FINANCE INDIA
Vol. XVIII No. 3, September 2004
Pages – 1251-1258

The Random Walk Hypothesis on the Bombay Stock Exchange

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Abstract

Stock prices on the Bombay Stock Exchange (BSE) are examined to test for the random walk hypothesis. Fourteen randomly picked stocks and the BSE 500 plus the BSE 100 stock indexes using weekly returns during July 2001-October 2003 are studied using the Dickey-Fuller unit root test and Lo and MacKinlay's variance ratio test. This time period is chosen as it includes the current rolling settlement procedure of the BSE. The findings are that stocks on the Bombay Stock Exchange follow a random walk. However, the BSE 500 and BSE 100 stock indexes exhibited some stationarity. Nevertheless, the non-random results for the index are similar to that discovered in the US market by Fama and French (1988) and Lo and MacKinlay (1988). The implications of these results are that investors cannot earn excess profits using past stock prices as their sole source of information.

THE FORCES OF globalization have renewed interest in India. India is now emerging as a key player in international business and with this increasing global importance, renewed attention is being focused on the efficiency of its economic and financial institutions and markets. This paper is an attempt to analyze the efficiency of the Indian stock market focusing on the Bombay Stock Exchange.

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Submitted December 2001 ; *Accepted* March 2004

The proper functioning of a stock market is the underlying basis of the efficient market hypothesis. There are several levels of efficiency, of which the most basic is that the past history of stock prices cannot be used to forecast future prices, enabling investors to earn excess returns. Recently the notion of efficient markets has been assaulted by some event study anomalies, greater stock and bond price volatilities compared to actual economic events, and irrational excesses such as the overreaction to news resulting in a subsequent correction. Nevertheless, faith in efficient markets persists.

The testing of efficient markets can take several forms. This paper examines the form known as the random walk hypothesis on the Bombay (Mumbai) Stock Exchange (BSE) in India. The BSE is chosen, among the 23 stock exchanges in India, as it is the oldest and still a very popular stock market in the country.

Research on the random walk has been conducted in other capital markets. For the US market Fama and French (1988) studied 82 stocks, 10 deciles by size portfolios, 17 industry portfolios and 2 stock indexes using a first order autocorrelation test of OLS slope coefficients of stock returns across the 1926-85 period. Lo and MacKinlay (1988) examined 2 stock indexes over the 1962-85 period developing and using the Lo and MacKinlay variance ratio test. The empirical evidence for both studies on the US stock markets supported the rejection of the random walk model.

Similar results that stocks do not follow a random walk are found by; Blasco, Del Rio and Santamaria (1977) researched the Madrid Stock Exchange for 27 stocks in Spain during 1980 to 1992 using the Ljung-Box-Pierce test and Brock, Dechert and Sheinkma test; Chang and Ting (2000) analyzed 1 stock index in Taiwan from 1991 thru 1998 employing the Lo and MacKinlay variance ratio test; Darrat and Zhong (2000) studied 2 stock indexes, Shanghai and Shenzhen Stock Exchanges, in China during the 1991 thru 1998 period utilizing the Lo and MacKinlay variance ratio test; Grieb and Reyes (1999) examined 2 stock indexes from both the Sao Paulo Exchange in Brazil and Mexican Stock Exchange in Mexico from 1989 to 1995 using the Lo and MacKinlay variance ratio test; Huber (1997) investigated 7 stocks and 2 stock indexes on the Vienna Stock Exchange in Austria during 1986 thru 1992 applying the Lo and MacKinlay variance ratio test; Huang (1995) surveyed 9 stock indexes in Asian markets representing Hong Kong, Indonesia, Malaysia, Japan, Singapore, Philippines, Korea, Taiwan and Thailand working with both the Augmented Dickey-Fuller test and the Lo and MacKinlay variance ratio test. The results across the markets are mixed both supporting and refuting the random walk hypothesis. Jha and Nagarajan (2000) examined the cointegration of 10 stocks trading on both the Bombay and National Stock Exchange in India for the July 1996 to July 1997 period. Employing the Johansen and Juselius Vector Autoregression test they demonstrate co-integration and thus market efficiency.

In this paper we examine 14 stocks trading on the Bombay Stock Exchange as well as the Bombay Stock Exchange Index (BSE 500 and BSE 100) for evidence that they follow a random walk lending support for market efficiency.

I. Methodology

The existing literature states that the random walk process consists of two implications: a unit root and uncorrelated increments. Consequently, the random walk can be supported by either detection of a unit root or finding that the stock increments are serially uncorrelated. Therefore, this study performs two separate techniques to test for both implications of the random walk process.

The unit root test for stationarity is the Dickey-Fuller test. A time series that has a unit root is nonstationary and follows a random walk.

According to Lo and MacKinlay (1988), we can test the random walk hypothesis using a variance ratio test that is "sensitive to correlated price changes but which is otherwise robust to many forms of heteroskedasticity and nonnormality." Also, unlike the unit root test, the variance ratio test does not rely on nuisance parameters. The Lo and MacKinlay variance ratio test uses the fact that the variance of the increments in a random walk is linear in the sampling period. Simply stated, that means the variance of $Y_t - Y_{t-2}$ is twice the variance of $Y_t - Y_{t-1}$. Consequently, we can check the plausibility of the random walk model by comparing the variance estimate of $Y_t - Y_{t-1}$ to, for example, the one-half or one-fourth of $Y_t - Y_{t-2}$.

Consider the random walk process

$$Y_t = Y_{t-1} + \mu_t + \varepsilon_t \tag{1}$$

Where Y_t is a series of stock returns of length $nq + 1$, μ_t is an arbitrary drift parameter and ε_t is a random disturbance term with zero mean and constant variance.

We study the random walk hypothesis using two statistical tests: (1) Dickey-Fuller Test for unit root and (2) Lo and MacKinlay's variance ratio test.

For the Dickey-Fuller Test a regression is run:

$$Y_t = \rho\, Y_{t-1} + \varepsilon_t \tag{2}$$

Where the ρ coefficient is the test for a unit root equal to 1. The term unit root refers to the root of the polynomial in the lag operator and implies the time series is nonstationary. If ρ equals 1, and therefore the time series is a unit root, the stock can be thought of as following a random walk.

For theoretical and empirical reasons the Dickey-Fuller test is run as a regression,

$$\Delta Y_t = (\rho - 1) Y_{t-1} + \varepsilon_t \tag{3}$$

which is then rearranged as,

$$\Delta Y_t = \delta Y_{t-1} + \varepsilon_t \tag{4}$$

for Lo and MacKinlay's variance ratio test, the random disturbance term from equation 1 can either be assumed to have constant variance, that is homoscedasticity, or time-varying variance, that is heteroscedasticity. The variance ratio is:

$$VR(q) = \left(\sigma^2(q) / \sigma(1)\right) \tag{5}$$

where,

$$\sigma^2(q) = \left(q(nq - q + 1)(1 - q/nq)\right)^{-1} \sum_{K=q}^{nq} (Y_k - Y_{k-q} - q\bar{Y})^2 \tag{6}$$

$$\sigma^2(1) = (nq - 1)^{-1} \sum_{K=1}^{nq} (Y_k - Y_{k-1} - \bar{Y})^2 \tag{7}$$

$$\bar{Y} = (nq)^{-1} \left(Y(nq) - Y(0)\right), \tag{8}$$

In the case of homeoscedastic error terms the test statistic is

$$Z_1(q) = \sqrt{nq}(VR(q) - 1)(2(2q-1)(q-1)(q-1)/3q)^{-1/2} \tag{9}$$

which has a zero mean and variance of 1 for all step lengths of q

In the case of heteroscedastic error terms the test statistic is

$$Z_2(q) = \sqrt{nq}(VR(q) - 1)(V(q))^{-1/2} \tag{10}$$

where,

$$V(q) = \sum_{j=1}^{q-1} A((j))^2 \frac{(nq) = \sum_{k=j+1}^{nq}((Y_k - Y_{k-1} - \bar{Y})^2 (Y_{k-j} - Y_{k-j-1} - \bar{Y})^2)}{\sum_{k=1}^{nq}(Y_k - Y_{k-1} - \bar{Y})^2)} \tag{11}$$

and

$$A(j) = 2(q - j)/q \tag{12}$$

which also has a mean and variance of 0 and 1 respectively.

II. Data and Hypothesis

We gathered daily closing prices for the Bombay Stock Exchange BSE 500 and BSE 100 Indexes (market value weighted) and 14 stocks from July 4, 2001 through October 31, 2003. Fourteen stocks are chosen as it is comparable in number to what other researchers have done in this field of literature. The entire data set was obtained from the BSE website (http://www.bseindia.com/histdata/stockprc.asp).

The stocks on the BSE were numbered sequentially. Then random numbers were selected from a random numbers table to assemble the sample size. Infrequently traded stocks were deleted and replaced before the final sample was finalized.

The hand gathered data was stored in the Microsoft Excel - 2000 format and the daily data was then converted into weekly returns. The weekly stock return is based on the Wednesday closing price of each week. If Wednesday's price is missing, the stock was deleted. Weekly returns are used so as to avoid biases (in daily data) such as nonsynchronous trading. This transformation results in 115 weekly returns per stock/index.

The null hypothesis is that we do not reject that stocks follow a random walk. Thus, for the Dickey-Fuller Test

$$\delta = 0 \tag{13}$$

With a tau test statistic less than the critical value at an alpha level of 5 percent, two-tail test and, Lo and MacKinlay's Variance Ratio Test for the heteroscedastic error term of

$$VR(q) = 1$$

for lags (q) of 2, 4, 8, and 16, with a z-statistic less than the critical value at an alpha level of 5 percent, two-tail test.

III. Results

The results of the Dickey-Fuller test for unit root are shown in Table I. Observing each and every test statistic for the original time series of the BSE 500 Index, BSE 100 Index and all 14 stocks we find that they exhibit a unit root at the 5% alpha level. Therefore, the time series is nonstationary and the random walk hypothesis cannot be rejected. For this analysis using returns for the entire sample all statistics provide support for the time series to be non-stationary and therefore bolstering the random walk hypothesis.

The results of Lo and MacKinlay's variance ratio test are reported in Table II. Upon examination of the table it is evident that the results are a little mixed. For the stocks there is overwhelming support for the null hypothesis. That is, we cannot reject the random walk hypothesis. However, there is a statistically significant indication of stationarity for Cummins/Kirloskcum at the lag where q equals 2. Nonetheless, Cummins/Kirloskcum is non-random as evidenced by nonstationary level z-statistics of VR at q equaling 4, 8 and 16. Moreover, Bajaj Auto and Essel Packing generated statistically significant z-statistic VR variables but for only the lag of q equaling 16.

The variance ratio test for the BSE 500 stock index itself generated nonrandom results at all q lags of 2, 4, 8 and 16. On the other hand, the BSE 100 stock index shows stationary (nonrandom) results only at a q of 2 and 4.

Table I
Dickey Fuller Unit Root Test
(July, 2001 – October 2003)

	Bombay Stock Exchange n=115	Regression Coefficient	Standard Error	Tau Value*
1	ABB Ltd.	0.007	0.019	0.358
2	Bajaj Auto	0.013	0.013	0.946
3	Bhel-Ltd	0.018	0.018	0.989
4	Cummins/Kirkloskcum	-0.027	0.032	-0.835
5	EsselPacking	-0.029	0.022	-1.318
6	HDFC	-0.038	0.025	-1.538
7	HindPetrol	-0.024	0.019	-1.264
8	ICIC Ltd.	-0.020	0.028	-0.716
9	Indian Alum	-0.001	0.018	-0.066
10	Indus Ind Bank	-0.019	0.022	-0.861
11	Ingersol	-0.030	0.016	-1.837
12	Reliance	-0.007	0.030	-0.223
13	Siemens	0.001	0.017	0.039
14	Titan Industries	-0.010	0.023	-0.464
BSE 500 Index		0.015	0.118	0.891
BSE 100 Index		0.012	0.022	0.528

Note : *A large negative Tau indicates stationarity

Table II
Variance Ratio Test
(July, 2001 – October 2003)

	Bombay Stock Exchange n=115	Lag Q = 2		Lag Q = 4		Lag Q = 8		Lag Q = 16	
		VR	Z	VR	Z	VR	Z	VR	Z
1	ABB Ltd.	0.9131	-0.9206	1.0207	0.1219	1.1053	0.3166	0.8011	-0.5265
2	Bajaj Auto	1.1086	1.0229	1.2832	1.4269	1.5237	1.4246	2.0313	2.4859
3	Bhel-Ltd	0.9881	-0.1152	0.9477	-0.2910	1.0294	0.0792	0.6953	-0.7351
4	Cummins/ Kirloskcum	0.7268	-2.6293	0.6665	-1.7077	0.5056	-1.3429	0.4947	-1.1858
5	EsselPacking	1.1023	1.1230	1.2147	1.2366	1.4318	1.1879	1.9148	2.2555
6	HDFC	0.9593	-0.6508	0.9638	-0.3291	0.9275	-0.3772	0.9654	-0.1599
7	HindPetro	1.1037	1.0823	1.1569	0.8666	1.3073	0.8613	1.2162	0.5360
8	ICICI ltd.	1.1061	0.8935	1.1241	0.6011	1.0665	0.1707	0.5766	-0.9970
9	Indian Alum	1.1481	0.7137	1.0093	0.0279	0.6743	-0.6472	0.5659	-0.7703
10	Indus Ind Bank	1.0672	0.6642	1.0775	0.4005	1.0766	0.2065	0.6316	-0.8718
11	Ingersol	1.0065	0.0666	0.9138	-0.4782	0.5598	-1.3054	0.4984	-1.2423
12	Reliance	1.0856	0.7612	1.1160	0.5722	1.1257	0.3101	1.0554	0.1255
13	Siemens	1.0975	0.9199	1.1910	0.9834	1.0367	0.1014	0.8757	-0.3055
14	Titan Industries	1.0376	0.3829	1.1804	0.9971	1.1870	0.5245	0.8790	-0.3023
Average Varience Ratio			1.0322		1.0618		1.0398		0.9430
BSE 500 Index		1.2457	2.42	1.4749	2.59	1.7882	2.13	1.9005	2.20
BSE 100 Index		1.2450	2.36	1.4560	2.41	1.7066	1.85	1.6917	1.65

Note: VR for lag 2 equals 1 + autocorrelation

IV. Conclusions

The empirical results from the Dickey-Fuller test for a unit root did not reject the null hypothesis for the entire data sample, including all 14 stocks and the BSE 100 stock index. This provides us with evidence supporting the random walk hypothesis for the time series.

Our empirical findings from the variance ratio test suggests that stocks on the Bombay Stock Exchange follow a random walk process. Our empirical findings from Lo and MacKinlay's variance ratio test supports the random walk process for stocks on the Bombay Stock Exchange. However, there is an indication of stationarity for the BSE 500 stock index. Nonetheless, random results are displayed by the BSE 100 Index. Our findings are consistent with the conclusions of many other researchers (see, for example, Lo and MacKinlay (1988), Fama and French (1988) in the U.S. capital market). It should be noted that rejection of the random walk hypothesis would not necessarily imply rejection of market efficiency. According to Summers (1986), the rejection of the random walk hypothesis in a given market can only mean the findings are inconsistent with the particular martingale process of a random walk. A possible explanation for the rejection of the random walk hypothesis is market imperfection arising from suboptimal information transparency, which prevents proper dissemination of information among investors. The rejection of the random walk process also conforms with Fama and French's (1988) hypothesis on the mean reverting behavior of stock prices as a possible result of overreacting to sudden changes in fundamentals. These conclusions are similar to those found in the U.S. stock market and elsewhere. The implications of these results are that investors cannot earn excess profits using past stock prices as their sole source of information.

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