INVESTMENT QUARTERLY

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WORLD MARKET SURVEY

Demise of the 'New World Order'

A little more than a year ago, the conventional wisdom was that the United States was at the forefront of a fundamentally new era in world economic history. The advent of the Internet had "changed everything." The Internet would make possible the elimination of multiple layers of middlemen in distribution chains for everything from raw iron ore to computers. The consequent enormous increase in distribution and manufacturing efficiency, and a concomitant permanent reduction in the levels of standing inventory for most industries, meant that the business cycle was a thing of the past. We had entered a new age of ever-increasing prosperity, and bear markets would not recur because the discipline of the market would exert its influence through a million tiny incremental adjustments, rather than clumping corrections together, causing a recession. There would be no landings, either soft or hard; just an ascent of corporate profits more or less steep. With risk gone, there was no reason for asset allocation, so it was sensible to allocate one's entire portfolio to a few good tech

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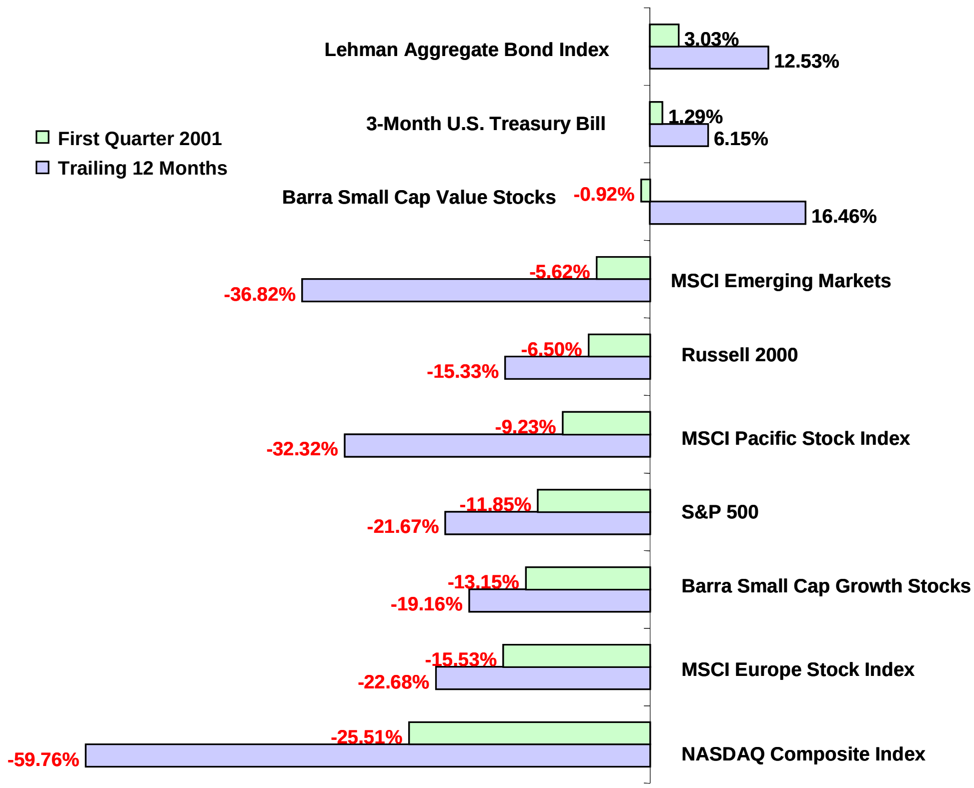
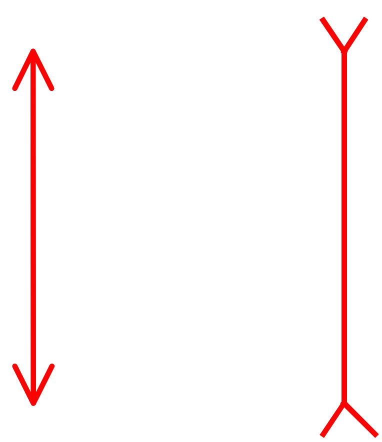
PERFORMANCE OF WORLD EQUITY MARKETS:
APRIL 2000 THROUGH MARCH 2001



THE GREAT DEBATE: BEHAVIORAL VS. STANDARD FINANCE

A great debate is raging in academic finance departments and the professional money management community. This debate is between standard finance, which has its roots in the quantitative and statistical analysis underlying modern portfolio theory, and behavioral finance, which has its roots in cognitive psychology. Depending on one's perspective, behavioral finance either complements or challenges the fundamental precepts of standard finance. In the early 1980s, researchers (primarily D. Kahneman & A. Tversky) applied discoveries in cognitive psychology to investment decision making under conditions of uncertainty. Early behavioral finance research focused on identifying systematic biases in how people perceive and react to risk and uncertainty. The evidence suggests that people "are often influenced by cognitive illusions, which are analogous to perceptional illusions. An illusion is an error that persists even after one recognizes that it is an error." [Amos Tversky, "The Psychology of Risk"]

A well-known example of a cognitive error is the persistence of inaccurate measurement caused by the optical illusion illustrated at right. Which line is longer?



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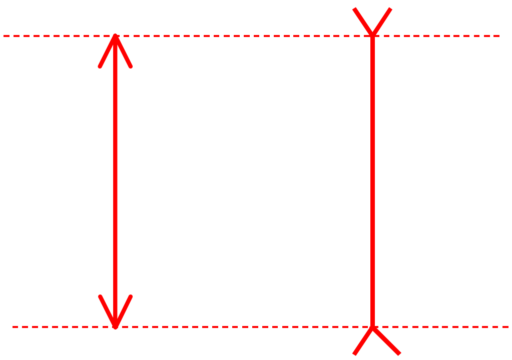
Although it is not obvious in the first graphic, the lines are equal in length. The source of confusion is, of course, the perceptual framing of the lines. Adding metrics (such as the dashed lines, below) can help disperse the illusion. However, even when the illusion is revealed, it can be difficult to overcome. Modern advertising is built, in part, on the realization that such framing is a powerful way to manipulate perception.



Behaviorists Claim Investor Decisions Often not Rational

Advocates of behavioral finance contend that 'normal' decision making may not be 'rational.' [These two terms have a technical meaning throughout what follows, so it would be well to take note of them.] They point to numerous examples of "bounded rationality." Loosely speaking, bounded rationality means that people pursue rational methods to arrive at solutions under conditions of risk or uncertainty, but only to a limited extent. For example, a human in a dark room asked to gauge the diameter of an illuminated disk, but with no information about its relative distance, nevertheless tends to arrive at a conviction about the correct answer. Whether or not the data really suffice, the human brain seems hardwired to suggest solutions to problems it encounters. One possible explanation is that confidence in some solution or other, never mind how erroneous, provides an evolutionary advantage. After all, a wholly paralyzing uncertainty makes meaningful action impossible. Better to err somehow, use the degree of error to calibrate subsequent behavior, and thus cobble together an appropriate response than to remain befuddled and end up as dinner for a predator.

Overconfidence is a cognitive error manifest in a variety of situations. One study demonstrated that when stock analysts say that they are 80% sure that the price of a given stock will exceed a particular value, they are correct less than 60% of the time. In virtually all opinion surveys, most respondents believe they are above average drivers. Another somewhat alarming study found that when doctors are 90% confident in a diagnosis of pneumonia, their accuracy is less than 50%. A corollary finding indicates that once an investment forecast is reached, the decision maker exhibits a propensity to discount or ignore evidence that suggests a contrary point of view. This is known as the "often wrong but never in doubt" syndrome.

Developments in Behavioral Finance

Behavioral finance has developed in several directions. Psychological research has been used to:

1) Reexamine classic models of decision making based on game theory, on stochastic processes and on statistical distributions;
2) Evaluate the likelihood and impact of cognitive errors made by market analysts and participants;
3) Challenge models of asset price forecasting such as the well known Capital Asset Pricing model; and,
4) Call into doubt a central tenet of modern portfolio theory—namely, the efficient market hypothesis.

The stakes of this admittedly arcane debate are huge. If cognitive flaws are prevalent, systematic, and exploitable, their understanding could inform market-beating money management systems. Money managers who avoid overconfidence and other cognitive errors discussed below would enjoy a tremendous competitive advantage.

Assumptions of the Standard Models

The standard finance investor is *rational*; the behavioral finance investor is *normal*. The standard model incorporates the findings of modern portfolio theory developed by Nobel Prize winners Harry Markowitz, William Sharpe, Merton Miller, Myron Scholes, Robert Merton, and other leading economists. The standard model's investor operates in a world where each market agent:

- Has full access to relevant information;
- Has homogeneous expectations regarding expected return and risk;
- Is risk averse (prefers a sure outcome to an uncertain outcome given equal expected return); and,

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...from a probabilistic point of view, the best strategy is asset diversification, rather than asset concentration.

- Seeks to maximize his utility function for wealth accumulation (achieve the greatest amount of wealth for any given level of risk).

Conclusions from the Standard Model

In such a world, the investor is primarily concerned to build a portfolio that optimizes risk-adjusted expected wealth accumulation out to the planning horizon. Under conditions of uncertainty, placing large bets on any one prediction is dangerous. Thus from a probabilistic point of view, the best strategy is asset diversification, rather than asset concentration.

Sharpe was interested in how a Markowitz mean-variance optimizing investor behaves in the marketplace under conditions of equilibrium (i.e., there is no novel datum and all market transactions clear). Following the assumptions made by Markowitz, Sharpe concludes that, on a risk-adjusted basis, arbitrage assures that all assets have the same price per unit of expected return. If any asset has relatively low risk and relatively high expected returns, arbitrageurs will buy it in large quantities, thus quickly driving up the price to the point where risk and return reach equilibrium. T-Bills paying higher than the risk-free rate will not last long! The only way to achieve a higher expected return than that of the market as a whole is to assume greater risk (*beta*). Likewise, Sharpe posits that, in equilibrium, the portfolio that maximizes return per unit of risk (i.e., the most efficient portfolio) is the market portfolio, wherein positions in each asset are weighted according to their aggregate weighting vis a vis the market as a whole. The resulting Sharpe Capital Asset Pricing Model forms the underlying intellectual rationale for indexed investing.

Behaviorists Question Standard Model

Advocates of behavioral finance question the reasonableness of the Sharpe/Markowitz assumptions. They contrast the standard model's wholly rational decision making with a series of counterexamples taken from psychology. The major points of difference:

Asset Integration: the standard model assumes that the investor makes decisions in terms of their effects on the whole portfolio. The decision to buy or sell depends on an evaluation of the impact on the risk and return of the investor's aggregate investment position – i.e., on the likelihood that it will contribute to or diminish terminal wealth at a given level of risk. The behavioral model, on the other hand, assumes that the investor segregates the outcomes of decisions regarding risk and uncertainty so that they are evaluated in isolation. Investment choices are evaluated in terms of the probability of a more immediate gain or a loss. The standard investor looks for investments with offsetting return patterns that can be combined into an efficient portfolio. The behavioral investor looks at investments to determine which ones have the highest expected payoffs (highest positive changes or lowest negative changes in wealth) over the near term. The classic investor seeks a portfolio where investments have differing patterns of returns; the behavioral finance investor bundles assets with promising returns into a portfolio.

Mental Accounting: one possible explanation for the propensity of the investor to think in terms of asset segregation rather than asset integration is the phenomenon of mental accounting. Tversky offers an interesting example of mental accounting:

When asked the question: "Imagine that you have paid $50 for a theater ticket. When you get to the theater you discover that you have lost the ticket and it cannot be recovered. Would you pay $50 for another ticket?" When asked this question, 46% of respondents said that they would buy a replacement ticket.

When asked the question: Imagine that you have decided to see a play that costs $50 per ticket. As you arrive at the theater, you discover that you have lost a $50 bill. Would you pay $50 to buy a ticket to see the play? When asked the question in this manner, 88% of respondents said that they would buy a ticket.

What accounts for the difference in responses? Evidence suggests that the "lost ticket" group has a mental account labeled "theater entertainment." When they discover that this account has suffered a decline of $50, they are reluctant to see it decrease by an additional $50. The account is, therefore, closed. The people who lost $50, however, have not assigned the money to any particular account. Therefore, spending an extra $50 simply means that one or more unspecified accounts (gifts, lunches, movies, etc.) will have to be trimmed back. It is easier to spend an extra $50 when the expenditure is assigned to "general accounts."

Specifically, if people maintain separate "mental accounts" for their goals and objectives, they no longer treat money as a fungible commodity that can be managed to optimize

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the total portfolio. Rather, goals and the assets earmarked for their successful attainment are segregated. Much of the financial planning industry is built on the behavioral finance model — the investor has a pyramid of goals and the crucial objectives (at the base of the pyramid) are funded with "safe" low-return/ low-variance assets. Equity positions are not added to the portfolio until there is sufficient funding to meet more critical financial objectives. Equity is merely an asset that gives you a shot at being rich and is to be owned only after more important matters have been funded with bonds, CDs and passbook savings accounts.

Reference Dependence: this is another possible explanation for the propensity to segregate decisions regarding purchase and sale of assets. The classic model of decision making assumes that the investor considers only the probable (risk-adjusted) outcome on terminal wealth — is it more or less likely that expected value will increase or decrease if I make such and such a choice? The behavioral finance model assumes that people make asset management selections based on their current point of reference. The decision making process can therefore be manipulated simply by changing the decision maker's point of reference. In situations where people weigh the possibility of a possible gain or loss by undertaking a risky investment, they become risk averse; in situations where people weigh the consequences of a sure loss against the chance of either a larger or smaller loss, they become risk seeking. That is to say, they are often willing to gamble on achieving the small loss and avoiding the catastrophic loss rather than locking in the mid-sized loss even when the comparative expected value of the gamble is not favorable. This cognitive error is offered as the explanation for investor reluctance to sell a losing stock.

Biased Expectations: the classic model assumes that investors are accurate and unbiased forecasters (e.g., Markowitz assumes that all investors share the same parameter values with respect to an asset's expected return, variance, and covariance; and, additionally, that investor expectations reflect all relevant information). Behavioral research, on the other hand, indicates a propensity for unjustified overconfidence in one's forecasts made under conditions of uncertainty.

Risk Aversion: the classic model assumes that investors always prefer a sure outcome to an uncertain outcome given equal expected returns. The behavioral model, however, posits that investors are risk seeking when losses are involved — i.e., people would rather take a gamble between a small and a large loss rather than lock in a medium-sized loss. For example, anecdotal evidence suggests that, when investing other people's money, fiduciaries manifest a degree of loss aversion not operative in their decisions about their personal portfolios. Some behavioral finance advocates therefore advance the proposition that there is an endemic 'agency friction' problem. Investment committees become so loss averse that they insist on an unwarranted conservatism that forces managers to build sub-optimal portfolios. The loss aversion problem is exacerbated because of the term limits on committee service. Fiduciary committee members have a reputational concern ("the portfolio flourished under my tenure"), which is reflected in their demand for frequent performance reviews that often decompose the portfolio into an investment-by-investment examination. Such an approach is the antithesis of that recommended by modern portfolio theory.

Behaviorists Cite 'Irrational' Investor Conduct

Behavioral finance advocates offer examples of 'normal' (as opposed to 'rational') investor behavior:

Preference for Cash Dividends: Investor preference for dividends (and abhorrence of reductions in dividends) is not adequately explained under standard finance theory. Under the current tax code, investors should prefer capital gains to dividends; but they don't. This phenomenon can be explained in terms of "framing" or mental accounts. Investors segregate cash dividends into a spending account and capital gains into a principal account. Conventional wisdom reinforces the maxim that one is allowed to harvest the fruit; but the branches are cut at peril. The inclination to segregate investment returns into mental accounts is the consequence of imperfect self-control. Investors struggle against the temptation to spend more than their portfolio can support (the temptation to cut branches). Because they are seen as return on principal rather than a return of principal, dividends allow the investor to harvest fruit without damaging the tree.

Disposition to hold losers too long: this tendency is sometimes explained by reference to the concept of "regret." Selling a loser entails marking mental accounts to market, "booking" a painful reduction in wealth. Worse, it is tantamount to taking responsibil-

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The behavioral finance model assumes that people make asset management selections based on their current point of reference. The decision making process can therefore be manipulated simply by changing the decision maker's point of reference.

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Everyone remembers the attractiveness of "new paradigm" stocks. Unfortunately, "new paradigm" meant conglomerates in the 1960s; hard-asset stocks like gold and oil companies in the 1970s; Japanese stocks in the 1980s; and tech in the 1990s. There seem not to be any "new paradigm" stocks in the 2000s — perhaps the market is looking for leadership.

ity for the loss. Holding preserves the chance for a rebound and the avoidance of regret. Regret comes with the realization that different choices would have generated better results. Regret is often worsened by hindsight bias: the belief that unpredictable events were, in fact, inevitable and should have been foreseen. Hindsight bias fosters the illusion that the market is predictable and that losses are due to inexcusable errors in forecasting. Finally, it is interesting to note the interplay between regret and overconfidence. Perhaps incurring regret by realizing a current loss on sale is unwise because your prediction was not, in fact, actually wrong — it was merely premature. Hold on to the stock long enough and when things change you will be proven right — just as you knew all along!

Preference for Stocks of Good Companies: Everyone remembers the attractiveness of "new paradigm" stocks. Unfortunately, "new paradigm" meant conglomerates in the 1960s; hard-asset stocks like gold and oil companies in the 1970s; Japanese stocks in the 1980s; and tech in the 1990s. There seem not to be any "new paradigm" stocks in the . The preference of the 'normal' investor for stocks of good companies reflects "value-expressive preferences." Such preferences are easy to see in the marketplace. A good example is the contrast between Timex and Rolex watches. In a strict utilitarian, value-maximizing world, consumers would recognize that Rolex watches are overpriced. Demand for them remains strong, however, not because they work better than Timex watches, but rather because they express the values of a coveted lifestyle. Growth stocks are like Rolex watches and value stocks are like Timex watches. Both utilitarian and value-expressive forces drive market prices. Under the behavioral finance market model, the stock market will exhibit Rolex "bubbles" from time to time as investor overreactions drive growth stock prices to unsustainable levels. Investors will then overreact to past overreactions, and the bubble will burst. Conversely, the wise market observer will spot Timex "buying opportunities" as investors start paying attention to "market fundamentals." In behavioral finance, asset prices reflect both rational and non-rational investor preferences.

Behaviorists Identify Two Types of Investors

Ultimately, then, behavioral finance argues that capital markets are driven by two kinds of investors:

1) Information traders: these are Markowitz standard model investors, free of cognitive error; and,

2) Noise traders: these are normal investors who incorporate value-expressive judgments into the security selection decision.

The fundamental argument of behavioral finance is that noise traders are important enough that at the margin they can sway markets, tugging prices away from their equilibria.

Money Managers Adopt Behaviorists' Insights

It is perhaps not surprising that the insights and vocabulary of behavioral finance have been readily absorbed by large segments of the US money management industry. It seems to have found a welcome home among market timers and tactical asset allocators. Behavioral finance advocates claim to have discovered market anomalies, where extreme price volatility indicates investor irrationality ("the cognitive error of overreaction"). From this it is but a short step to the argument that stock prices reflect fads, trends and mob psychology. Financial markets are then no longer viewed as rational, and when investment gurus read the barometer of market sentiment they can seem credible.

One such guru, George Soros, argued that the critical determinant of investment success was a mystical quality he called "reflexivity," meaning sensitivity and responsiveness to emerging trends. His book was published shortly before he issued a public apology for losing billions of dollars of investor money betting wrong on the ruble.

A Recent Behaviorist Prediction

The February 11, 2001 Sunday edition of the *New York Times* opines that:

"If the behaviorists are correct, shares of companies on the New York Stock Exchange are overvalued and the Dow Jones industrial average has further to fall. And if the behaviorists prevail, the mainstream view of a rational, self-regulating economy may well be amended and policies adopted to control irrational, sometimes destructive behavior."

Response from Efficient Market Proponents

Behavioral finance, it seems, may yet be the savior of active management, whether of portfolios by fund managers or of the economy by central planners. But the voices of the economists who founded the efficient market

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hypothesis have not been silent in the face of this onslaught at the foundations of their theory. They argue that there is always a danger in applying the insights of one science (psychology) to the subject matter of another (economics). Although the principles of behavioral finance sound plausible enough, they often amount to little more than an argument by analogy. Advocates of the standard finance model have had an easy time poking holes in some arguments proposed by behavioral finance.

Fama Raises the Bar for Behaviorists

This brings us to a 1998 Journal of Financial Economics article ("Market efficiency, long-term returns, and behavioral finance") by University of Chicago Professor Eugene Fama, who first coined the phrase "efficient market hypothesis" in the 1970s. When Fama first developed the efficient market hypothesis he freely acknowledged that analysts with superior skill could achieve abnormal profits. He argued that this would be difficult, however, because the current price of each security reflects all currently available information. Price change is a function of new (i.e., future) information, which is by definition unknowable. Likewise, Fama freely acknowledged that market sentiment could result in either overreactions ("irrational exuberance") or underreactions to news. He argued, however, that it would be impossible to predict the direction and magnitude of such reactions ahead of time, and that therefore there is no way to exploit them to make an abnormal profit.

Fama's new research explores the range of anomaly literature in great detail. He points out that some behavioral finance advocates chronicle market overreactions followed by market reversals, while others chronicle market underreactions (prices react slowly to news and therefore the investor has an opportunity to make an abnormal profit by exploiting the stock's momentum). After an exhaustive review, Fama concludes that the anomalies "split randomly between underreaction and overreaction." This is consistent with market efficiency because "in an efficient market apparent underreaction will be about as frequent as overreaction." Fama reminds behavioral finance researchers that "market efficiency [qua hypothesis] can only be replaced by a better specific model of price formation, itself potentially rejectable by empirical tests." He concludes that behavioral finance has a daunting task:

"It must specify biases in information processing that cause the same investors to under-react to some types of events and over-react to others. The alternative must also explain the range of observed results better than the simple market efficiency story; that is, the expected value of abnormal returns is zero, but chance generates deviations from zero (anomalies) in both directions."

Synthesizing Behavioral and Standard Models

New research seeks insight in a synthesis of the behavioral and standard finance models. Andrew Lo at MIT's Laboratory for Financial Engineering, for example, has been at the forefront of such research. Researchers like Lo ["The Three P's of Total Risk Management" Financial Analysts Journal (January/February, 1999)] believe that the attempt to apply findings from psychology to economics will contribute to greater understanding of standard models of market behavior. If the program is successful, future market models will explicitly incorporate prices, probabilities, and preferences. But as Lo points out, the basic supply/demand models dating back to Smith and Ricardo in the 18th century already incorporated these elements *implicitly*. Behavioral research findings are thus not really new, because demand curves have always represented the preferences of consumers for quantities demanded at various prices.

Lo asks:

- What kinds of risk preferences yield evolutionary advantages?
- As evolutionary pressures change over time with changes in the nature of economic interactions, will this influence future risk preferences?
- Does risk preference have a biological component, as addiction, sexual preferences, and other behavioral attributes seem to?
- How do people learn from their own experiences and from interactions with others in economic contexts?

One popular, albeit insupportable, viewpoint is that asset prices are driven far from their "true" equilibria by subjective, inconsistent probability assessments. Lo acknowledges the contributions of behavioral finance to our understanding of subjective probability. Objective probability is readily verifiable. [The odds of rolling a six on a single throw of a fair die are one in six; and, if anyone contends that the odds are

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...(efficient market proponents) have not been silent in the face of this onslaught at the foundations of their theory. They argue that there is always a danger in applying the insights of one science (psychology) to the subject matter of another (economics). Although the principles of behavioral finance sound plausible enough, they often amount to little more than an argument by analogy.

Lo's research points away from the conclusion that market volatility is driven by irrational factors. The likely explanation lies not with a propensity to make fundamental and fatal cognitive errors (the fear and madness of crowds), but with relatively small flaws in human judgment.

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one in seven, start the game immediately because you have a wonderful risk-free arbitrage opportunity!] Subjective probability, by contrast, is the assigning of odds to events that cannot be measured or empirically verified. One example is the odds for the existence of life on other planets. These odds measure merely the degree of belief in, rather than the relative frequency of an event. But even subjective probabilities are constrained by the laws of probability, and therefore prices derived from subjective probability assessments will not be inconsistent. The reason is arbitrage:

"To see why, consider an individual who attaches a probability of 50 percent to an event H and 75 percent to its [mutually exclusive] complement H^c [i.e. the likelihood that event H does not happen].... Such subjective probabilities imply that such an individual would be willing to take a bet at even odds that H occurs and, at the same time, would also be billing to take a bet at 3:1 odds that H^c occurs. Someone taking the other side of these two bets–placing $50 on the first bet and $25 on the second–would have a total stake of $75 but be assured of winning $100 regardless of the outcome, yielding a riskless profit of $25–an arbitrage!"

Market participants who are out of step in their probability assessments are easy pickings for seasoned traders. In the market, as in poker, those who pursue suboptimal betting strategies, unless lucky, quickly leave the game.

Lo's research points away from the conclusion that market volatility is driven by irrational factors. The likely explanation lies not with a propensity to make fundamental and fatal cognitive errors (the fear and madness of crowds), but with relatively small flaws in human judgment. Drawing on the work of sociologist Charles Perrow, Lo argues that "certain catastrophes are unavoidable consequences of systems that are simply too complex and too unforgiving." Perrow, discussing the disaster at the nuclear reactor at Three Mile Island, pointed to two sources of complexity in a system:

Interactive complexity occurs in systems of many parts, in which each component can interact with and influence the performance of many other components. The complexity of the interactions lead to system-wide results that could not have been predicted by looking at the probable range of outcomes for any part of the system. In mathematical terms, the system is non-linear.

Tight Coupling complexity occurs in systems where the performance of any part in a sequence of components depends on the reliability of preceding components. The probability that the system will fail is the sum of the probabilities that any one of the coupled components will fail.

In systems that exhibit a sufficient degree of complexity, accidents are expected rather than flukes. In terms of behavioral and standard finance, asset pricing is the result of rational rather than normal investors. The reason is not that normal investors don't count; rather, the reason lies in the system: "accidents are normal in industrial systems so complex and nonlinear that small and unpredictable errors in human judgment can often cascade quickly and inexorably into major catastrophes." Recognizing that even fully deterministic nonlinear equations can exhibit extraordinarily complex behaviors [see our companion article, "Predictability and Mathematics" beginning on page 8], Lo points to the integration of behavioral finance with the mathematics of nonlinear dynamical systems as a particularly promising avenue of investigation. Such an integration means understanding consumer preferences and modeling them "in a framework that enables individuals and institutions to manage their respective risks systematically and successfully."

Inconsistent Behavior is not Irrational Behavior

In conclusion, we point out that, not only is inconsistent behavior not the same as irrational behavior, it is *characteristic* of optimal decision making in the face of conditional probabilities or non-linear combinations of random variables. Mathematicians have long known that, for most processes, the common conclusion of each sub-population does not translate into a verifiable conclusion for the aggregated data. In terms of financial economics, a diversified portfolio behaves differently than the summed behavior of its component investments; in terms of capital market models, varied sub-populations of individual preferences, risk-tolerances, and reference framing, do not constitute evidence of market irrationality.

Under the efficient market hypothesis, the information processing capability of the market does not depend on either the perfect accuracy or the perfect rationality of every participant, or indeed of any participant. Rather, the market succeeds robustly under the likely assumption that all traders are somewhat irrational and inaccurate (i.e., humanly finite and

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fallible). In order for the market as a whole to process new data and price securities properly, all that is required is that a few traders (in the limit, just one will suffice) be more rational and accurate than not. Any argument that there are not even a few such traders will have a hard time explaining how our species survived the Paleolithic Age. At any moment, the most rational and accurate traders will be the most successful arbitrageurs; but this is just to say that they will be the most successful at driving market prices to their "true" values.

Markets as Computational Systems

Capital markets are superb examples of massively parallel distributed computational systems, where many thousands of cheap, error-prone processors work on the same problem simultaneously and their outputs are fed back as data and refined over some large but finite number of iterations. This process cannot be instantaneous, if only because any process must by definition take some time to occur. It cannot be perfectly accurate, because in a constantly changing world, the data of any computation, because they refer to a past state of affairs, are no longer perfectly true. Thus the dictum "garbage in, garbage out" applies to markets a fortiori. Nevertheless, distributed computational systems can be very fast and accurate indeed; that's how our brains manage to coordinate hitting a ball with a bat. Even when all traders err to some degree, the volume of transactions and the velocity of information about those transactions ensure that errors will quickly cancel each other out across the market as a whole. Thus there is plenty of room for individuals to commit all the intellectual errors discovered by behavioral finance, in the context of a market that quickly compensates for such errors by netting them against each other. It is this rapid, precise compensation which makes the markets efficient.

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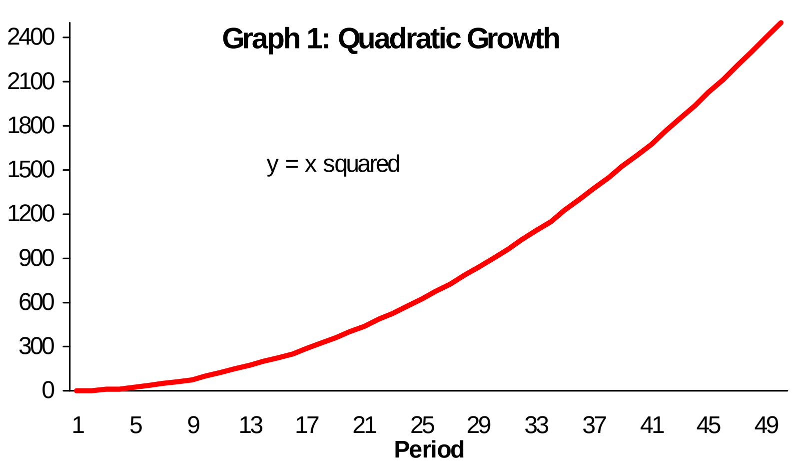
PREDICTABILITY AND MATHEMATICS

Even if this world were governed by set-in-stone equations, predictability is elusive. Consider the implications of the following set of equations. Graph one depicts a well-behaved growth curve that maps the quadratic function—each y-axis value is simply the square of each x-axis value. We know the equation responsible for generating values [$y = x^2$] and can predict with absolute certainty the y values for any portion of the x-axis time line. The equation provides perfect predictability.



Graph two depicts a second equation that also appears to provide complete predictability. This equation (technically an ordinary differential equation that maps a logistical growth curve) is often used in the science of ecology. Nevertheless, it has properties that make it very interesting for the investor as well. In terms of ecology, the equation [$p_{n+1} = p_n(a - b_{pn})$] says that the population of elk in the next period depends on the population of elk in the current period increased by a growth factor (a) and decreased by a subtraction factor (b) which, in this example, is the number of wolves. The model has certain affinities with a retirement account in that the investor expects to achieve a rate of growth but also expects to thin the herd (subtract dollars) by making periodic distributions.

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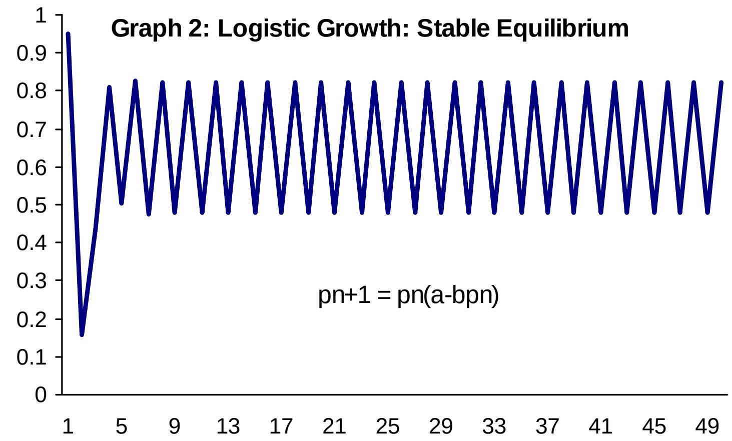
PREDICTABILITY AND MATHEMATICS



The logistical curve exhibits exactly what we would expect from any dynamic system governed by a deterministic equation — i.e., if we know the current values of the system we can predict future values. In this case, the investor-ecologist does not worry about a dip in the value of the elk population because he knows that elk and wolf populations are cyclical and that bad elk (portfolio) years will be offset by good elk (portfolio) years.

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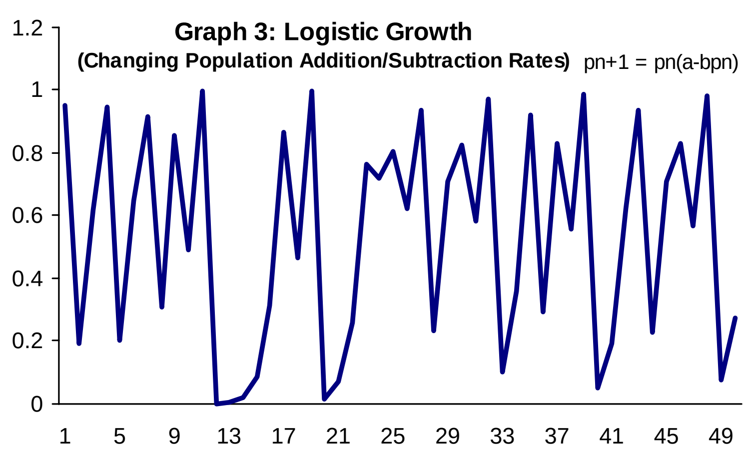
Implications of Changing Constants

The third graph depicts the same fully determined equation. The only difference is that the values for the constant terms a and b have been altered. You would expect that in a fully determined world merely altering the value of a constant would not destroy predictability. After all, a constant is exactly that — a constant. Whereas graph two promises a safe, predictable, money management formula, graph three (below) indicates that such a goal may be elusive.



Small Incremental Changes Have Large Cumulative Effects

The final graph (on page 10) confirms our new intuition regarding predictability (or lack thereof) even within a simple, fully determined world governed by equations. This graph depicts an overlay of the equation mapped in graph 3 (blue line) with a new equation (red line) that makes a "one-in-a-million" change in the value of the initial elk population (portfolio value). An increase in the wolf population is, of course, analogous either to a slight increase in the distribution rate, or to a slight decrease in initial portfolio value. The slightest change in the initial values of the portfolio, the distributions, or expenses appears, at first, not to have any impact on the map of the value curve. This fact holds true for the first eleven time periods. The convergence, however, explodes at period twelve and, thereafter, knowledge of the trajectory of graph 3 provides no information regarding the trajectory of graph 4. The past (track record) seems to have no predictive value.

Sensitivity to initial conditions (portfolio values, money management costs, portfolio management strategies, and distribution requirements) implies that specific long-term forecasts of the state of the system are impossible to make even though the system is thoroughly governed by an underlying equation which has no random terms.

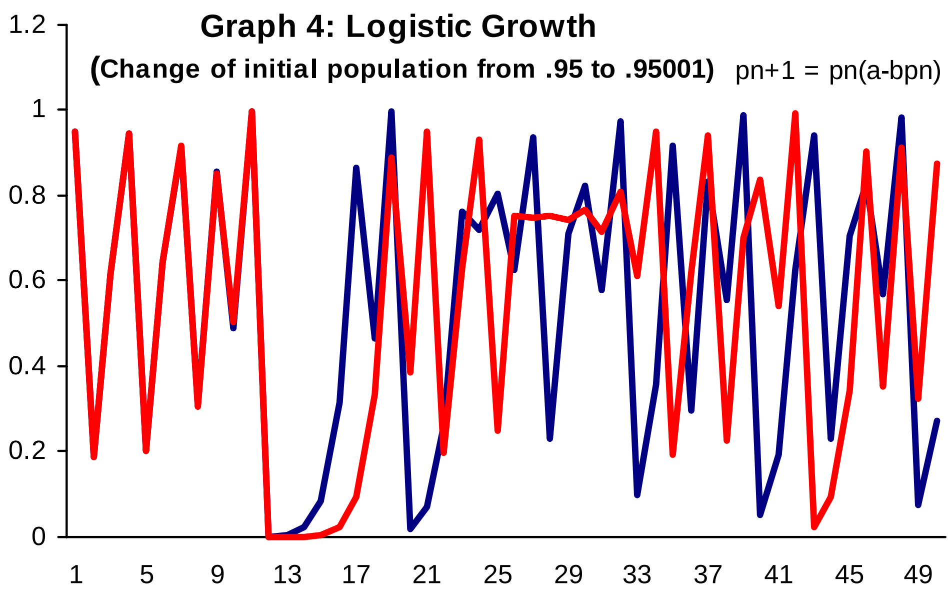
Deterministic Models Break Down as Variables Become Uncertain

If we move from a fully determined world (a world of constant values for a and b) to a world where a and b are allowed to become random variables, we must abandon all hope of developing and using specific, point-estimate forecasts. The mathematics tells us that we cannot use a deterministic model. Rather, we need a probabilistic model that reveals the likelihood of particular future outcomes.

(Continued on page 10)

PREDICTABILITY AND MATHEMATICS

(Continued from page 9)



Uncertainty undermines our ability to decide. Attaching probabilities to future events, however, changes the vague notion of uncertainty into identifiable and measurable risk. Not only is risk measurable, it can often be managed in a way that increases the chances of favorable future outcomes.

A probabilistic model should be able to illustrate:

- The likelihood of a bad outcome;
- The magnitude of the damage; and,
- The costs, if any, of reducing the likelihood of a bad outcome.

Trivially, we make risk assessments constantly in our daily lives. For example, an evaluation of the consequences of driving a car indicates that there is a small likelihood of a bad accident on any trip. The magnitude of such an outcome could be severe in that the accident might be fatal. The strategy that will minimize the likelihood of an occurrence of this worst-case outcome is the decision never to ride in a car (the "minimize the minimum" or "min/min" strategy). The opportunity costs of pursuing such a strategy, however, may be unacceptably high in that the consequence is to remain homebound.

Modeling Uncertain Outcomes

Modeling the range of possible outcomes for an investment portfolio, however, is not a trivial undertaking.

A mathematical expression for such a model takes the form of a stochastic differential equation for which there is no closed form (analytical) solution. This means that we must utilize numerical techniques such as simulation analysis. Fortunately, such tasks are tractable to computer analysis. Since World War II, scientists have modeled and studied likely outcomes under conditions of uncertainty by means of simulation analysis. Modeling the behavior of a single independent random variable is easy. Simply determine its past behavior: i.e., what is the average past result and, from period-to-period, how far has it deviated from the average. Assuming that you have a representative sample, this information gives valuable insight into the range of possible future behavior. For investment portfolios, however, there are several variables to consider. Uncertain variables include life expectancy, investment return, and inflation rates. While the behavior of each variable is of interest, success is determined by the complex interaction of all the variables. A successful outcome depends on the interactions between each investment in the portfolio as well as the impact of inflationary environments. Tens of thousands of calculations must be made to get good data upon which to base a decision. If the model either ignores or freezes the value of any variable, it yields data that leads to a spurious conclusion. This is the type of system that Lo categorized as manifesting interactive complexity.

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SURVEY OF INDICES & FUND AVERAGES
PERIOD AND ANNUAL COMPOUND RETURNS

	Quarter Ending 3/31/01	Trailing Twelve Month Period	5 Years Ending 3/31/01	10 Years Ending 3/31/01
Inflation Index & Risk Free Rate				
Consumer Price Index	1.03%	2.69%	2.46%	2.68%
U.S. 3 Month Treasury Bills	1.29	6.15	5.36	4.91
U.S. Stock Market (Large Companies)				
Standard & Poor's 500 Stock Index	-11.85	-21.67	14.18	14.41
Barra Large Cap Growth Stock Index	-17.41	-38.19	13.74	13.63
Barra Large Cap Value Stock Index	-6.53	-1.07	13.82	14.72
Average Large Cap Blend Fund ‡	-13.01	-21.11	11.75	12.50
U.S. Stock Market (Small Companies)				
Russell 2000 Stock Index	-6.50	-15.33	7.76	11.81
DFA 9-10 Small Company Stock Fund	0.73	-19.82	9.67	14.63
Russell 2000 Growth Stock Index	-15.21	-39.82	2.51	8.03
Russell 2000 Value Stock Index	0.97	19.44	11.85	14.81
Average Small Cap Blend Fund ‡	-4.94	-0.73	10.81	13.01
Fixed Income (Bond) Markets				
Lehman Government Bond Index	2.52	12.33	7.51	7.95
Average Intermediate Gov't Bond Fund	2.41	11.26	6.41	6.96
Lehman Municipal Bond Index	2.23	10.93	6.57	7.32
Avg. California Intermediate Muni Bond Fund ‡	1.79	9.26	5.59	6.59
CSFB Global High Yield Bond Index	4.93	0.76	5.07	9.85
Average High Yield Bond Fund ‡	3.82	-3.68	3.67	8.92
Salomon Br. Non-Dollar World Gov't Bonds	-9.10	-10.46	0.06	6.22
Average International Bond Fund ‡	-0.67	1.90	3.78	5.14
International Stocks				
MSCI EAFE Foreign Stock Index	-13.73	-25.88	3.43	5.90
Average Foreign Stock Fund ‡	-14.31	-28.67	5.47	7.23
MSCI Europe Stock Index	-15.53	-22.68	10.75	11.07
MSCI Pacific Stock Index	-9.23	-32.32	-6.20	-0.33
MSCI Emerging Markets Free Index	-5.62	-36.82	-7.01	1.71
Average Emerging Markets Fund ‡	-6.72	-37.84	-4.96	0.19

‡ Source: Morningstar Principia 3/31/01

WORLD MARKET SURVEY

(Continued from page 1)

stocks, or, for broader diversification, to funds tracking the S&P 500 or NASDAQ 100 indices. One could then simply sit back, fend off headhunters and harvest capital gains.

Shifting Conventional Wisdom

This has been a tough year for investors who bought the conventional wisdom in December 1999. Most equity markets turned south in March of 2000, and have not looked back. The chart on the first page, which shows the results for most major asset classes since the beginning of the rout a little more than four quarters ago, is strong coffee indeed. The conventional wisdom has shifted again, as it seems to have a habit of doing, and has realized that risk is eternal and ubiquitous. The temptation for the last year has been to pull out of the markets entirely, just as in 1999 the obvious smart move was to load up on NASDAQ.

Either move is equally imprudent, of course. At the risk of sounding to our regular readers (and especially our clients) like a broken record, we cannot resist the temptation to use the last 24 months of market history as an object lesson in the sources of investment success. Success doesn't come from assuming no risk – that strategy eliminates real after-tax return. Success doesn't come from chasing returns and buying the asset (or asset class) that has been performing well lately – that strategy leads to runaway risk, as those who focused their portfolios on tech stocks have been so painfully reminded.

Investment success comes from assuming and controlling risk by means of careful, thorough, effective diversification. Good diversification enables the portfolio to hold a basket of extremely volatile assets, which owned in isolation would be extremely risky, but which in combination are less volatile even than most broad market indices. The result of such diversification is a reduction in variance drain, the tax on portfolio returns imposed by volatility.

The retreat in equity markets worldwide over the last 3 months was broad and relentless. Essentially all asset classes were down substantially, with the exception of fixed income securities and small cap value stocks. Large cap value has also proven its usefulness over the last 12 months; though the category is down so far this year.

On the international equity side, stocks were down in all but five of the 34 world markets we survey. Only Taiwan was up significantly. However, international investing is not dead. Over the last quarter, 24 of 34 world markets outperformed the Dow Jones US Stock Index. That means that owning a basket of internationally diversified equities damped portfolio volatility, reducing variance drain. And reducing variance drain is the key to long-term wealth accumulation.

Can Value 'Evaporate'?

We close with a word about where the money has gone. The popular press likes to characterize the size of market corrections in terms of the change in the overall market capitalization of the stock market. Thus we hear such things as "With the downturn in US equity markets, over $1 trillion has evaporated from the US economy." That's pretty scary; and sells a lot of papers, but it's wrong.

The first thing to understand is that a company's market capitalization (e.g. IBM) is calculated by multiplying the current stock price by the number of shares outstanding. The price is determined by the most recent transaction in the stock. However, that price reflects investor's cost for just a marginal few shares of IBM. When IBM has been bid up, most of the owners bought their shares at a much lower price. Thus the amount that all current owners actually invested in IBM shares is much lower than IBM's current stock market cap. Capitalization, for a company or for a stock market, is simply a point-in-time estimate of discounted future value expected by investors.

When IBM shares drop in price after a sustained period of increases, only those who bought their shares most recently actually lost money. But their money did not evaporate; it had already been transferred to the selling traders on the other side of the transaction when they bought IBM. It is no longer invested in IBM shares, but in other assets, either real or financial. Thus, although it is true that market corrections do reflect investors' changing assessments of future profitability, they do not mean that real value has disappeared from the economy. At most, stock market corrections mean that the growth in the overall value of the economy is likely to slow. But it takes a hurricane, a war, a riot, an earthquake, a firestorm, or something similar to make that value evaporate. .

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