NONLINEAR STUDIES OF TIME SERIES OF STOCK PRICES AND INDICES - APPLICATION OF PHYSICS TO FINANCIAL SYSTEMS

Summary of the thesis

Submitted for the Degree

Of

"DOCTOR OF PHILOSOPHY"

In

PHYSICS

SUBMITTED By

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2012

Summary:

Chapter 1 begins with introduction to the econophysics approaches to economic systems, especially financial markets. Physics of financial markets is discussed starting with a Brownian like market. Random walk model is described as a versatile model of stock price dynamics, which shows how cumulative random effects can give rise to a well-understood distribution. However, the deviation of the observed stock price (or market index) movements from that expected for a pure random walk indicates the possibility of effects other than independent and uncorrelated random events playing a role.

Chapter 2 describes in brief about different methods of data characterization. Characteristic patterns of variation over time represent a defining feature of complex systems. Despite the intrinsic dynamic, interdependent and nonlinear relationships of their parts, complex systems exhibit robust systemic stability. Nonlinear analysis provides a novel tool to evaluate the overall properties of a complex system. The data analysis basically measure variations, including time domain analysis, frequency distribution (spectral analysis), scale invariant (fractal) behavior (detrended fluctuation and power law analysis) and regularity (approximate and multiscale entropy) and Lyapunov exponent which is a measure of sensitive dependence on initial conditions.

Chapter 3 reports the detrended fluctuation analysis (DFA) studies of different time series data. DFA is developed specifically to distinguish between intrinsic fluctuations generated by complex systems and those caused by external or environmental stimuli acting on the system. Variations that arise because of extrinsic stimuli are presumed to cause a local effect,

whereas variations due to the intrinsic dynamics of the system are presumed to exhibit long-range correlation. DFA attempts to quantify the presence or absence of long range scale-invariant (fractal) correlation. The first step in the technique to calculate DFA is to map a time signal, such as a series of stock price, to an integrated series. The integrated series is calculated by the sum of the random variable. DFA measures scale invariant behavior because it evaluates trends of all sizes, trends that exhibit fractal properties (similar patterns of variation across multiple time scales). A component of the DFA calculation involves the subtraction of local trends (more likely related to external stimuli) in order to address the correlations that are caused by nonstationarity, and to help quantify the character of long-range fractal correlation representing the intrinsic nature of the system.

Chapter 4 deals with Multiscale Entropy Analysis (MSE). Entropy is a measure of disorder or randomness, as embodied in the Second Law of Thermodynamics, namely the entropy of a system tends toward a maximum. In other words, states tend to evolve from ordered statistically unlikely configurations to configurations that are less ordered and statistically more probable and the spontaneous reverse occurrence is statistically improbable to the point of impossibility. Entropy is the measure of disorder or randomness. It is shown that SampEn has the advantage of being less dependent on the length of the data series in question. Thus, given the temporal complexity of data on multiple scales, multiscale entropy is a robust measure of complexity. Initial investigations of multiscale entropy have been promising, but comprehensive evaluation remains to be performed.

Chapter 5 reports the Layapunov exponent characterization of the time series. Lyapunov exponent measure the rate of divergent or convergent behavior of two nearby initial points of a dynamical system is studied through Lapunov exponent determination. Lyapunov exponent is measured to determine the rate of attraction to and repulsion from a fixed point in state space. It is a measure of the rate of divergence of nearby trajectories – a key component of chaotic dynamics. It is also a quantitative measure of the sensitive dependence on the initial conditions. Average Lyapunov exponent describes the averaged rate of divergence (or convergence) of two neighboring trajectories.

Chapter 6 reports the result of Principal Component Analysis (PCA) of time series data. By conducting PCA in a sequence of steps, the numbers of components are extracted. The first component accounts for a fairly large amount of the total variance. Each succeeding component accounts for progressively smaller amounts of variance. Although a large number of components may be extracted in this way, only the first few components are important enough to be retained for interpretation. Eigenvalues are calculated to determine the amount of variance that is accounted for by a given component. The Eignenvalue for each component is presented. The purpose of the analysis is to reduce a number of observed variables into a relatively smaller number of components. This cannot be effectively achieved if it retains to components that account for less variance than had been contributed by individual variables. Principal Component Analysis reduces data dimensionality by performing a covariance analysis between factors. As such, it is suitable for data sets in multiple dimensions. The mathematical procedure is used to transform a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables or principal components. It is shown that the first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

This study comprise of the idea that if there are big set of data and one wishes to analyze them in terms of the relationship between the individual points in the data set, PCA is a powerful and extremely useful tool for analyzing data whenever there is large number of data’s and it is desired to extract most significant data’s from those data points.

Chapter 7 gives the conclusions and the future perspectives for the research. The conclusions made on the present investigation are discussed briefly with respect to the following points: (i) Underlying dynamics of the participants (ii) scaling properties of the price variations (iii) Sensitivity of price and index variations to initial conditions (iv) Entropy contents of price and index data (v) dimensionality reduction. Finally the main conclusions drawn from the present investigation have been discussed and perspective for future work has been mentioned.