Review

Reviewed Work(s): Chaos and Order in the Capital Markets: A New View of Cycles, Prices, and Market Volatility by Edgar E. Peters

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students understand the economics of swaps will need to supplement this book with outside readings.

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Chaos and Order in the Capital Markets: A New View of Cycles, Prices, and Market Volatility. By EDGAR E. PETERS. New York: John Wiley, 1991. Pp. xii + 240.

Edgar Peters's *Chaos and Order in the Capital Markets* is a well-written introduction to the concepts of chaos and nonlinear dynamics and their applications to financial markets. The ideas of chaotic systems originated from the physical sciences. While these ideas have been applied to economics and finance in academic circles, they are not easily accessible to the general public. Peters's book fills the gap by presenting these ideas in a clear and simple style. The discussion is grounded in economic intuition and applications, and is very readable to anyone with an MBA degree. Exact statements and proofs are omitted, since they are available elsewhere.

Peters begins by describing the failures of the random walk model of asset prices, i.e., that price changes are serially independent, and identically and normally distributed. Peters argues that normality is a key assumption in mean variance analysis. Thus, the fact that observed price changes are not normally distributed is particularly troublesome. Peters proceeds to argue that chaotic dynamics, possibly mixed with noise, is a potential cause of nonnormality.

[3] The opinions expressed in this review are those of the author and do not necessarily represent the views of the Federal Reserve Bank of Atlanta or the Federal Reserve System.

To illustrate the ideas of chaotic dynamics, Peters employs some simple geometric shapes such as the Sierpinski Triangle. The Sierpinski Triangle is a triangle with an infinite number of triangles inside it. In fact, each triangle contains an infinite number of triangles. In other words, the shape is similar regardless of the resolution. There is infinite complexity inside a finite space. In an analogous manner, financial time series also exhibit self-similarity, since it is difficult to distinguish between the plots of the daily, weekly, and monthly returns of the S & P 500 series. Peters also points out that this feature differentiates fractal shapes from regular geometric shapes, and thus cannot be described using simple Euclidean geometry. The Sierpinski Triangle is more than one dimension but less than two. While the Sierpinski Triangle can be generated by a completely deterministic rule, it can also be the result of a random game. Thus, Peters points out that there are two types of fractals: deterministic and random.

To measure the complexity of a fractal, its fractal dimension can be determined. This measures how much space the fractal fills up. Before doing so, Peters uses the concept of the Hurst exponent to demonstrate that financial time series do not obey the random walk model. The Hurst exponent measures the average cycle length of a time series. The technique used is called the rescaled range (R/S) analysis. The Hurst exponent of a random time series is 0.5. If the Hurst exponent is between 0 and 0.5, the time series is mean reverting. If it is between 0.5 and 1, the time series is persistent. Thus, the random walk model implies that the Hurst exponent of returns should be 0.5.

Peters estimates the Hurst exponents for the S & P 500 monthly returns to be 0.78. To measure the accuracy of this estimator, Peters calculates the Hurst exponent after scrambling the series. He shows that the scrambled series has a Hurst exponent of 0.51. Estimates of the Hurst exponent are given for a number of other financial time series, including monthly returns for individual stocks, the stock indices of the United Kingdom, Japan, and Germany, the 30-year Treasury bond yield, Treasury bill yields, and four exchange rates (the U.S. dollar against the Japanese yen, German mark, British pound, and Singapore dollar). With the exception of the Singapore dollar to U.S. dollar exchange rates, all the series have Hurst exponents between 0.5 and 1. Peters also estimates the Hurst exponent of several economic indicators, such as industrial production, new business formation, housing starts, and the leading economic indicators. These series also have Hurst exponents between 0.5 and 1. The implication is that there seems to be an average (aperiodic) cycle between 4 to 5 years in economic time series.

To test the stability of the Hurst exponent for the S & P 500, Peters uses daily returns from 1929 to 1990. He shows that the Hurst exponent is stable over ten-year subperiods, ranging from 0.57 to 0.62. The average cycle length of 4 years is present in the data regardless of the measuring interval. However, the Hurst exponent of the daily data is much lower than that of monthly data (which is 0.78). Peters resolves this inconsistency as follows. It is possible that there is short-term Markovian dependence in the data, which dies down quickly. However, there is strong evidence of long memory dependence which never dies down. This violates the random walk model.

In order to describe the dynamic behavior of financial time series, Peters employs the mathematics of nonlinear dynamic systems. Nonlinear behavior is generated by the stretching and bending of space. This produces the sensitivity to initial conditions of chaotic systems. If one knows the actual map generating the data, one can easily observe the nonlinear dynamics. If one does not know the actual map generating the data, as in the case of financial time series, one must rely on other methods. Peters provides two: the correlation dimension which measures the fractal dimension, and the Lyapunov exponent which measures the speed of information loss due to the stretching of the map.

These techniques are applied to detrended stock indices. The correlation dimension is estimated to be 2.33 for the S & P 500, which means that the complexity of the series is quite low. The Lyapunov exponent is estimated to be 0.0241 bits/month, which means that all predictive power is lost after 1/0.0241, or 42 months. Peters notes that when the S & P 500 data are scrambled, the correlation dimension rises to 4. He concludes that there is evidence of nonlinear dynamics in the data which is ignored by the random walk model.

To sum up, I enjoyed reading Peters's book. It is straightforward and unpretentious. Peters delivers what he sets out to do, namely, to provide a nontechnical introduction to the methods of chaotic and nonlinear systems, with applications to financial time series. The main conclusion is that there is strong evidence against the random walk model, in terms of nonnormality and long memory dependence. Thus, a new model is required to provide a good description of the behavior of financial prices.

I have only four criticisms. First, Peters identifies the random walk model (i.e., returns are independent, and identically and normally distributed) with the efficient market hypothesis. Modern economic and finance theory does not require independence nor normality. For example, the generalized method of moments test in Hansen and Singleton (1982) is valid for a large class of distributions and serial correlation patterns.

Second, while Peters correctly points out that market efficiency does not imply random walks, he erroneously claims that random walks imply market efficiency. This is simply not true.

Third, Peters fails to mention that the efficient market (or rational expectations) hypothesis is not directly testable, since expectations are not observable. An equilibrium model is required. Thus, all tests of market efficiency/rational expectations is joint with a model of market equilibrium. A rejection may be caused by market inefficiency/irrational behavior, or by an incorrect model of market equilibrium.

Fourth, Peters attributes the evidence of nonnormality and dependence (e.g., long memory) to chaotic behavior. This ignores a large class of nonlinear time series models which are not chaotic (for example, the autoregressive conditional heteroskedasticity model of Engle (1982), or the threshold autoregressive model of Tong and Lim (1980)). The correlation dimensions of unscrambled data from these models will also be lower than those of scrambled data.

In spite of these criticisms, I would still highly recommend the book to anyone who wants a good nontechnical introduction to chaotic systems and their applications to financial time series.

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Profit-Making Speculation in Foreign Exchange Markets. By PATCHARA SURAJARAS and RICHARD J. SWEENEY. Boulder, Colorado: Westview Press, 1992. Pp. xiv + 280.

There are many books on how to make profits in stock and bond markets. In this book, Surajaras and Sweeney argue that investors can earn a substantial and significant amount of profit from investing in spot foreign exchange markets. My initial reaction was skepticism. But, on reflection, I realized that the result is simply further evidence that simple market efficiency fails. (Regardless, I will still distinguish between measured profits and economic profits.) Several technical trading rules and several ways to form portfolios are presented. Not only do the authors show there are profits, they investigate many issues that efficient market economists would raise to dispute the results. In this way, both Wall Street traders and academic economists may find something of value in this book.

There are five parts to the book. Following the introduction, part 2, "Tests and Data," reviews the evidence on foreign exchange market efficiency, highlighting the results on technical trading rules. The authors argue that technical analysis may be a better way to test for market efficiency, since "technical methods include the possibilities of both linear and nonlinear relationships and are not limited to direct time-dependent relationships" (p. 27). For the academic economist, technical trading rules provide a different way to document the "inefficiency" in the foreign exchange market.

The authors use daily data from July 1, 1974 to May 14, 1986. However, since the market in 1993 is very different from the market in 1986, I wondered whether the profits were still available. For example, according to a survey by the Federal Reserve Bank of New York and the Bank for International Settlements, daily turnover in U.S. foreign exchange markets was $59