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Abstract

An attempt is made in this paper to examine whether stock returns in two premier stock exchanges in India namely, Bombay Stock Exchange (BSE) and National Stock Exchange (NSE) follow a random walk. Towards this end, data on major indices during the period 1997 to 2009 are analyzed using non-parametric Runs and BDS tests. The findings of the study reveal that the stock returns do not follow a random walk during the sample period.

Key Words: Random walk hypothesis, efficient market hypothesis, mean-reversion, return-anomalies

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1. Introduction

The behaviour of stock returns has been well debated and researched in financial economics over the years. Prominently, two extreme views are popular in this context. One view has been that stock returns are generated by a random process and therefore, it is not possible to predict their future movements based on past information. This is formally stated as the random walk hypothesis (RWH). Validation of this hypothesis implies that the market is informationally efficient (Fama, 1991). The other view is the mean-reversion view, according to which the stock returns are mean-reverting and are generated out of a stationary stochastic process. In this study, an attempt is made to empirically investigate the behaviour of stock returns in the context of two premier Indian stock markets namely, Bombay Stock Exchange (BSE) and National Stock Exchange (NSE). The specific focus of the study is to check whether stock returns follow a random walk or not.

Though there are a few studies on Indian stock markets (Sharma and Kennedy, 1977; Poshakwale, 2002; Chaudhuri and Wu 2003, 2004), this study is justified on the following grounds. First, the available studies refer to the 1980's and 1990's and therefore could not capture the recent market microstructure changes of the markets. This study covers the time period in which the changes have taken place. Second, the present study uses daily data from two premier stock markets in India, BSE and NSE and covers a wider set of indices tending to be exhaustive. Finally, the study rather appropriately employs non-parametric techniques as stock returns are known to follow non-normal distribution. The non-parametric tests used are Runs test and Brock et al (BDS, 1996) test of independence.

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1. Fama (1970) has done extensive survey of market efficiency. Also see Lo and Mac Kinlay (1988)

The rest of the paper is organized as follows. Section II briefly reviews the work on random walk hypothesis. Data used in study are outlined in section III. The empirical results and conclusion of the study are presented in sections IV and V respectively.

II. Review of previous work

As a background to the study, a brief of previous works on the return behaviour, most of them having been formulated in terms of random walk hypothesis is presented. Previous work on random walk hypothesis is truly vast. Hence, we have attempted to present a brief review of only select important works in this area. Sharma and Kennedy (1977) using runs test and spectral technique found that monthly returns in the BSE follow RWH. The studies of Working (1960), Samuleson (1965) and Fama (1970), and Niederhoffer and Osborne (1966) suggested that stock price movements are not serially correlated and therefore, it is impossible to make abnormal profit from random investment. Similar results were reported by Jennergeen and Korsvold (1974) in their study of Norwegian and Swedish markets. Contrary to these findings, French and Roll (1986) observed statistically significant negative serial correlation in daily returns even though they were skeptical about the economic significance of such returns. In a similar vein, Keim and Stambaugh (1986) found statistically significant predictability in stock prices by using forecasts of predetermined variables. Solnik (1973) observed more apparent deviations from random walk in European markets. Interestingly, Fama and French (1988) cast doubts on the validity of RWH showing that long horizon returns are negatively correlated (mean reversion). In the same year, Lo and Mackinlay (1988) by using variance ratio test proved that stock prices do not follow RWH. While the study of Poterba and Summers (1988) revealed positive and negative serial correlation for short and long horizons returns respectively, Jagadeesh (1990) reported positive serial correlation for long horizons.

Balvers *et al* (2000) noted rejection of RWH in eighteen developed nations. Similarly, Blasco *et al* (1997) rejected the hypothesis in case of Spanish stock market. However, De Penna and Gil Alana (2002) concluded that random walk could not be rejected. Interestingly, Gilmour and McManus (2001) provided empirical evidence of random walk for Central European Markets namely, Czech Republic, Hungary and Poland. But the study rejected the RWH at the same time on the basis of model comparison tests. They attribute the inconsistency in results to particular martingale process of random walk.

Studies from the emerging markets also have thrown inconsistent evidences. Butler and Malaikah (1992) empirically concluded that returns in Kuwait followed random walk while Saudi did not. Abraham *et al* (2002) showed that observed index levels in Saudi Arabia, Kuwait and Bahrain do not confirm to RWH, whereas the corrected returns are supportive of weak-form of market efficiency. Smith (2007) who investigated whether Middle East Stock Markets follow random walk or not found that largely Israeli, Jordanian, Lebanese markets were weak form efficient while Kuwait and Oman markets did not follow random walk. These contradictory results for Middle Eastern emerging markets are further explained by Al Khzali *et al* (2007) who concluded that Saudi and Bahraini strongly supported random walk while Kuwait failed within the critical bounds. The study concluded that the results were decisive since sign variance ratio tests are more powerful than runs test used by Abraham *et al* (2007).

The studies of Frennberg and Hansson (1993) for Sweden, Ayadi and Pyun (1994) for Korea, Urrutia (1997) and Worthington and Higgs (2003) for Latin America also rejected random walk. Urrutia (1995) found positive auto-correlation in monthly returns of some Latin American countries. Huber (1995) concluded that Austrian stock market did not follow random walk. This is because of thinness of the market. Two other studies on Latin American stock markets by Ojah and Karemera (1999) and Greib and Reyes (1999) provided mixed results.

While the former found evidence in favour of RWH for emerging Latin American countries, the latter found evidences against RWH in Mexican market and pro-RWH results in the Brazilian market. The rejection of random walk was further supported by Worthington and Higgs (2003) for seven Latin American countries. They performed autocorrelation, unit root, and multiple variance ratio tests. It was shown that empirically that Portuguese, the another emerging market did not follow random walk (Dias J *et al* 2002, Worthington and Higgs 2004 and Borges 2007). All these evidences for emerging markets are consistent with the observation of Harvey (1993) that emerging markets do not follow RWH as they are less efficient than their developed counter parts.

The Asian emerging markets also showed mixed results. Refuting the findings of previous studies for other markets, Liu *et al* (1997) reported that Chinese markets were efficient. Darrat and Zhong (2000) and Lee *et al* (2001) provided ample evidence in favour of market efficiency. Recently Lock (2007 a) Charles and Darne (2008) also concluded that Share A of Chinese stock market followed random walk while Share B were not efficient. This can be explained by existence of asymmetric information since share A are traded by Chinese nationalist and Share B largely by FIIs (Lock 2007 b). Behavioral differences between national and FIIs are responsible for such contrast (Charles and Darnes 2008).

Further, Huang (1995), Alam *et al* (1999) and Chaing *et al* (2000) found that emerging Asian markets, were not efficient. Supporting these findings, Husain (1997) found that random walk was not valid in Pakistan equity markets because of presence of strong dependence of stock returns. However, not agreeing with these findings, Cooray (2004) who employed unit root, autocorrelation and spectral test empirically evidenced that South Asian markets as such India, Bangladesh, Pakistan and Sri Lanka followed random walk.

Korea, one of the major Asian markets reported that market returns did not follow the RWH (Ryoo and Smith 2002). Out of a total of seven countries investigated by Smith and Ryoo (2002), six markets did not follow RWH, except South African market where evidences supported the RWH. Chaudhuri and Wu (2003), and Smith and Ryoo (2003) by and large found evidences against RWH in markets of seventeen emerging economies and four European economies respectively.

The Indian stock market does not seem to confirm to the applicability of random walk as reported by Poshakwale (2002), Chaudhuri and Wu (2004), Ahmed *et al* (2006). Interestingly, however, Chawla *et al* (2006) concluded that Nifty and Sensex followed random walk and thus are weak form efficient.

The efficient market hypothesis in European Stock Market was investigated by Borges (2008). The study employed autocorrelation, runs, ADF unit root and variance ratio tests. The study found that while the markets in France, Germany, the U.K and Spain followed a random walk, there existed positive serial correlation in returns of Greece and Portugal. Hoque *et al* (2007) also noted rejection of RWH in majority of eight emerging markets. Nakamura and Small (2007) by using a new method namely, small-shuffle surrogate (SSS) method concluded that the US and Japanese markets follow RWH. Similar were the findings of Lock (2007 b) for Taiwan market. Methodologically improved, the study by Lim and Brooks (2008) employed the rolling bicorrelation test on 50 countries. The study found that deviation from random walk is more persistent in low income economies. The variations may be due to low GDP and variations in property rights protection in low income countries. Recently, Worthington and Higgs (2009), who performed ACF, Unit root and multiple variance ratio tests in Australian stock market for a long period (1875-2006), concluded that Australian stock market did not follow a random walk.

To sum up, the foregoing review reveals a mixed picture of empirical evidences on return behaviour.

III. Data

The present study has used daily data on fourteen indexes of varying time ranges from BSE and NSE. The sample indexes and their time coverage are given in the appendix. These Indexes are considered owing to the fact that they represent diverse sectors of the economy. The indices chosen for the study help to examine the relative efficiencies between the two markets (NSE and BSE) and variations in efficiencies across indices and sector within the markets. Moreover, most of these indexes have the track record of at least five years. The index values of NSE are collected from the official website of NSE and index values of BSE are collected from the CMIE-PROWESS data base.

III. Empirical Results:

The present study employs two non parametric tests namely, the runs test and BDS test. The choice of the tests is appropriate as the sample indices are shown to be asymptotically non-normal (see table 1). The runs test is a popular non-parametric test of random walk. Further disccuion about the runs test may be found in Siegel (1956). The runs test statistics are shown in table 2. The actual runs are number of change in returns, positive or negative, observed in the returns series. The expected runs are the change in returns required, if the data is generated by random process. If the actual runs are close to expected number of runs, it indicates that the returns are generated by random process. The C is variance of the returns. The standard normal Z statistics tests whether actual number of runs is consistent with the independence hypothesis.

Brock *et al* (1996) is a portmanteau test for time based dependence in a series. It has power against a variety of possible deviations from independence including linear dependence, non-linear dependence, or chaos. The *m* denotes the embedded dimension (period histories.), **ε**

is a distance that is used to decide if returns are near each. The estimate of the correlation integral value is the proportion of pairs of m period histories that are near each other. The BDS statistics is estimated at different m, and ε.

The descriptive statistics for the fourteen indices are given in table 1. The highest average returns are obtained in CNX Infrastructure. This reflects the performance of this index owing to considerable growth of infrastructure sector in India. The CNX Bank and CNX 100 are the other indices which show higher mean returns. Further, the CNX IT has the highest standard deviation (0.052) and lowest is of CNX Nifty (0.017). With the sole exception of BSE 100, the returns are negatively skewed implying the returns are flatter to the left compared to normal distribution. The significant kurtosis indicates that return distribution has sharp peaks compared to a normal distribution. The significant Jarque-Bera statistic confirmed that index return is non- normally distributed. This would call for an analysis of random walk using non-parametric tests.

The table 2 provides runs test statistics. It can be seen from the table that the actual runs of return indices namely, CNX Nifty, CNX Nifty Junior, CNX 500, CNX Defty, CNX Bank Nifty, BSE Sensex, BSE 100, BSE 200 and BSE 500 are less than the expected runs. The negative Z values indicate the positive correlation in returns series. The number of runs for CNX IT, CNX Infrastructure, BSE Midcap and BSE Smallcap exceeds the expected number of runs. This implies the presence of negative serial correlation. With the sole exception of CNX 100, the hypothesis of random walk has been rejected by all the indices.

Table: 1: Descriptive Statistics of Stock Returns

Variable	Mean	Median	Minimum	Maximum	Standard deviation	Skewness	Kurtosis	Jarque-Bera	P-value
CNX Nifty	0.000340	0.001168	-0.130539	0.079691	0.017438	-0.519211	4.475148	2566.928	0.000000
CNX Junior	0.000456	0.001895	-0.131333	0.082922	0.020527	-0.678203	3.807871	1987.318	0.000000

CNX 100	0.000654	0.002108	-0.130494	0.080065	0.017992	-0.859112	5.926253	2414.447	0.000000
CNX 500	0.000427	0.001904	-0.128847	0.076945	0.017731	-0.772766	4.553660	2327.864	0.0000
CNX Defty	0.000233	0.001184	-0.141131	0.089858	0.018438	-0.472041	4.698742	2792.704	0.0000
CNX IT	0.000175	0.000998	-2.365839	0.145567	0.052223	-32.051150	1449.945	2327.864	0.0000
CNX Bank	0.000657	0.000735	-0.151380	0.114014	0.021577	-0.419269	4.193256	1731.887	0.0000
CNX Infrastructure	0.000676	0.002033	-0.150214	0.102127	0.021883	-0.767701	6.057552	2064.842	0.0000
BSE Sensex	0.000342	0.001147	-0.118092	0.085915	0.017754	-0.371325	3.511066	1471.438	0.0000
BSE 100	0.000395	0.001556	-1.473311	0.552934	0.023958	-1.473311	244.0782	66926.37	0.0000
BSE 200	0.000407	0.033690	-1.037087	1.084561	0.033690	1.394998	712.4875	5085.416	0.0000
BSE 500	0.000255	0.001944	-0.249828	0.075327	0.018640	-1.727030	17.37390	2973.094	0.0000
BSE Mid Cap	0.000145	0.002699	-0.120764	0.078359	0.017902	-1.373015	7.010821	3002.329	0.0000
BSE Small Cap	0.000233	0.002825	-0.108357	0.064767	0.018712	-1.234866	4.141240	1232.220	0.0000

Table 2: Run Test Statistics

Variables	Observations	Actual Runs	Expected Runs	Z-statistic
CNX Nifty	2526	1144	1258	- 4.59*
CNX Nifty Junior	2527	1081	1183	- 4.35*
CNX Defty	2516	1193	1253	- 2.42*
CNX IT	1881	1183	939	11.32*
BSE Sensex	2477	1126	1231	- 4.29*
BSE 100	2501	1104	1231	- 6.41*
BSE 200	2500	1079	1228	- 6.10*
CNX 500	2024	872	993	- 5.5*

CNX Bank Nifty	2526	1114	1259	-5.83*
BSE 500	2009	851	982	- 5.10*
CNX 100	1130	533	546	- 0.85
CNX Infrastructure	877	670	423	17.31*
cBSE Midcap	1006	557	472	4.36*
BSE Smallcap	1006	471	219.47	5.28*

The BDS test is performed at various embedded dimension (m) like 2, 4, 6, 8, 10 and also at various distance like 0.5s, 0.75s, 1s, 1.25s and 1.5s where s denotes the standard deviation of the return. In table 3, value in the first row in each cell represents the correlation integral (C_m) value and the first value in the second row is the BDS test-statistic followed by the p-values in the parentheses. The BDS tests the null hypothesis that return series are i.i.d. Rejection of the null hypothesis implies that random walk hypothesis does not pass the test. The value of correlation integral is less than for all return indices. It is very clear from the results that BDS test rejects the null hypothesis of independence and thereby random walk hypothesis too for all the fourteen indices. It shows that returns are dependent. There may be non-linear structure in the returns series. The BDS test is powerful than the runs test. Runs test suffers from a reduction in test power due to the loss of information in the transformation from returns to their signs.

Table 3: BDS Test Statistics

Indexes	**m=2, ε = 0.5*S***	**m=4,ε = 0.75*S***	**m=6, ε = *S***	**m=8,ε = 1.25*S***	**m=10,ε = 1.5*S***
CNX Nifty	0.118 12.38 (0.0000)	0.072 20.45 (0.0000)	0.083 26.80 (0.0000)	0.117 31.25 (0.0000)	0.167 32.25 (0.000)
Nifty Junior	0.131 16.00 (0.0000)	0.088 24.28 (0.0000)	0.104 30.74 (0.0000)	0.145 35.60 (0.0000)	0.198 36.99 (0.0000)
CNX Defty	0.124 12.69 (0.0000)	0.078 20.31 (0.0000)	0.090 26.23 (0.0000)	0.127 30.56 (0.0000)	0.180 31.77 (0.0000)
CNX IT	0.345 19.35 (0.0000)	0.366 25.36 (0.0000)	0.452 25.64 (0.0000)	0.561 25.07 (0.0000)	0.672 24.16 (0.0000)
BSE Sensex	0.117 12.83 (0.0000)	0.073 21.42 (0.0000)	0.085 28.39 (0.0000)	0.121 33.38 (0.0000)	0.172 34.70 (0.0000)
BSE100	0.200 15.55 (0.0000)	0.173 24.20 (0.0000)	0.222 29.30 (0.0000)	0.298 30.35 (0.0000)	0.381 28.83 (0.0000)
BSE 200	0.348 16.07 (0.0000)	0.374 23.03 (0.0000)	0.474 24.58 (0.0000)	0.578 23.51 (0.0000)	0.674 21.48 (0.0000)

CNX 500	0.133 14.77 (0.0000)	0.091 23.20 (0.0000)	0.110 31.01 (0.0000)	0.154 35.92 (0.0000)	0.208 36.36 (0.0000)
CNX Bank Nifty	0.118 12.18 (0.0000)	0.071 17.86 (0.0000)	0.078 21.90 (0.0000)	0.107 24.63 (0.0000)	0.152 25.71 (0.0000)
BSE 500	0.143 14.58 (0.0000)	0.103 23.35 (0.0000)	0.126 30.64 (0.0000)	0.173 34.37 (0.0000)	0.230 34.05(0.0000)
CNX 100	0.138 11.48 (0.0000)	0.099 18.82 (0.0000)	0.123 25.53 (0.0000)	0.172 29.40 (0.0000)	0.231 29.72 (0.0000)
CNX Infrastructure	0.151 10.37 (0.0000)	0.114 17.67 (0.0000)	0.142 23.69 (0.0000)	0.190 26.67 (0.0000)	0.245 26.89 (0.0000)
BSE Micap	0.165 13.39 (0.0000)	0.127 18.92 (0.0000)	0.158 23.91 (0.0000)	0.207 25.53 (0.0000)	0.260 24.32 (0.0000)
BSE Smallcap	0.136 13.91 (0.0000)	0.092 17.90 (0.0000)	0.107 21.53 (0.0000)	0.145 23.32 (0.0000)	0.195 22.87 (0.0000)

Note: The table reports the BDS test results. Here, 'm' and 'ε' denote the dimension and distance, respectively and 'ε' equal to various multiples (0.5, 0.75, 1, 1.25 and 1.5) of standard deviation (*s)* of the data. The value in the first row of each cell is BDS statistic (C-m value) and the first value in the second row is the test-statistic followed by the corresponding p-value in parentheses. The asymptotic null distribution of test statistics is N (0.1). The BDS statistic tests the null hypothesis that the increments are independently and identically distributed, where the alternative hypothesis assumes a variety of possible deviations from independence including non-linear dependence.

V Conclusion

This study has investigated the evidences of random walk from emerging Indian stock markets. Towards this end, two non-parametric tests are used to analyze the daily data on fourteen market indexes from two major stock exchanges namely, Bombay Stock Exchange (BSE) and National Stock Exchange (NSE), in India. The empirical results from the non-parametric Runs and BDS tests resoundingly rejected the RWH in Indian stock markets. These findings are consistent with those of earlier studies of Poshakwale (2002), Chaudhuri and Wu (2003, 2004) on Indian stock markets who found evidences against the RWH. Given the fact that the study of sample of

fourteen index returns do not follow normal distribution, the evidences from this study assume importance.

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Appendix: Sample Indexes – Time Period Covered

S.No	Index	Time Period	% to Total Market Capitalisation
1	CNX Nifty	02/06/1997 – 30/01/2009	61.70
2	CNX Junior	02/06/1997 – 30/01/2009	9.89
3	CNX Defty	02/06/1997 – 30/01/2009	-
4	CNX IT	02/06/1997 – 30/01/2009	14
5	BSE Sensex	01/01/1998 - 30/01/2009	46.53
6	BSE 100	01/01/1998 - 30/01/2009	75.67
7	BSE 200	01/01/1998 - 30/01/2009	85.24
8	CNX 500	07/06/1999 – 30/01/2009	84.24
9	CNX Bank Nifty	01/01/2000 – 30/01/2009	7
10	BSE 500	03/01/2000 – 30/01/2009	93.51
11	CNX 100	01/01/2003 – 30/01/2009	68
12	CNX Infrastracture	01/01/2004 – 30/01/2009	18.84
13	BSE Micap	01/01/2004 – 30/01/2009	12.80
14	BSE Smallcap	01/01/2004 – 30/01/2009	3.74
Note: The values in the last column are latest values available in the website of BSE and NSE.			