Reconciling Efficient Markets with Behavioral Finance: The Adaptive Markets Hypothesis*

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Abstract

The battle between proponents of the Efficient Markets Hypothesis and champions of behavioral finance has never been more pitched, and there is little consensus as to which side is winning or what the implications are for investment management and consulting. In this article, I review the case for and against the Efficient Markets Hypothesis, and describe a new framework—the Adaptive Markets Hypothesis—in which the traditional models of modern financial economics can co-exist alongside behavioral models in an intellectually consistent manner. Based on evolutionary principles, the Adaptive Markets Hypothesis implies that the degree of market efficiency is related to environmental factors characterizing market ecology such as the number of competitors in the market, the magnitude of profit opportunities available, and the adaptability of the market participants. Many of the examples that behavioralists cite as violations of rationality that are inconsistent with market efficiency—loss aversion, overconfidence, overreaction, mental accounting, and other behavioral biases—are, in fact, consistent with an evolutionary model of individuals adapting to a changing environment via simple heuristics. Despite the qualitative nature of this new paradigm, I show that the Adaptive Markets Hypothesis yields a number of surprisingly concrete applications for both investment managers and consultants.

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1 Introduction

Much of modern investment theory and practice is predicated on the Efficient Markets Hypothesis (EMH), the notion that markets fully, accurately, and instantaneously incorporate all available information into market prices. Underlying this far-reaching idea is the assumption that market participants are rational economic beings, always acting in their own self-interest and making decisions in an optimal fashion by trading off costs and benefits weighted by the statistically correct probabilities and marginal utilities. These assumptions of rationality, and their corresponding implications for market efficiency, have come under attack recently from a number of quarters. In particular, psychologists and experimental economists have documented a number of departures from market rationality in the form of specific behavioral biases that are apparently ubiquitous to human decision-making under uncertainty, several of which lead to undesirable outcomes for an individual's economic welfare.

While there is little doubt that humans do exhibit certain behavioral idiosyncrasies from time to time, there is still no clear consensus as to what this means for investment management. Although a number of alternatives have been proposed, no single theory has managed to supplant the EMH in either academic or industry forums. This state of affairs is partly due to the enormous impact that modern financial economics has had on theory and practice over the last half century. It is difficult to overturn an orthodoxy that has yielded such insights as portfolio optimization, the Capital Asset Pricing Model, the Arbitrage Pricing Theory, the Cox-Ingersoll-Ross theory of the term structure of interest rates, and the Black-Scholes/Merton option pricing model, all of which are predicated on the EMH in one way or another. Although behavioral versions of utility theory (Kahneman and Tversky, 1979), portfolio theory (Shefrin and Statman, 2000), the Capital Asset Pricing Model (Merton, 1987; Shefrin and Statman, 1994), and the Life Cycle Hypothesis (Shefrin and Thaler, 1988) have been advanced, these models have yet to achieve the kind of general acceptance among behavioralists and practitioners that the EMH enjoys among its disciples.

But another reason for the fragmentary nature of behavioral finance is the dearth of fundamental axioms from which all behavioral anomalies can be generated. For example, while Kahneman and Tversky's (1979) prospect theory can generate behavior consistent with loss aversion (see Section 2), their framework cannot generate overconfidence and regret at the same time. The behavioral literature is sometimes criticized by EMH proponents as primarily observational, an intriguing collection of counterexamples without any unifying principles to explain their origins. To a large extent, this criticism is a reflection of the differences between economics and psychology (see Rabin, 1998, 2002 for a detailed comparison). The field of psychology has its roots in empirical observation, controlled experimentation, and clinical applications. From the psychological perspective, behavior is often the main object of study, and only after carefully controlled experimental measurements do psychologists attempt to make inferences about the origins of such behavior. In contrast, economists typically derive behavior axiomatically from simple principles such as expected utility maximization, resulting in sharp predictions of economic behavior that are routinely refuted empirically.

In this article, I describe a new paradigm that reconciles the EMH with behavioral biases in a consistent and intellectually satisfying manner, and then provide several applications of this new paradigm to some of the more practical aspects of investment management and consulting. Called the "Adaptive Markets Hypothesis" (AMH) by Lo (2004), this new framework is based on some well-known principles of evolutionary biology—competition, mutation, reproduction, and natural selection—and I argue that the impact of these forces on financial institutions and market participants determines the efficiency of markets and the waxing and waning of investment products, businesses, industries and, ultimately, institutional and individual fortunes. In this paradigm, the EMH may be viewed as the "frictionless" ideal that would exist if there were no capital market imperfections such as transactions costs, taxes, institutional rigidities, and limits to the cognitive and reasoning abilities of market participants. However, in the presence of such real-world imperfections, the laws of natural selection or, more appropriately, "survival of the richest", determine the evolution of markets and institutions. Within this paradigm, behavioral biases are simply heuristics that have been taken out of context, not necessarily counterexamples to rationality. Given enough time and enough competitive forces, any counterproductive heuristic will be reshaped to better fit the current environment. The dynamics of natural selection and evolution yield a unifying set of principles from which all behavioral biases may be derived.

Although the AMH is still primarily a qualitative and descriptive framework, it yields some surprisingly concrete insights when applied to practical settings such as asset allocation, risk management, and consulting. For example, the AMH implies that: (1) the equity risk premium is not constant through time but varies according to the recent *path* of the stock market and the demographics of investors during that path; (2) asset allocation can add value by exploiting the market's path dependence as well as systematic changes in behavior; (3) all investment products tend to experience cycles of superior and inferior performance; (4) market efficiency is not a 0/1 property but varies continuously over time and across markets; and (5) individual and institutional risk preferences are not likely to be stable over time.

In Section 2, I review several of the most prominent biases documented in the behavioral literature, and Section 3 contains a rebuttal of these examples from the EMH perspective. To reconcile these two opposing perspectives, in Section 4 I present some recent results from the cognitive neurosciences literature that shed new light on both rationality and behavior. These results provide the foundation for the AMH, which is summarized in Section 5. Several applications of the AMH to the practice of investment management are outlined in Section 6. I conclude in Section 7 with a discussion of a new and broader role for consultants, one that involves a more intimate relationship between consultant and investor, as well as a new relationship between consultant and manager.

2 Motivation

To illustrate the conflict between the EMH and behavioral finance, consider the following example of overconfidence drawn from study by Russo and Shoemaker (1989). In their study, a number of subjects were asked to provide 90% confidence intervals for a series of general-knowledge questions with numerical answers (see Table 1). In other words, instead of providing numerical estimates for each question, subjects were asked to give lower and upper bounds so that each interval bracketed the correct answer with 90% probability. If subjects accurately assessed their degree of uncertainty with respect to each question, they should be wrong about 10% of the time. In other words, each subject should be able to correctly bracket the answers in 9 out of 10 questions. In a sample of over 1,000 participants, Russo and Shoemaker (1989) found that less than 1% of the subjects scored 9 or better, and most individuals missed four to seven of the 10 questions. They conclude that most individuals are considerably more confident of their general knowledge than may be warranted, i.e., they are overconfident. Overconfidence has been demonstrated in many other contexts and seems to be a universal trait among most humans, as observed by Garrison Keillor in his fictional town of Lake Wobegon, "...where all the women are strong, all the men are good-looking, and all the children are above average".

Self-Test of Overconfidence	90% Confidence Interval	
	Lower	Upper
1. Martin Luther King's age at death	______	______
2. Length of the Nile River (in miles)	______	______
3. Number of countries in OPEC	______	______
4. Number of books in the Old Testament	______	______
5. Diameter of the moon (in miles)	______	______
6. Weight of an empty Boeing 747 (in pounds)	______	______
7. Year in which Wolfgang Amadeus Mozart was born	______	______
8. Gestation period of an Asian elephant (in days)	______	______
9. Air distance from London to Tokyo (in miles)	______	______
10. Deepest known point in the ocean (in feet)	______	______

Table 1: Russo and Shoemaker's (1989) self-test of overconfidence (answers provided in the Appendix).

A second example involves another aspect of probability assessment in which individuals assign probabilities to events not according to the basic axioms of probability theory, bur according to how "representative" those events are of the general class of phenomena under consideration. Two psychologists, Tversky and Kahneman (1982), posed the following question to a sample of 86 subjects:

> Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations. Please check off the most likely alternative:

- Linda is a bank teller.
- Linda is a bank teller and is active in the feminist movement.

Despite the fact that "bank teller" cannot be less probable than "bank teller and feminist" (because the latter category is a more restrictive subset of the former), almost 90% of the subjects tested checked the second response as the more likely alternative. Tversky and Kahneman (1982, p. 98) concluded: "As the amount of detail in a scenario increases, its probability can only decrease steadily, but its representativeness and hence its apparent likelihood may increase. The reliance on representativeness, we believe, is a primary reason for the unwarranted appeal of detailed scenarios and the illusory sense of insight that such constructions often provide".

This behavioral bias is particularly relevant for the current risk-management practice of "scenario analysis" in which the performance of portfolios is simulated for specific market scenarios such as the stock-market crash of October 19, 1987. While adding detail in the form of a specific scenario to a risk-management simulation makes it more palpable and intuitive—in Tversky and Kahneman's (1982) context, more "representativeness"—it also decreases the likelihood of occurrence. Therefore, decisions based largely on scenario analysis may overestimate the likelihood of those scenarios and, as a result, underestimate the likelihood of more relevant outcomes.

A third example of a behavioral bias—one involving risk preferences—is a slightly modified version of another experiment conducted by Kahneman and Tversky (1979), for which Kahneman was awarded the Nobel Prize in Economics in 2002.[1] Suppose you are offered two investment opportunities, A and B: A yields a sure profit of $240,000, and B is a lottery ticket yielding $1 million with a 25% probability and $0 with 75% probability. If you had to choose between A and B, which would you prefer? Investment B has an expected value of $250,000, which is higher than A's payoff, but this may not be all that meaningful to you because you will receive either $1 million or zero. Clearly, there is no right or wrong choice here; it is simply a matter of personal preferences. Faced with this choice, most subjects

[1]Tversky died in 1996, otherwise he would no doubt have shared the prize with Kahneman.

prefer A, the sure profit, to B, despite the fact that B offers a significant probability of winning considerably more. This behavior is often characterized as "risk aversion" for obvious reasons. Now suppose you are faced with another two choices, C and D: C yields a sure loss of $750,000, and D is a lottery ticket yielding $0 with 25% probability and a loss of $1 million with 75% probability. Which would you prefer? This situation is not as absurd as it might seem at first glance; many financial decisions involve choosing between the lesser of two evils. In this case, most subjects choose D, despite the fact that D is more risky than C. When faced with two choices that both involve losses, individuals seem to be "risk seeking", not risk averse as in the case of A-versus-B.

The fact that individuals tend to be risk averse in the face of gains and risk seeking in the face of losses can lead to some very poor financial decisions. To see why, observe that the combination of choices A-and-D is equivalent to a single lottery ticket yielding $240,000 with 25% probability and −$760,000 with 75% probability, whereas the combination of choices B-and-C is equivalent to a single lottery ticket yielding $250,000 with 25% probability and $-\$750,000$ with 75% probability. The B-and-C combination has the same probabilities of gains and losses, but the gain is $10,000 higher and the loss is $10,000 lower. In other words, B-and-C is formally equivalent to A-and-D plus a sure profit of $10,000. In light of this analysis, would you still prefer A-and-D?

A common response to this example is that it is contrived because the two pairs of investment opportunities were presented sequentially, not simultaneously. However, in a typical global financial institution, the London office may be faced with choices A and B and the Tokyo office may be faced with choices C and D. Locally, it may seem as if there is no right or wrong answer—the choice between A and B or C and D seems to be simply a matter of personal risk preferences—but the globally consolidated financial statement for the entire institution will tell a very different story. From that perspective, there *is* a right and wrong answer, and the empirical and experimental evidence suggests that most individuals tend to select the wrong answer. Therefore, according to the behavioralists, quantitative models of efficient markets—all of which are predicated on rational choice—are likely to be wrong as well.

These examples illustrate the most enduring critique of the EMH: individuals do not always behave rationally. In particular, the traditional approach to modeling behavior in economics and finance is to assert that investors optimize additive time-separable expected utility functions from certain parametric families, e.g., constant relative risk aversion. This is the starting point for many quantitative models of modern finance, including mean-variance portfolio theory and the Sharpe-Lintner Capital Asset Pricing Model. However, a number of studies have shown that human decision-making does not seem to conform to rationality and market efficiency, but exhibits certain behavioral biases that are clearly counterproductive from the financial perspective, e.g., overconfidence (Fischoff and Slovic, 1980; Barber and Odean, 2001; Gervais and Odean, 2001), overreaction (DeBondt and Thaler, 1986), loss aversion (Kahneman and Tversky, 1979; Shefrin and Statman, 1985; Odean, 1998), herding (Huberman and Regev, 2001), psychological accounting (Tversky and Kahneman, 1981), miscalibration of probabilities (Lichtenstein et al., 1982), hyperbolic discounting (Laibson, 1997), and regret (Bell, 1982; Clarke et al., 1994). For these reasons, behavioral economists conclude that investors are often—if not always—irrational, exhibiting predictable and financially ruinous behavior that is unlikely to yield efficient markets.[2]

Grossman (1976) and Grossman and Stiglitz (1980) go even further. They argue that perfectly informationally efficient markets are an *impossibility*, for if markets are perfectly efficient, there is no profit to gathering information, in which case there would be little reason to trade and markets would eventually collapse. Alternatively, the degree of market *inefficiency* determines the effort investors are willing to expend to gather and trade on information, hence a non-degenerate market equilibrium will arise only when there are sufficient profit opportunities, i.e., inefficiencies, to compensate investors for the costs of trading and information-gathering. The profits earned by these attentive investors may be viewed as "economic rents" that accrue to those willing to engage in such activities. Who are the providers of these rents? Black (1986) gave us a provocative answer: "noise traders", individuals who trade on what they consider to be information but which is, in fact, merely noise. But if noise traders are constantly being taken advantage of by informed traders,

[2]It should be emphasized, however, that irrationality does not necessarily lead to violations of efficient markets. Certain forms of irrationality are simply irrelevant for the price discovery process, hence they have no impact on the EMH. See, for example, the case of a "Dutch Book" in Section 2 in which irrational probability beliefs concerning a particular random event yield arbitrage profits, implying that such irrationality is unlikely to have a material impact on the prices of securities associated with that event. The importance of a given behavioral pattern for financial market prices is highly context-dependent, and must be considered on a case-by-case basis.

how do they persist? The answer is a slightly modified version of P.T. Barnum's well-known dictum: "A noise-trader is born every minute"![3]

3 Rational Finance Responds

The supporters of the EMH have responded to these challenges by arguing that while behavioral biases and corresponding inefficiencies do exist from time to time, there is a limit to their relevance and impact because of opposing forces dedicated to exploiting such opportunities.[4] A simple example of such a limit is the so-called "Dutch Book", in which irrational probability beliefs can result in guaranteed profits for the savvy arbitrageur. Consider, for example, an event E, defined as "the S&P 500 index drops by 5 percent or more next Monday", and suppose an individual has the following irrational beliefs: there is a 50 percent probability that E will occur, and a 75 percent probability that E will *not* occur. This is clearly a violation of one of the basic axioms of probability theory—the probabilities of two mutually exclusive and exhaustive events must sum to one—but many experimental studies have documented such violations among most human subjects.

These inconsistent subjective probability beliefs imply that the individual would be willing to take both of the following bets B_1 and B_2:

$$B_1 \;=\; \begin{cases} \$1 & \text{if } E \\ -\$1 & \text{otherwise} \end{cases} \quad , \quad B_2 \;=\; \begin{cases} \$1 & \text{if } E^c \\ -\$3 & \text{otherwise} \end{cases}$$

where E^c denotes the event "not E". Now suppose we take the opposite side of both bets, placing \$50 on B_1 and \$25 on B_2. If E occurs, we lose \$50 on B_1 but gain \$75 on B_2, yielding a profit of \$25. If E^c occurs, we gain \$50 on B_1 and lose \$25 on B_2, also yielding a profit of \$25. Regardless of the outcome, we have secured a profit of \$25, an "arbitrage" that comes at the expense of the individual with inconsistent probability beliefs. Such beliefs are not sustainable, and market forces—namely, arbitrageurs such as hedge funds and proprietary trading groups—will take advantage of these opportunities until they no longer exist, i.e.,

[3]The epithet "A sucker is born every minute", commonly attributed to P.T. Barnum was, in fact, due to David Hannum, one of Barnum's competitors. See `http://www.historybuff.com/library/refbarnum.html` for details.

[4]See, for example, Rubinstein (2001) and Merton and Bodie (2005).

until the odds are in line with the axioms of probability theory.[5] Therefore, proponents of the EMH argue that there are limits to the degree and persistence of behavioral biases such as inconsistent probability beliefs, given the substantial incentives for identifying and exploiting such occurrences. While all of us are subject to certain behavioral biases from time to time, EMH disciples argue that market forces will always act to bring prices back to rational levels, implying that the impact of irrational behavior on financial markets is generally negligible and, therefore, irrelevant.

But this last conclusion relies on the assumption that market forces are sufficiently powerful to overcome any type of behavioral bias, or equivalently, that irrational beliefs are not so pervasive as to overwhelm the capacity of arbitrage capital dedicated to taking advantage of such irrationalities. This issue cannot be settled by theory, but is an empirical matter that requires highly structured data analysis and statistical inference. The question of market rationality can be reduced to a quantitative comparison of the economic forces of rationality versus the behavioral tendencies that are endemic to most market participants.

One anecdotal type of evidence is the series of financial manias and panics that have characterized capital markets ever since the 17th century when tulip bulbs captured the imagination of the Dutch. From 1634 to 1636, "tulip mania" spread through Holland, causing the price of tulip bulbs to skyrocket to ridiculous levels, only to plummet precipitously afterwards, creating widespread panic and enormous financial dislocation in its wake.[6] Other examples include: England's South Sea Bubble of 1720; the U.S. stock market crashes of October 1929 and October 1987; the Japanese real estate bubble of the 1990's; the U.S. technology bubble of 2000; the collapse of Long-Term Capital Management and other fixed-income relative-value hedge funds in 1998; and the current real-estate bubble in England. These examples suggest the forces of irrationality can dominate the forces of rationality, even over extended periods of time.

What, then, does this imply for the practice of investment management, much of which

[5]Only when these axioms are satisfied is arbitrage ruled out. This was conjectured by Ramsey (1926) and proved rigorously by de Finetti (1937) and Savage (1954).

[6]According to MacKay (1841), at the peak of this bubble in 1636, one particularly rare species of tulip—the viceroy—was purchased for the following bill of goods: two lasts of wheat; four lasts of rye; four fat oxen; eight fat swine; twelve fat sheep; two hogsheads of wine; four tuns of beer; two tons of butter; one thousand pounds of cheese; a complete bed; a suit of clothes; and a silver drinking cup. By 1637, bulbs that were worth 6,000 florins at the height of the mania were trading for less than 500 florins, if they traded at all.

is based on the EMH framework? Before turning to this issue in Sections 5 and 6, we need to digress for a moment in Section 4 to develop a better understanding of the ultimate sources of behavioral biases.

4 A Neurosciences Perspective

Since much of the debate surrounding the EMH and its behavioral exceptions centers on rationality in human behavior, we might look to the recent literature in the cognitive neurosciences for additional insights. There have been a number of recent breakthroughs in linking behavior with specific brain functions, and this research has led to a significant reformulation of psychological and neurophysiological models of decision-making. Many of these breakthroughs have come from new research tools in the neurosciences such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), where sequences of images of a subject's brain are captured in real time while the subject is asked to perform a certain task. By comparing the amount of blood flow to different parts of the brain before, during, and after the task, it is possible to detect higher levels of activation in certain regions of the brain, thus linking the performance of the task to those regions. These technologies have revolutionized much of psychological research, providing important neurophysiological foundations for a variety of cognitive processes and patterns of behavior.[7]

One example that is especially relevant for financial decision-making is the apparent link between rational behavior and emotion. Until recently, the two were considered diametrical opposites, but by studying the behavior of patients that lost the ability to experience emotion after the surgical removal of brain tumors, Damasio (1994) discovered that their ability to make rational choices suffered as well. One patient—code-named Elliot—who lost his emotional faculties after having a portion of his frontal lobe removed, experienced a surprisingly profound effect on his day-to-day activities, as Damasio (1994, p. 36) describes:

> When the job called for interrupting an activity and turning to another, he might persist nonetheless, seemingly losing sight of his main goal. Or he might interrupt the activity he had engaged, to turn to something he found more captivating at

[7]See Camerer, Loewenstein, and Prelec (2004) for an excellent review of the neurosciences literature that is most relevant to economics and finance. Gazzaniga and Heatherton (2003) is an excellent and comprehensive introduction to the "new" field of psychology.

> that particular moment... The flow of work was stopped. One might say that the particular step of the task at which Elliot balked was actually being carried out too well, and at the expense of the overall purpose. One might say that Elliot had become irrational concerning the larger frame of behavior...

Apparently, Elliot's inability to feel—his lack of emotional response—somehow caused him to make irrational choices in his daily decisions.

This conclusion surprises many economists because of the association between emotion and behavioral biases. After all, isn't it fear and greed, or "animal spirits" as Keynes once suggested, that cause prices to deviate irrationally from "fundamentals"? In fact, a more sophisticated view of the role of emotions in human cognition is that they are central to rationality (see, for example, Damasio, 1994, and Rolls 1990, 1994, 1999).[8] Emotions are the basis for a reward-and-punishment system that facilitates the selection of advantageous behavior, providing a numeraire for animals to engage in a "cost-benefit analysis" of the various actions open to them (Rolls, 1999, Chapter 10.3). Even fear and greed—the two most common culprits in the downfall of rational thinking, according to most behavioralists—are the product of evolutionary forces, adaptive traits that increase the probability of survival. From an evolutionary perspective, emotion is a powerful tool for improving the efficiency with which animals learn from their environment and their past. When an individual's ability to experience emotion is eliminated, an important feedback loop is severed and his decision-making process is impaired.

What, then, is the source of irrationality, if not emotion? The neurosciences literature provides some hints, from which we can craft a conjecture. The starting point is a basic fact about the brain: it is not a homogeneous mass of nerve cells, but is a collection of specialized components, many of which have been identified with particular functions and types of behavior. For example, the *brainstem*, which is located at the base of the brain and

[8] Recent research in the cognitive neurosciences and economics suggest an important link between rationality in decision-making and emotion (Grossberg and Gutowski, 1987; Damasio, 1994; Elster, 1998; Lo, 1999; Lo and Repin, 2002; Loewenstein, 2000; and Peters and Slovic, 2000), implying that the two are not antithetical, but in fact complementary. For example, contrary to the common belief that emotions have no place in rational financial decision-making processes, Lo and Repin (2002) present preliminary evidence that physiological variables associated with the autonomic nervous system are highly correlated with market events even for highly experienced professional securities traders. They argue that emotional responses are a significant factor in the real-time processing of financial risks, and that an important component of a professional trader's skills lies in his or her ability to channel emotion, consciously or unconsciously, in specific ways during certain market conditions.

sits on top of the spinal cord (see Figure 1), controls the most basic bodily functions such as breathing and heartbeat and is active even during deep sleep. The *limbic system*, which is comprised of several regions in the middle of the brain, is responsible for emotions, instincts, and social behavior such as feeding, fight-or-flight responses, and sexuality. And the *cerebral cortex*, which is the tangled maze of "gray matter" that forms the outer layer of the brain, is what allows us to think complex and abstract thoughts and where language and musical abilities, logical reasoning, learning, long-term planning, and sentience reside. These three groups form the "triune brain" model proposed by MacLean (1990) and illustrated in Figure 1, which he refers to as the "reptilian", "mammalian", and "hominid" brains, respectively. This terminology underscores his hypothesis that the human brain is the outcome of an evolutionary process in which basic survival functions appeared first, more advanced social behavior came second, and uniquely human cognitive abilities emerged most recently (within the last 100,000 years).

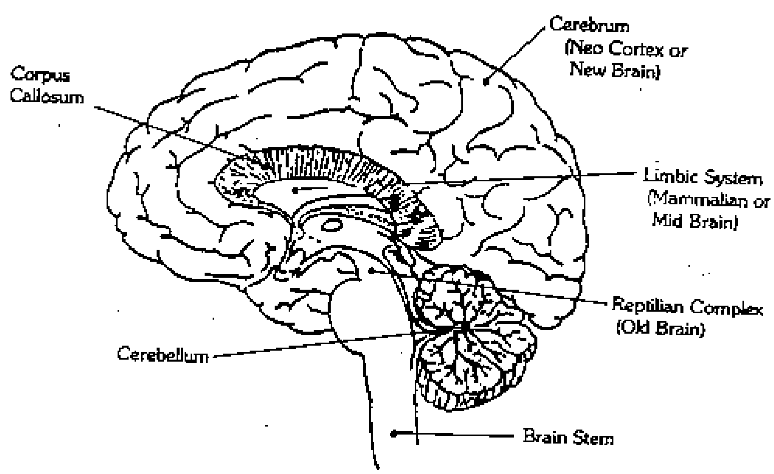

Figure 1: The triune brain model of MacLean (1990) (source: Caine and Caine, 1990).

The relevance of the triune brain model for our purposes is that it provides a deeper foundation for some of the behavioral biases that affect financial decision-making. In particular, behavior may be viewed as the observable manifestation of interactions among several components of the brain, sometimes competitively and other times cooperatively. For example, the urge to flee from danger may be triggered in the mammalian brain by an approaching stranger in a dimly lit corridor, but this urge may be overridden by the hominid brain, which understands that the dim lighting is due to a temporary power outage and that the approaching stranger is wearing a policeman's uniform and therefore unlikely to represent an immediate threat. However, under other circumstances, emotional responses can overrule more complex deliberations, e.g., in the midst of a bar fight in which there is real physical danger. Indeed, neuroscientists have shown that emotion is the "first response" in the sense that individuals exhibit emotional reactions to objects and events far quicker than they can articulate what those objects and events are (see Zajonc, 1980, 1984).

Moreover, it is well-known that the primacy of emotional reactions—especially fear and the fight-or-flight response—can identify danger well ahead of the conscious mind (see de Becker, 1997). In fact, extreme emotional reactions can "short-circuit " rational deliberation altogether (see Baumeister, Heatherton, and Tice, 1994), i.e., strong stimulus to the mammalian brain seems to inhibit activity in the hominid brain. From an evolutionary standpoint, this seems quite sensible—emotional reactions are a call-to-arms that should be heeded immediately because survival may depend on it, and higher brain functions such as language and logical reasoning are suppressed until the threat is over, i.e., until the emotional reaction subsides.

However, in our current environment, many "threats" identified by the mammalian brain are not, in fact, life-threatening, yet our physiological reactions may still be the same. In such cases, the suppression of our hominid brain may be unnecessary and possibly counterproductive, and is implicitly acknowledged in the common advice to refrain from making any significant decisions after experiencing the death of a loved one, or a similar emotional trauma. This is sage advice, for the ability to "think straight" is genuinely physiologically hampered by extreme emotional reactions.[9]

The complexity of the interactions among the three divisions of the brain may be illustrated by two examples. The first involves the difference between a natural smile and a "forced" smile (see Damasio, 1994, pp. 141–143 and Figure 7-3), which is easily detected by most of us, but why? The answer lies in the fact that a natural smile is generated by the

[9]Other familiar manifestations of the antagonistic effect of emotion on the hominid brain include being so angry that you cannot see ("blinded by your anger", both physically and metaphorically), and becoming tongue-tied and disoriented in the presence of someone you find unusually attractive. Both vision and speech are mediated by the hominid brain.

mammalian brain (specifically, the anterior cingulate) and involves certain involuntary facial muscles that are not under the control of the hominid brain. The forced smile, however, is a purely voluntary behavior emanating from the hominid brain (the motor cortex), and does not look exactly the same because involuntary muscles do not participate in this action. In fact, it takes great effort and skill to generate particular facial expressions on cue, as actors trained in the "method" school can attest—only by conjuring up emotionally charged experiences in their past are they able to produce the kind of genuine emotional reactions needed in a given scene, and anything less authentic is immediately recognized as "bad acting".

The second example is from a study by Eisenberger, Lieberman, and Williams (2003) in which they deliberately induced feelings of social rejection among a group of subjects and then identified the regions of the brain that were most activated during the stimulus. They discovered that two components were involved, the anterior cingulate and the insula, both of which are also known to process physical pain. In other words, emotional trauma—hurt feelings, emotional loss, embarrassment, and shame—can generate the same kind of neural response that a broken bone does. Many who have experienced the death of a loved one have commented that they felt *physical* pain from their loss despite the fact that no physical trauma was involved, and we are now beginning to develop a neuroscientific basis for this phenomenon. Eisenberger, Lieberman, and Williams (2003, p. 292) conclude that "...social pain is analogous in its neurocognitive function to physical pain, alerting us when we have sustained injury to our social connections, allowing restorative measures to be taken".

These two examples illustrate some of the many ways in which specialized components in the brain can interact to produce behavior. The first example shows that two different components of the brain are capable of producing the same outcome: a smile. The second example shows that the same components can be involved in producing two different outcomes: physical and emotional pain. The point of specialization in brain function is increased fitness in the evolutionary sense. Each specialized component may be viewed as an evolutionary adaptation designed to increase the chances of survival in response to a particular environmental condition. As environmental conditions change, so too does the relative importance of each component. One of the unique features of Homo sapiens is the ability to adapt to new situations by learning and implementing more advantageous behavior, and this is often accomplished by several components of the brain acting together. As a result, what economists call "preferences" are often complicated interactions among the three components of the brain, as well as interactions among subcomponents within each of the three.

This perspective implies that preferences may not be stable through time, but are likely to be shaped by a number of factors, both internal and external to the individual, i.e., factors related to the individual's personality, and factors related to specific environmental conditions in which the individual is currently situated. When environmental conditions shift, we should expect behavior to change in response, both through learning and, over time, through changes in preferences via the forces of natural selection. These evolutionary underpinnings are more than simple speculation in the context of financial market participants. The extraordinary degree of competitiveness of global financial markets and the outsize rewards that accrue to the "fittest" traders suggest that Darwinian selection is at work in determining the typical profile of the successful investor. After all, unsuccessful market participants are eventually eliminated from the population after suffering a certain level of losses.

This neuroscientific perspective suggests an alternative to the EMH, one in which market forces and preferences interact to yield a much more dynamic economy, one driven by competition, natural selection, and the diversity of individual and institutional behavior. This is the essence of the Adaptive Markets Hypothesis.

5 The Adaptive Markets Hypothesis

The application of evolutionary ideas to economic behavior is not new. Students of the history of economic thought will no doubt recall that Thomas Malthus used biological arguments—the fact that populations increase at geometric rates whereas natural resources increase at only arithmetic rates—to arrive at rather dire economic consequences, and that both Darwin and Wallace were influenced by these arguments (see Hirshleifer, 1977, for further details). Also, Joseph Schumpeter's view of business cycles, entrepreneurs, and capitalism have an unmistakeable evolutionary flavor to them; in fact, his notions of "creative destruction" and "bursts" of entrepreneurial activity are similar in spirit to natural selection and Eldredge and Gould's (1972) notion of "punctuated equilibrium". However, Wilson (1975) was the first to systematically apply the principles of competition, reproduction, and natural selection to social interactions, yielding surprisingly compelling explanations for certain kinds of human behavior, e.g., altruism, fairness, kin selection, language, mate selection, religion, morality, ethics, and abstract thought.[10] Wilson aptly named this new field "sociobiology", and its debut generated a considerable degree of controversy because of some of its possible implications for social engineering and eugenics.

These ideas have recently been exported to a number of economic and financial contexts,[11] and at least two prominent practitioners have proposed Darwinian alternatives to the EMH: in a chapter titled "The Ecology of Markets", Niederhoffer (1997, Ch. 15) likens financial markets to an ecosystem with dealers as "herbivores", speculators as "carnivores", and floor traders and distressed investors as "decomposers"; and Bernstein (1998) makes a compelling case for active management by pointing out that the notion of equilibrium, which is central to the EMH, is rarely realized in practice and that market dynamics are better explained by evolutionary processes.

Clearly the time has come for an evolutionary alternative to market efficiency, and this is the direction taken in Farmer and Lo (1999), Farmer (2002), and Lo (2002, 2004). In this section, I provide a brief summary of Lo's (2004) AMH.

Contrary to the neoclassical postulate that individuals maximize expected utility and have rational expectations, an evolutionary perspective makes considerably more modest claims, viewing individuals as organisms that have been honed—through generations of natural selection—to maximize the survival of their genetic material (see, for example, Dawkins, 1976). This perspective implies that behavior is not necessarily intrinsic and exogenous, but evolves by natural selection and depends on the particular environment through which se-

[10] See, for example, Barkow et al. (1992), Pinker (1993, 1997), Crawford and Krebs (1998), Buss (1999), Gigerenzer (2000), and the emerging literature in "evolutionary psychology", which is reviewed in detail in the recent text by Barrett, Dunbar, and Lycett (2002).

[11] For example, economists and biologists have begun to explore the implications of sociobiology in several veins: direct extensions of Wilson's (1975) framework to economics (Becker, 1976; Hirshleifer, 1977; Tullock, 1979); evolutionary game theory (Maynard Smith, 1982; Weibull, 1995); evolutionary economics (Nelson and Winter, 1982; Andersen, 1994; Englund, 1994; Luo, 1999); and economics as a complex system (Anderson, Arrow, and Pines, 1988). Hodgson (1995) contains additional examples of studies at the intersection of economics and biology, and publications like the *Journal of Evolutionary Economics* and the *Electronic Journal of Evolutionary Modeling and Economic Dynamics* now provide a home for this burgeoning literature.

Evolutionary concepts have also appeared in several financial contexts. For example, in a series of papers, Luo (1995, 1998, 2001, 2003) explores the implications of natural selection for futures markets. Hirshleifer and Luo (2001) consider the long-run prospects of overconfident traders in a competitive securities market. And the literature on agent-based modeling pioneered by Arthur et al. (1997), in which interactions among software agents programmed with simple heuristics are simulated, relies heavily on evolutionary dynamics.

lection occurs. That is, natural selection operates not only upon genetic material, but upon biology (recall the specialized components of the triune brain model), and also social behavior and cultural norms in *Homo sapiens*.

To operationalize this perspective within an economic context, Lo (2004) revisits the idea of "bounded rationality" first espoused by Nobel-Prize-winning economist Herbert Simon. Simon (1955) suggested that individuals are hardly capable of the kind of optimization that neoclassical economics calls for in the standard theory of consumer choice. Instead, he argued that because optimization is costly and humans are naturally limited in their computational abilities, they engage in something he called "satisficing", an alternative to optimization in which individuals make choices that are merely satisfactory, not necessarily optimal. In other words, individuals are bounded in their degree of rationality, which is in sharp contrast to the current orthodoxy of rational expectations, where individuals have unbounded rationality (the term "hyper-rational expectations" might be more descriptive). Unfortunately, although this idea garnered a Nobel Prize for Simon, it has had relatively little impact on the economics profession until recently,[12] partly because of the near-religious devotion to rationality on the part of the economics mainstream, but also because of one specific criticism levelled against satisficing: what determines the point at which an individual stops optimizing and reaches a satisfactory solution? If such a point is determined by the usual cost/benefit calculation underlying much of microeconomics (i.e., optimize until the marginal benefits of the optimum equals the marginal cost of getting there), this assumes the optimal solution is known, which eliminates the need for satisficing. As a result, the idea of bounded rationality fell by the wayside, and rational expectations has become the *de facto* standard for modeling economic behavior under uncertainty.

Lo (2004) argues that an evolutionary perspective provides the missing ingredient in Simon's framework. The proper response to the question of how individuals determine the point at which their optimizing behavior is satisfactory is this: such points are determined not analytically, but through trial and error and, of course, natural selection. Individuals make choices based on past experience and their "best guess" as to what might be optimal, and

[12] However, his work is now receiving greater attention, thanks in part to the growing behavioral literature in economics and finance. See, for example, Simon (1982), Sargent (1993), Rubinstein (1998), Gigerenzer et al. (1999), Gigerenzer and Selten (2001), and Earl (2002).

they learn by receiving positive or negative reinforcement from the outcomes. If they receive no such reinforcement, they do not learn. In this fashion, individuals develop heuristics to solve various economic challenges, and as long as those challenges remain stable, the heuristics will eventually adapt to yield approximately optimal solutions to them.

If, on the other hand, the environment changes, then it should come as no surprise that the heuristics of the old environment are not necessarily suited to the new. In such cases, we observe "behavioral biases"—actions that are apparently ill-advised in the context in which we observe them. But rather than labelling such behavior "irrational", it should be recognized that sub-optimal behavior is not unlikely when we take heuristics out of their evolutionary context. A more accurate term for such behavior might be "maladaptive". The flopping of a fish on dry land may seem strange and unproductive, but under water, the same motions are capable of propelling the fish away from its predators. And the antagonistic effect of human emotional reactions on logical reasoning described in Section 4 is maladaptive for many financial contexts.

By coupling Simon's notion of bounded rationality and satisficing with evolutionary dynamics, many other aspects of economic behavior can also be derived. Competition, cooperation, market-making behavior, general equilibrium, and disequilibrium dynamics are all adaptations designed to address certain environmental challenges for the human species, and by viewing them through the lens of evolutionary biology, we can better understand the apparent contradictions between the EMH and the presence and persistence of behavioral biases.

Specifically, the Adaptive Markets Hypothesis can be viewed as a new version of the EMH, derived from evolutionary principles. The primary components of the AMH consists of the following ideas:

(A1) Individuals act in their own self interest.

(A2) Individuals make mistakes.

(A3) Individuals learn and adapt.

(A4) Competition drives adaptation and innovation.

(A5) Natural selection shapes market ecology.

(A6) Evolution determines market dynamics.

The EMH and AMH have a common starting point in A1, but the two paradigms part company with A2 and A3. In efficient markets, investors do not make mistakes, nor is there any learning and adaptation because the market environment is stationary and always in equilibrium. In the AMH framework, mistakes occur frequently, but individuals are capable of learning from mistakes and adapting their behavior accordingly. However, A4 states that adaptation does not occur independently of market forces, but is driven by competition, i.e., the push for survival. The interactions among various market participants are governed by natural selection—the survival of the richest, in our context—and A5 implies that the current market environment is a product of this selection process. A6 states that the sum total of these components—selfish individuals, competition, adaptation, natural selection, and environmental conditions—is what we observe as market dynamics.

For example, prices reflect as much information as dictated by the combination of environmental conditions and the number and nature of "species" in the economy or, to use the appropriate biological term, the *ecology*. By species, I mean distinct groups of market participants, each behaving in a common manner. For example, pension funds may be considered one species; retail investors, another; marketmakers, a third; and hedge-fund managers, a fourth. If multiple species (or the members of a single highly populous species) are competing for rather scarce resources within a single market, that market is likely to be highly efficient, e.g., the market for 10-Year U.S. Treasury Notes, which reflects most relevant information very quickly indeed. If, on the other hand, a small number of species are competing for rather abundant resources in a given market, that market will be less efficient, e.g., the market for oil paintings from the Italian Renaissance. Market efficiency cannot be evaluated in a vacuum, but is highly context-dependent and dynamic, just as insect populations advance and decline as a function of the seasons, the number of predators and prey they face, and their abilities to adapt to an ever-changing environment.

The profit opportunities in any given market are akin to the amount of natural resources in a particular local ecology—the more resources present, the less fierce the competition. As competition increases, either because of dwindling food supplies or an increase in the animal population, resources are depleted which, in turn, eventually causes a population decline, thereby decreasing the level of competition and starting the cycle all over again. In some cases, cycles converge to corner solutions, i.e., certain species become extinct, food sources are permanently exhausted, or environmental conditions shift dramatically. However, a key insight of the AMH—taken directly from evolutionary biology—is that convergence to equilibrium is neither guaranteed nor likely to occur at any point in time. The notion that evolving systems must march inexorably towards some ideal stationary state is plain wrong.[13] In many cases, such equilibria do not exist, and even when they do, convergence rates may be exceedingly slow, rendering the limiting equilibria virtually irrelevant for all practical purposes. The determinants of cycles versus convergence are, ultimately, the combination of market participants and natural resources in the market ecology. By viewing economic profits as the ultimate food source on which market participants depend for their survival, the dynamics of market interactions and financial innovation can be readily derived.

Under the AMH, behavioral biases abound. The origins of such biases are heuristics that are adapted to non-financial contexts, and their impact is determined by the size of the population with such biases versus the size of competing populations with more effective heuristics. During the Fall of 1998, the desire for liquidity and safety by a certain population of investors overwhelmed the population of hedge funds attempting to arbitrage such preferences, causing those arbitrage relations to break down. However, in the years prior to August 1998, fixed-income relative-value traders profited handsomely from these activities, presumably at the expense of individuals with seemingly "irrational" preferences. In fact, such preferences were shaped by a certain set of evolutionary forces, and might have been quite rational in other environmental conditions. Therefore, under the AMH, investment strategies undergo cycles of profitability and loss in response to changing business conditions, the number of competitors entering and exiting the industry, and the type and magnitude of profit opportunities available. As opportunities shift, so too will the affected populations. For example, after 1998, the number of fixed-income relative-value hedge funds declined dramatically—because of outright failures, investor redemptions, and fewer startups in this sector—but many have reappeared in recent years as performance for this type of investment strategy has improved.

[13] For a concrete example, consider the rolling serial correlation of monthly returns of the S&P Composite Index from 1871 to 2003, described in more detail in Section 6. As a measure of market efficiency, the serial correlation coefficient should converge to zero over this 133-year period if markets are becoming progressively more efficient over time. However, Figure 2 tells a very different story—the cyclical behavior of the serial correlation coefficient is likely the result of institutional changes in equity markets as well as the entry and exit of various market participants.

6 Applications

The new paradigm of the AMH is still in its infancy, and certainly requires a great deal more research before it becomes a viable alternative to the EMH. However, it is already clear that an evolutionary framework can reconcile many of the apparent contradictions between efficient markets and behavioral exceptions. The former may be viewed as the steady-state limit of a population with constant environmental conditions, and the latter involves specific adaptations of certain groups that may or may not persist, depending on the particular evolutionary paths that the economy experiences.

Apart from this intellectual reconciliation, there is still the question of how relevant the AMH is for the practice of investment management. After all, despite the limitations of the EMH, it has given rise to a wealth of quantitative tools for the practitioner. Part of this treasure trove of applications comes from the EMH's much longer history—behavioral models have only recently begun to gain some degree of respectability in the academic mainstream. Moreover, the internal consistency and logical elegance of the EMH framework are almost hypnotic, and it is all too easy to forget that the EMH is merely a figment of our imagination, meant to serve as approximations—and not terribly accurate ones—to a far more complex reality. Unlike the law of gravity and the theory of special relativity, there are no immutable laws of Nature from which the EMH can be derived.

Also, once we depart from the highly structured framework of the EMH, there are seemingly endless possibilities for modeling economic behavior. However, this should not dissuade us from the quest to derive mathematical embodiments of behavioral research, otherwise we risk becoming the drunkard searching for his lost keys outside the bar where he left them, just because the lighting is better in the street. In particular, quantitative implications of the AMH may be derived through a combination of deductive and inductive inference—for example, theoretical analysis of evolutionary dynamics, empirical analysis of evolutionary forces in financial markets, and experimental analysis of decisionmaking at the individual and group level—and are currently under investigation. But even at this formative stage, the AMH yields several concrete applications for investment management and consulting.

Preferences Matter

Perhaps the most immediate application is to individual and institutional risk preferences. Despite their usefulness in other contexts, the heuristics that many psychologists and economists have documented as "behavioral biases" are often counterproductive for the purposes of building and preserving financial wealth. To avoid such pitfalls, one must first be aware of them. Therefore, one critical set of applications involves the proper measurement and management of preferences.

The quantitative measurement of preferences has a long history in psychology, economics, operations research, and the new field of marketing science. Each of these disciplines emphasizes different aspects of individual decision-making: psychological surveys are designed to capture broad characteristics of personality (Costa and McCrae, 1992), economists perform choice experiments with various lotteries to elicit risk preferences (MacCrimmon and Wehrung, 1986), and market-research consultants conduct field studies of consumer preferences as inputs to product-design efforts (Urban and Hauser, 1993). In light of the emerging neuroscientific view of preferences as interactions among specialized components in the brain, the proper measurement of preferences may require a combination of each of these approaches.[14]

In particular, the kind of risk-preference questionnaires used by brokerage firms and financial advisors may be a useful starting point, but a typical subject's responses are not likely to yield a stable estimate of the subject's true financial decision-making process. For example, suppose a 35-year-old subject fills out such a questionnaire prior to experiencing the untimely loss of a spouse, and then fills out the same questionnaire a few months after the tragic event—should we expect the responses from the two questionnaires to be identical? Despite the fact that love, family, and death are typically not included in standard financial decision-making paradigms such as portfolio optimization and asset allocation, nevertheless, the human brain does not necessarily compartmentalize decisions in the same way.

[14] Simon's (1982) seminal contributions to this literature are still remarkably timely and their implications have yet to be fully explored. More recent research on preferences include Kahneman, Slovic, and Tversky (1982), Hogarth and Reder (1986), Gigerenzer and Murray (1987), Dawes (1988), Fishburn (1988), Keeney and Raiffa (1993), Plous (1993), Sargent (1993), Thaler (1993), Damasio (1994), Arrow et al. (1996), Laibson (1997), Picard (1997), Pinker (1997), and Rubinstein (1998). Starmer (2000) provides an excellent review of this literature.

More generally, Statman (2004a) observes that investors have multi-faceted objectives in mind when formulating their investment decisions, hence the effective consultant will help the investor to acknowledge and articulate these objectives before making any recommendations. By developing more encompassing survey instruments—not just risk-preference questionnaires—we may be able to develop a more complete, hence a more stable and predictive, model of individual and institutional preferences. One alternative is to measure more fundamental aspects of an individual's personality such as "temperament" and relate these measures to risk attitudes and investment decisions.[15]

While measuring preferences has been well-studied, the *management* of preferences is a politically sensitive issue, especially for economists, who tend to shy away from most "normative" implications of their ideas. Because of the inherent difficulties in comparing levels of happiness between two individuals, most economists take individual preferences as given and actively avoid weighing one consumer's gains against another's losses, except in the unit of measurement defined by each individual: their own utility functions.[16] "To each his own", as the saying goes. However, one of the lessons from the recent neurosciences literature is that preferences are not immutable or one-dimensional, but are the sum total of complex interactions between competitive and cooperative components of the brain. What we take to be "preferences" may, in one instance, reflect largely hardwired autonomic responses of the limbic system and, in another instance, be the result of careful deliberation mediated by the prefrontal cortex.

This level of complexity, while challenging, holds out the hope that preferences can be actively managed so as to produce more desirable outcomes. However, what does "more desirable" mean? In the general economic context, this phrase has little content because

[15]For example, using a well-known personality profiling instrument—the Keirsey (1998) Temperament Sorter—Statman and Wood (2005) show that risk attitudes can be related to personality types. Lo, Repin, and Steenbarger (2005) use daily emotional-state surveys as well as personality inventory surveys to construct measures of personality traits and emotional states for a group of 80 day-traders, and correlate these measures with daily normalized profits-and-losses records. They find that subjects whose emotional reaction to monetary gains and losses was more intense on both the positive and negative side exhibited significantly worse trading performance, and large sudden swings in emotional states seem especially detrimental to cumulative profits-and-losses.

[16]The one exception to this general ethos of aversion to interpersonal comparison of utility is welfare economics, the branch of economics specifically focused on social welfare issues such as poverty, economic inequality, and related policy issues. Schumacher (1973) provides a highly readable layman's introduction to equality versus efficiency from an economic perspective.

utility is presumed to be the ultimate objective, hence it makes no sense to say that one can manage preferences to yield higher utility because utility is itself the metric by which success is gauged. However, in the context of investment management, "more desirable" does have independent meaning apart from an individual's utility function, e.g., a minimal level of real wealth at retirement, a minimum probability of a pension fund's assets exceeding liabilities over a 10-year horizon, or a consistent investment process for making asset-allocation decisions over time. In each of these cases, one can argue that certain types of preferences lead to less attractive outcomes with respect to these objectives. For example, loss aversion generally leads to lower expected real wealth at retirement than a logarithmic utility function. Therefore, if building wealth is a priority for an individual or institution, actively managing the investor's preferences is critical.

Asset Allocation Revisited

Another application of the AMH framework to investment practice involves asset allocation decisions, the selection of portfolio weights for broad asset classes. An implication of the AMH is that to the extent that a relation between risk and reward exists, it is unlikely to be stable over time. Such a relation is determined by the relative sizes and preferences of various populations in the market ecology, as well as institutional aspects such as the regulatory environment and tax laws. As these factors shift over time, any risk/reward relation is likely to be affected.

A corollary of this implication is that the equity risk premium is not a universal constant, but is also time-varying and path-dependent. This is not so revolutionary an idea as it might first appear—even in the context of a rational expectations equilibrium model, if risk preferences change over time, then the equity risk premium must vary too. The incremental insight of the AMH is that aggregate risk preferences are not fixed, but are constantly being shaped and reshaped by the forces of natural selection. For example, until recently, U.S. markets were populated by a significant group of investors who have never experienced a genuine bear market—this fact has undoubtedly shaped the aggregate risk preferences of the U.S. economy, just as the experience of the past four years since the bursting of the technology bubble has affected the risk preferences of the current population of investors.[17]

[17]One specific behavioral mechanism by which this path dependence is generated is the representativeness

In this context, natural selection determines who participates in market interactions; those investors who experienced substantial losses in the technology bubble are more likely to have exited the market, leaving a markedly different population of investors today than four years ago. Through the forces of natural selection, history matters. Irrespective of whether prices fully reflect all available information, the particular path that market prices have taken over the past few years influences current aggregate risk preferences.

A second implication is that contrary to the classical EMH, arbitrage opportunities do exist from time to time in the AMH. As Grossman and Stiglitz (1980) observed, without such opportunities, there will be no incentive to gather information, and the price-discovery aspect of financial markets will collapse. From an evolutionary perspective, the existence of active liquid financial markets implies that profit opportunities must be present. As they are exploited, they disappear. But new opportunities are also continually being created as certain species die out, as others are born, and as institutions and business conditions change. Rather than the inexorable trend towards higher efficiency predicted by the EMH, the AMH implies considerably more complex market dynamics, with cycles as well as trends, and panics, manias, bubbles, crashes, and other phenomena that are routinely witnessed in natural market ecologies. These dynamics provide the motivation for active management as Bernstein (1998) suggests, and gives rise to Niederhoffer's (1997) "carnivores" and "decomposers".

A third implication is that investment strategies will also wax and wane, performing well in certain environments and performing poorly in other environments. Contrary to the classical EMH in which arbitrage opportunities are competed away, eventually eliminating the profitability of the strategy designed to exploit the arbitrage, the AMH implies that such strategies may decline for a time, and then return to profitability when environmental conditions become more conducive to such trades. An obvious example is risk arbitrage, which has been unprofitable for several years because of the decline in investment banking activity since 2001. However, as M&A activity begins to pick up again, risk arbitrage will start to regain its popularity among both investors and portfolio managers, as it has just this year.

A more striking example can be found by computing the rolling first-order autocorrelation

bias described in Section 2.

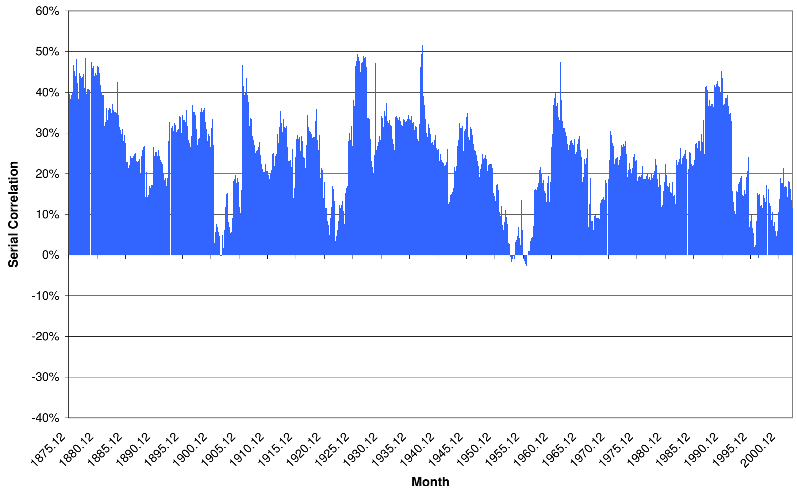

Figure 2: First-order autocorrelation coefficients for monthly returns of the S&P Composite Index using 5-year rolling windows from January 1871 to April 2003. Data Source: R. Shiller, `http://aida.econ.yale.edu/ shiller/data.htm`.

$\hat{\rho}_1$ of monthly returns of the S&P Composite Index from January 1871 to April 2003 (see Figure 2). As a measure of market efficiency (recall that the Random Walk Hypothesis implies that returns are serially uncorrelated, hence ρ_1 should be 0 in theory), $\hat{\rho}_1$ might be expected to take on larger values during the early part of the sample and become progressively smaller during recent years as the U.S. equity market becomes more efficient. However, it is apparent from Figure 2 that the degree of efficiency—as measured by the first-order autocorrelation—varies through time in a cyclical fashion, and there are periods in the 1950's when the market was more efficient than in the early 1990's!

Such cycles are not ruled out by the EMH in theory, but in practice, none of its existing empirical implementations have incorporated these dynamics, assuming instead a stationary world in which markets are perpetually in equilibrium. This widening gulf between the stationary EMH and obvious shifts in market conditions no doubt contributed to Bernstein's (2003) recent critique of the policy portfolio in strategic asset-allocation models, and his controversial proposal to reconsider the case for tactical asset allocation.

A final implication of the AMH for asset allocation is that characteristics such as value and growth may behave like "risk factors" from time to time, i.e., portfolios with such characteristics may yield higher expected returns during periods when those attributes are in favor. For example, during the U.S. technology bubble of the late 1990's, growth stocks garnered higher expected returns than value stocks, only to reverse after the bubble burst. While such nonstationarities create difficulties for the EMH—after all, in that framework, a characteristic is either a risk factor or it is not—the AMH places no restrictions on what can or cannot be a risk factor. Whether or not a particular characteristic is "priced" depends on the nature of the population of investors at a given point in time; if a significant fraction of investors prefers growth stocks over others, a growth-factor risk premium arises. As the number of growth-oriented investors dwindles—either because they retire and withdraw their wealth from the stock market, or because a new generation of investors enters the stock market with its own preferences—the growth premium declines, and other characteristics may emerge in its place.

The natural question that follows is how do we determine which characteristics are priced and which are not? Although the AMH does not yet offer quantitative methods for answering this question, some qualitative guidelines are available. The main determinants of any factor risk premium revolve around the preferences of market participants and how they interact with the natural resources of the market ecology. This suggests a specific research agenda for identifying and measuring priced factors that coincide with the study of any complex natural ecosystem: construct summary measures of the cross section of preferences of current investors and the population sizes of investors with each type of preference, develop a parsimonious but complete description of the market environment in which these investors are interacting (including natural resources, current environmental conditions, and institutional contexts such as market microstructure, legal and regulatory restrictions, and tax effects), and specify the dimensions along which competition, innovation, and natural selection operate. Armed with these data, it should be possible to tell which characteristics might become risk factors and under what kinds of market conditions. Of course, gathering this kind of data is unprecedented in economics and finance, and likely to be a nontrivial undertaking. However, this may very well be the price of progress within the AMH framework.

The bottom line is that active asset-allocation policies may be appropriate for certain investors and under certain market conditions. If the investor population changes, if investors' preferences change, if environmental conditions change, and if these changes can be measured in a meaningful way, then it is indeed possible to construct actively managed portfolios that are better able meet an investor's financial objectives. Whether or not the cost/benefit analysis supports active management is, of course, a different question that depends as much on business conditions in the investment management industry—fee structures, total size of assets to be managed, and the amount of competition for assets and managerial talent—as it does on the magnitude and nature of the portfolio manager's skills. Moreover, measuring the kind of changes described above is no mean feat, especially given the lack of relevant data such as investor preferences, demographics, and the cross-sectional distribution of stock holdings. The AMH does not imply that asset allocation is any less challenging, but does provide a rationale for the apparent cyclical nature of risk factors and points the way to promising new research directions.

The Dynamics of Competition and Market Ecology

One final application of the AMH framework to investment management is the insight that *innovation* is the key to survival. The EMH suggests that certain levels of expected returns can be achieved simply by bearing a sufficient degree of risk. The AMH implies that the risk/reward relation varies through time, and that a better way of achieving a consistent level of expected returns is to adapt to changing market conditions. Consider the current theory of the demise of the dinosaurs from a "killer asteroid" (Alvarez, 1997), and ask where the next financial asteroid might come from. The AMH has a clear implication for all financial market participants: survival is ultimately the *only* objective that matters. While profit maximization, utility maximization, and general equilibrium are certainly relevant aspects of market ecology, the organizing principle in determining the evolution of markets and financial technology is simply survival.

The natural tendency for all organisms to push for survival requires both managers and consultants to maintain a certain degree of breadth and diversity in their skills and focus. By evolving a multiplicity of capabilities that are suited to a variety of environmental conditions, investment managers are less likely to become extinct as a result of rapid changes in those conditions. And by acknowledging that changes in business conditions can influence both investment performance and investor preferences, consultants will be better prepared to provide the kind of advice and support that will be of most value to their clients. Managers have to innovate constantly to stay ahead of the competition, and consultants need to innovate as well.

Like motherhood and apple pie, innovation is an easy concept to embrace. However, in the context of the AMH, it takes on an urgency that is generally missing from most financial decision-making paradigms such as the EMH, modern portfolio theory, and the CAPM. Innovation and adaptability are the primary drivers of survival, hence a certain flexibility and open-mindedness to change can mean the difference between survival and extinction in financial markets.

7 The Evolving Role of the Consultant

Skeptics have sometimes facetiously discounted the role of consultants as glorified scapegoats for sponsors of underperforming pension funds, but as independent third parties, investment management consultants are ideally positioned to play a central role in the asset management industry. Within the context of the AMH and behavioral finance, the consultant can provide several valuable services that are currently not available.

First, the consultant can assist managers and investors in dealing with preferences in a more serious fashion. Instead of simply matching an investment product with a buyer, the consultant can offer three far more valuable services: (1) educating investors and managers about preferences, expectations, and potential behavioral biases to guard against; (2) assisting investors in articulating, critically examining and, if necessary, modifying their risk preferences to suit their stated investment objectives, constraints, and current market conditions; and (3) matching an investment manager's preferred investment process with an investor's suitably modified risk preferences.

These new services may be more challenging than they seem. In many cases consultants will be the bearers of bad news—no one enjoys being told that his preferences are inconsistent with their objectives, and that they may need to change their expectations if they do not wish to be disappointed. However, this is the essence of a fiduciary's responsibility, to have the client's best interests in mind, and how else can one's best interests be determined except through a deep understanding of the client's preferences? Of course, the very best consultants already do this in an informal and intuitive manner by investing time and effort in establishing long-term relationships with their clients and their managers. However, a more systematic approach using the latest innovations in psychological testing and investment technology is likely to yield even more significant benefits and for a broader set of consultants and their clients.

Second, by being sensitive to the changing nature of financial markets, and the ebb and flow of investment products and market cycles that this implies, the consultant will be in a better position to support and advise their clients. Unfortunately, this means that traditional tools such as mean-variance optimization and risk budgeting are no longer sufficient for addressing a pension plan's concerns, and more dynamic models that adapt to changing market conditions are needed (see Ang and Bekaert, 2004, for a recent example). Also, the consultant must be familiar with a wider spectrum of investment products and services, and must monitor not only current performance characteristics but also the cyclical nature of each asset class and how it relates to current business conditions.

Third, to achieve these lofty goals, the consultant must undertake continuing education and training to be at the forefront of investment theory and practice. Such training will include not only financial technology, but also the latest advances in the cognitive neurosciences—at least to the extent that such advances are relevant to the financial decision-making process—and new methods for implementing investment policies under time-varying preferences and business conditions. Although such training may seem unrealistically demanding—especially since some of the relevant tools and methods for implementing behavioral models like AMH have yet to be developed—significant benefits to the consulting community could accrue almost immediately by including some basic information on investor psychology and dynamic asset-allocation models in existing training and certification programs like the IMCA's CIMA program. Over time, as some of these ideas prove their worth in the investment community, the pace of research and development will quicken considerably and more applications of behavioral research to investment management will become available.

This ambitious agenda does raise the bar for the investment management industry, and implies a more active and intimate role for consultants than the status quo. In fact, one could argue that the consultant's new role is not unlike the role of a psychotherapist, and this analogy may not be completely inappropriate. Unlike basic service providers of a homogeneous commodity, consultants are typically not dealing with "one-size-fits-all" investment products.

A much deeper understanding of each client's objectives, constraints, and perspectives—in short, the client's thought processes—is necessary for a consultant to dispense the appropriate advice. Such an understanding can only be developed through a relationship of trust, not unlike the relationship between patient and therapist. Of course, investment managers must have some understanding of these issues as well, but the current division of labor suggests that consultants—as disinterested third parties—are in the best position to provide independent advice to investors.

We are at the threshold of an exciting new era in investment theory and practice, where a number of disciplines are converging to yield a more complete understanding of how to make sound financial decisions. And as new challenges arise in the investment management industry, those who are better equipped to meet those challenges will flourish, and those who are not may perish, for Tennyson's memorable phrase "Nature, red in tooth and claw,..." applies with equal force to the landscape of financial competition.

A Appendix

This Appendix contains a brief guide to the behavioral finance literature (Section A.1) and the answer key to Russo and Shoemaker's (1989) overconfidence self-test (Section A.2).

A.1 Suggested Readings

Investment professionals rarely have the luxury of immersing themselves in the academic literature, and in fields as rapidly changing as behavioral finance and the cognitive neurosciences, the challenges to the uninitiated are even greater. Therefore, in this section I provide a rather idiosyncratic and incomplete but more manageable guide to the most relevant references for the ideas discussed in this article, loosely grouped according to five general themes.

Efficient Markets Hypothesis

Most investment professionals will need no references to the EMH literature because the ideas in this line of research pervade the current investment orthodoxy. Nevertheless, for completeness, and for a historical perspective on the development of these ideas, I recommend two references: Bernstein (1992), a fascinating and highly readable intellectual history of quantitative finance; and Lo (1997), a reference collection of the most significant academic papers in the market efficiency literature. Three recent papers that focus squarely on the debate between EMH and behavioral finance are Rubinstein (2001), Malkiel (2005), and Merton and Bodie (2005), all of which provide eloquent summaries of the efficient markets mainstream.

Behavioral Finance

The behavioral finance literature contains several branches, and unlike the EMH literature, has not yet coalesced into an integrated whole.

A good overview of "mainstream" behavioral finance is provided by Shefrin (2000) and Statman (1999, 2004b,c), two of the pioneers of this strand of the literature. Also, recent interviews of Robert Shiller and William Sharpe in this journal present additional context for behavioral theories in the current literature.

A second branch of the literature is not part of economics or finance at all, but lies within the more established field of psychology, which has had a strong impact on behavioral finance and economics, as underscored by the fact that the Nobel Prize in economics was awarded to a psychologist, Daniel Kahneman, in 2002. A number of popular expositions of fascinating psychological experiments documenting behavioral biases have been published over the years, but my two favorites are by Gilovich (1991) and Dawes (2001). Plous (1993) provides a more academic and comprehensive exposition of the behavioral biases literature, and does so in a remarkably readable fashion. And for those interested in the differences and similarities between the academic disciplines of economics and psychology, Rabin (1998, 2002) provides a thought-provoking comparison.

The third branch contains the most recent research in behavior, which incorporates ideas from economics, finance, psychology, and the cognitive neurosciences. As a result, it is currently not considered part of either the mainstream finance or economics literatures but has begun to develop an identity of its own, now known as "neuroeconomics". Camerer, Loewenstein, and Prelec (2004) provide an excellent review of this emerging discipline.

Adaptive Markets Hypothesis

The Adaptive Markets Hypothesis is a term coined by me in Lo (2004) and has yet to become part of the standard lexicon of financial economists and investment professionals. However, evolutionary principles have been applied to many economic and financial models. Unfortunately, because the applications are so context-specific, there is no single literature on which the AMH relies. In fact, the ideas underlying the AMH have been inspired by several literatures: bounded rationality in economics (Simon, 1982, is the classic reference, of course); complex systems (Farmer, 2002); evolutionary biology (Wilson, 1975, in particular); evolutionary psychology (Pinker, 1997, provides a popular account of this new field, and Barrett, Dunbar, and Lycett, 2002, is an excellent reference text for researchers); and behavioral ecology (Mangel and Clark, 1988).

Cognitive Neurosciences

As a discipline, psychology has undergone a revolution over the past few years because of the confluence of new technologies like brain-imaging and interdisciplinary collaborations between neuroscientists and psychologists, and the two disciplines are now often considered one, sometimes called "brain sciences", and more often called "cognitive neurosciences". Any serious student of behavioral economics and finance cannot afford to ignore this literature, as some of the examples in this article have shown. Damasio (1994) provides a riveting popular account of the clinical research that led to his seminal ideas on the role of emotion in rationality, and gives us digestible portions of neuroanatomy and neurophysiology along the way. But this book is now somewhat dated—in this fast-paced field, 10 years makes a huge difference in terms of progress and perspective—and more recent popular expositions are available. My two recent favorites are Restak (2003), a clinical neurologist and very experienced science writer, and Ramachandran (2004), a world-renowned neuroscientist. Finally, Gazzaniga and Heatherton (2003) is a comprehensive reference text that does an excellent job of connecting the traditional psychology literature with more recent research in the neurosciences.

A.2 Answer Key to Overconfidence Test

Self-Test of Overconfidence	Answers
1. Martin Luther King's age at death	39 Years
2. Length of the Nile River (in miles)	4,187 Miles
3. Number of countries in OPEC	13 Countries
4. Number of books in the Old Testament	39 Books
5. Diameter of the moon (in miles)	2,160 Miles
6. Weight of an empty Boeing 747 (in pounds)	390,000 Pounds
7. Year in which Wolfgang Amadeus Mozart was born	1756
8. Gestation period of an Asian elephant (in days)	645 Days
9. Air distance from London to Tokyo (in miles)	5,959 Miles
10. Deepest known point in the ocean (in feet)	36,198 Feet

Table A.1: Answer key for Russo and Shoemaker's (1989) self-test of overconfidence.

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