Appendix E - **UNIVERSITY HONORS PROGRAM**
SENIOR PROJECT - APPROVAL

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PROJECT TITLE: Chaos Theory versus the Efficient Market Hypothesis in Financial Markets

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed: John C. Ketchen, Faculty Mentor

Date: 04/11/02

General Assessment - please provide a short paragraph that highlights the most significant features of the project.

Comments (Optional):

Carrie Michelle Thomas wrote a senior project entitled Chaos Theory versus the Efficient Market Hypothesis in Financial Markets. In her paper, Michelle describes the Efficient Market Hypothesis (EMH) commonly taught in university level finance classes as the standard market theory. She describes various kinds (levels) of EMH. She argues that many of the underlying assumptions for EMH have proven false or at least questionable. She next describes Chaos Theory as an explanation of how the market works. While not adequately developed as a predictive tool, Michelle argues that Chaos Theory more accurately describes market activity than EMH. In the closing section, she argues that universities should teach both theories to finance students. She offers a wide range of bibliographic resources including books, periodicals, and internet.

Michelle has written a solid senior honors paper. She demonstrates a good understanding of both EMH and Chaos Theory. She argues persuasively that university students should learn about both theories, and her resources show thorough research.

John C. Ketchen, Ph.D.

Chaos Theory versus the Efficient Market Hypothesis in Financial Markets

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The purpose of this paper is to gain a better understanding of financial market movements and dynamics by examining two competing theories: Chaos Theory and the Efficient Market Hypothesis. The objective is not to favor one theory over the other but to simply present an overview and brief analysis of each. Arguments for and against both theories' relevance to financial markets will be discussed along with the importance of teaching both theories in college level financial classes. Means of educating students on the Efficient Market Hypothesis and Chaos Theory will be listed and discussed.

Overview

To explain how the Efficient Market Hypothesis and Chaos Theory affect financial markets, a brief overview of financial markets is in order. A definition and explanation of the Efficient Market Hypothesis will be covered, and the Central Limit Theorem will be applied to analyze this theory. Chaos Theory will be discussed along with its limits in utilization. A hypothesis that is associated with Chaos Theory, termed Fractal Market Hypothesis, will be explained along with the Regression Analysis, which can be applied to analyze this hypothesis. Only an overview of Regression Analysis will be completed along with an account of a company, which has successfully implemented Chaos Theory in its investment strategies.

Financial Markets

The purpose of a financial market is to channel funds from savers to those individuals or institutions that are willing to pay for them. Basically, a capital market's chief function is to allocate resources optimally and provide liquidity. However, proponents of the two theories disagree on the financial markets' design. Efficient Market Hypothesis supporters believe that prices in the markets are inherently fair. Those defending Chaos

Theory disagree. Edgar E. Peters, a long time student of Chaos Theory, says, "Markets were never designed to insure fair pricing; markets were created simply to bring people together, to provide a forum for discussion and a place for trading." (Peters-Uncertainty 132)

There are many types of markets; some of which are the bond markets, stock markets, derivative markets, and foreign markets. However, only data from the equity or stock markets will be utilized in the analysis of the Efficient Market Hypothesis for the following reasons:

- Large volumes are traded on the equity markets;
- It is believed to be one of the most efficient markets in the world;
- The equity market has a long trading history, which allows for data that dates back to the 1800's to be applied; and
- Data for daily stock movements is available, which is relatively difficult to obtain from other financial market sources. (Rose 4)

Efficient Market Hypothesis

Efficient Market Hypothesis states that securities markets are efficient, with the prices of securities fully reflecting all available information (Fama 1575). The idea behind market efficiency is that "competition will drive all information into the price quickly." The proposal of an efficient market is predominantly due to Eugene F. Fama's Ph.D. dissertation written in the early 1960's entitled "The Behavior of Stock Market Prices." It argued that securities will be appropriately priced and reflect all information if the market includes investors who are rational. If the market is efficient, an investor will be unable to outperform the market consistently. (Investor Home) Others who assisted in

the evolvement of the Efficient Market Hypothesis include Ball and Brown, who noted in 1968 that the markets forecasted 80% of the information in announcements before their release and the three to six month returns after the announcements were approximately zero. With these new concepts entering the financial field, others followed with "true event" studies and financial models, which aided in verifying that markets were efficient. Before these studies, stock market prices were thought to be only noisy estimates and could not be evaluated or understood. One event study was the famous dividend split paper written by Fama, French, Jensen, and Rolls in 1969. Financial models completed due to the Efficient Market Hypothesis include Sharpe and Litner's CAPM Model and Black and Scholes' Black Scholes Model. (Ball) The CAPM model describes the relationship between risk and expected return by explaining that the expected return of a security or portfolio is equal to the risk-free rate plus the risk premium of the certain security or portfolio. The model provides a straightforward method to make investment decisions. The Black Scholes Model is applied to calculate the value of European call options (Equade Internet Ltd.). These models gained support and credibility for the new theory and the studies surrounding it.

An efficient market identifies a security's economic value by reflecting all available information concerning the asset almost immediately. Available information is grouped into two types of knowledge. The first group is information that is reasonably inferred, which means that prices will reflect beliefs of the market before the event actually occurs. The other group is all known information, which includes past information, current information, and announcements of future events. The market price is not required to shift instantaneously or adjust to the perfect price following the release

of new information. After an announcement is released, the price only must change quickly and to an "unbiased estimate of the final equilibrium price." The final equilibrium price will be reached after investors decide the new information's relevance on the stock price. (Jones 255)

There are four conditions that need to occur in order for an efficient market to exist. First, there must be a large number of rational investors, who actively participate in the market. A rational investor is one who wishes to maximize their expected return for a given level of risk (Peters-Patterns 79). Second, information must be costless and widely available to all market participants. Third, information must be dispersed in a random fashion, which implies that announcements are independent from each other. Finally, investors must react quickly and fully to new information. (Jones 256)

Three Forms of the Efficient Market Hypothesis

The three forms of the efficient market are weak form, semi-strong form, and strong form. Weak form efficient states that all historical prices and volume data already are reflected in the current price of a stock and should not be of value in predicting future price changes (Jones 257). Semi-strong form states that all publicly known and available data is quickly incorporated into the stock price. This implies that an investor cannot act on new public information and expect to earn above-average returns. Strong form states that stock prices fully reflect all information whether it is public or nonpublic, which means that insiders cannot make abnormal profits in the market. (Jones 258) The Efficient Market Hypothesis implies that no person can outperform the market consistently because stock prices are random and cannot be anticipated or profited from. If someone does outperform the market, the accomplishment is purely based on luck or

by statistical chance. (Peters-Patterns 79) The question is raised of why portfolio managers exist and why they may do better than a person who randomly picks stocks.

The answer lies not in the returns of the stocks chosen but in the risk of the portfolio chosen. If the market is efficient, portfolio managers still are able to attain an appropriate level of diversification for the portfolio. This will eliminate firm specific risk. The managers must maintain the desired risk level for a certain type of portfolio and must pursue tax breaks in order to maximize the profits for the investors. Transaction costs also must be factored into the portfolio since they can have a significant impact on the portfolio's return. (Jones 262)

Central Limit Theorem

The underlying principal in which the Efficient Market Hypothesis is established is through the Central Limit Theorem, which states that as a sample of independent random numbers approaches infinity, the probability function approaches the normal distribution curve. First, this implies that the Efficient Market Hypothesis believes that market changes are random; and if the market changes are plotted over a period of time, they should construct the normal curve. The Central Limit Theorem can be applied to historical data in order to find a correlation between the Efficient Market Hypothesis and the certain financial market from which the data is taken. (Peters-Fractal 53)

Process

The data being analyzed are daily stock returns from February 16, 1885 to July 2, 1962. The data from February 16, 1885 to January 3, 1928 are from the Dow Jones Industrial Average and railroad stocks. The daily dividend yield is adjusted by adding Cowels yield for the month and then dividing by trading days. The data from January 4, 1928 to July

2, 1962 are from the S&P composite portfolio value weighted average return. The data are adjusted by adding CRSP value weighted dividend yield for the month and then dividing by the trading days. The data must be adjusted for dividends because stock prices reflect the dividend yields; and if the data is not adjusted, the markets will not reflect pure information. (Schwert 1990) This data will be analyzed using the SPSS program. The SPSS program graphs the points of the stock returns and then graphs the normal distribution curve. If the points construct a normal curve, the Efficient Market Hypothesis is proven true for the given source of data. The graph is shown on page 25.

From the graph, it is shown that the data deviates from the normal curve; thus, the data does not agree with the Central Limit Theorem. There are at least two possible reasons for the data to differentiate from the normal curve. First, there are only 22,474 daily stock returns in the sample, which is far less than the Central Limit Theorem's requirement for a sample number close to infinity. Thus, the function may not have enough independent random numbers in the sample to reach the normal curve distribution. Another case is that the sample fits another form of a curve such as a uniform distribution curve, which allows for the sample to still be random.

However, since the Central Limit Theorem is the underlying principal for the Efficient Market Hypothesis, and this theorem is inaccurate by the market data tested, the hypothesis does not fully explain these market movements. On the graph, the red data plots outside the extreme sides of the normal distribution curve. The red data's extreme points on the graph indicate large events such as market crashes, and the Efficient Market Hypothesis does not allow for such events to occur. Some other reasons why the Efficient Market Hypothesis does not correlate well with market movements are as follows:

- People can be irrational when investing in the markets, which is confirmed when people invest at the peak of a bubble right before a crash (Cohen 39);
- Information is not evenly distributed; two examples being insiders have more information than the public does and money managers have a larger support staff and faster information flow than does the individual investor;
- The theory was developed to complement statistical tools that were already in practice, which gave mathematical tools the ability to predict the market; and
- Anomalies were discarded in order to allow for the Efficient Market Hypothesis to function (Peters-Fractal 41).

Some of Ray Ball's anomalies for the Efficient Market Hypothesis are stated below.

Anomalies

Ball defines three categories of anomalies. The first are empirical anomalies, which are problems in fitting the theory to the data. Some examples are price overreaction, excessive volatility, and under-reactions to good earnings announcements. The second category of anomalies is the "defects in efficiency as a model of the stock market." One example is that we assume information costs are zero, which is not true; however, we assume this because the costs of information are unknown. Another is that some investors, such as Warren Buffet, have access to better information than the public. Yet, analysts reporting on these investors' practices and investment behaviors reduce their advantage in the market. The third category is "problems in testing efficiency as a model of stock markets." One problem is having to test both efficiency and the model of the market at the same time instead of separating the two. Another is the seasonal changes in

risk. For example, firms typically announce major events on Mondays or in December. (Ball)

Despite the fact that Ray Ball agrees that there are limitations to the Efficient Market Hypothesis, he still supports the theory by saying, "The theory of efficient markets is, like all theories, an imperfect and limited way of viewing the stock markets. The issue will be impossible to solve conclusively while there are so many binding limitations to the asset pricing models that underlie empirical tests of market efficiency" (Ball). Since the Efficient Market Hypothesis is an imperfect fit, other explanations for market movements have been created. In this paper, Chaos Theory will be an ulterior explanation.

Chaos Theory

Chaos Theory is the study of deterministic chaos, which is unpredictable behavior that is governed by rules. It asserts that systems consist of various elements in constant interaction with each other. The numerous connections between the interacting elements enable complex systems to spontaneously self-organize and constantly adapt to changing conditions. (Cohen 64) Therefore, a chaotic or complex system has both local randomness and global determinism (Peters-Patterns 27). Complexity Theory is very much like Chaos Theory in the fact that both study self-organizing systems, which cannot be predicted and their components cannot be studied in isolation (Valle 4). Therefore, for the purposes of this paper the terms, Chaos Theory and Complexity Theory can be interchanged.

These systems can be man-made or natural and can occur in social structures and in human beings. Two examples of chaotic or complex systems include trees and lungs.

Both have global determinism because they are easily recognizable by sight and by function. However, each has local randomness because the exact way the branches diverge on a specific tree or in a specific lung is undeterminable. The local randomness allows for self-correction in a determined shape, which can alleviate problems and increase chances of survival. (Peters-Uncertainty 132)

Some analysts that study these chaotic systems believe that financial markets are one of the many systems that are both non-linear and dynamic. Market prices seem to be highly random but contain some type of trend. The amount of trend varies with the type of market and the time frame being analyzed. One concept involved in Chaos Theory is fractals. (Chaos and the Stock Market)

A fractal is an object in which the parts are in some way related to the whole. The example above of the branching network in a tree also is a good example of a fractal. Each branch is different from the others; however, the branches are similar to the structure of the whole tree. (Peters-Fractal 4) The whole tree has a global structure since everyone can predict the general shape of a tree. However, the individual branches have local randomness because we are unable to distinguish the length, the number of leaves, or the diameter of each branch. (Peters-Fractal 5) Financial markets seem to have similar characteristics to fractals because at closer time periods, the prices generate more and more detail.

Another characteristic of chaotic systems is its "sensitive dependence on initial conditions," which causes the systems to be difficult to predict. Because current situations cannot be accurately described and errors are hard to find in such complex systems, financial markets movements are near impossible to predict. (Chaos and the

Stock Market) At one time, it was thought that nonlinear systems could be broken down into linear equations if one could obtain enough information to describe all the variables in a system. However, even if all of this information were available, "nonlinearity's disproportion of cause and effect would still make it impossible to derive any prediction" (Berreby 78). Chaos Theory attempts to look at less of the information and more at the overall patterns of change, and this is how financial markets are studied.

Because one would have to find only a few variables to describe the whole financial world, attempts to discover the underlying rules that govern the market have not been very successful. Therefore, no mathematical proof has been presented to confirm that financial markets are chaotic. (Cohen 64) Since the Efficient Market Hypothesis is easily utilized through statistical methods but does not conform well to market data, and Chaos Theory explains market data but mathematical formulas cannot be applied; another hypothesis must be employed. One potential compromise between the two theories is Fractal Market Hypothesis.

Fractal Market Hypothesis

The Fractal Market Hypothesis states that a market consists of many investors, who have different investment horizons and vary in their analysis of information due to their individual time horizons. An investment horizon is defined as the amount of time one plans to hold his or her money in an investment. Under the above two circumstances, the market remains stable. However, when the investment horizons become uniform, the market becomes unstable. (Peters-Fractal 309) Here are three major conditions in the financial markets, which advocates of the Fractal Market Hypothesis believe support their theory. First, markets exist when sufficient liquidity ensures stability. Next, prices have

a short-term noisy component due to random processes. Finally, prices have a long-term component due to economic and/or nonlinear deterministic processes. (The Fractal Market Hypothesis WebPages)

From this information, the Fractal Market Hypothesis implies that price changes are due to information being meaningful only to a certain investment segment. Therefore, an equilibrium price does not exist because people value investments differently. The hypothesis also allows for major events to occur, an example being stock market crashes. These events occur, the hypothesis assumes, when long-term or short-term investors act as the other. When long-term investors begin to behave like short-term investors, the long-term time horizon is eliminated; thus, liquidity is lost because short-term investors are unable to trade with anyone. Long-term investors will begin to analyze incoming information in the same manner as their counterparts, and this will guide their investment decisions. Therefore, the short-term investors are unable to sell their investments, and the prices of investments begin to decrease. If there is a rapid decrease in investment prices, and investors in other time horizons begin to frighten and sell their investments, the financial market could crash. A situation when only short-term investors are available is possible if there is an unstable environment, government, business sector, etc. (Peters-Fractal 46)

The opposite situation is applicable when short-term investors transfer into a long-term time horizon. In this situation, prices increase until the prices are extremely high compared to the value of the investments. An obvious example was the late 1990's when technical stocks were highly overpriced compared to the value of the companies. A condition when only long-term investors are available is possible if there is a very stable

environment, a stable government, and people are willing to risk more because of the high returns being achieved, etc. (Peters-Fractal 46)

Instead of fitting the hypothesis to established statistical and mathematical techniques like the Efficient Market Hypothesis did, one of Fractal Market Hypothesis' underlying principals is that it was actually based on the data or returns from the market. Then its founders looked towards statistics and mathematics to prove the hypothesis. The hypothesis also allows for investors to be irrational because investors read and analyze data differently. Since investors could be irrational, the price does not have to be at equilibrium. This means that major and unlikely events are allowed to happen, and this is what occurs in a market.

Another underlying principal of Fractal Market Hypothesis is its belief in short-term stochastic processes with long-term deterministic processes. Rescaled Range (R/S) Analysis is a method implemented to test the Fractal Market Hypothesis. Rescaled Range Analysis is a method that distinguishes random time series from fractal time series. The analysis can be processed through different statistical computer programs. The idea behind Rescaled Range Analysis is to compare the results of an independent, random system that has been analyzed to the results of a system questioned to be random. If there are any significant differences between the two systems, the unknown system possesses some underlying or persisting cycles causing the process to have deterministic factors. (Peters-Fractal 65)

However, the Fractal Market Hypothesis does not fit the financial markets exactly because the hypothesis is unable to consider every variable in the market. The more variables allowed into the equation or the hypothesis, the closer the market can be

replicated. More research is being done in hopes of finding the rules that govern the marketplace. Some groups, however, have had success employing Chaos Theory in the market place.

The Prediction Company

One such group of men includes Doyne Farmer, Norman Packard, and James McGill, who began the Prediction Company and employed Chaos Theory into their predictions of market movement with much success. In 1993, their computer systems could place up to 500,000 variables on graphs to try to find patterns in market data, and each year the computer systems increase their abilities. However, in these billions of data points, patterns will only appear rarely and thus, not very predictable. (Berreby 81)

Packard says that a profitable way to employ Chaos Theory is to find "pockets of predictability." These pockets of predictability are simple systems that are masked by the larger complex system. If one can find these small pockets, one can take advantage of the pocket and earn high returns. Packard compares the chaos of the markets to that in the rapids of a river. All the tumbling, swirling water moving down the river looks chaotic; however, every once in a while, a small area moves in a swirling fashion that is recognizable for a short period of time. If a person finds these "familiar swirls" in the stock market, he can profit from movement for a short period of time. (Berreby 81)

In the beginning the Prediction Company did not fare so well, not hitting quarterly objectives in 1995. The company still had defects in their software and in theory. By the end of 1996 and through 1997, however, the company was generating returns in spite of the panics on and crashes of major stock exchanges. In 1998 with the fall of exchanges around the world, famous analysts and speculators lost large amounts of money. Some

include D. E. Shaw & Company and the famous Long-Term Capital Management Hedge Fund, which was provided a rescue package totaling $3,600,000,000 by the government. Through all of this, the Prediction Company retained its profitability, experiencing its most successful year to date. (Bass 127-9) Even though the Prediction Company has enjoyed success with their forecasts, they say a full understanding of chaos in the financial markets is years away. (Berreby 81)

Educational Sources

Since both theories are incomplete in explaining market movements, both theories, along with others, need to be taught as part of a financial curriculum at a college level institute. Below is a compilation of sources that can be employed as educational tools for students, professors, and investment professionals. The list includes books, articles, and web sites from many distinguished authorities on both the Efficient Market Hypothesis and Chaos Theory. The texts are separated into two groups by theory, and each source's content is explained. At the end, a comprehensive list of the sources for educational purposes is presented without explanation.

Efficient Market Hypothesis' Educational Sources

The Efficient Market Hypothesis is the most common theory taught in financial classes at the university level. Some reasons for its high acceptance are as follows:

- The evidence presented through empirical studies on financial markets supports the Efficient Market Hypothesis relatively well;
- The Efficient Market Hypothesis is clearly proven with established statistical tools;

- Financial models have been completed due to the hypothesis and are now useful tools in the market place. Some examples include the CAPM model and the Black-Scholes model;
- The Efficient Market Hypothesis was the first theory to explain market movements and since the 1960's, has been the most adopted theory;
- The theory is easy to understand and an uncomplicated way to explain market movements;
- The conditions needed in the market place in order for an efficient market to occur are not realistic; however, given these theoretical conditions, the financial markets can be better understood through close approximations; and
- The hypothesis is a "clean benchmark that allows one to sidestep the messy problem of deciding what is reasonable information and deciding on trading costs" (Fama 1575).

Therefore, almost all university level financial textbooks will contain information on the Efficient Market Hypothesis. Brief overviews of the theory, including definitions, the three forms of the hypothesis, some anomalies, and the derived financial models, can be found in most investment analysis and financial markets and management texts. Because of the prevalent information on the theory, only a few other sources will be discussed below.

Some of the most important sources of information on the Efficient Market Hypothesis are papers and texts written by Eugene F. Fama. He is the individual distinguished for originating the theory and is still one of the most noted experts on the subject of efficient markets. Some of works include "Random Walks on Stock Market

Prices," written in 1965 and then republished in 1995. This work is a simplified version of his Ph.D. thesis that states his theory of the efficient market, which states that no information or analysis can result in the out performance of the overall market because securities will reflect all available information, and prices will be close or at their intrinsic values.

Another paper of his entitled "Efficient Capital Markets: II" published in the Journal of Finance in 1991 depicts his view of the research accomplished and information acquired about efficient markets since its introduction twenty years earlier. Fama's recent paper titled "Market Efficiency, Long-Term Returns, and Behavior Finance" written in 1997 explains the relevance of a theory about efficient markets regardless of anomalies produced. This paper can be downloaded from the Social Science Research Network, on which Fama is a member of the Board of Trustees. The website address is <www.ssrn.com>. Other impressive working papers on the Efficient Market Hypothesis along with other topics including Chaos Theory can be downloaded from this site.

Texts by Ray Ball are also good sources on the Efficient Market Hypothesis, including a paper written by him and Brown in 1968 about earnings announcements. This paper assisted in the evolvement and the acceptance of the Efficient Market Hypothesis. A more recent article of his is "The Theory of Stock Market Efficiency: Accomplishments and Limitations" written in 1994. This article examines the evolvement of the theory observing both the anomalies found and the strides attained in the financial realm.

Another source on the Efficient Market Hypothesis is Burton G. Malkiel's book entitled A Random Walk Down Wall Street. This investment strategy book asserts that it

is impossible to outperform the market over a long period of time; thus, investing in index funds is the most effective way to earn any returns. He arrives at such a conclusion by analyzing various types of investment options including money market accounts, Roth IRA's, and tax-exempt funds, just to name a few.

One website that gives pertinent information about both the Efficient Market Hypothesis and the Random Walk Theory is the Investor Home Website. Its contents include definitions, a brief history of the theories, some technical and some stock market anomalies, debated issues, and important links. The website address is <www.investorhome.com/emh.htm>.

Chaos Theory's Educational Sources

Since Chaos Theory in conjunction with the financial markets is a relatively new study, few college level financial text books include any content on the subject. Besides being a new study, other reasons prevail on why Chaos Theory is not regarded as an alternative to the Efficient Market Hypothesis in college level classes. Some other reasons are as follows:

- The theory cannot be explained with regular statistical knowledge and tools;
- The mathematics employed in Chaos Theory are nonlinear; thus hard to explain to undergraduate students without a relatively advanced mathematical background;
- The types of tests performed on financial market data when applying Chaos Theory are near impossible to replicate without advanced computer programs and the expertise to operate the computer programs;
- Few people have made great strides in the advancement of knowledge on this topic; thus, information on Chaos Theory is limited, incomplete, and very complicated; and

- Because of its new implementation into the financial field, many finance professors and professionals have not completed any specialized training on the topic; therfore, teaching the theory becomes a daunting task.

Below are listed courses, articles, and websites that will assist both professors, professionals and students in understanding Chaos Thoery and its effects on financial markets.

Two articles about the Prediction Company's procedures and results in the stock market are good examples of how Chaos Theory has been successfully utilized in a realistic financial setting. Since the inventors of the Prediction Company are some of the few that have succeeded in applying Chaos Theory to financial markets, their ideas may revolutionize the prevailing concepts behind investing. Even though these new investor gurus do not provide any of their secret formulas for success in the market place, the basic concepts behind Chaos Theory and the importance of persistance in developing new techniques to "beat the market" are discussed in both articles. One article entitled "Chaos Hits Wall Street" by David Berreby was written in March 1993 in Discover. The other article is by Thomas A. Bass titled "Black Box" and was published in April and May of 1999 in The New Yorker. The first article describes how the company began, and the other presents the company's performance records.

Edgar E. Peters is another author with many books and articles on Chaos Theory and Complexity Theory. His works stretch from basic concepts of the theories with little or no math to advanced mathmatics utilized in proving the existence of the theories. Therefore, one has the ability to work at his or her intended level or advance in levels by conquering the concepts in each of Peters' works. His works discussed here are Patterns

in the Dark: Understanding Risk and Financial Crisis with Complexity Theory, Chaos and Order in the Capital Markets: A New View of Cycles, Prices, and Market Volatility, and Fractal Market Analysis: Applying Chaos Theory to Investments and Economics.

Peters' Patterns in the Dark presents his most conceptual explanation of the theories with little or no mathematical equations displayed; therefore, this book is for an individual who desires an overview of Chaos Theory and its applications to financial markets. He offers recognizable examples, which are easily grasped by those at any skill level in market evaluation. His examples not only originate from market or economic models but from natural scientific models, social models, and artistic creations. The main function of this work is to offer a new perspective of looking at the financial marketplace.

Chaos and Order in the Capital Markets by Edgar E Peters was written in 1991 and was one of the first books to introduce Chaos Theory into the realm of finance. It is now dubbed the classic source on the topic, and provides a comprehensive overview of Chaos Theory and fractals in reference to investments and financial markets, while rebuking the Efficient Market Hypothesis. The book covers fractals, Rescaled Range Analysis, fractal statistics, and analysis of chaotic systems. New analytic tools discussed include genetic algorithms, wavelets, complexity theory, fuzzy logic, and artificial intelligence. This book is intended for investment professionals and those who have a high leveled mathematical background. The mathematical models are explained; however, some knowledge on the subject is useful. A second edition of this book was printed in 1996 and includes up-to-date examples of occurrences of chaos in the market place and the latest technologies generated in this field

In Fractal Market Analysis, Peters attempts to explain financial markets through the use of fractals, Rescaled Range Analysis, and nonlinear dynamic models. He explains turbulent market movements through his mathematical valuations and furnishes economic mathematical models to enhance asset valuation and portfolio selections. This book is very complex with a need for advanced mathematical skills.

Bernice Cohen's, The Edge of Chaos, examines historical market crashes, from the European Tulip Craze of the latter part of the 1500's to modern day international stock market crashes. She argues, with the stock market crashes as her evidence, that markets cannot be completely random and that investors have proven themselves to be anything but rational. She offers examples of discrepancies in the Efficient Market Hypothesis and explains why Chaos Theory may be a more appropriate match with financial movements than the Efficient Market Hypothesis.

Sources on Chaos Theory and Fractal Market Hypothesis abound on the internet. The sites that will be discussed here are "What is Chaos," "Chaos Theory and Fractal Geometry," "In a World of Order…Chaos Reigns!," and "The Fractory."

The first site listed is a five-part course about Chaos Theory, which is in layman's terminology. The site is by Dr. Mathew A. Trump, a physics professor at the University of Texas at Austin. Basically, the course explains what determinism is, what initial conditions or measurements are needed, why there is uncertainty in measurements in this experimental science, what dynamical instability is and its relationship to chaos, and what different characteristics give rise to a chaotic system. The whole course requires no more than twenty minutes to read and provides a brief scientific approach to chaotic systems. Even though this website has little to do with financial markets, a comprehension of

chaotic systems as a science is needed in order to affiliate financial markets to chaotic systems.

The second website listed, "Chaos Theory and Fractal Geometry" by Kelleen Farrell, is an excellent site for both students and teachers. In fact, the site was designed to inform students about Chaos Theory through courses on the following topics: 1) the history and mathematics of Chaos Theory, 2) dynamical systems, 3) graphing non-linear equations, 3) iterations, 4) the mathematics of fractals, 5) Mandelbrot and Julia sets, and 6) measurement and scale. Besides the courses, the website includes interactive activities, advanced topics on Chaos Theory for teachers, mathematical educational sites, links to other informative websites, and a list of other helpful references. Through the courses, students should be familiarized on the following skills and concepts. They include graphing non-linear equations, producing iterations and feedback loops, and applying the principles of chaos in realistic situations. This site has information for students at all levels; thus, it is a suitable site to begin the study of Chaos Theory. The website address is <http://home.inreach.com/kfarrell/course.outline.html>.

The ThinkQuest website is a fantastic place to begin investigating Chaos Theory and fractals since the sites on ThinkQuest are designed by middle and high school students, who are only beginning their education on these subjects as well. These students' sites are quite impressive with their interactive games, means to design fractal images, and informative links and references. A description of two of the sites are below; however, others are available at <http://www.thinkquest.org> by searching under "Chaos Theory."

The first site presented is by Mike Ross, Andrea Kraynak, and Mike Traeger titled, "In a World of Order…Chaos Reigns!" The website's address is <http://library.thinkquest.org/3120/>, and the site is separated into three sections. The first component furnishes a brief history on Chaos Theory including the applicable mathematical principles. The second part presents real-life examples of chaotic behavior including evidence from the stock markets. The final section is titled "Chaotic Library" and provides fractal images and animated fractals along with a glossary of chaotic terms.

The other site suggested from ThinkQuest's library is titled "The Fractory" and was designed by David Green, Alex Kulesza, and Keith Bergstresser. This site was awarded first place by ThinkQuest in 1996, and its web address is <http://library. thinkquest.org/3288/fractals.html>. The information on this site has been separated into five levels by order of difficulty. The first level examines various fractal designs and allows you to design your own fractal illustrations. The second level displays text that explains the use of fractals and their importance in realistic circumstances. The third level is conceptual and describes how fractals are generated, while the fourth level employs mathematics in its explanation of fractals. The fifth level provides a list of other links and references to assist your exploration of and interest in fractals

This list of sources is by no means complete, and there are many more valuable references on both the Efficient Market Hypothesis and Chaos Theory. The objective is to use these listed sources along with others to advance one's knowledge and to gain new perspectives on the stock market and investment analysis. New perspectives allow for change and fresh ideas, which in the market, may translate into an enhanced investment strategy and the ability to exploit the market and make incredible returns.

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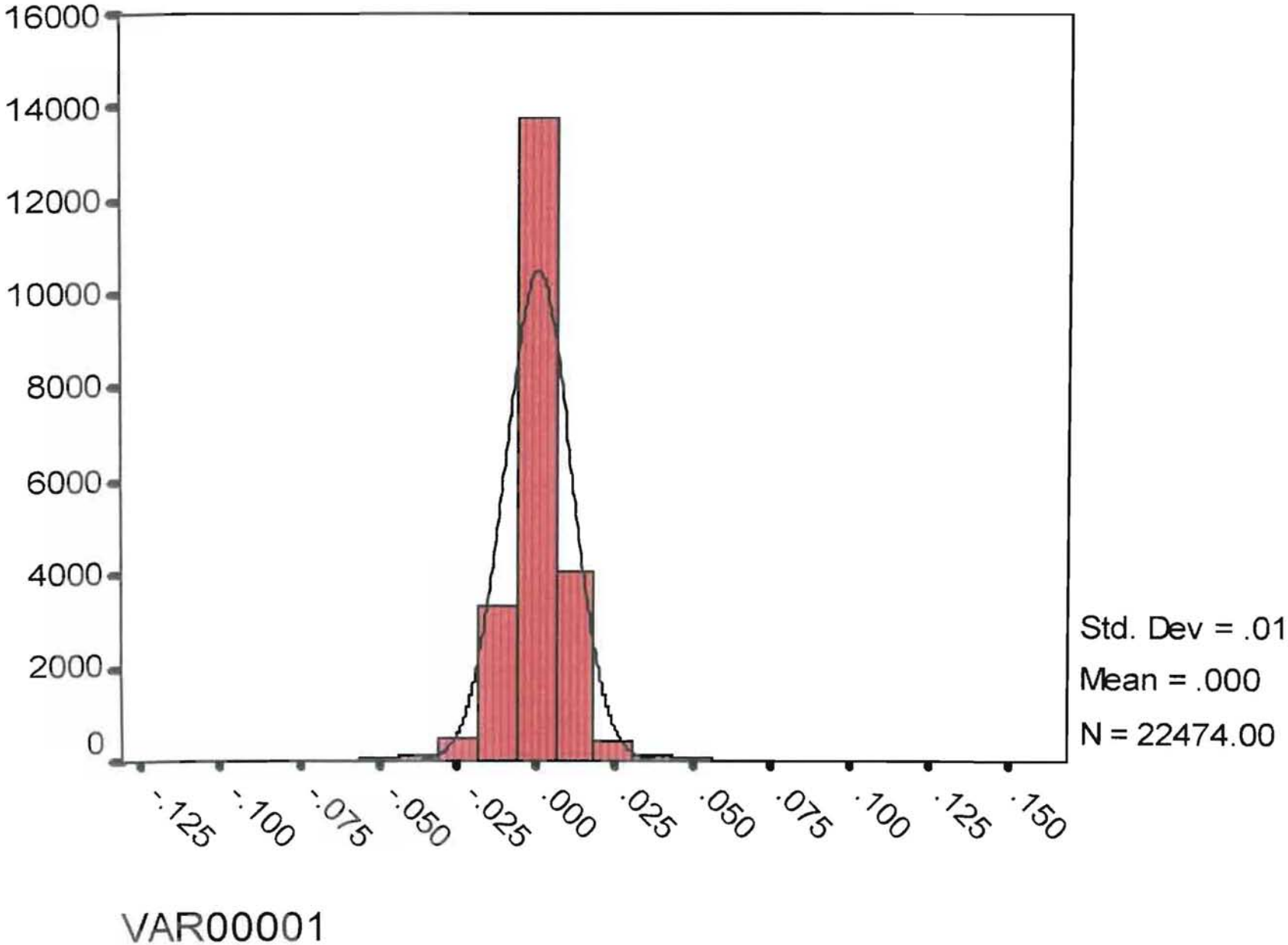

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