Scientific Frontiers and Technical Analysis

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Abstract

Are there scientific foundations to Technical Analysis (TA) or is it a pseudo-science? Academia, embracing the Random Walk Theory, the Efficient Market Hypothesis (EMH) and Modern Portfolio Theory (MPT) has argued the latter for some 20 years or more. In fact, according to current orthodoxy, both TA and Fundamental Analysis are fruitless distractions and cannot add value. The advent of Behavioral Science has illuminated some of the flaws in the standard model. Andrew W. Lo's Adaptive Markets Hypothesis reconciles efficient markets with human behavior by taking an evolutionary perspective. According to Lo, markets are driven by competition, adaptation, and natural selection. What is missing is a more accurate and comprehensive model of the market itself. Chaos and Complex system theories provide a more comprehensive understanding of market behavior. The markets can be seen as chaotic, complex, self-organizing, evolving and adaptive, driven by human behavior and psychology. Patterns in the market are emergent properties. Identifying these patterns has predictive value, but certainties must be left behind; only probabilities remain. TA, shown to be the inductive science of financial markets, is an essential tool for identifying these emergent properties and analyzing their probabilities. Lastly, so that the science of TA may advance, the field must distinguish between scientific, empirically based, market analysis theory and the categories of interpretation and practical trading strategies.

I. Art, Science, and Fallacies

We see only what we know.

Johann Wolfgang von Goethe

Universities are the vanguard of emerging scientific thought. Yet, in the academic community, we find that TA does not fare well. TA is largely ignored, denigrated, or simply dismissed. In their well-respected paper, *The Predictive Power of Price Patterns* (1998), Dr. Gunduz Caginalp and Henry F. Laurent, wrote, "The gulf between academicians and practitioners could hardly be wider on the issue of the utility of technical analysis." John Nofsinger, Assistant Professor of Finance, Washington State University, recently confirmed this perception, reiterating that there is "one of the greatest gulfs between academic finance and industry practice (Peter Kendall, co-editor of the *Elliott Wave Financial Forecast* in *Technically Speaking*, 2003, April)."

Burton G. Malkiel, Professor of Economics, Princeton University, is one of the most prominent economists in the world. He authored the very influential financial classic, *A Random Walk Down Wall Street* and is a leading proponent of the EMH. With ties to the Vanguard Group, he is a vocal advocate of indexing. In his book, Malkiel sets the tone for what has become a prevailing attitude among academics: "Obviously, I'm biased against the chartist. This is not only a personal predilection but a professional one as well. TA is anathema to the academic world." "Anathema" means formally set apart, banished, exiled, excommunicated, or denounced. These scathing comments from the head of the economics department are unlikely to attract much undergraduate or graduate study to say the least. Ironically, "Anathema" is a Greek word originally meaning "something lifted up as an offering to the gods" and "something sacred." Worthy of note, Malkiel took aim at investment management professionals in general and not only technicians. He is best known for writing that a "blindfolded monkey throwing darts" could pick better stocks than most money managers could.

What is it about TA that warrants such disdain? John J. Murphy (1999) defines TA as "the study of market action, primarily through the use of charts, for the purpose of forecasting future price trends." Murphy notes that TA has three key premises; namely, that market action discounts everything, price moves in trends and history repeats. Martin J. Pring adds that TA "deals in probabilities, never certainties" and has "three essential areas: sentiment, flow of funds, and market structure indicators."

Although defined as an empirical science, leaders in the field shy away from its scientific foundations stressing the art of the practice. Murphy (1999) says, "Chart reading is an art." Pring (2003) also concludes that TA is an art. Accomplished TA researcher, Professor Henry O. Pruden makes the subtle yet significant distinction that the interpretation of technical patterns is an "art form" ("Chart Analysis as Sequential Art," *Journal of Technical Analysis*, 2004, #62). Aaron Task, in *Technically Speaking,* (2003, May), wrote, "Looking forward, I think the best thing MTA members can do is to stress the 'art' of chart reading over the science," in response to Peter Kendall's eloquent advocacy for the scientific aspects of TA. The "art advocates" do not want to defend TA scientifically.

Most of the art vs. science debate arises out of confusion. In any field, it is easy to confuse the practice or practitioners with the knowledge base. An art is an applied knowledge or applied science. Recently, John R. Kirby seeking to clear-up the art vs. science debate, quoted highly regarded Technical Analyst Ralph Acampora: "'Art' means a skill acquired by experience, study, or observation. 'Science' is a body of knowledge with its own axioms, rules, and language (*Technically Speaking*, 2005, January)."

From a scientific perspective, personality should not cloud empirical evidence. However, the aura of a powerful personality can have a huge impact on a field and some technicians have received substantial publicity for making sensational predictions rather than measured projections. When these predictions have failed to materialize it has brought discredit to the field. The academic community takes predictions very seriously and when a model fails to predict accurately, the underlying hypothesis is rejected.

Looking past the sins of a few, the most common criticism of TA is that it is a self-fulfilling prophecy. Typically, the argument goes like this: 1) Market patterns appear randomly; 2) Some investors use TA; 3) These investors respond to the same market patterns; 4) The investor response causes the markets to behave as the investors had anticipated; 5) The market response reinforces the believe that there is predictive value in TA; 6) It is investor behavior based on false beliefs that generates the anticipated market action.

The most obvious flaw in the argument is that you cannot isolate the behavior of technicians from other investors in any accurate, empirical manner. Even if it were possible, it is illogical to think that the behavior of one group should be isolated from the behavior of all investors. The market, by definition, is a function of all of its participants. Even if we were to assume all participants were technicians, it does not follow that all would act in unison. Aside from this obvious error, the argument has other logical flaws.

Robert K. Merton formalized the structure and consequences of social behavior in his book, *Social Theory and Social Structure* (1968). Merton first taught at Harvard then became Chairman of the Department of Sociology at Tulane University, and eventually joined Columbia University in 1941. He coined the term "self-fulfilling behavior," as well as other popular terms such as "role model" and "unintended consequences." According to Merton, "The self-fulfilling prophecy is, in the beginning, a false definition of the situation evoking a new behaviour which makes the original false conception come true." Therefore it can be concluded from Merton's definition that embedded in the "self-fulfilling prophecy" argument is the assumption that TA is based on false beliefs. We can see the argument is circular: TA is based on false beliefs; therefore, it is false. Moreover, it is illogical to apply truth functions to investor beliefs. Markets are a function of investor opinions and beliefs, regardless of the validity of those opinions or beliefs.

Efficient market proponents insist that the current price of a security is the best estimate of its true value. Efficient markets imply that self-fulfilling prophecies as traditionally understood are impossible. Therefore, any mainstream economists espousing the self-fulfilling prophecy argument are contradicting themselves. It follows, then, that self-fulfilling prophecy critics, if they are to remain consistent, must assume inefficient markets—something to keep in mind.

Does "self-fulfilling" behavior occur in the markets? If we are to assume that it does, then how is "non-self-fulfilling" behavior defined? Obviously, it is nonsense and not a useful construct for analysis. The term 'self-fulfilling' is not empirical but metaphysical and, as demonstrated, burdened with preconceptions. Taken together, one must conclude that the self-fulfilling prophecy argument is a canard.

There are more useful concepts to describe investor behavior such as "self-reinforcing behavior" as developed in Complexity Theory (Arthur, 1988). The phenomenon people are calling "self-fulfilling" is really self-reinforcing behavior. Self-reinforcing behavior among investors is most likely rooted in their expectations, but is not dependent upon the validity of their beliefs. Whether the underlying beliefs are true or false is not relevant.

Robert J. Shiller (2001), Professor of Economics at Yale University, takes a more sophisticated angle on the self-fulfilling prophecy critique of TA. He argues that TA plays a contributing role in market movements because technical reports are issued daily and therefore market participants are following and using TA. Shiller does not try to explain why or how TA is used. Instead, he sees TA as adding a broad underlying behavioral structure to the market that reinforces technical principles "solely because people are using them." Shiller uses the term "self-fulfilling prophecy" in *Irrational Exuberance* idiosyncratically to define his specialized version of "feedback loop theory." The feedback loop theory, according to Shiller, is "a scientist's term for what might popularly be called a vicious circle, a self-fulfilling prophecy, a bandwagon effect" and is synonymous with "the phrase *speculative bubble*." He considers TA a contributing factor in this phenomenon. Yet, his characterization of TA is consistent with Merton's definition of a self-fulfilling prophecy; therefore, he assumes TA is based on false beliefs. In addition, as noted before, Shiller has no way to determine what particular market action is based on technical opinions and what is not; thus his criticism is sheer speculation. Most importantly, Shiller did not do any research to determine how technical reports corresponded with the internet bubble. Anecdotally, there were many technicians warning that a bubble was underway months before the eventual reversal. In fact, prima facie evidence points to several top fundamental analysts as reinforcing the bubble, not technicians.

Shiller fails to consider that TA was developed and effective before there were daily technical reports. Moreover, it would follow from Shiller's argument that TA would be significantly more effective and influential today in the so called "Information Age" than it was 50 or 100 years ago, and that there should be, but is not, a progressive pattern of growing influence over time. Germane to Shiller's thesis, history shows boom and bust cycles with wild speculative market peaks and sudden crashes, but they occurred long before a price chart was ever drawn. Shiller references Charles Mackay's classic, *Memoirs of Extraordinary Popular Delusions and the Madness of Crowds*, written in 1841, he should have taken this into account.

Shiller is right when he says TA plays a contributing role in market movements, but he should have limited his argument to this point. It is accurate to say that TA may be a self-reinforcing force in the market and contribute to investor expectations whether rational, nonrational, or irrational. However, it is illogical for Shiller to claim that technical principles are reinforced "solely because people are using them" because that view cannot be empirically supported.

The other most common critique against TA is that it is "too subjective." Among experienced technicians, there is often disagreement about the interpretation of a particular chart pattern. The flaw is this argument is that there is a distinction between interpretation and a factual chart pattern. There is rarely, if ever, a disagreement over the facts of a chart or any other data set to be analyzed. The disagreement is about the interpretation of those facts. Do we criticize medicine as being too subjective because two doctors have different interpretations of a set of symptoms? No, we simply conclude, based on outcomes, that perhaps one doctor is a better diagnostician than the other is.

Murphy (1999) has pointed out that the "too subjective" and "self-fulfilling prophecy" criticisms are contradictory and cancel each other out. Either TA accurately reflects real market events or it does not. Critics want to use the subjective argument against TA when technicians fail to deliver and the self-fulfilling prophecy argument when they do. It is incumbent on critics to prove that TA does not reflect real market events. As noted above, this is virtually impossible, since there is rarely disagreement over market facts, only the interpretation of those facts.

At the core, these criticisms confuse the knowledge base with the practice. The science of TA does not have any influence on markets themselves, while the practice does. Most academics dismiss the science of TA out of hand and few want to acknowledge any success by practitioners, despite the Federal Reserve Bank of NY, Olser & Chang, writing over 10 years ago that, "Technical analysis, the prediction of price movements based on past movements, has been shown to generate statistically significant profits despite its incompatibility with most economists' notions of 'efficient markets'."

II. Modern Finance and Anomaly Projection

When you're average, you're just as close to the bottom as you are to the top.

Alfred North Whitehead

John Bollinger recently wrote, "Fundamental, technical, quantitative and behavioral analysts face the same common adversary, the markets and the Efficient Market Hypothesis." EMH, CAPM, and MPT are the foundations of contemporary Finance. They are well-defined, compatible, and self-reinforcing concepts. The definitions are mathematically based, cogent and standardized. The formulations are irresistibly compelling, and valuable insights can be derived from the models' mathematical relationships developed by top economists over several decades. Harry Markowitz, William Sharpe, and

Merton Miller received the Nobel Prize in 1990 for their development of MPT. Built on Markowitz's algorithm for constructing optimal portfolios, MPT uses Sharpe's Capital Asset Pricing Model (CAPM) and other statistical techniques to derive optimal tradeoffs between risk and return based on various historical assumptions. Their model presumptively explains how an asset's return compensates the investor for bearing risk. If accepted, these models dismiss the possibility of any productive result from applied analysis. How well does the model map onto the real world? As we shall find, MPT is based on the ideal, not the real.

Andrew W. Lo, Professor at the MIT Sloan School of Management and Director and the MIT Laboratory for Financial Engineering, argues that, "Unlike the law of gravity and the theory of special relativity, there are no immutable laws of nature from which the EMH has been derived." Certainly, efficiencies are observed in financial markets, but as we shall see, the assumptions of the EMH standardize the concept of efficiency to an untenable level.

EMH proponents simply ignore many forces critical to markets when those forces are difficult or currently beyond our ability to model mathematically. In MPT, variables are held constant, except for the few permissible, in a linear equation. Tautological arguments support the framework of MPT and conclusions are deduced, not observed. Contemporary finance is linear reductionism based on the EMH and its corollaries. However, matters of observational science– including economics–must be inferred by induction, not deduction from a priori assumptions, to accurately correspond with reality.

Observation shows that markets have different levels of efficiency, varying over time and circumstances. Levels of efficiency between major currency markets and micro-cap stocks are substantial, for instance. Liquidity is critical to market efficiency and liquidity factors are always changing. During market shocks, for example, liquidity can all but disappear in even the most efficient markets.

The EMH assumes each price change is independent from the last. The "Random Walk" of the market dictates that the previous change in the value of a variable, such as price, is unrelated to future or past change. Statistical data collection implicitly defines each data point as independent. Based on such contextual assumptions, the data can appear random when the data points are treated as discrete events. Consequently, Shiller argues that efficient market theorists make the mistake of assuming that no changes can be predicted, just because "it is difficult to predict day to day changes (2001)." It is true that prices do not have memories, but it seems that many modern economists have forgotten that people do. As the behavioral scientists have documented and as an obvious tenet of TA, price points are not random. People take action based on their perception of a particular price, the history of prices and their expectations of future prices.

When confronted with empirically observed inconsistencies in their assumptions, Fama (2005) and other modern mainstream economists refer to them as "anomalies." However, the facts line-up differently. In recent years, especially with the advent of Behavioral Science, the flaws in the standard model are finally being addressed in academic circles. The documented examples of inconsistencies have grown so large that it is now obvious the market described by the EMH is itself the anomaly (Sloan 1996, Bodie-Kane-Marcus 2003, Jaffe 2006, MacKinlay 2006). Well-established academic proponents of the EMH have stated that the EMH needs to be reworked, most notably, Kenneth J. Arrow of Stanford University. Arrow, who won the Nobel Price in Economics in 1972 for his mathematical work on General Equilibrium Theory in support of the EMH, has acknowledged that the hypothesis is empirically false (Paul Ormerod, 2005).

Current orthodoxy has attempted to treat markets as if they are amenable to modern physics. The axiom of equilibrium in the markets is a primary example. Equilibrium is appealing to the mathematician since it implies an equation with equivalent sums on each side of the equal sign. However, "equilibrium" is a poor model for the economies and markets. Stuart Kauffman, an expert on Complexity Theory argues that, "all free-living systems are non-equilibrium systems (1995)." Homeostasis is a more accurate model for markets. 'Homeostasis', a biological term, when applied to Finance, illuminates the biological basis of markets. Notably, homeostasis is multi-variable and nonlinear in nature and cannot be reduced to a simple equation.

III. The Behavior Finance Critique of the Standard Model

We think in generalities, but we live in detail.

Alfred North Whitehead

Behavioral Science points out the obvious: humans are animals, subject to biological constraints. Humans are prone to a multiplicity of errors and studies demonstrate that these errors are especially prevalent in complex systems like financial markets or when making financial decisions, in particular. Humans routinely exhibit irrational and nonrational behavior. In fact, rational behavior may be the exception to the rule. As the famous playwright Oscar Wilde observed, "Man is a rational animal who always loses his temper when he is called upon to act in accordance with the dictates of reason." How rational are investors? If investors are shown to be relatively irrational, then is it logical to assume the markets are rational? If the markets are not as rational as assumed by MPT, what are the implications for effectively modeling markets.

Richard Thaler, Professor of Behavioral Science and Economics at the Graduate School of Business at the University of Chicago and 2002 Nobel Price winner Daniel Kahneman, Professor of Psychology at Princeton University are the founders and leading proponents of Behavioral Finance. Some of their ideas have been in scholarly development for over 30 years, but had been largely dismissed until the internet bubble shattered the neoclassical grip on economic thought. Their core premise is that humans make errors, especially with respect to investing. Some of their most popular observations include the "Hindsight bias," commonly referred to as "Monday morning quarterbacking" and the "Overconfidence bias" or the many ways people fail to assess risk properly (Kahneman and Tversky: 1972, 1973, Barber and Odean: 2000, 2001). Today, there are literally hundreds of studies showing "bias" in financial markets.

Bodie, Kane and Marcus wrote that, "Behavioral Science fully demonstrates that individual behavior is not well approximated by standard utility analysis of economic theory (2003)." Even Fama, the leading proponent of the EMH, has had to modify his views. In 2005, Fama acknowledged in a broadly attended conference of his peers that because of poorly informed investors, markets could become "somewhat irrational." Thaler, a leading proponent of Behavioral Finance, mocked Fama with whom he has had a longstanding intellectual feud by replying, "I guess we're all behaviorists now (WSJ, 2005)." Behavioral evidence has forced Fama to adjust his concept of efficiency. His definition of efficiency now incorporates the belief that the market is efficient in reflecting mass states of consciousness and rational states are just one of many states and not likely a dominant one. Fama does not explain how the dominant nonrational states can be mathematically modeled.

Kendall, in a 2003 issue of *Technically Speaking* issued a strong endorsement of Behavioral Finance as supporting TA because behavioral observations coincide with technical themes. Pruden refers to TA as "applied behavioral finance." TA documents the observations of Behavioral Finance. The study of market behavior shows that there are common tendencies that are played out repeatedly. One tendency is for investors, and people in general, to extrapolate the past into the future. This tendency causes trends to persist, something well documented in the TA body of knowledge.

Pruden argues that markets reflect the thoughts, emotions, and actions of real people as opposed to the idealized economic investor that underlies the EMH (*Journal of Technical Analysis*, W-S 2003). Behavioral Finance considers these elements unlike neoclassical economics. In the final analysis, markets are epiphenomenal manifestations of biological activity. Behavioral Science illustrates the fact that humans are animals subject to the influences and constraints of our biology and our environment. While neoclassical economics has the Platonic appeal of perfect ideas, the application to markets is limited because there is no incorporation of human behavior and its biological origin.

IV. Biology, Evolution and Financial Markets

Every man takes the limits of his own field of vision for the limits of the world.

Arthur Schopenhauer

Human experience and behavior is ultimately rooted in the brain. The human brain is a unique structure in the animal world. Its size and complexity sets us apart. One of the traits directly related to our evolved brain is an advanced ability for memory and data processing.

Howard Fields MD/PhD and Professor of Neuroscience at UC San Francisco, asserts that memory is about collecting important data and "from a biological or evolutionary perspective, memory is about the future (Fields 2005)." Vital experiences related to survival and reproduction "are immediately apparent, and memories of them are socked away permanently," according to Fields. Heightened states of attention, stress, and novelty stimulate memory consolidation. Fear and greed are biochemical states that reinforce memory retention (LeDoux, New York University 2005). Memories are consolidated for survival, not necessarily accuracy. Each night the brain sorts through fresh memories, integrating them with other memories and biochemically isolating them in various brain regions for permanent storage, while many short-term memories are simply discarded. Individual brain chemistry determines how well memories are retained or integrated (Fields 2005). Memories are the foundation of our personal database. Even under ideal circumstances, people typically do not possess all the information needed to make accurate decisions (Dunning, Heath, Suls 2005). Some level of misinformation corrupts all of our memories. The memories about oneself may be our most corrupted pool of information. Individuals consistently make false self-assessments. "Mispredictions," usually overoptimistic ones, arise because people do not have all the information they need to make accurate forecasts (Dunning, Heath, Suls, 2005). Important details of the future are missing in almost any decision. People fail to adjust to the reality that many or future facts are unknown, unknowable or unpredictable.

David A. Dunning, Professor of Psychology at Cornell University and Professor of the Graduate School of Business at Stanford University and Jerry Suls, Professor of Psychology at the University of Iowa have completed many studies on what they refer to as the problem of "flawed self-assessment." In the absence of "complete feedback, people harbor inflated views about the wisdom of their decisions." In many environments, success is hard to define, and as a result, people regularly assess themselves as "above average" in competency (Dunning, Meyerowitz, Holzberg, Cornell, 1989). People misjudge their skills in relation to others by ignoring crucial information. Comparative judgments "paradoxically involve very little actual comparison," due to egocentrism (Dunning, Heath, Suls 2005). People have tendencies to create arbitrary standards of measurement in order to compare themselves. Though arbitrary, these standards consistently permit individuals to present themselves in a favorable light.

Errors rise with increasing "incompetency" as well. Incompetent individuals "suffer a double curse: their deficits cause them to make errors and also prevent them for recognizing what makes their decisions erroneous and the choices of others superior" (Dunning, Heath, Suls, 2005). Incompetency rises with stress levels. Stress can be caused by information overload, new or unusual circumstances, competition, sleep deprivation, environmental stresses such as cold or heat, dietary stresses, workloads, financial pressures, impaired health conditions of all kinds, and especially those related to "transduction." Transduction is the process of processing stimuli into facts about the world.

Additionally, people have difficulty predicting their emotional responses and the decisions they will make in relation to those emotions. Fear and greed or decisions surrounding money come readily to mind, as well as hunger, sleepiness, and other visceral states. When people are in a logical state of mind, their decisions "mispredict" their reactions in "hot" or emotional/visceral states (Dunning, Heath, Suls, 2005). Memory, access to memories, and the embedded information related to memories are state dependent. Dunning, Heath, and Suls conclude that, "In sum, a wealth of evidence suggests that people may err substantially when they evaluate their abilities, attributes, and future behavior (2005)."

The research from neuroscience and psychology provides a solid foundation for the theories of Behavioral Finance. Many contemporary economists have had to integrate Behavioral Finance into their models. Based on observations, rather than reflecting anomalies, Behavioral Finance exposes market participants for what they are—human beings. Aristotle, defining humans as "rational animals" 2300 years ago, set the course for Western philosophy. Yet, rational consciousness is fragile and easily overshadowed by the slightest biochemical alteration. Operating under the influence of human biological and behavioral peculiarities, less than ideal circumstances predominate in financial markets.

V. The Adaptive Market Hypothesis

Both competition and cooperation are observed in nature. Natural selection is neither egotistic or altruistic. It is rather, opportunistic.

Theodosius Dobzhansky

Dr. Andrew W. Lo is the first to "reconcile" human behavior, the theory of evolution and neoclassical models. He calls his reconciliation "the Adaptive Market Hypothesis." Lo's new framework has traditional models of modern economics coexisting with behavioral models in a logically consistent manner, representing essentially, "two sides of the same coin (2004)." Rather than the neoclassical assumption that individuals are rationally maximizing "expected utility," his evolutionary model argues that individuals through generations of natural selection seek to maximize the survival of their genetic material. Human behavior evolves by natural selection and is dependent on the surrounding ever-changing environment.

According to Lo, individuals act in their self-interest and in doing so they will often make mistakes and from these mistakes, individuals learn and adapt. Competition drives individuals to innovate. Natural selection shapes market ecology and evolution determines market dynamics. Lo argues that natural selection operates not only upon genetic material, but also on biological activity, social behavior, and culture. In societies, it becomes "survival of the richest." Individuals develop heuristic steps to tackle economic challenges that "eventually will adapt to yield approximately optimal solutions (2005)."

Lo addresses the more glaring flaws in the EMH. Evolving systems, he says, do not converge on an ideal state, and "equilibria" may never occur as described in the EMH. "Aggregate risk preferences" are not fixed, as assumed by the EMH, but are constantly being shaped by the forces of natural selection. In the EMH, history is a "trendless fluctuation," but according to Lo, and intrinsic to evolution through the process of natural section, history matters. Each event has an impact on future outcomes.

The particular path that market prices have taken over the recent past, influences current aggregate risk preferences, according to Lo. Successful behavior reinforces itself over time, while unsuccessful behavior is self-limiting. Adaptability and innovation are the primary drivers of survival. Flexibility and open-mindedness to change can mean the difference between survival and extinction in the financial markets. Rather than only the trend toward higher efficiencies dictated by the EMH, the AMH implies and incorporates more complex market dynamics. Trends, cycles, bubbles, panics, manias and other phenomena are common in "natural market ecologies," according to Lo.

In the EMH, skill is qualitative and provides no value over time. In the AMH, 'skill' is equivalent to knowledge or discernment. With the AMH in mind, TA can be seen as an adaptable tool and flexible system for rapidly changing financial markets. At the core, TA is a technology. A very common phrase among technicians is that "it works." Even among the newest practitioners, it is widely accepted that advantages flow to the user. The level of utility is so high there is usually little concern as to why it works.

The AMH reinforces the important role of history as perceived by technicians. TA is focused on the significance of history in shaping events and outcomes. Yet, TA is inherently innovative and novelty-sensitive. Like evolution itself, TA is dynamic, not static. Practitioners are conditioned to be in constant feedback loop with the markets to assess change, process it, and adapt accordingly.

VI. Interdisciplinary Models For Financial Markets

Chance favors the prepared mind.

Louis Pasteur

Lo's thought-provoking introduction of evolution into market theory is a daring risk for a well-established professor at a top university. It takes courage to challenge the current orthodoxy, but with increasing frequency, respected members of the academic community are speaking-up. It is likely that ignored market theories will get a credible evaluation in coming years as the critical mass builds for a new paradigm. Through the years, theorists from various disciplines have modeled the markets to increase general understanding and investor success. Many of these models have not been thoroughly studied.

Chaos Theory is the study of unstable, aperiodic behavior in deterministic nonlinear dynamical systems. Translated into nonmathematical language, Chaos Theory attempts to explain phenomena in nature that starts from an orderly state and evolves into a non-repeating or disorderly state. The mathematical formulas that characterize chaotic systems depend on the details of initial conditions. Relatively simple formulas can generate complexity, disorder, and even unpredictable order with repetitive qualities. A chaotic system is deterministic, in that, it can be defined initially with a relatively simple formula. However, the data generated from the system rapidly becomes insoluble. The application of Chaos Theory to financial markets is irresistible, since markets often appear chaotic. Market openings can be treated like "initial conditions" and although there is an order, no two days are alike. Markets have patterns that appear repetitive but are not the same. The nonlinearity and the multivariable nature of markets offer the most compelling allure for using Chaos Theory to model markets.

Benoit B. Mandelbrot, Professor of Mathematical Sciences at Yale University is recognized as the founder of fractal geometry in 1975 and, later, popularized Chaos Theory. His work originated out of his interest in financial markets. Other interests took him away from financial markets for many years as he pursued a quantitative model for "roughness." Roughness is used to describe the actual nature of physical phenomena. Clouds are not spheres, mountains are not triangles, and coastlines are not straight lines. Mandelbrot has shown that fractals are useful models for many natural phenomena including Brownian motion. Brownian motion, of course, was the inspiration for Malkiel's "Random Walk Theory" central to the EMH.

Mandelbrot has recently turned his attention back to the financial markets with renewed vigor. "Like the weather, markets are turbulent," he states, associating finance with Chaos Theory. Turbulence is one of the well-established applications of Chaos Theory (2004). According to Mandelbrot, markets are much more risky than assumed. His penetrating critique of the standard model is that it focuses on asset allocation as opposed to actual market behavior, noting the unpredictably wild price swings of the markets. Mandelbrot takes a fractal view of the financial markets, rather than a behavioral perspective. The cause of the volatility is not human behavior in Mandelbort's mind, but the structure of the market itself. Because he misses core behavioral influences, he believes markets can be reduced to mechanics and the principles of physics—an obvious dead-end in my opinion. Nevertheless, his observations are fascinating and worthy of note since his keen insights expose the weaknesses of MPT.

He argues that history, or what he prefers to call "memory," matters in the markets. Mandelbrot relies on the mathematically defined concepts of "permanence" and "dependence" developed by other mathematicians. These equations are designed to describe "long-term memory" in the markets. These mathematicians attempt to draw a mechanistic relationship between prices defined as memory or "statistical dependence," without any reference to human brains associated with this memory or dependence.

Mandelbrot develops the idea of "market trading time," and its corollary, the fact that market-timing matters. Volatility and "titanic events" underscore the role of timing, he argues. The unfolding of events in the markets has a "multifractal nature," because there is an unlimited potential for scaling, as there are "no intrinsic time scales."

Prices often "leap" and there are constant exceptions to the "Principle of Continuity," according to Mandelbrot. The Principle of Continuity, otherwise known as "cause and effect" is one of the core assumptions of empirical science and applied mathematics, including calculus. For Mandelbrot, markets are "discontinuous" and operate in "psychological time." Mandelbrot does not seem to notice that psychological time implies a human component. "Markets are deceptive," he adds, and it is difficult to discern meaningful patterns from "noise" or "chance," unlike EMH proponents who think it is impossible.

Mandelbrot argues that any model of the market must be probabilistic. However, the data does not conform to the standard Bell Curve as assumed under MPT. On the contrary, price changes are statistically dependent and not normally distributed. "The data overwhelmingly show that the magnitude of price changes depends on those of the past, and the bell curve is nonsense. Speaking mathematically, markets can exhibit dependence without correlation (2004)." Mandelbrot's observations are in direct opposition to the EMH and highly supportive of TA.

One may assume that Mandelbrot would embrace TA based on his view of markets. Instead, Mandelbrot is a harsh critic of TA, casting it pejoratively as "financial astrology." Mandelbrot slanders technicians further, calling TA a "confidence trick." A con is no more than a swindle and implies the intention of purposefully misleading unsuspecting investors for financial gain. This is a reckless claim that cannot be substantiated.

He believes that "chartists can at times be correct," but it is because of self-fulfilling prophecy. He declares, "Everybody knows what everybody else knows about the support points, so they place their bets accordingly (2004)." I have already shown the self-fulfilling prophecy critique to be a specious argument. In addition, as noted earlier, TA was developed, applied, and considered beneficial before "everybody" knew about support points. Moreover, newly developed and, often, proprietary methods back-test successfully, without "everybody" knowing about them and are commonly held in secret if proven successful.

Although condemning TA, incredibly he edges to the precipice of embracing the discipline. Mandelbrot acknowledges, "Price charts have meaning" and do not "all vary by the whim of luck." In Mandelbrot's spellbinding book, *The (Mis)behavior of Markets: A Fractal View of Risk, Ruin and Reward* (2004), his investigations provide the most devastating critique of the standard model to date, while inadvertently supporting TA. However, he explicitly parts company with technicians and proceeds to contradict himself.

His misguided 'coup de grace' against TA is worth exploring since it exposes specious arguments often used by critics. Mandelbrot notes that by running fractal formulas on his computer he can create two and three dimensional mountain graphs "randomly." "Chance alone can produce deceptively convincing patterns," he proffers. Mandelbrot explains that observers cannot tell the difference between real and arbitrary patterns. Rhetorically, he asks the reader to identify the "real chart" from the manufactured ones. Since it is impossible to distinguish the real chart, he reasons, real charts must be inherently random also. He concludes that people simply project a pattern onto random data. We are inclined to see "spurious patterns" where none exists because it is the nature of our minds to do so, according to Mandelbrot. The argument is alluring since psychologists have shown for years that people will manipulate, often capriciously, complex and seemingly random information into meaningful patterns. Neuroscientists have demonstrated that our brains are wired to organize a mass of sense data into orderly patterns.

Nevertheless, it is only necessary to point out Mandelbrot's contradiction to dismantle his argument. Namely, on one page of his book he writes that charts have meaning and then on another he writes that they are random creations of chance. He wants it both ways to suit his argument. It was Aristotle who pointed out that if one permits the introduction of a contradiction into an argument then anything could be proven. Yet, it is interesting to address his argument in a vacuum, as if it stood alone, since many modern economists would agree with Mandelbort's argument and not contradict themselves about TA as Mandelbrot does.

All told, Mandelbrot's argument is based on a "category mistake". The philosopher Gilbert Ryle defined a category mistake as a semantic or ontological error when a property is ascribed to something that could not possibly have that property. In this case, it is an error to attribute randomness to an actual, context-dependent, fundamentally rich chart of the Dow Jones index, for example. In practice, a seasoned technician could identify an actual chart of various periods given a modicum of contextual clues. Similarly, one can imagine a seasoned geographer being able to pick out an actual local mountain range from a collection of Mandelbrot's three-dimensional creations. If Mandelbrot were lost in the Santa Monica Mountains, he would want his rescuer to know the terrain, not a randomly selected volunteer. We can only hope he takes the same precaution with his portfolio manager.

Similarly, Random Walk Theorists make the same mistake with a deceptive coin tossing exercise repeated in economics courses across the country. Students are asked to flip coins, assigning a plus to "heads" and a minus to "tails." The students then plot their results onto a Cartesian coordinate system. When the points are connected forming a graph, classic technical patterns are observed. The Random Walkers declare speciously that this proves that technical analysis is nonsense, since the chart patterns can be generated "randomly." The inference is that the actual market patterns noted by technicians are randomly generated as well. As in Mandelbrot's argument, randomness is assumed an ontological or innate characteristic of the data. Yet, it is not. Market data is content and context-dependent. Therefore, it is erroneous to prescribe randomness to data that is not random. How many investors flip a coin before buying or selling securities? Price data is not generated by a random process like a coin toss, but by human intentionality. Moreover, any data set plotted graphically will have similar patterns. I could plot the daily high temperature in my community, for instance. Does it follow that the pattern generated is random like that from coin tosses? Of course not. It is a ridiculous inference.

J. Doyne Farmer and John J. Sidorowich provide yet another reason why the random coin toss argument is specious, by noting that if "we made precise measurements of the motion of the coin as it left our hand, we could predict the final outcome. People who are skilled in flipping a coin properly can do this (1998)." One can imagine someone getting the feel for flipping "heads" by developing a methodology. Like shooting free throws, it is easy to imagine someone on a hot streak, intentionally flipping "head" after "head." Farmer and Sidorowich highlight the illogic of applying mechanistic principles to human behavior and complex systems in general. They argue, "Randomness occurs to the extent that something cannot be predicted." However, as they note, identifying randomness is an empirical process. "With a better understanding of the underlying dynamics, better measurements, or the computational power to process a sufficient amount of information," they argue, "behavior that was previously believed random might become predictable." Supporting my view of "apparent randomness," they argue that the leading cause of unpredictability is "ignorance (1998)."

A friend of mine, returning from his first trek through the Amazon jungle, told me that, "everything was green." After several years of intense botanical study, he returned to the jungle and said he had a completely different experience. Now, he was able to detect many different shades of green, identify variations of leaf shapes and discern layers of order like the dynamics of competition among plants, for instance. The myriad of describable patterns were obvious to him while before he saw only a monochromatic blur.

Another similar example is my experience with the ocean. Having lived near the ocean my whole life, I have been active in and on the water since I was young child. When with less experienced ocean-going friends, I occasionally make an off-hand comment about the obvious trends I see developing in the swells, tides or wind and inevitably my "predictions" unfold. With incredulous astonishment my friends would ask, "How did you know that would happen?"

Both the Amazon jungle and ocean examples are effective allegoric characterizations of how one's knowledge base affects perception. To the inexperienced and unknowledgeable, the market can seem chaotic and random, but to the experienced and informed, the pulse of intensity seen in volume numbers and other measures, the variation in price movements, the underlying structure and cyclic patterns are all very familiar and may offer a predictive advantage over other uninformed investors.

Randomness, on which Mandelbrot bases his argument, is problematic. He and many of his colleagues may be conferring more potency to the term than it is entitled. Scientists have a very difficult time defining or generating true randomness. Brian Hayes, Computer Scientist and author said that, "After 40 years of development, one might think that the making of random numbers would be a mature and trouble-free technology, but it seems the creation of unpredictability is ever unpredictable." Hayes made that comment 12 years ago, and a quick review of current thinking on the topic indicates any ostensible model of randomness has proven ephemeral.

Philosophically, true randomness may be possible only if one forgoes "cause and effect," something most scientists do not wish to entertain. The definition of randomness, "the apparent lack of purpose, cause, or order" is noteworthy for my emphasis on the word "apparent." What may be random to most observers may not be so to an informed party. Evidently, "randomness," as used by some economists, appears to describe their experience rather than the object of the data itself. Mathematically, randomness is the lack of bias or correlation. Mandelbrot ascribes a lack of correlation to the markets in general. Perhaps, like the Random Walkers, in the end his argument is circular: the markets are random because they are random.

Ultimately, Mandelbrot is too wedded to the modern mainstream view adjusted for his special brand of "fractally wild randomness" and has not assimilated behavioral science into his work. Extreme market volatility is explained better by psychology, than chance. In addition, Mandelbrot has not resolved the inconsistency that his mathematical insights are incompatible with the mathematical assumptions of the standard model. He misses the fundamental contradiction of defining the markets as nonlinear, while subscribing to the linear calculations of MPT. To the neoclassicists he is undoubtedly a heretic, but he insists on their mantle.

Jeremy J. Siegel, Professor of Finance at Wharton, like Mandelbrot, writes about "noise" in the markets. Recently, in the Wall Street Journal (June 2006), Siegel proposed the "Noisy Market" Hypothesis. In a direct attack on the EMH, Siegel says that the "prices of securities are *not* always the best estimate of the true underlying value of the firm." According to his "new paradigm," because of "*temporary* shocks," and what he calls "noise," prices are obscured from "their true value." Examples of noise would include the activities of speculators, momentum traders, insiders and institutions, "that often buy and sell stocks for reasons unrelated to fundamental value, such as for diversification, liquidity, and taxes." Mandelbrot uses the term 'noise' often, and in a similar way, in his recent book. Mandelbrot equates 'noise' with randomness or chance, while Siegel implies that it represents causal price distortions, as described in Complexity Theory. Siegel could have included other reasons to explain market noise; like performance driven behavior, management changes, investment objective changes, the list goes on. When you add it all up, the question comes to mind: "What's left?" Again, 'noise' does not appear to be useful construct.

Siegel is on the right track when he says, "…we're at the brink of a huge paradigm shift. The chinks in the armor of the efficient market hypothesis have grown too large to be ignored." He concludes, "The noisy market hypothesis, which makes the simple yet convincing claim that the prices of securities often change in ways that are unrelated to fundamentals, is a much better description of reality…"

Given the advent of Behavioral Finance, it is noteworthy that Mandelbrot and Siegel, like many prominent economists, do not even mention the contributions of the field. Why the bias against acknowledging behavioral influences? Behavioral factors are difficult to measure and virtually impossible to formalize. Consequently, modern portfolio theorists are inclined to circumvent them. Circumvention is a common methodology in applied mathematics, but it is always used explicitly as a strategy to solve otherwise insoluble problems. Yet, many economists cavalierly ignore the human element altogether. Irrational and nonrational factors are only quantifiable in nonlinear terms and impossible to model in traditional equations. Most academics would rather risk being incomplete than jettison the mathematical framework developed over the last 50 years. If one *excludes* TA, as the academic community is so wont to do, there is no way for them to include human behavior and remain consistent. TA assesses behavioral influences and attempts to measure nonlinear data.

Robert A. Haugen, in The *New Finance: Overreaction, Complexity and Uniqueness* (2004), is critical of the EMH, what he calls the "standard rational model." He is also critical of pure behavioral models. Haugen says current models "are fundamentally flawed because they fail to account for the *complexity* and the *uniqueness* of behavioral interactions on ultimate outcomes." Most rational and behavioral models assume an orderly environment, but "markets are complex, ranging between order and chaos," a key theme throughout his work. Haugen, in an earlier book reference, was obviously influenced by *The Economy as an Evolving Complex System: Santa Fe Institute Studies in the Sciences of Complexity Proceedings* (1988). Interestingly, the Forward is by none other than Nobel Laureate Kenneth J. Arrow, the reformed neoclassical economist. Arrow also co-edited the book, and significantly, one of the chapters is by Stuart Kauffman.

According to Haugen, current economic sophistication cannot come close to mapping complexity because of the sheer quantity of variables, what he calls "the myriad of unique interactions in the market place." Mathematically, the problem is "intractable," he asserts. Because each individual interaction is unique, simple economic models are rendered "meaningless." Haugen calls his model "The New Finance," where investors "view, understand, and then predict the behavior of the macro environment, rather than attempting to go from assumptions about micro to predictions about macro." He adds, "The market is in such a constant state of complex interaction that no individual behavior, rational or irrational, can be aggregated, modeled, or generalized under an assumption of a fixed set of external conditions."

Haugen started out his academic career as an efficient market theorist and believed in a "rational market." In 1996, Haugen and a colleague published what *Barron's* described in 2006 as a "ground-breaking study," abandoning the notion that markets are efficient. I should mention that all of Haugen's writings are fascinating works, written with zeal, wit, and humor.

Haugen writes that he has developed proprietary "state-of-the-art expected return statistical models" to get "very high rates of return in the financial markets." He indicates his model takes advantage of extreme levels of volatility when they occur in the markets. Based on the evidence presented in his book, *Beast on Wall Street: How Stock Volatility Devours Our Wealth* (1999), Haugen describes three types of volatility: "event driven," "error driven" and "price driven." Event driven volatility is consistent with price changes described by the EMH, essentially, instantaneous price changes in response to real economic events. Error driven volatility is consistent with the under and over-reactions of investor behavior described by Behavioral Finance. Price driven volatility is the most prevalent form by a significant degree and is caused by traders responding to the actions of other traders. Price driven volatility is "the overwhelming driving force" in the markets and somewhat arbitrarily tied to fundamental values where "prices react to price changes." From the perspective of initiating investments, it can be inferred from Haugen's arguments that as volatility measures get extreme, the potential for successful outcomes soar, reminding me of Baron von Rothschild's axiom: "Buy when there is blood in the streets." Haugen defines "bias" as the "aspect of inefficient market pricing whereby the market tends to underestimate the power of competitive entry and exit…"

In his book*, The Inefficient Stock Market: What Pays Off and Why* (2002), Haugen includes TA as part of his formula for identifying the best stocks to own. He coins the phrase "Technical Payoff" which is the "component of return that can be statistically related to some aspect of the previous history of a stock's performance."

To his credit, Haugen attacks the bias against observational science in economics head-on. Haugen argues that induction is the only effective way to observe "macro behavior." Sounding like a technician, he says, "An inductive effort, such as this, attempts to peer through the fog of interactive, price driven volatility, searching for patterns and tendencies (2004)." The process of inductive reasoning is the foundation of observational science. Conclusions drawn from the scientific method are made by induction. In science, laws are formulated from limited observations of recurring phenomenal patterns. Scientists induce the universal from the particular.

Similarly, applying the rules of induction, Shiller wrote, "It is important to collect information directly on the popular models that people have with regard to speculative markets, and the associated investor behavior." "Direct evidence" can be collected "by using experimental methods or by observing investors in the actual investing environment (2001)."

Although this makes perfect sense to technicians, Haugen's and Shiller's scientific approach to markets is virtually unheard of among leading academics. It is interesting and somewhat revealing to note that the Austrian School, the early founders of classical economics in the early 1900s, rejected the use of observation, believing humans were too complex. Austrian economists rejected extrapolating from historical data and made the behavioral assumption that humans were logical rather than reactive. Out of these views, they developed the concept of "utility" or satisfaction, that all human act logically to remove primary dissatisfactions. Obviously, these core assumptions still hold sway in academia today.

Haugen's focus on complex interactions, chaos and uniqueness are important concepts in Complexity Theory. Complexity Theory appears to be at the core of Haugen's views, yet he does not refer to it directly. Instead, like Shiller, he writes as if Complexity Theory is a given.

According to Stuart Kauffman, the most complex and coordinated behavior occurs in networks at the edge of chaos (1993). For Kauffman, a complex system has many independent agents interacting with each other in many ways, undergoing spontaneous self-organizational behavior that is intrinsically adaptive. He sees chaos as a phenomenon in complex systems, but while Chaos Theory recognizes and chronicles order in nonlinear systems, he feels the theory fails to account for it. Instead, Complexity Theory focuses on "cycles," "webs," and "patterns" (Pines, 1988). The insight of self-organization is the critical missing piece, according to Kauffman. Self-organization occurs on many scales and may be a fundamental law of nature. Complexity Theory and self-organization can explain Mandelbrot's concepts of fractal geometry, self-similarity, and discontinuity. Kauffman sees self-organization as at least as important as natural selection in describing natural phenomena.

Stuart A. Kauffman, physician, biologist, complex systems researcher and former Professor of Biochemistry and Biophysics at the University of Pennsylvania, started the BIOS Group, a company using complex systems methodology to solve business-related problems. Kauffman rose to prominence as a researcher at the Santa Fe Institute, a non-profit research center dedicated to the study of complex systems. He is the author of several "must read" books on Complexity Theory and its application to evolution and financial markets. As we shall see, Complexity Theory provides additional deep insights into market behavior.

VII. Complexity Theory and Financial Markets

Seek simplicity but distrust it.

Alfred North Whitehead

As Stuart Kauffman writes, self-organization is the "root source of order" and leads to the "laws of complexity" and natural selection acts upon or within this context of inherent order. "Life and its evolution have always depended on the mutual embrace of spontaneous order and selection's crafting of that order (1995)." Self-organization and the emergent properties resulting from the laws of complexity are observed at all levels "from ecosystems to economic systems undergoing technological evolution." Kauffman states, "Complex adapting systems" from single cells to economies "evolve to a natural state between order and chaos." He sees the small, best choices of agents triggering significant and substantial co-evolutionary change as they compete and cooperate to survive. "Self-organization may be the precondition of evolvability itself. Only those systems that are able to organize themselves spontaneously may be able to evolve further (1995)."

The work of Kauffman and others, highlights that simple rules lead to complex, often fractal patterns. These simple rules generate patterns that cannot be reduced to a linear equation. Complexity Theorists argue that when formulas will not work, predictive certainty fails, probabilities remain, and outcomes must be observed. This insight, when applied to the market, reinforces the observational strengths of TA.

Kauffman's work shows that self-organization merges with natural selection to yield unanticipated and increasingly complex results. Out of self-organization comes the spontaneous formation of patterns. Rather than a "random walk," Kaufman sees an "adaptive walk." The adaptive walk leads to "improvement steps" towards optimization. History matters in complex systems or as Nobel Laureate Ilya Prigogine wrote, history is a "time irreversible process" and implies "an evolutionary pattern (1996)."

With respect to economics, Kauffman writes that "agents" are constantly reworking their applications to maximize success, thus creating a "persistently changing pattern of action." Kauffman, harmonious with Lo's AMH, notes that, "Economics has its roots in agency and the emergence of advantages of trade among autonomous agents." Agents optimally develop a map of their neighbors to predict their behavior. The economy, like all complex systems, is context-dependent. All variables are interrelated.

One of the core principles of Complexity theory is that agents learn and adapt and this can be observed in the markets. Any model that incorporates adaptive behavior leads to a significant increase in the complexity of the dynamics (Bayraktar, Horst, Sircar: July 2003, revised March 2004). As mentioned earlier in Lo's AMH, adaptive success can be seen as a self-organizing property in the markets. Success creates a "positive feedback loop" and is an example of "self-reinforcing behavior" (Arthur, 1988). We may recall that Shiller drew upon the concepts of feedback loops and self-reinforcing behavior to explain market volatility. It seems obvious that these forces drive market efficiencies too.

Complexity theory integrates the concepts of self-organization, selection, evolution, and chance. It also incorporates cooperation, a concept missing from most models but certainly very apparent in the markets and human behavior, in general. Friedrich Hayek, 1974 Nobel Prize winning economist, while influenced by the Austrian School, coined the term "catallaxy" as a "self-organizing system of voluntary co-operation," while defending capitalism. Ahead of his time, he saw the markets as coming out of "spontaneous order" and being "the result of human action, but not of human design," predating the concepts of self-organization and emergent properties. Incidentally, in a salute to Hayek, Adam Smith's "invisible hand," can be seen as an emergent property of evolving market participants competing and cooperating for successful outcomes.

Emergence is a central concept in complex systems. Researchers are still developing a scientific consensus on the various forms. One definition of emergence is the process of complex pattern formation from simple rules as developed by Stephen Wolfram and further by Kauffman. Emergent properties are features of a system that arise unexpectedly from interactions among the related components. As Kauffman states, "the whole is greater than the sum of its parts," so emergent properties must be considered relative to the system's component interactions in aggregate and not simply by the study of the property itself. Interactions of each component to its immediate surroundings cause a complex process that leads to order.

Most technicians operate with these principles in mind when evaluating securities and markets. The agents or investors, in this case, acting on their own behalf, operate within the regulatory rules of the various markets. Through these individual interactions, the complexity of the market emerges. Technicians seek to identify and measure emergent structures and the spontaneous order appearing in the market at many different levels of analysis.

Perry J. Kaufman is one of the earliest traders to combine TA with Complexity Theory. He is one of the first to create multivariable computer models for making adaptive market decisions. The focus of his work over the last 30 years has been to understand the "interactions of complex market structures using technical and quantitative tools."

VIII. Market Patterns as Emergent Properties

The hypotheses we accept ought to explain phenomena which we have observed. But they ought to do more than this: our hypotheses ought to fortell phenomena which have not yet been observed.

William Whewall

The work of contemporary economists, such as Shiller, Siegel, John Y. Campbell, Karl E. Case, Sanford J. Grossman, shows that market volatility is related to "patterns of human behavior" and these patterns are reflected in price action. Price trends are caused by both economic fundamentals and changes in opinion or psychology.

While technical patterns, such as ascending triangles, falling wedges and the like, are criticized for being hard to identify, they provide a technology for working with the complexity of the markets (Caginalp and Balenovich JTA W-S 2003). To the uninformed, TA can appear arbitrary and unscientific, but complex systems require flexible, adaptive models that can change as fast as the data appears and patterns materialize.

Emergent properties appear when a number of agents operate in an environment, like the markets, forming more complex behavior as a group. There are intricate, causal, feedback relationships across different scales. The emergent properties are often unpredictable and unprecedented (novelty) and may represent a new dimension to a system's evolution. The systems components interact to produce patterns. Patterns are emergent properties of the system.

When applied to the markets, TA seeks to identify emerging properties as they surface. TA's role is to filter out extraneous information that necessarily exists in a complex system (Kauffman 2000). TA may be the only effective method to quantify and measure the nonlinear data emerging out of a complex system like the market. TA is the key discipline that classifies market patterns and other market phenomena.

In a complex system like the market, TA utilizes analytic geometry to make sense of the nonlinear data that is mapped onto a Cartesian coordinate system. The nonlinear data has patterns that reflect the emerging properties of the market. Technicians draw on the body of knowledge of TA to analyze and make sense of the emerging patterns. Drawing from Complexity theory, TA seeks to identify formations that result from interactions between local and global information in the market. Global feedback can have local impact, influencing local activity, and vice versa, local activity can have a global impact. Charts and other technical tools are epiphenomenal representations of local and global market information. Complexity Theory defines local information as inherently incomplete, and even global information is incomplete. Since markets are complex systems, information is incomplete and, therefore, it follows that markets cannot be efficient. Inefficiencies imply that the recognition of emergent properties or market patterns is not only possible, but provides an adaptive advantage.

Market formations are emergent properties of underlying market information. The formation of price trends is just one emergent property. Virtually all modern economists admit to the formation and duration of trends, as the evidence is incontrovertible. Cycles are another example, although somewhat more controversial. Technicians, of course, identify and measure trends and cycles on many different levels of the market.

Complexity Theory uses the term "criticality" or critical point phenomena to describe what has popularly become known as a "tipping point," and somewhat similar to the antiquated cliché, "the straw that broke the camel's back." These terms refer to a system when at some critical moment after a period of incremental change, there is a sudden and dramatic change. One common example is the sand pile, where new sand grains are added slowly until at some critical moment, there is an avalanche. As the sand pile gets larger, the phenomenon repeats itself, just on a larger scale, and the cycle continues repeatedly. Although the phenomenon repeats itself, each occurrence is unique and while unpredictable on an absolute scale, an experienced observer can learn to anticipate when the critical moment will occur. Technicians routinely observe this can kind of behavior in the markets, and seek to measure and anticipate patterns of criticality.

Complexity Theory also uses the term "cascade" to describe criticality or tipping point phenomena where there is an extended chain of causal impact, and one criticality immediately triggers another, generating an extended series of dramatic chain reactions. Cascades are also known as "multiplicative processes" and are observed throughout nature and on many different time scales, from microseconds to millions of years. Cascades are observed in financial markets when external events can trigger chain reactions across many separate but interrelated markets. The term 'contagion' is often used for this phenomenon as well as 'herd behavior', having become a cliché for investor behavior. Without referencing Complexity Theory, Shiller introduces the concept of cascades into his theory of volatility. Shiller talks about a "sequence of public attentions (2001)." According to Shiller "well known facts or images" that were previously "ignored or judged inconsequential" can attain "newfound prominence in the wake of breaking news." He continues, "These sequences of attention may be called "cascades," as one focus of attention leads to attention to another, and then another (2001)."

Catastrophe Theory is another offshoot of these ideas that has been applied to Finance, typically to describe "market crashes." Small changes in parameters can cause a previously stable system suddenly and massively to shift at "bifurcation points." Mathematic equations have been developed that have well-defined geometric structures. These traits and the obvious link to tipping points, cascades, contagions, and herd behavior have intrigued some market theorists.

Richard Dawkins, evolutionary biologist at Oxford popularized the concept of "meme". According to Dawkins, a meme is a "unit of cultural information" transmitted verbally or by demonstration from one person to the other. Memes are self-propagating and have an evolutionary influence on human knowledge and behavior. Memes are said to evolve via natural selection undergoing replication, mutation, survival, and competition. Some memes become extinct; others survive, replicate, and mutate, and the cycle of influence can be observed and monitored.

The concept of a meme is a useful way of understanding how Information Theory applies to human behavior. Information Theory is a discipline in applied mathematics, developed to understand how data is quantified, coded, processed and stored on a medium or communicated over a channel. Information Theory seeks to explain how communication can be accurately reproduced and then transmitted successfully. Because Information Theory typically translates human information into a mathematical code, it is very rigorous and well defined. These principles are imbedded in the concept of a meme. Memes reflect this kind of coding as it refers to ideas, not mathematically, but as a description of how it is possible for ideas to influence human behavior and cultural evolution on a local and global scale. Unlike a mathematical code, memes are more like genes in that they are considered environmentally interactive and mutable. Memes can be seen as emerging patterns—cohesive thought-forms—rising out of local information, having a global impact and, then globally influencing local behavior, in a constant feedback loop. Fiat currency is one of the most compelling examples and it does not take much imagination to see how memes can be applied to virtually any unit of value.

Kate Distin, in *The Selfish Meme*, refers to memes as "meta-representations" or representations about representations. Memes have representational content that influences human behavior. Memes preserve information and this information is active. Innovation according to Meme Theory is due to recombination and mutation. Memes compete for "survival" and people, institutions, and societies invest in the survival and propagation of particular memes.

The market can be defined as a representational system made-up of memes. The memes of the market compete for attention, acceptance, power, and influence. The survival of particular memes can mean financial success to those invested in that meme. One way of understanding market patterns is that they are emerging memes. As influential memes work their way through society they stimulate investor behavior, generating patterns in the market. TA recognizes existing memes in the market, identifies new memes as they emerge and notes the peak and eventual dissolution of previously influential memes. The comparative analysis of market memes is unique to TA.

IX. Market Analysis, Interpretation, and Intuition

Truth in science can be defined as the working hypothesis best suited to open the way to the next better one.

Konrad Lorenz

Technicians have the scientific firepower to challenge the current academic orthodoxy. The empirical evidence is on the side of TA. Phil Roth, President of the Market Technicians Association, has argued very effectively that TA is quantitative, rather than qualitative. When we look at the data, all analysis is technical in origin or includes technical components. TA is the most empirically based science of the markets. Technical data is objective data about the markets. Yet, it is imperative that we distinguish between technical data and interpretation.

The universal bridge between data and interpretation is mathematics. The "quants" want precision, but as we have seen, temporary estimates of probabilities may only be possible in a complex system. Markets and securities prices are not objects subject to the laws of physics. Mathematical models in a complex system must be seen as provisional and heuristic, rather than static. TA, an ideal tool, by its very nature can incorporate and integrate all mathematical models as they are mapped onto a complex system.

Complexity Theory shows the dichotomy between "qualitative" and "quantitative" may be an artificial distinction. Like trying to separate energy from matter or time from space, there are qualitative elements in every quantitative analysis and quantitative elements in every qualitative analysis in a biologically based system. As we move forward, we may wish to forgo the dichotomy. It comes down to interpretation of information, hypothesis formation, and testing. Of course, the ultimate test is risking capital.

In the process of distinguishing between the science of TA and the practice, it is important to understand the role of interpretation. Interpretation of data can occur in a scientific context and in the context of application. In the context of application, interpretation is a function of skill. True of every field and avocation, skill is a key factor in the application of information. Whether based on knowledge, experience, proficiency, or invention, skill matters. Even though MPT provides little room for the concept of skill, common sense indicates that skill matters in all areas of life. It is almost laughable to have to defend the argument that skill matters. Again, just because the current academic orthodoxy has difficulty defining, quantifying, and incorporating skill, does not mean it is an unimportant component in the markets.

As we have seen with Lo's AMH, a skill-based advantage will lead to evolutionary effects and survival benefits, most namely, success. Substantial rewards flow to the successful. It is to be expected that top performers will be very protective of their applications, systems, and insights. Secrecy and the proprietary nature surrounding any new technology are to be expected in order to maximize the competitive advantage of that technology.

Over time, some of these technologies have and will come to light for a variety of reasons. The body of knowledge of TA has grown and continues to grow as applications that are more technical are published and discussed. It is incumbent upon the leaders of the field to distinguish between the scientific aspects of these new revelations, the interpretation of these discoveries and insights, and their application. Not an easy task, because most come to TA for the technology, rather than the scientific underpinnings. Most seek an investment advantage over other market participants. The focus tends to zero in on application, results, and measures of success.

The scientific foundations of TA will become increasingly important as the field grows. As we have seen, cutting-edge scientific models support TA. Historically, modern economics, with limited results, has attempted to define value around random price fluctuations. More recently, Behavioral Finance has shed light on how emotion, cognitive processes, and human biology may influence markets. TA is the organizing principle that derives nonlinear solutions to the various probabilities of future price action around a locus of fundamental value and behavioral influences. By definition, TA incorporates all available information, models, systems, and disciplines. The key advantage of TA is that it is inherently model-independent (adaptable) while at the same time content and context-dependent (empirical). TA increases competency and success by making sense out of disparate and complex data, however modeled. TA is about gleaning and distilling as much market information as possible from available sources. This process of describing data is the science of TA.

TA is inherently heuristic, providing practitioners with a broad spectrum of tools to maximize intuitive interpretation. Intuition is the most condemned method of human cognition by the academic community. However, much scientific advancement is based on intuitive insights. Ultimately, the practice of TA is about accessing the intuition. In any complex system, analysis will often fail as the observer is easily overwhelmed by the mass of information. TA provides the experienced practitioner with clues about the unfolding present and its future implications, so that intuitive forecasts can be made. Intuition is what the "art advocates" have in mind, when they stress the art of TA. It is the intuitive skill set, developed over years of application, that the technician implements as an art form. The art of TA describes this experience.

John Bollinger wrote in July of 2004 about the need to integrate fundamental, technical, quantitative and behavioral science into what he calls "Rational Analysis." My preference is the term 'Market Analysis' as it is consistent with the term 'Technical Analysis' and the term comfortably accommodates all disciplines. The goal of the Market Analyst is to define core principles, develop possible market theories, delineate applications, and establish standards for performance measurement. With the use of computers and sophisticated modeling techniques, emerging market formations can correspond with a particular probability reading as to the direction and magnitude of price action within a given period. Caginalp and Balenovich suggested similar strategies offering predictive value with the use of algorithmic defined patterns from statistical computer testing (JTA W-S 2003). I look for continued advancement in the field with the creation of probabilistic forecasting programs.

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