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A study of correlations in the stock market

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HIGHLIGHTS

- Study of BSE returns over 8 years.
- Distribution of returns is not normal.
- Persistence of ACF.
- Large cross correlation due to external news.

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ABSTRACT

We study the various sectors of the Bombay Stock Exchange (BSE) for a period of 8 years from April 2006 to March 2014. Using the data of daily returns of a period of eight years we make a direct model free analysis of the pattern of the sectorial indices movement and the correlations among them. Our analysis shows significant auto correlation among the individual sectors and also strong cross-correlation among sectors. We also find that auto correlations in some of the sectors persist in time. This is a very significant result and has not been reported so far in Indian context. These findings will be very useful in model building for prediction of price movement of equities, derivatives and portfolio management. We show that the Random Walk Hypothesis is not applicable in modeling the Indian market and mean–variance–skewness–kurtosis based portfolio optimization might be required. We also find that almost all sectors are highly correlated during large fluctuation periods and have only moderate correlation during normal periods.

1. Introduction

The stock market is an extremely complex system with various interacting components [1]. The movement of stock prices are somewhat interdependent as well as dependent on a wide multitude of external stimuli like announcement of government policies, change in interest rates, changes in political scenario, announcement of quarterly results by the listed companies and many others. The overall result is a chaotic complex system which has so far proved very difficult to analyze and predict. In fact it is still not completely clear, what are the generic features that will appear in any stock market and what are the features which depend on the social, political and economic climate of the country and/or of the world. So it is important to study each market individually so that finally we can be sure that certain behaviors or patterns are universal. Although some amount of work has been done in understanding the stock markets in Europe [2] and the United States [3], the proper mathematical and statistical study of emerging markets like India are in their infancy [4].

So far, there is no exact understanding on which external stimulus has how much effect on the stock prices or even how the self interactions of the various stocks or the various sectors drive the market. Broadly speaking, the price movement of a

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particular stock can be classified as (i) market (common to all stocks), (ii) sector (related to a particular business sector) and (iii) idiosyncratic (limited to an individual stock). While it is virtually impossible to develop any theory for this idiosyncratic movement, it is possible to analyze, study and build models for the other two types of stock movement. From an investors point of view, the most important reason to understand the stock market is to get the maximum possible return on an investment with the minimum possible risk. So a better understanding of the stock market will lead to better theories of portfolio management.

One important step in improving our understanding of the stock market is to study how the stock price movement of one stock affects the price of other stocks. One way to do this would be to see how one stock movement affects the others within the same sector. Another is to study how the overall prices of the various sectors are correlated. The goal of this study is to try to determine and quantify, from the available data, some of the possible correlations which might exist between the stock prices. This will not only enhance the understanding of the stock market as a whole but will play a crucial role in investment decisions like portfolio management. A systematic model independent analysis of the data that we do will also help in building more efficient and enhanced models which will give adequate weightage to the various relations which exist between movement of stock prices across sectors in a market and may help in forecasting future trends. Studies of such correlations have been carried out to a limited extent in the context of New York Stock Exchange [5], but to the best of our knowledge, no such study exists for the Bombay Stock Exchange (BSE) [6].

To understand the financial market, it is very important to know the distribution of the return on a stock. Our data consists of the daily returns of 12 sectors of stocks of the BSE for Financial Year (FY) 2006 to FY 2013 i.e. 1990 days from 3rd April 2006 to 31st March 2014. We will be treating each sector as one entity in the rest of the paper. This approach is novel and has not been carried out before, at least in the context of Indian markets.

If $P_i(t)$ is the index of the sector $i = 1, \ldots, N$ at time t, then the *(logarithmic) return* of the ith sector over a time interval $t = 1$ to $t = T$ days in the interval is defined as

$$R_i(t) \equiv \ln P_i(t+1) - \ln P_i(t). \tag{1}$$

In our case $T = 1900$, the number of days we have considered, and $N = 13$ because we look at the following 12 sectors S&P BSE Auto (Auto), S&P BSE Bankex (Bankex), S&P BSE Consumer Durables (CD), S&P BSE Capital Goods (CG), S&P BSE FMCG (FMCG), S&P BSE Health care (HC), S&P BSE IT (IT), S&P BSE Metal (Metal), S&P BSE Oil and Gas (Oil and Gas), S&P BSE Power (Power), S&P BSE Realty (Realty) and S&P BSE Teck (Teck) and the S&P BSE SENSEX (Sensex) which serves as the benchmark. The plot of the Sensex index and the log return over the time interval under consideration is given in Fig. 1. From Fig. 1, it is clear that we can divide the entire period in two sub interval (i) from FY 2006 to FY 2009 as large fluctuation period and (ii) from FY 2010 to FY 2013 for normal period. We shall discuss how the cross correlations of the sectors are markedly different in these two periods, later in the paper.

Obviously the mean return of the ith sector is given by

$$\bar{R}_i = \frac{1}{T}\sum_{t=1}^{T} R_i(t). \tag{2}$$

Defining $R'_i = (R_i(t) - \bar{R}_i)$, we can write the kth moment of the ith sector as

$$m_k(i) = \frac{1}{T}\sum_{t=1}^{T} (R'_i(t))^k. \tag{3}$$

For example, the second moment gives the variance as

$$\sigma(i) = \frac{1}{T}\sum_{t=1}^{T} (R'_i(t))^2. \tag{4}$$

These definitions are used in the analysis subsequently.

Our paper is organized as follows. In Section 2 we explore the individual sectors mentioned above and use the data to determine some features of the distribution of the returns and find significant deviations from normality. We then calculate the auto correlation of log returns for all sectors indices, to test the market efficiency, and find that there is significant auto correlation in most of the sectors of BSE at lag 1. The more surprising result is that the analysis of our data shows that the auto correlations in some sectors persist at higher lags. In Section 3 we analyze the cross-correlations among sectors in BSE. Our study spans over FY 2006–2013, a time span which consisted a period large fluctuation in indices movement and normal fluctuation period. We find that, almost all sectors are highly correlated during period 2006–2009 and they are moderately correlated during 2009–2013. We finally conclude in Section 4 with a summary of our results and its interpretations.

2. Understanding BSE sectors

It is commonly believed that the distribution for log return of a stock or for log change in a index movement is a normal distribution. However, many empirical studies shows deviation from this perception. Consequently, any prediction based on the normal distribution will generally fail. In particular, if there is any deviation from normality, the Random Walk