CHAPTER 7

CONCLUSIONS

7.1 Conclusions

The nonlinear analysis to characterize and differentiate financial signals, or sequences of data in time produced by financial systems, was performed through different methods. Financial data collected as a series in time may be considered a sum of rhythmic variations with distinct frequencies. With the goal of providing a single means of characterizing a whole series of data, a set of techniques were applied to perform analysis of financial data sets.

Power behavior of time series was studied through DFA using C++ coding to obtain the scaling exponent of the power law followed by the time series. Power law behavior describes the dynamics of stock market fluctuations, and avalanches. 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. Through this approach a scaling exponent can be assigned to a complex and random looking time series which is the characteristics of given time series.

DFA study of a time series offers the advantage of a means to investigate long range correlations within a financial signal due to the intrinsic properties of the system producing the signal, rather than external stimuli unrelated to the properties of the system. In addition, the calculation is based on the entire data set and is 'scale free', offering greater potential to distinguish signals based on scale specific measures. Theoretically, the scaling exponent varies from 0.5 (random numbers) to 1.5 (random walk). A scaling exponent greater than 1.0 indicates a loss in long range scaling behavior r and an alteration in the underlying system. The technique was initially applied to detect long range correlations in DNA sequences but has been increasingly applied to financial time signals.

In the DFA study, it was found that for long time periods the scaling exponents tend towards 1.5 indicating the efficient behavior of the stock market at sufficiently long time intervals. However under certain conditions a change in scaling exponent is observed which indicates the trending pattern of the market. However given sufficient time the pattern disappears again can be attributed to the efficiency of the market.

The principal advantage to DFA is the lack of confounding due to nonstationary data. Although DFA represents a novel technological development in the science of fluctuation analysis and has proven its significance, whether it offers information distinct from traditional spectral analysis is debated. Data requirements are greater than with other techniques and have been suggested to include at least 8000 data points, as noted by empirical observations. It is inappropriate to simply 'run' the DFA algorithm blindly on data sets. Finally, although appealing in order to simplify comparison, the calculation of two scaling exponents (one for small and one for large n) represents a somewhat arbitrary manipulation of the results of the analysis. The assumption that the same scaling pattern is present throughout the signal remains flawed, and therefore techniques without this assumption are being developed and are referred to as multifractal analysis.

Index values, their trading volume, P\E values etc. form aperiodic but bounded trajectory and this trajectory can be characterized using Lyapunov exponent. Since the Lyapunov exponent is found to be negative for the data studied most of the time, it confirms the absence of chaos for the period under study, λ remains negative most of the time. However this study does not include intraday data. It would be interesting to study short term behavior of P/E values as the effect of fundamental changes would be negligible for intraday variations in P/E value. Time series data for different indices were studied using Lyapunov Exponent method. The Lyapunov exponent for trading

volume of NIKKEI was found to be positive for the data studied, confirming the presence of chaos for the period under study. It shows the divergent behavior of trajectory. However in all other cases the Lyapunov exponent was found to be negative for the data studied confirming the absence of chaos for the period under study. It shows the convergent behavior of trajectory.

MSE analysis of different time series was performed using C++ software and it was shown that Sample Entropy describes the complexity and regularity of experimental time series data. Sample Entropy statistics agree with theory for random numbers with known probabilistic character over a broad range of operating conditions. It maintains relative consistency and has residual bias for very short record lengths, in a large part because of non-independence of templates. The Sample Entropy does not count templates as matching themselves and does not employ a template-wise strategy for calculating probabilities. This statistics provide an improved evaluation of time series regularity and should be useful tool in studies of the dynamics of financial time series.

Principal component analysis was conducted in a sequence of steps, with subjective decisions being made at many of these steps. The number of components extracted was equal to the number of variables being analyzed. The first component can be expected to account 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 will be important enough to be retained for interpretation. An eigenvalue represents the amount of variance that is accounted for by a given component. The eigenvalue for each component is presented. Each column in the matrix (running up and down) presents information about one of the six components. The most commonly used criteria for solving PCA that is the number-of-components problem or the

eigenvalue-one criterion was adopted. With this approach any component was retained and interpreted with an eigenvalue greater than 1.00.

The rationale for this criterion is straightforward. Each observed variable contributes one unit of variance to the total variance in the data set. Any component that displays an eigenvalue greater than 1.00 is accounting for a greater amount of variance than had been contributed by one variable. Such a component is therefore accounting for a meaningful amount of variance, and is worthy of being retained. On the other hand, a component with an eigenvalue less than 1.00 is accounting for less variance than had been contributed by one variable. The purpose of reducing a number of observed variables into a relatively smaller number of components cannot be effectively achieved if retains to components that account for less variance than had been contributed by individual variables. For this reason, components with eigenvalues less than 1.00 are viewed as trivial, and are not retained.

Through (PCA) data dimensionality was reduced by performing a covariance analysis between factors. As such, it is suitable for data sets in multiple dimensions, such as a large experiment in gene expression. It was concluded that Principal component analysis is appropriate when measures on a number of observed variables are obtained and it is desired to develop a smaller number of artificial variables (called principal components) that will account for most of the variance in the observed variables. The PCA may then be used as predictor or criterion variables in subsequent analyses.

The mathematical procedure involves steps that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called "principal components". 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.

It identifies patterns in data and expresses the data in such a way as to highlight their similarities and differences. It gives an advantage that once patterns are found in data; it can be compressed without much loss of information. This study comprise of the idea that 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 tool for analyzing data. It is way of identifying patterns in data and expressing the data in such a way as to highlight their similarities and differences.

In this way PCA proved itself as an extremely useful tool whenever there is large number of data's and it is desired to extract most significant data's from those data points. Thus in brief this study is an effort to characterize a complex time series data underlying a complicated nonlinear dynamics of the financial markets. DFA assigns a scaling exponent to the time series a characteristic of its trend. Lyapunov exponent is a characteristic to sensitive dependence on initial condition and can be a predictor of the presence of chaos. Multiscale Entropy Analysis provides an idea about the complexity of the data and can be used to diagnose the presence of information and transition towards the efficient behavior.

However it is not always easy to handle a very long time series. Further the noise component also increases with data length. Principal Component Analysis can be used to reduce the dimensionality of the data without much loss of information whereas the noise level is reduced significantly.

In this study the multifractal behavior of the data is not taken into account. The data taken in this study are generally closing value. Intraday data can be studied for the short term behavior of different markets. The Lyapunov

exponents are calculated for low dimension matrices due to computational limitations. Study of Lyapunov exponent of high dimensional matrices may provide generalized idea of underlying dynamics. Similarly reduction of dimensionality could be done for short time series due to computational limitation. The study of sufficiently long series may provide more accurate means of forecasting.

The main objective of this study is not to predict the market indices, rather the aim is to understand the dynamical behavior of the financial system through the tools available in physics, which can enrich the economic thinking.

7.2 Future Perspectives

This study provides a holistic approach to form diagnostic tool for characterization of complex data. This can be useful in understanding the underlying dynamics of the market participants.

1. The present study can be used to effectively understand the market participant's behavior in the stock and other markets.

2. Sometimes stock prices are manipulated by participants or group of participants. This study can enable to identify such manipulations by observing the change in price behavior through different characteristic parameters.

3. The correlation in time series data under consideration, which causes deviation from random walk character, can be obtained.

4. Since the correlations themselves do not explain other observed features of price fluctuations, like power laws followed by these variations. The exponents of power laws can be obtained followed by these variations at different situations.

5. Finally a black box like software can be designed to forecast the future direction, however it requires further research to include tools.

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