Tests of Random Walk in Indian Stock Market Returns: An Application of Variance Ratio Test

K. BANUMATHY AND R. AZHAGAIAH

The primary objective of the study is to test the random walk hypothesis (RWH)for Indian stock returns. The daily closing prices of 24 firms of BSE 500 were collected for the period of 10 years ranging from 1st January 2003 to 31st December 2012, which were selected based on Multi-Stage Non-Random Sampling Technique. The study used normality test, stationarity test and the variance ratio (VR)test for the hypothesis that the stock market (SM)returns follow a random walk. Overall, the study found that the RWH is rejected for all the firms implying that there exists a non-random behaviour of returns and the Indian SMdoes not show the characteristics of random walk which means that the mean reverting tendencies of return series exists in both long-run as well as in the short-run period.

Keywords: Random walk hypothesis, stock market returns, variance ratio test.
JEL Classification:C22 and G14.

Introduction

A random walk ***(RW)*** is a useful model in understanding stochastic processes across a variety of scientific disciplines. If a stock price series follows a ***RW***, the return has no mean-reversion tendency and, hence, a shock to the price will lead to increasing deviations from its long-run equilibrium. If, on the other hand, a stock price series does not follow a ***RW*** it follows that future equity prices are predictable based on past prices. Thus, it is possible to design profitable trading schemes based on historical equity data. **Lo** and **MacKinlay (1988)** proposed to test ***RWH*** using variance ratio ***(VR)*** test to find out the permanent and temporary components in stock returns. They proposed a test statistic which is robust under the heteroscedastic ***RWH***. The ***VR*** test assesses the null hypothesis that a univariate time series is a ***RW***.

K. Banumathy, Ph.D. is Faculty in India International School, Mangaf, Kuwait.
E.Mail: banukarunanithy@gmail.com

Dr. R. Azhagaiah, Associate Professor and Head of the Department, Department of Commerce, Avvaiyar Government College for Women (Affiliated to Pondicherry University), Karaikal, Puducherry (U.T.), India.
E.Mail: drrazhagaia@yahoo.co.in

One of the recent additions to the ***VR*** test literature is the mean reversion and overreaction of stock prices. Mean reversion is often attributed to overreaction by investors, in which any information shock to the price series is temporary and the effect dies down quickly. **De Bondt**and**Thaler (1990)** argued investors in the ***SM*** overreact to new information.

The objective of the paper is to investigate whether prices in Indian stock market *(SM)* follow a ***RW*** process as it is the oldest *SM*incorporated in 1875. The name of the first share trading association in India was *'Native Share and Stock Broker Association'*,which later came to be known as Bombay Stock Exchange ***(BSE)***.The BSE India SENSEX is the India's first *SM*index and is tracked worldwide. It is an index of 30 stocks representing 12 major sectors.In August 9, 1999, BSE Limited constructed a new index, called BSE-500, consisting of 500 scrips, which represents nearly 93% of the total market capitalization on BSE. BSE 500 covers 20 major industries of the economy. The presence and absence of ***RW*** is evaluated using BSE 500 stocks. Hence, the study is made comprehensive including the stocks of BSE firms in India.

Literature of Review

Attempts have been made by researchers to investigate the behaviour of *SM* in many countries. A number of studies tested the hypothesis that the return series exhibit random walk ***(RW)*** behaviour. For instance,Smith and Ryoo (2003) examined the *RWH*of stock indices of five European markets viz., Greece, Hungary, Poland, Portugal and Turkey. Using the multiple *VR* test the study found that the hypothesis of *RW*is rejected for all the four markets except for Turkey, whereas it follows a *RW*. **Chen (2009)** examined the ***RWH*** for ten Pacific Basin foreign-exchange markets and rejected the ***RWH*** using the Lo and MacKinlay ***VR*** tests. **Madhusoodanan (1998)** applied ***VR*** test at aggregate level of indices and disaggregate level of individual stocks and found that at aggregate level, the ***RWH*** cannot be accepted and the movement is persistent, whereas at the disaggregate level of 120 individual stocks, it shows significant autocorrelation. The individual stocks also showed evidence on persistence.

Li and Liu (2012)analysed the *RWH* of 34 MSCI country indices from 1988 to 2010 and pointed out that out of 34 markets, 25 markets follow a *RW*. In the same way, Smith *et al.* (2002) examined the *RWH* for eight African *SM*s, in which seven markets showed that the return does not follow a *RW*and the hypothesis is rejected because of autocorrelation. Wen (2009) reported that the prices or returns in the spot energy markets are unpredictable and therefore the market participants are unable to make abnormal returns in future.**Mbululu *et al.* (2013)** used nominal USD / ZMK exchange rates from 2003 to 2012 to investigate the validity of ***RWH*** in the Zambian foreign

exchange market. The result rejected the ***RWH*** and supported for the violation of the weak form market-efficiency hypothesis.

Charles and **Darne (2009)** pointed out that Argentina, Brazil, Chile and Mexico rejected the ***RWH*** indicating that these markets have not been weak-form efficient. **Chen (2008)** used **Lo** and **MacKinlay's (1988)** conventional ***VR*** test, **Chow** and **Denning's (1993)** simple multiple ***VR*** test, and **Wright's (2000)** non-parametric ranks and signs-based ***VR*** tests to test the ***RWH*** of the Euro/ US dollar exchange-rate market using data from 1999 to 2008. The results supported the ***RWH*** and concluded that the Euro/US dollar exchange-rate market was regarded as weak-form efficient. On the other hand, many studies viz., **Poterba** and **Summers (1988); Black (1990); Cecchetti *et al.* (1990)** and **Jog** and **Schaller (1994)** found evidence of mean reversion in the return series. To sum up, although the literature on ***RWH*** is vast, there is no consensus among the researchers regarding long-run and short-run behaviour of the return in Indian *SM*. The review of previous research works show mixed empirical evidence regarding the behaviour of the stock returns. Moreover; there is very little work which has tested the ***RWH*** for Indian *SM*. Hence, the present study investigates the behaviour of return in both the long-run as well as the short-run periods in Indian *SM*.

Objective and Hypothesis Developed for the Study

The objective of the study is to investigate whether stock price returns on the *BSE* depict a random sequence. The hypothesis developed for the study is as follows:

*H_0: Returns of **BSE** 24 firms follows a random walk*
*H_1: Returns of **BSE** 24firms follows non-random walk*

The above hypothesis is tested using *VR* test using Eviews 7 package.

Research Methodology

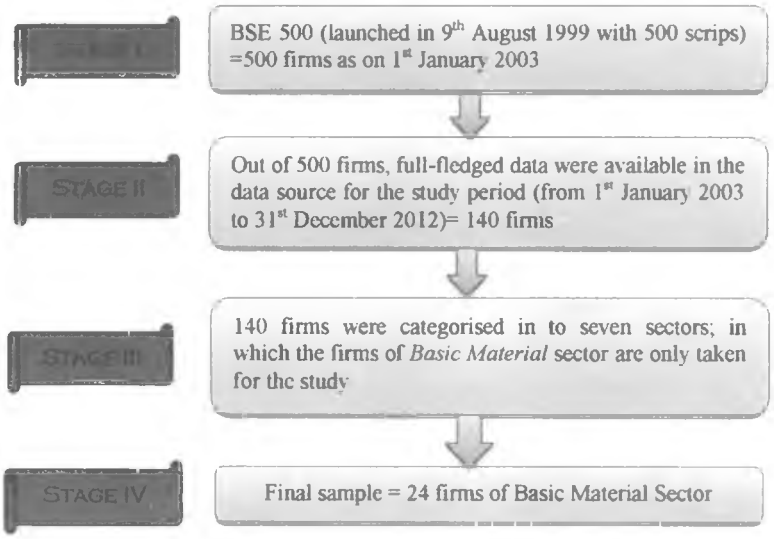
Data Source and Period of the Study

The stock price behavior follows ***RW*** is an on-going debatable issue and it inspires to use the latest data for further testing ***RWH***. Initially, the daily closing prices of *BSE* 500 firms from 1st January 2003 to 31st December 2012 were collected using the data source called Centre for Monitoring Indian Economy Pvt. Ltd. *(CMIE)* Prowess package.*Next*, the *BSE* 500 firms are classified in to seven sectors viz., *Basic Material*, *Consumer Cyclical*, *Consumer Non-cyclical*, *Energy & Utilities*, *Industrial* and *Technology* Sectors.

Using *Multi-Stage Non-Random Sampling Technique*, the stocks have been selected for the study *(vide figure 1)*. The present study used only the

Basic Material sector in to consideration, which comprises 24 firms. The ***RW***behavior of *SM*return on 24 firms of *Basic Material* sector is tested.

Figure 1
Sampling Design for Stock Selection



Research Tools Used for the Study

The daily return is calculated, which is the first difference in logarithm of closing prices as given below:

$$r_t = \log\left(\frac{P_t}{P_{t-1}}\right) x100$$

Where P_t and P_{t-1} are the closing market prices of individual firms at the current day and previous day respectively.

First, the distributional properties of daily price return series (r_t) of the selected 24 firms under*Basic Material*sector are computed using descriptive statistics. *Second*, the study tested for stationarity in the data series. The formal method to test the stationarity of a series is the unit root test, which is used to detect the presence and form of non-stationarity.*Finally*, the variance ratio ***(VR)*** is employed to analyse the behavior of returns in short-run and long-run periods for all the firms of ***BSE***.

Descriptive Statistics

Descriptive statistics provides the historical account of return behaviour, which includes mean, standard deviation, skewness, kurtosis including the Jarque-Bera statistics, which tests for normality. If the residuals are normally distributed, the histogram should be bell-shaped and the Jarque-Bera statistic should not be significant. It strongly rejects the hypothesis of normal distribution.

H_0: *Series is normally distributed (JB=0)*
H_1: *Series is not normally distributed (JB‘‘‘0)*

Testing for Stationary

Unit root tests are used to test for stationarity. The well known unit root test, namely Augmented Dickey Fuller ***(ADF)*** test **(Dickeyand Fuller, 1979)** is applied to examine the unit root in the time series data. The hypothesis is stated below:

H_0: *Series is non-stationary* (There is unit root)
H_1: *Series is stationary* (There is no unit root)

If the series is stationary then the unit root will be absent and vice versa.If the test statistics value is more than the critical values, the H_0 cannot be rejected.

Variance Ratio Test

The study undertaken by **Lo** and **MacKinlay (1988)** is the foundation of the ***VR*** test approach. It is by far the most important study on the ***RWH***. Hence, it is used for identifying how do the stock returns of the selected firms under *Basic Material*sector behave, i.e. whether they behave in long-run or in short-run.**Lo** and **Mackinlay (1988)** test the ***RWH*** using the ***VR*** test using the statistics mentioned below:

$$X_t = \mu + X_{t-1} + \varepsilon_t$$

Where

X_t = log price process
μ = drift parameter
ε_t = random disturbance error

The ***VR*** is given by the formula: $VR(q) = \dfrac{\frac{1}{q} Var(p_{t-1} - p_{t-q})}{Var(p_{t-1} - p_{t-1})} = \dfrac{\sigma^2(q)}{\sigma^2(1)}$

Where, *Var* is the variance operator and q is the positive integer and the null hypothesis $VR(q) = 1$.

H_0: *Returns of* ***BSE*** *firms follows a random walk*
H_1: *Returns of* ***BSE*** *firms follows non-random walk*

The ***RWH*** requires that the ***VR*** for all the chosen intervals*(q)* be equal to one. If ***VR*** is less than one then the series is said to be '*mean reverting*' and if ***VR*** is greater than one then the series is said to be '*persistent*'.

Results and Discussion

*Table 1*shows that the daily return is positive for all the 24 firms. It ranges between 0.187% for ***SESAGOA*** and 0.031% for ***HINDAL***. From the σ, it is inferred that the volatility in daily share price returns is high for ***JSWSTL***$(\sigma = 3.68)$ and it is low for ***ASIAN***$(\sigma = 1.69)$. The ***S*** is close to zero for few number of firms viz., ***AMBUJA***, ***ASIAN***,***CHAMBAL***, ***GUJNARM*** and ***JINDSAW***. The negative and positive ***S*** for most of the firms indicates that the daily return series of *Basic Material* firms are departure from normality.

Table 1. **Descriptive Statistics of Returns of Basic Material Stocks for the period from 2003 to 2012**

S.No.	Firms	Mean $(\bar{X})$	Standard Deviation (σ)	Skewness *(S)*	Kurtosis *(K)*	Jarque-Bera Statistic	Sig
1.	ACC	0.087	2.23	-0.403	7.33	2014.23*	0.0000
2.	AKZO	0.081	1.93	0.067	10.72	6205.75*	0.0000
3.	AMBUJA	0.089	2.28	-0.039	5.90	873.72*	0.0000
4.	ASIAN	0.121	1.69	-0.025	8.52	3168.63*	0.0000
5.	BASF	0.075	2.30	0.766	9.93	5235.23*	0.0000
6.	CASTROL	0.071	1.94	0.913	8.44	3423.04*	0.0000
7.	CHAMBAL	0.070	3.37	0.019	13.31	11056.70*	0.0000
8.	DEEPAK	0.079	2.87	0.270	8.39	3053.35*	0.0000
9.	GUJALKA	0.061	3.19	-0.074	15.03	15062.24*	0.0000
10.	GUJFERT	0.102	3.06	0.187	8.52	3183.39*	0.0000
11.	GUJNARM	0.039	2.64	0.020	7.25	1877.91*	0.0000
12.	HINDAL	0.031	2.84	-0.230	6.90	1605.10*	0.0000
13.	HINDZINC	0.175	3.25	0.327	7.71	2350.60*	0.0000
14.	INDCEM	0.063	3.29	0.150	6.44	1238.92*	0.0000
15.	JINDSAW	0.080	3.08	0.003	6.93	1603.94*	0.0000
16.	JSWSTL	0.121	3.68	0.407	6.97	1707.64*	0.0000
17.	MADCEM	0.099	2.55	0.261	8.60	3288.77*	0.0000
18.	MAHSEAM	0.053	2.45	-0.345	14.51	13824.47*	0.0000
19.	PIDILITE	0.117	2.13	0.506	13.22	10970.35*	0.0000
20.	PRISM	0.086	3.36	0.541	6.36	1292.84*	0.0000
21.	SAIL	0.088	3.35	0.197	7.84	2451.87*	0.0000
22.	SESAGOA	0.187	3.43	0.235	6.25	1118.64*	0.0000
23.	TATCHEM	0.073	2.47	-0.114	7.20	1841.64*	0.0000
24.	TATSTL	0.060	2.95	-0.319	6.36	1214.42*	0.0000
ALL Firms (Average)		0.088	1.71	-0.718	8.75	3647.73*	0.0000

Source: Computed results based on compiled data collected from CMIE Prowess package.
**Significant at 1% level.*

From ***K*** of daily share price return series of all basic metal firms under study, which are positive and are above three, it is inferred that the daily return series are leptokurtic and fat tailed. The Jarque-Bera statistics, which are significant at 1% level for all the firms, strongly reveal the fact that the daily returns of 24 firms of *Basic Material* sector under study do not conform to the normal distribution. Hence the null hypothesis of normality is rejected.

Table 2. **Results of Unit Root Test for Basic Material Stocks for the period from 2003 to 2012**

S.No.	Firms	Levels		First Difference	
		ADF Statistics	Sig	ADF Statistics	Sig
1.	ACC	0.83	0.8904	-47.06	0.0001
2.	AKZO	1.33	0.9541	-51.60	0.0001
3.	AMBUJA	-1.08	0.2557	-49.90	0.0001
4.	ASIAN	3.67	1.0000	-47.90	0.0001
5.	BASF	1.13	0.9339	-45.32	0.0001
6.	CASTROL	-0.71	0.4108	-48.96	0.0001
7.	CHAMBAL	-0.46	0.5144	-29.54	0.0000
8.	DEEPAK	-0.16	0.6281	-48.34	0.0001
9.	GUJALKA	-0.36	0.5566	-47.80	0.0001
10.	GUJFERT	-0.88	0.3336	-49.20	0.0001
11.	GUJNARM	-0.49	0.5053	-47.52	0.0001
12.	HINDAL	-1.37	0.1598	-49.90	0.0001
13.	HINDZINC	-1.26	0.1909	-50.15	0.0001
14.	INDCEM	-0.68	0.4247	-49.65	0.0001
15.	JINDSAW	-1.41	0.1479	-49.65	0.0001
16.	JSWSTL	-0.40	0.5413	-46.11	0.0001
17.	MADCEM	-2.07	0.0365	-52.62	0.0001
18.	MAHSEAM	-0.59	0.4623	-48.77	0.0001
19.	PIDILITE	-1.62	0.0997	-52.63	0.0001
20.	PRISM	-0.18	0.6197	-37.41	0.0000
21.	SAIL	-0.60	0.4584	-47.79	0.0001
22.	SESAGOA	-1.60	0.1036	-48.46	0.0001
23.	TATCHEM	0.09	0.7124	-44.80	0.0001
24.	TATSTL	-0.48	0.5062	-47.89	0.0001
ALL Firms (Average)				-42.89	0.0001
MacKinnon One Sided Test Critical values			1% level -2.57	5% level -1.94	10% level -1.62

Source: Computed results based on compiled data collected from CMIE Prowess package.

The results of ***ADF*** test investigating whether the daily share price (levels) and its returns (first difference) are stationary for the firms under *Basic Material* sector are shown in *table 2*. From the table, it is inferred that the ***ADF*** test statistics are insignificant thereby it reveals that the stock prices are non-stationary. However, the ***ADF*** test statistics are highly significant

at 1 % level for the first difference, i.e., for return series, which led to reject the null hypothesis of unit root. The H_0 is accepted, which implies that the series are non-stationary and has unit root, i.e. integrated of order zero. However, H_0 of unit root is rejected at first difference for all the firms, as the ***ADF*** statistics are significant at 1% level, which implies that the return series are stationary and are integrated of order one. That is, though share prices are non-stationary, daily price return series are stationary for all the firms of *Basic Material* sector.

Table 3. **Results of Variance Ratio Test for Daily Return Series of Basic Material Stocksfor the period from 2003 to 2012**

Firms	Estimates & Test Statistics	Lags (q Days)								
		q=30	q=60	q=90	q=120	q=180	q=240	q=360	q=480	q=500
	VR	0.035	0.017	0.012	0.009	0.006	0.004	0.003	0.002	0.002
ACC	Z(q)	-7.82*	-5.56*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-1.93
	Z*(q)	-6.39*	-4.70*	-3.93*	-3.46*	-2.87*	-2.52*	-2.10**	-1.85	-1.82
	VR	0.031	0.016	0.011	0.008	0.005	0.004	0.003	0.002	0.031
AKZO	Z(q)	-7.85*	-5.56*	-4.55*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.85*
	Z*(q)	-5.31*	-4.20*	-3.64*	-3.27*	-2.81*	-2.51**	-2.13**	-1.89	-5.31*
	VR	0.034	0.017	0.011	0.009	0.006	0.004	0.003	0.002	0.034
AMBUJA	Z(q)	-7.83*	-5.56*	-4.55*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.83*
	Z*(q)	-5.88*	-4.33*	-3.64*	-3.22*	-2.71*	-2.39**	-2.02**	-1.80	-5.88*
	VR	0.032	0.016	0.011	0.009	0.006	0.004	0.003	0.002	0.032
ASIAN	Z(q)	-7.84*	-5.57*	-4.55*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.84*
	Z*(q)	-6.18*	-4.74*	-4.01*	-3.54*	-2.96*	-2.60*	-2.15**	-1.89	-6.18*
	VR	0.036	0.018	0.012	0.009	0.006	0.005	0.003	0.002	0.036
BASF	Z(q)	-7.81*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.81*
	Z*(q)	-6.56*	-4.93*	-4.13*	-3.64*	-3.04*	-2.67*	-2.22**	-1.94	-6.56*
	VR	0.034	0.018	0.012	0.009	0.006	0.004	0.003	0.002	0.034
CASTROL	Z(q)	-7.83*	-5.56*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.83*
	Z*(q)	-5.73*	-4.33*	-3.67*	-3.25*	-2.73*	-2.41**	-2.02**	-1.79	-5.73*
	VR	0.034	0.018	0.012	0.009	0.006	0.005	0.003	0.002	0.034
CHAMBAL	Z(q)	-7.82*	-5.56*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.82*
	Z*(q)	-4.61*	-3.59*	-3.05*	-2.70*	-2.27**	-2.00**	-1.69	-1.51	-4.61*
	VR	0.035	0.017	0.012	0.009	0.006	0.005	0.003	0.002	0.035
DEEPAK	Z(q)	-7.81*	-5.56*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.81*
	Z*(q)	-5.31*	-4.04*	-3.44*	-3.06*	-2.59*	-2.30**	-1.95	-1.73	-5.31*
	VR	0.034	0.017	0.011	0.009	0.006	0.004	0.003	0.002	0.034
GUJALKA	Z(q)	-7.82*	-5.56*	-4.55*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.82*
	Z*(q)	-5.61*	-4.23*	-3.57*	-3.16*	-2.66*	-2.35**	-1.99**	-1.77	-5.61*
	VR	0.036	0.018	0.012	0.009	0.006	0.005	0.003	0.002	0.036
GUJFERT	Z(q)	-7.81*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.81*
	Z*(q)	-6.07*	-4.57*	-3.85*	-3.39*	-2.82*	-2.47**	-2.06**	-1.83	-6.07*
	VR	0.036	0.018	0.011	0.009	0.006	0.004	0.003	0.002	0.036
GUJNARM	Z(q)	-7.81*	-5.55*	-4.55*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.81*

	Z*(q)	-5.73*	-4.33*	-3.67*	-3.25*	-2.73*	-2.41**	-2.02**	-1.79	-5.73*
	VR	0.037	0.019	0.013	0.009	0.007	0.005	0.003	0.002	0.037
HINDAL	Z(q)	-7.80*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.80*
	Z*(q)	-5.96*	-4.42*	-3.70*	-3.27*	-2.72*	-2.39**	-1.99**	-1.75	-5.96*
	VR	0.035	0.018	0.012	0.009	0.006	0.004	0.003	0.002	0.035
HINDZINC	Z(q)	-7.82*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.82*
	Z*(q)	-5.95*	-4.40*	-3.68*	-3.25*	-2.73*	-2.41**	-2.04**	-1.81	-5.95*
	VR	0.035	0.018	0.012	0.009	0.006	0.004	0.003	0.002	0.035
INDCEM	Z(q)	-7.82*	-5.56*	-4.55*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.82*
	Z*(q)	-6.27*	-4.70*	-3.96*	-3.50*	-2.94*	-2.58*	-2.15**	-1.90	-6.27*
	VR	0.037	0.019	0.013	0.009	0.006	0.005	0.003	0.002	0.037
JINDSAW	Z(q)	-7.80*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.80*
	Z*(q)	-6.26*	-4.65*	-3.92*	-3.47*	-2.90*	-2.56**	-2.14**	-1.88	-6.26*
	VR	0.037	0.019	0.013	0.010	0.006	0.005	0.003	0.002	0.037
JSWSTL	Z(q)	-7.80*	-5.55*	-4.54*	-3.93*	-3.22*	-2.79*	-2.28**	-1.97**	-7.80*
	Z*(q)	-6.21*	-4.63*	-3.90*	-3.44*	-2.89*	-2.54**	-2.13**	-1.88	-6.21*
	VR	0.033	0.017	0.011	0.008	0.006	0.004	0.003	0.002	0.033
MADCEM	Z(q)	-7.83*	-5.56*	-4.55*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.83*
	Z*(q)	-5.65*	-4.39*	-3.75*	-3.34*	-2.82*	-2.49**	-2.08**	-1.84	-5.65*
	VR	0.036	0.017	0.012	0.009	0.006	0.004	0.003	0.002	0.036
MAHSEAM	Z(q)	-7.81*	-5.56*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.81*
	Z*(q)	-5.22*	-4.05*	-3.48*	-3.12*	-2.64*	-2.34**	-1.96**	-1.73	-5.22*
	VR	0.036	0.018	0.012	0.009	0.006	0.005	0.003	0.002	0.036
PIDILITE	Z(q)	-7.81*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.81*
	Z*(q)	-5.49*	-4.32*	-3.70*	-3.32*	-2.82*	-2.48**	-2.05**	-1.80	-5.49*
	VR	0.037	0.018	0.012	0.009	0.006	0.004	0.003	0.002	0.037
PRISM	Z(q)	-7.80*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.80*
	Z*(q)	-6.12*	-4.59*	-3.84*	-3.38*	-2.83*	-2.49**	-2.08**	-1.84	-6.12*
	VR	0.036	0.018	0.012	0.009	0.006	0.004	0.003	0.002	0.036
SAIL	Z(q)	-7.81*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.81*
	Z*(q)	-5.60*	-4.29*	-3.64*	-3.23*	-2.74*	-2.43**	-2.05**	-1.82	-5.60*
	VR	0.035	0.018	0.012	0.009	0.006	0.005	0.003	0.002	0.035
SESAGOA	Z(q)	-7.82*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.82*
	Z*(q)	-6.60*	-4.86*	-4.05*	-3.56*	-2.96*	-2.59*	-2.16**	-1.90	-6.60*
	VR	0.038	0.019	0.013	0.010	0.006	0.005	0.003	0.002	0.038
TATCHEM	Z(q)	-7.79*	-5.55*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.79*
	Z*(q)	-5.78*	-4.33*	-3.66*	-3.23*	-2.70*	-2.37**	-1.98**	-1.75	-5.78*
	VR	0.037	0.018	0.013	0.009	0.006	0.005	0.003	0.002	0.037
TATSTL	Z(q)	-7.80*	-5.56*	-4.54*	-3.94*	-3.22*	-2.79*	-2.28**	-1.97**	-7.80*
	Z*(q)	-5.50*	-4.08*	-3.44*	-3.04*	-2.54**	-2.24*	-1.89	-1.68	-5.50*

Source: Computed results based on compiled data collected from CMIE Prowess package.
VR – Variance Ratio
Z(q) Estimated with assumption of homoscedasticity
Z(q) Estimated with assumption of heteroscedasticity robustness*
**Significant at 1% level, **Significant at 5% level.*

To analyze the share price returns of the selected 24 firms under *Basic Material* sector and to study their behavior in short-run and long-run, ***VR***

test is used for both the short lags and long lags (from lag of 30 days to lag of 500 days) and the results are shown in *table 3*.

In the table, for shorter and longer lags, the ***VR***is shown along with test statistics under the assumption of both the homoscedasticity *(Z(q))* and the heteroscedasticity*(Z*(q))*. It is inferred from the table that the ***VR*** is less than one for all the selected lags of all the 24 firms, which evidences for negative serial correlation in the share price returns.

The ***VR*** decreases with the interval length of q expand. This scenario is visible for all the firms, which shows that there has been a mean reverting tendency of return series in both the short-run as well as the long-run. The test statistics estimated under the assumption of homoscedasticity are significant for all the lags of all the firms, which rejects ***RW*** in the return series in terms of both the short-run as well as the long-run. However, the rejection may be attributed to the presence of heteroscedasticity or serial correlation in the data series.

Hence, the test-statistics $Z^*(q)$ robust to heteroscedasticity is estimated for all lags. If the behavior of ***RW*** robust to heteroscedasticity is also rejected in time series data, then it may be due to serial correlation in the data series. Here, heteroscedastic robust test statistic $Z^*(q)$ are also significant for all the firms in respect of all the lags ranging from 30 to 500. At one per cent level for all the intervals, the H_0 *"returns of* ***BSE*** *24 firms follows a random walk* of***RW"*** is rejected, hence it is concluded that there is a non-random behavior in both the short-run as well asthe long-run and such behavior is not due to heteroscedasticity but likely due to serial correlation in respect of daily share price return series for all the firms.

Summary and Conclusion

The objective of the paper is to investigate whether prices in Indian *SM*returns follow a random-walk process. The study used the daily closing prices of 24 firms of BSE 500. *First,* the descriptive statistics were calculated in order to know the distributional properties and the normality of the returns of 24 firms during the study period of 10 years.*Secondly,* the study used *ADF* test to investigate whether the daily returns are stationary series. *Finally,*the *VR* test suggested by Lo and MacKinlay (1988) is used to test ***RW***in the stock returns for homoscedasticity and heteroscedasticity assumptions. The results of *VR* test reveals that Indian stock return does not follow a *RWH*, in other words, there exists a non-random behaviour of return both in long-run and short-run lags. The ***VR*** test concludes that the ***RWH*** is rejected for all the 24 firms, and the tendency is towards mean reversion *(VR<1)*. The results of the study confirm the mean reverting behaviour of stock returns and overreaction of stock price during the study period.

REFERENCES

1. Black, F, 1990. "Mean Reversion and Consumption Smoothing". Review of Financial Studies,3(1): 107-114.
2. Cecchetti, S. G., L. Pok-Sam, and N. C. Mark, 1990. "Mean Reversion in Equilibrium Asset Prices". American EconomicReview,80(3): 398-418.
3. Charles, A., and O. Darne, 2009. "Variance Ratio Tests of Random Walk: An Overview". Journal ofEconomic Surveys, 23(3): 503-527.
4. Chen, J. H, 2008. "Variance Ratio Tests of the Random Walk Hypothesis of the Euro Exchange Rate".International Business & Economics Research Journal, 7(12): 97-106.
5. Chen, S, 2009. "Random Walks in Asian Foreign Exchange Markets: Evidence from New Multiple Variance Ratio Tests". Economics Bulletin, 29(2): 1296-1307.
6. Chow, K.V., and K. C. Denning, 1993. "A Simple Multiple Variance Ratio Test". Journal of Econometrics, 58(3): 385-401.
7. De Bondt, W. F. M., and R. Thaler, 1990. "Do Security Analysts Overreact?" American Economic Review, 80(2): 52-57.
8. Dickey, D. A., and W. A. Fuller, 1979."Distribution of the Estimators for Autoregressive Time Series with a Unit Root".Journal of American Statistical Association, 74(366): 427-31.
9. Jog, V., and H. Schaller, 1994. "Finance Constraints and Asset Pricing: Evidence on Mean Reversion". Journal of EmpiricalFinance,1(2): 193-209.
10. Li, B., and B. Liu, 2012."A Variance-Ratio Test of Random Walk in International Stock Markets".The Empirical Economics Letters 11(8): 775-782.
11. Lo, A.W., and C. A. MacKinlay, 1988. "Stock Prices Do Not Follow Random Walks: Evidence From a Simple Specification Test". Review of Financial Studies, 1(1): 41-66.
12. Madhusoodanan, T. P, 1998. "Persistence in Indian Stock Market Returns: An Application of Variance Ratio Test". Vikalpa, 23(4): 61-73.
13. Mbululu, D., C. J. Auret, and L. Chiliba, 2013. "Do Exchange Rates Follow Random Walk? A Variance Ratio Test of the Zambian Foreign-Exchange Market".Southern African Business Review, 17(2): 45-66.
14. Poterba, J. and L. Summers, 1988. "Mean Reversion in Stock Returns: Evidence and Implications". Journal of FinancialEconomics, 22(1): 27-59.
15. Smith, G., and H. J. Ryoo, 2003."Variance Ratio Tests of the Random Walk Hypothesis for European Emerging Stock Markets".The European Journal of Finance, 9(3): 290-300.
16. Smith, G., K. Jeferis, and H. J. Ryoo, 2002. "African Stock Markets: Multiple Variance Tests of Random Walks". Applied Financial Economics, 12(7): 475-484.
17. Wen, C. C, 2009."A Variance Ratio Test of Random Walk in Energy Spot Markets". Journal of Quantitative Economics, 8(1): 105-117.
18. Wright, J, 2000. "Alternative variance ratio tests using ranks and signs". Journal of Business and Economics Statistics,18(1): 1-9.

Appendix - A

LIST OF FIRMS SELECTED FOR THE STUDY WITH ABBREVIATION

S.No.	Firms	Abbreviation
1.	A C C Ltd.	*ACC*
2.	Akzo Nobel India Ltd.	*AKZO*
3.	Ambuja Cements Ltd.	*AMBUJA*
4.	Asian Paints Ltd.	*ASIAN*
5.	B A S F India Ltd.	*BASF*
6.	Castrol India Ltd.	*CASTROL*
7.	Chambal Fertilisers & Chemicals Ltd.	*CHAMBAL*
8.	Deepak Fertilisers & Petrochemicals Corpn. Ltd.	*DEEPAK*
9.	Gujarat Alkalies & Chemicals Ltd.	*GUJALKA*
10.	Gujarat State Fertilizers & Chemicals Ltd.	*GUJFERT*
11.	Gujarat Narmada Valley Fertilizers & Chemicals Ltd.	*GUJNARM*
12.	Hindalco Industries Ltd.	*HINDAL*
13.	Hindustan Zinc Ltd.	*HINDZINC*
14.	India Cements Ltd.	*INDCEM*
15.	J S W Steel Ltd.	*JINDSAW*
16.	Jindal Saw Ltd.	*JSWSTL*
17.	Madras Cements Ltd.	*MADCEM*
18.	Maharashtra Seamless Ltd.	*MAHSEAM*
19.	Pidilite Industries Ltd.	*PIDILITE*
20.	Prism Cement Ltd.	*PRISM*
21.	Steel Authority Of India Ltd.	*SAIL*
22.	Sesa Goa Ltd.	*SESAGOA*
23.	Tata Chemicals Ltd.	*TATCHEM*
24.	Tata Steel Ltd.	*TATSTL*

Source: CMIE Prowess package.