that prices are significantly in error. Public information should already be embedded in prices. Indeed, stocks are highly responsive to news that clearly relates to them. Even if he were fortunate enough to be possessed of non-public but not inside information, it may do him more harm than good if he is tempted to take a position based on it – for the price may already reflect other non-public information known to other investors which may nullify the effect of his 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 the price before he makes a bet based on his information.

The securities market is not the only example for which the aggregation of information across different 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, 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) where the missing sub was found.[6]

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

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[6] Described in S. Sontag and C. Drew, *Blind Man's Bluff: The Untold Story of American Submarine Espionage* (HarperCollins 1998).

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.

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 very good approximation of tomorrow's expected price. But today's price by itself says little about the full range of tomorrow's possible outcomes and their probabilities. However, in the last quarter of the 20th century, even this information has now become aggregated across investors and compactly conveyed: in the form of the prices of options.[7] Open interest and trading volume in derivatives, whether domestic or international, now eclipses outstanding units and trading volume in underlying assets. I have estimated elsewhere that the trading volume in derivatives around the world, measured in terms of the value to which a derivative is a right, is in excess of one quadrillion dollars per year.[8] So the securities market today probably does a better job of aggregating the wisdom of those that trade in it than ever before.

Basis for Minimally Rational Markets

Financial economists have even better reasons to believe that markets are at least <u>minimally</u> rational. Most basic is the idea that profitable trading strategies are self-destructive. In practice, their profitability is limited by their tendency to move prices against themselves as they are exploited, and eventually they will be discovered and eliminated from overuse by other investors.

A much weaker argument is that irrational investors self-destruct leaving the field open only to those that are rational. For example, an irrational investor can destroy himself by trading too actively and thereby running up significant trading costs. However, the general result that irrational investors become poor and therefore have little influence on market prices is quite

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[7] A discussion of methods for extracting probability distributions from the prices of derivatives can be found in M. Rubinstein, "Implied Binomial Trees," *Journal of Finance* 69, No. 3 (July 1994), pp. 771-818.

[8] M. Rubinstein, *Derivatives: A PowerPlus Picture Book* (In-the-Money, 1999), p. 66.

sensitive to the assumed set up. At one extreme, Alchian[9] has argued that even if all investors are irrational, aggregate market forces can result in market rationality. At the other extreme, Thaler has argued that irrational investors get richer not poorer.

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

Trading of irrational investors, if not expressed in a consistent manner cross-sectionally, can be self-canceling, leaving the determination of prices in the hands of the rational investors. In this instance even the most market-savvy investor can only earn average returns since he will see all asset prices as correctly determined. Behavioralists have been quick to reply that this argument does not apply to their findings since they are based on <u>systematic</u> irrational behavior. In other words, they believe they can identify situations where irrational investors will be systematically optimistic, or systematically pessimistic. Even if this were true on occasion, the potential for self-cancellation shows why the game of investing is so different than, for example, chess where even a seemingly small advantage can lead to consistent victories. Humans are accustomed to thinking of games, and by extension life, in this way. I believe that is a key reason why it is so hard to persuade lay investors that markets are rational: they implicitly lump the market with other arenas of competition in their experience.

But the most telling reason why markets are rational comes from behavioralist thinking itself (although behavioralists don't seem to have drawn the same implication I have): overconfidence leads investors to believe they can beat the market. Either a money manager is overconfident about his abilities, or in an effort to convince his clients about his superior abilities, he develops a façade of overconfidence. While overconfidence can express itself in other ways, surely it causes many investors to spend too much on research (or to trade too quickly based on 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 still remain and are occasionally found encouraging

[9] A. Alchian, "Uncertainty, Evolution and Economic Theory," *Journal of Political Economy* 58 (June 1950), pp. 211-221.

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 too efficient, reflecting not only the information that was cost-effective to learn and impound into prices but even more information that it did not pay to gather and impound. While overspending on research is not in one's self interest, it does create a positive externality for passive investors who now find that prices are even more informationally efficient and markets deeper than they should be.

Remember the chestnut about the professor and his student. On one of their walks, the student spies a hundred dollar bill simply lying in the open on the ground. But the professor assures his student that it could not be there since otherwise 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 worry about this sort of thing.

Some Empirical Evidence

For empirical evidence that investors overspend on research and transact too quickly based on their information, one need only look to the long history of mutual fund performance, by far the most widely studied database of the results of professional investing. I remember when Jensen's 1969 study of mutual funds[10] almost single-handedly convinced me that large cap equity markets were for practical purposes at least minimally rational. He showed that the average mutual fund did not outperform a market index. Indeed, it under-performed by about the size of its fees and trading costs. Of course, some mutual funds in his sample had better returns even after adjusting for CAPM risk than the market index. But he argued that there was no evidence that any one mutual fund outperformed the index more than would have occurred by chance. I became so convinced of this that since the Vanguard S&P 500 Index fund became available in 1976, my consistent response to inquiries about what stocks to buy has been to buy Vanguard, or perhaps now, some more broadly based index fund.[11] Now, 30 years later, the evidence is even stronger than it was in 1969. The continuing performance of these funds as well as the broad consensus of the substantial research into this issue that has occurred since lend further support to Jensen's

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[10] M. Jensen, "Risk, the Pricing of Capital Assets, and the Evaluation of Investment Portfolios," *Journal of Business* 23, No. 2 (1968), pp. 389-416.

[11] 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.

results. This is a step on which those that advocate irrational 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 as any market anomaly on the other side. In fact, piling on the metaphors, the behavioralists have nothing in their arsenal to match it; it is a nuclear bomb against their puny rifles.

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 whether or not various anomalous strategies can actually be implemented; we will really never know until they are. We can argue as long as we like about whether an anomalous strategy is due to data mining, and we will really never 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 that now span 50 years of thousands of smart and highly compensated individuals who spent most of their waking hours studying markets and conclude that at least they could not find successful anomalous strategies. Even if with the unfair advantage of hindsight such strategies existed, they were not clever enough to discover them.

For me, unless and until those who advocate minimal market irrationality can directly counter this argument with evidence from actual profits and losses, game over.

Here I report the results (see Table 1) of my own admittedly casual study of stock-picking ability by mutual funds. I wanted to see how good my 1976 advice was to buy the Vanguard S&P 500 fund. To isolate stock picking ability, I compared Vanguard to the other funds in its Morningstar category (Domestic Equity/Large Blend). In this category there were 79 funds with 15-year track records. I was pleased to see that Vanguard's reinvested rate of return per annum before taxes was 17.94%, the 6th best fund over this period. As expected in a minimally rational market modified by overconfidence, the median fund return is about 2.5% less, indicating that the average fund had simply wasted about that amount in research, trading costs and perhaps inefficient administration. The average fund may have received no benefit whatsoever from its

research (Carhart[12] estimates that the typical fund has 1.17% in expenses and .78% in trading costs).

A problem with these results is survivorship bias. Carhart, in his exhaustive 1962-1993 study, found that every year about 3.5% of funds drop out, presumably because of poor performance. This would suggest that about one-third of the funds in existence 15 years ago may have dropped out. In that case, a crude correction for survivorship bias means that Vanguard was probably the 6th best performing fund out of about 120, placing it at the 5th percentile. Of course, it was not the best performing fund. Five others did better. But even the best performing fund (Fidelity Magellan) only outperformed Vanguard by less than 2% per annum. And how did that happen? To be sure one would have to do the statistics, but it would seem to me this is probably even worse than should have occurred simply by chance. Some had to be lucky, and these funds were the lucky ones.

Table 1: Mutual Fund Performance
(Vanguard S&P 500 Index Fund 7/31/99)

Universe = Domestic Equity/Large Blend (Morningstar Category)
(not corrected for survivorship bias)

	Sample Size	Vanguard Rank	Vanguard Return*	Median Fund Return*	Top Fund Return*
5-year**	357(60)***	13(1)	25.02%	20.79%	29.86%
10-year	132(60)	11(3)	16.95%	14.30%	21.61%
15-year	79(60)	6(4)	17.94%	15.51%	19.83%

* after fees but not considering load or taxes
** most recent 12 month range 11%-63%, top decile > 44%, bottom decile < 24%
*** numbers in parentheses are based on a universe of all funds in existence since 76/08 (Vanguard's inception); most recent 12 month range 18%-61%, top decile > 46%, bottom decile < 23%

A less ambiguous measure of Vanguard's success comes from looking at only the last five years and restricting the universe only to those still existing funds started prior to Vanguard (August 1976). It is unlikely that any fund that started before August 1976 and was still existing 5 years ago has dropped out since. So this sample may be totally free of survivorship bias. Out of the 60 funds in this sample, Vanguard was the #1 performing fund. So, in this case, we don't even have

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[12] M.M. Carhart, "On Persistence in Mutual Fund Performance," *Journal of Finance* (March 1997), pp. 57-82.

to justify minimal market rationality by claiming that the better performing funds were lucky because there weren't any![13]

These findings strongly suggest that mutual fund managers and/or their clients are overconfident. This persuades them to over-invest in research (and be too quick to trade based on it to overcome trading costs). Some of their research may reveal that some stocks are mispriced, and the funds take advantage of that. But on the whole, the research is wasted. It may be that for every dollar invested in research, only a nickel of benefit is received. What makes matters even worse for these funds is that their joint activity and that of other overconfident investors makes the market in a sense too informationally efficient and even less attractive than a purely rational market to pursue with active money management. I'm not sure about you, but as for myself, I'll stick with Vanguard.

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 that I know of is avarice or greed: more wealth (or more consumption) is better than less, other things equal. This is so universally believed that it is easy to forget that it is an important statement about human psychology. And it is not trivial since I don't think we would say it applies to animals or very young children.

Second on the list is the assumption of risk aversion which has a long history of evidence drawn from many diverse situations. Perhaps, it does not apply at all times and places, but it is generally believed to be a more or less pervasive aspect of human behavior. Finance models often get quite specific about risk aversion, assuming for example that, other things equal, as an investor's

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[13] Some related evidence is presented in a recent UC Davis/Berkeley working paper, "Brokerage Houses and Their Stock Recommendations: Does Superior Performance Persist" by B. Barber, R. Lehavy and B. Trueman. Looking at brokerage house stock recommendations for the period 1987-1996, they find no reliable evidence of performance persistence or statistically significant differences in the abnormal returns of the best and worst brokerage houses.

wealth increases he is willing to invest more money in risky assets – again an assumption well supported by evidence.[14]

Next on the list is <u>impatience</u>: the tendency to value consumption more today over consumption tomorrow. Behavioralists pejoratively refer to this as low self-control, but it is entirely consistent with the Savage axioms.

Finally, it has long been a bad habit of financial economists to model rational choice in terms of time-additive utility functions (I plead guilty as well). These imply that how much you consume today has no effect on the utility of consumption tomorrow. It doesn't take an elaborately staged behavioral experiment to know this can't be right. Allowing for <u>habit formation</u> may be analytically difficult, but it is completely consistent with rationality. Reference points is perhaps the most distinctive feature of prospect theory, but this is really quite similar to the older idea of habit formation in economics. For many results in finance this is of no importance, but for many so called anomalous observations it is. Since time-additivity is clearly counterfactual, it should not be surprising to find that it will lead to the wrong conclusions in some situations. I realized this in 1976 in a paper I published in 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 standard deviations of these rates were almost the same – a result that later became subsumed under the equity premium puzzle. Did I then throw in the towel and blame this predictive failure on 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.

How can Theories of Rational Markets Account for Anomalies?

So what does a good financial economist do when faced with mounting anomalous evidence? First, he points 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 might very well come up with something useful. But the odds are, even if he does, it won't be worth much, and ex-ante he certainly should not have expected that his profits would more than cover his costs. Because

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[14] Recent work, admittedly by behavioral economists, indicates that in many circumstances the assumption of risk aversion needs to be amended for "loss aversion," that is, strong aversion to wealth falling below current wealth . Of course, this, in itself, is perfectly consistent with individual rationality.

of this, even in a rational market, a real anomaly could exist and someone might luck into finding it, but ex-ante his expected profits are no better than zero, or with overconfidence affecting prices, actually negative.

Second, many so called anomalies are empirical illusions created by data mining, survivorship bias, selection bias, short-shot bias (my term for the failure to appreciate the possibility of rare events that are not in an historical sample), trading costs (particularly the invisible market impact costs in paper profit studies), and the high variance of sample means (implying that luck can play a big role in realized returns). Rather than deal with these here, it is best to discuss them later in the context of particular anomalies.

Finally, the good financial economist does not blame his failure to explain non-illusory anomalous evidence on irrationality. He looks elsewhere. If his model is single-period or if his multi-period model assumes stationarity or a random walk, therein may lie the problem. Despite rumors to the contrary, there is nothing about market rationality that forces asset prices to follow a random walk.[15] Or maybe, as I had, he has not considered habit formation. This 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 short-sale constraints may show up in prices.

For the most part financial economists usually 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 these processes are. Many finance models assume homogenous beliefs, clearly a severe counterfactual limitation for some purposes.

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[15] In my paper, "The Valuation of Uncertain Income Streams and the Pricing of Options," *Bell Journal of Economics* 7, No. 2 (Autumn 1976), pp. 407-425, I asked under what conditions would a random walk (by that I meant serially uncorrelated market portfolio returns) arise naturally in equilibrium. In the context of a market populated by investors with additive logarithmic utility functions in consumption, 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. Since aggregate consumption need not be serially uncorrelated, a random walk would not generally be a feature of equilibrium even in rational markets. Therefore, the finding that stock prices exhibit reversals in the short- and long-run and momentum in the intermediate-run, even if true, is not prima facie evidence of market irrationality.

Perhaps, the most important missing generalization in almost all work on asset prices thus far has been uncertainty about the demand curves (via uncertainty about endowments or preferences) of other investors. This injects a form of endogenous uncertainty into the economy that may be on a par with exogenous uncertainty about fundamentals.

Five Anomalies

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

1. *Excess Volatility: Asset prices vary far too much relative to fundamentals.*

Even if true, this observation, popularized by Robert Shiller,[16] has a good explanation 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". 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.[17] 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 and past price changes and volume only provide 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%. If they do not, other investors may infer that their information is even more negative than they had originally believed. Taking this into account, even investors who were previously optimistic

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[16] The economist Paul Krugman appears to be a recent convert. In his regular *New York Times* editorial column, he wrote (January 5, 2000, p. A25): "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."

[17] It is useful to break apart the sources of uncertainty about other investors into two types: (type 1) uncertainty about the positions and preferences of other investors, and (type 2) uncertainty about the fundamental beliefs of other investors concerning expected cash flows. Roughly speaking, the first can lead to time-varying discount rates (the denominator of present value calculations), and the other 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 over-invest in risky securities. But 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. This is extra volatility deriving from type 1 uncertainty.

based on their own fundamental information may now revise downward their estimates, and prices could fall much further than would otherwise have been the case.

This endogenous uncertainty may also explain that while stock prices typically react to news about fundamentals, they also seem to change when there is no 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 comes from the observation that excess volatility relative to fundamentals is much greater when the market is open for trading than when it is closed, say overnight, or over the weekend, or during a holiday. When the market is open, price/volume changes are clearly visible to all participants and these convey information about the preferences, trading positions and beliefs of other investors.

Until very recently,[18] the effect of this form endogenous uncertainty on asset prices has been largely unexplored in the literature; so it is too early to tell if it explains the magnitude of excess volatility relative to fundamentals.

2. Risk Premium Puzzle: Aggregate consumption is not sufficiently variable to justify the high realized return premiums (about 7%+) from investing in stocks in the United States.

The first anomaly is about excess volatility; the second is about excessive excess returns (market index returns minus the riskless return), again relative to the volatility of aggregate consumption. Juxtaposed in this way suggests that these may really be the same anomaly since excess returns have not been surprisingly high relative to the volatility of stock returns themselves. So the real question behind the risk premium puzzle may not be why are risk premiums so large, but rather why is the volatility of stock returns so large, and a potential reason for this 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 also help to explain the puzzle. Originally, the puzzle appeared in equilibrium models assuming additive utility of consumption over time that excludes habit formation in consumption. Generalized models that allow for habit formation

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[18] Recent papers working in this direction include N. Barbaris, M. Huang and T. Santos, "Prospect Theory and Asset Prices," working paper, Chicago/Stanford University (June 1999) and M. Kurz and M. Motolese, "Endogenous Uncertainty and Market Volatility," working paper, Stanford University (March 1999).

imply that consumption paths will be smoothed relative to wealth paths, so that the volatility of wealth can exceed the volatility of consumption.[19]

Another line of argument is suggested from 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 (ie, 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. This extreme risk aversion may help justify high realized risk premiums.

Compounding this is that extreme declines in stock prices are also very rare events, and as chance may have it, have occurred with much less frequency than the aggregate market has believed. So, in short, the US stock market may have performed much better than the market expected. This, itself, is not good evidence of market irrationality, since even assuming a lognormal distribution, the standard error of the realized percentage market return even over 50 years, is several percent; and 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, the large standard error of the realized market return could be significantly reduced. Unfortunately, we cannot rerun history to see what would have happened along other sample paths. However, we can look at other stock markets. To the extent their returns are independent, this is a good substitute for the apparent impossibility of time-travel to parallel universes (despite the suppositions of Michael Crichton in his 1998 novel, *Timeline*.) Jorion and Goetzmann[20] have performed just this experiment. They examine the 20th century returns of 39 stock markets around the world, including several such as Russia (which had a little problem in 1917) and Germany and Japan (which had a discontinuity at the end of WWII). The point is that not all stock markets performed as well as the US; indeed, not surprisingly, they report that the US 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.

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[19] See for example, J. Campbell and J. Cochrane, "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior," *Journal of Political Economy* (1999).

[20] P. Jorion and W. Goetzmann, "Global Stock Markets in the Twentieth Century," *Journal of Finance* (June 1999), pp. 953-980.

3. Book/Market, Value/Growth and Size: The CAPM says only the return on the market portfolio should be priced. Instead it appears from empirical work that the book/market ratio and size are priced across domestic and international markets. Related to this 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, Gene Fama defended market rationality against criticism by Richard Thaler by arguing that, although beta (hence the CAPM) did not seem to be much help in predicting cross-sectional realized returns, book/market and size were. Thaler's, Titman's and Lakonishok's joint response was that no one had a convincing rationality-based explanation of why book/market and size should have anything to do with it, since it was hardly obvious how these could reflect risk. Thaler further argued that these factors matter is evidence of market irrationality.

These extra-market factors, and other value vs growth measures such as price/earnings ratios and dividend yield, seem intuitively similar; in particular they all involve the stock price itself. This should make us immediately suspicious that they are at root the same effect and that that effect has something to do with the stock price. Indeed, as Berk[21] reports, purely accounting (non-stock price) variables used in place of size such as revenues or number of employees, have no relation to expected returns.

Moreover, Berk makes the following syllogistic argument: Consider firms with equal expected cash flows, but some have higher expected returns than others for <u>any</u> reason (perhaps because they are riskier):

1. Firms with higher expected returns must be worth less to investors.
2. Firms that are worth less to investors tend to be small (in terms of aggregate market value).
3. Therefore, firms with higher expected returns are small.

So the mere finding that firms with high expected returns are small has nothing to do with size serving as a proxy for risk and is neither evidence 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-WII US stocks, was later shown to be true for stock markets around the world and for pre-WWII US stocks. The confirming results of these so-called out-of-sample tests really may just

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[21] J. Berk, "A View of the Current Status of the Size Anomaly," forthcoming in D. Keim and W. Ziemba, eds., *Security Market Imperfections and World Wide Equity Markets* (Cambridge University Press).

follow from a tautology. Similarly, book/market and other price-dependent factors are also tautologically related to expected returns.

4. *Calendar Effects: The Monday effect is the strongest calendar effect. Although the US stock market has risen at about 10% per year since 1928, the Friday close-Monday close 3-day return has been negative.*

This anomaly is even stronger than the literature suggests. From 1928-1987 there were 12 non-overlapping 5-year periods. In every one Monday was not only negative, it was also the worst day of the week. Given the hypothesis that Monday was just as likely as any other day to be the worst day of the week, the probability of this (ignoring the fact that in a few years the market was open six days) is $(1/5)^{12} < .00000001$. Furthermore, of the 55 overlapping 5-year periods between 1928-1987, Monday was always negative and, in all but one, the worst day of the week. How could a rational market permit such an obvious and simple anomaly to go unchecked for over half a century?

Despite its persistence, the Monday effect is not large enough to justify a profitable trading strategy to exploit it assuming realistic trading costs. However, it would provide a basis for timing trades that an investor might make for other reasons. A recent paper by Sullivan, Timmerman and White[22] shows the effect could easily be due to data mining. Their paper examines a large universe of potential calendar effects and argues that an effect even as strong as the Monday effect could easily have occurred by chance. To add further water to and perhaps quench the fire, after 1987 the Monday effect disappeared. Indeed, from 1989-1998, Monday returns have not only been positive, but Monday has been the best day of the week! Calendar effects fans should not despair, however, since a new effect has been inaugurated, the "Thursday effect", with negative returns over this recent 10-year period.

5. *1987 Stock Market Crash: On October 19, 1987, the stocks on the NYSE fell approximately 29% in a single day, apparently absent any significant fundamental news.*

The reported decline in the S&P 500 Index for October 19, 1987 was 20%. But since many large stocks were inactively traded for long time-periods and orders were backed up, this undoubtedly understates the decline. The S&P 500 futures market, however, was actively trading even at the

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[22] R. Sullivan, A. Timmerman and H. White, "Dangers of Data-Driven Inference: The Case of Calendar Effects in Stock Returns," working paper, UC San Diego (June 1999).

end of the day, so its decline of 29% is probably a better indication of the true magnitude of the crash.

A number of forces could have converged to create the crash even in a rational market. First, prior to the crash date, the volatility of the market significantly increased. In fact, the 3 days from October 14-16, 1987, saw the largest 3-day percentage decline in the S&P 500 Index since 1940. Since the daily mean is near zero and variance is squared returns, this translates into a sudden extremely large upward shift in volatility. This shift may have convinced particularly risk-sensitive investors to exit the market on Monday. As they did and the market became chaotic, two of the usual protections which investors normally rely upon to reduce their risk exposure failed: liquidity and diversification. This prompted other less sensitive but nonetheless risk averse investors to exit the market as quickly as possible. Stocks stopped trading, exchange printers were backed up, market orders took perhaps 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, including stocks on international markets, fell together wiping out the normal refuge of 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. It would have difficult for many investors to know that these trades were not motivated by fundamentals. Here, again, we see price changes deriving from changing beliefs about the demand curves of other investors.

A recent paper by Hong and Stein[23] can be interpreted as providing a rational basis for the fact that since WWII the S&P 500 Index has had many more significant one-day declines than significant one-day rises. The paper argues that particularly after a market rise, the information of pessimistic investors is largely hidden from other investors due to constraints against short sales. The market makes its best guess about 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. It then became clear to the market 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.

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[23] H. Hong and J. Stein, "Differences of Opinion, Rational Arbitrage and Market Crashes," working paper, Stanford/Harvard University (September 1999).

Final Thought

There are those who will 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 claim these imply that the much more complex, long lasting, repetitive and subtle environment of the market is also irrational. There is a big leap of faith here. The market, as we have seen, has many special features that serve to protect it from aggregating these types of irrationalities 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*:

> *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.*