Some Further Evidence on the Behaviour of Stock Returns in India

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Abstract

This paper examines the stock return behaviour in two premier Indian stock markets using Chow-Denning multiple variance ratio and Hinich bicorrelation tests. The former test overcomes size distortion of conventional variance ratio test. The latter test is capable of detecting linear and non-linear dependencies. The study is based on 14 indices relating to the National Stock Exchange (NSE) and Bombay Stock Exchange (BSE), and relates to the period 02/06/1997 to 30/01/2009. The Chow-Denning test rejects the null of random walk for six indices. The Hinich test rejects the null of pure white noise for full sample period. However, the windowed test results of Hinich show that the serial dependencies are not consistent across the sample period for all indices. This indicates presence of episodic dependencies in stock returns surrounded by long periods of pure noise.

Keywords: Random walk, Serial dependence, Variance ratios, Bi-correlation, Episodic dependencies, Non-linearity, Mean-reversion, Pure noise

1. Introduction

The behaviour of stock returns has been extensively debated over the years. Researchers have examined the efficient market and random walk characterization of returns and alternatives to random walk. The validation of random walk implies that market is informationally efficient. In an efficient market, current prices 'fully reflect' available information and hence there is no scope for any investor to make abnormal profits (Fama, 1970). In respect of empirical evidences, the early studies have found evidences in favour of random walk hypothesis (RWH). In later period, however, studies have supported mean reversion in returns. The Fama's model is criticized for its assumption that market participants arrive at a rational expectations forecast. It is argued that trade demands heterogeneity (bull and bear traders) and therefore returns can be predicted. In other words, psychological and behavioral elements in stock price determination help to predict the future prices. Further, in contrast to Fama's model, Campbell *et al (*1997) states that asset returns are predictable to some degree. Consensus on this issue thus continues to be elusive. It has been pointed out that the use of several tests, parametric and non-parametric, each of which having been based on restrictive assumptions, has been a prime reason for lack of consensus. Further, the use of data of different frequencies has also been another reason for divergent findings.

The conventional tests such as auto correlation, runs, spectral and variance ratio tests have some limitations. They are capable of detecting only linear correlation in the series. The Great Market Crash of 1987 triggered interest in non-linear dependencies in the return series. Since then researchers have addressed the issue of presence of non-linear dependencies. It may be pertinent to note that rejection of presence of linear correlation does not validate EMH as non- linear dependencies might help to predict the future prices (Granger and Anderson (1978). The issue of non-linear dependence in the series has been examined by Hinich and Patterson (1995). Following the framework of Hinich-Patterson, the portmanteau bi-correlation test is employed in this study to examine the issue of non-linear dependencies. Such a study has not been undertaken in the Indian context. Another important issue while testing the random walk hypothesis concerns the issue of size distortions in Lo-MacKinlay variance ratio test. Chow and Denning (1993) points that the sequential procedure of Lo-MacKinlay test leads to size distortion. Hence, they suggest multiple variance ratios test. Keeping the caveat in mind, the present study employed Chow-Denning multiple variance ratios test to overcome size distortion problem of individual variance ratio test. With a view to arrive at a more accurate idea about the behaviour of

stock returns, the present study seeks to generate evidences by employing the Chow-Denning multiple variance ratios and bi-correlation tests.

Given this backdrop, the objective of the present study is to examine the behaviour of returns in two premier Indian stock markets namely, National Stock Exchanges (NSE) and Bombay Stock Exchanges (BSE) during the period June 1997 – January 2009. The rest of the paper runs on the following well-designed track. Section II presents a brief review of previous work. The data and methodology of the study are described in section III. Section IV discusses the empirical results and concluding remarks are presented in the last section.

2. Review of previous work

Literature on random walk and market efficiency hypothesis has been truly abundant. Here an attempt is made to present a brief review of previous work. Bachelier (1900) is perhaps the first who theorised the concept of market efficiency. The seminal works of Samuelson (1965) and Fama (1965, 1970) triggered much interest in this area. The early works on random walk which examined the behaviour of stock returns by applying serial correlation tests have found markets as efficient (Working, 1965; Samuelson, 1965; Fama, 1965; Jennergeen and Korsvold, 1974). Later studies reported mean reversion in stock returns (French and Roll 1974; Fama and French, 1988; Poterba and Summers, 1988; Richards, 1995; Balvers *et al,* 2000). The continued application of serial correlation tests rather conventionally can be seen in literature.

The conventional techniques, such as serial correlation and non parametric runs test seem to suffer from restrictive assumptions. They tend to be less efficient to capture the patterns in returns. The most popular test of random walk since the publication of Lo and MacKinlay (1988) is the variance ratio test (henceforth, LMVR). The study by Lo and MacKinay rejected random walk for weekly stock returns suggesting mean-reversion in returns. Gilmore and Mc Manus (2001) applied LMVR and model comparison tests on Central European Markets. While the former test provides empirical evidence of random walk, the latter test rejects the same. According to the study, the inconsistency in results is due to particular martingale process of random walk.

Abraham *et al* (2002) who applied LMVR on emerging markets observe dependencies in returns at index values for Saudi Arabia, Kuwait and Bahrain. However, the corrected returns are in support of weak form of market efficiency. They attribute rejection of random walk in index level to infrequent trading. Al Khzali *et al* (2007) who examined stock returns in Middle Eastern countries show that Saudi Arabia and Bahraini strongly support random walk while Kuwait fails within the critical bounds. The study concludes that the results are decisive since sign variance ratio tests are more powerful than conventional runs test. Dias *et al* (2002) perform LMVR with other conventional tests on Portuguese market and find dependencies in return series. The studies by Ojah and Karemera (1999) and Greib and Eyes (1999) from Latin America empirically find mixed results. The former finds evidence in support of random walk for Latin America. The latter study, however, finds significant auto correlation in Mexican market and random walk behviour in Brazilian market. Such conflicting results are also observed by Lima and Tabak (2004). While the Chinese - A shares and Singapore stock market are weak form efficient, the Chinese - B shares and Hong Kong market reveal auto correlation in returns. The market capitalization and liquidity can explain such conflicting trends as the authors note.

Darant and Zhong (2000) and Lee *et al* (2001) report independence of returns series for Chinese market. The empirical findings of Fifield and Jetty (2008) support the earlier evidences of market efficiency in China. Eitelman and Vitanz (2008) who employed variance ratio test for 44 emerging and industrialized economies points out that the markets with poorer risk-adjusted performance are more likely to reject random walk than better performing markets.

The LMVR tests individual variance ratios for a specific aggregation investment horizon. This may results in size distortions. In order to overcome the deficiency in LMVR, recent studies employ Chow and Denning (1993) multiple variance ratios test along with other tests. The studies of Ayadi and Pyun (1994) for Korea and Worthington and Higgs (2003) for Latin America report dependencies in returns. Huber (1995) examines the Vienna stock exchange and concludes that random walk is rejected at highly significant level for daily returns in Vienna. However, individual stocks seem to follow a random walk. Thus, the thinness of market can lead to rejection of random walk. Ryoo and Smith (2002) show evidence against random walk in Korean market. Smith (2007) who investigates whether Middle East stock markets follow random walk or not finds that largely Israieli, Jordanian, Lebansese markets were weak form efficient while Kuwait and Oman markets reject RWH. Smith *et al* (2002) report auto correlation in returns of Botswana, Egypt, Kenya, Mauritius, Morocco, Nigeria and Zimbabwe. It is only in South Africa, the study finds empirical evidence in support of random walk. Segot and Lucey (2005) confirm random walk in Israel and Turkey.

The empirical evidence for Australia for longer period, 1875-2004 rejects the random walk (Worthington and Higgs, 2009) revealing strong serial dependence in the stock returns. Hoque *et al* (2007) also observe evidences rejecting RWH in the majority of eight emerging markets. Borges's (2007) findings from multiple variance ratio test corroborate the earlier findings of Dias *et al (2002)* and Worthington and Higgs (2004) that Portuguese stock returns are highly correlated. With multiple variance tests, an attempt is made to unmask sectoral efficiency of economies namely, Jordan, Qatar, Saudi Arabia and United Arab Emirates. The study finds inconsistent results among different sectors and different economies (Benjelloun and Squalli, 2008). The EMH in European stock market is investigated by Borges (2008). The study employed tests namely, autocorrelation, runs, ADF unit root and multiple variance ratio to test RWH. The study finds that while the markets in France, Germany, U.K and Spain followed a random walk, there exist positive serial correlation in returns of Greece and Portugal.

The conventional tests including variance ratio of Lo and MacKinlay (1988) examine the linear dependence in stock returns. These tests are not capable of capturing non-linearity in the return series. There may be presence of non-linear dependencies even though the tests reject presence of linear dependencies in returns. As pointed out by Granger and Anderson (1978), rejection of linear dependence does not mean independence. In this context, the non-linearity in stock returns assumes theoretical importance with practical implications. The non-linearity in daily stock returns for the NYSE is reported by Hinich and Pattern (1985). Besides, there are studies which test non-linear dependence as an alternative to random walk hypothesis. The studies of Scheinkman and Le Baron (1989), Hsieh (1991), Sewell *et al* (1993), Pagan (1996), Yadav *et al* (1999), among others, examine non-linearity in returns. The studies of Dahl and Nielson (2001), Blasco *et al* (1997), and Poshakwale (2002) employed Brock *et al* (1993) , popularly known as BDS test of independence to examine non-linear dependence in returns series. Blasco *et al* (1997) rejected random walk behaviour implying strong presence of non-linear dependencies. Similar conclusions are reported by Dahl and Nielson (2001). Refuting the earlier findings of efficiency, Lim and Brooks (2009) based on a battery of non-linearity tests reveal strong evidence of nonlinear serial dependence in the underlying returns generating process for all indices in China.

Methodologically improved, the studies by Lim (2008), Bonilla *et al (*2006), Lim *et al* (2008)a Lim *et al* (2008)b use bicorrelation test of Hinich (1995, 1996) to examine the behaviour of stock returns. Lim (2008**)** using bicorrelation test examines the sectoral efficiency of Malaysian stock market. It is observed that the Tin and Mining sector are relatively more efficient than the property sectors which exhibited wide deviations from random walk. The study concludes that the inefficiency was highest during the Asian financial crisis period. Bonilla *et al* (2006) report episodic non linear dependence in returns for Latin American countries. While the number of significant windows for Chile is highest, at least one window is significant for other countries such as Mexico, Brazil, Argentina, Colombia and Venezuela. This implies presence of non-linear dependencies in stock returns. However, inefficiency is not persistent.

A battery of non linear tests is performed by Lim *et al* (2008) a on non-overlapping sample for period 1992-2005 for ten Asian emerging markets. The non linear tests report non-linear dependencies in returns. The bi-correlation, in contrast, provides evidence of non-linear dependencies only in a few periods. The other periods seem to follow pure noise process. The study points out that inefficiency may be explained by market size and trading activity. Further, departures from random walk cannot be attributed to states of the market. For 50 countries, Lim *et al* (2008 b) using rolling bi-correlation test, observe that the low per capita economies persistently deviate from random walk than developed markets. The weak protection of property rights has been a possible explanation for such a trend.

As far as India is concerned, Sharma and Kennedy (1977), Barua (1981), Gupta (1995) observe that the stock returns in India conform to random walk hypothesis (Note 1). Mitra (2000) who employed neural network method rejected the random walk hypothesis. Similarly, Chaudhuri and Wu (2004) on the basis of unit root tests, conclude that returns in India do not follow a random walk. Poshakwale (2002) provides evidence of non-linear dependencies in BSE stock returns. A set of tests as such auto correlation, unit root, GARCH model and non parametric runs and Kolmogorov-Smirnov test find support against random walk (Ahmad *et al,* 2006). However, interestingly Chawla *et al* (2006) reports that Nifty and Sensex are weak form efficient. Thus, as in case of other markets, the results for India too remain inconclusive. But, largely Indian stock market does not conform to weak form efficiency, and exhibit dependencies.

To sum up, although, the literature on random walk and market efficiency is vast; there is no consensus among the researchers regarding efficiency of the market. The different tests yield different results. The empirical results of various studies appear to be sensitive to the tests employed for the analysis. However, broadly, the conventional parametric tests provide evidence in support of random walk while non parametric tests, such as

Brock *et al* (1996) overwhelmingly reject independence of returns. The review of literature provides mixed results regarding the returns behaviour, as is viewed in terms of random walk and linear and non-linear dependencies.

3. Data and Methodology

3.1 Data

Data used in this paper are daily stock returns of eight indices from National Stock Exchange (NSE) and six from Bombay Stock Exchange (BSE). The data ranges are different for different indices which are given in the appendix. These indices are considered because together they represent the total market. The set of indices serve the purpose of unmasking variations in the behaviour of different index returns. Besides, most of these indexes have the track record of at least five years. The daily index values of NSE are collected from the official website of NSE (www.nseindia.com) and index value of BSE are collected from the CMIE-Prowess data base.

3.2 Methodology

As mentioned above, the present study employs Chow and Denning (1993) multiple variance ratio test, and Hinich (1996) bicorrelation test. A brief description of these two tests is given here

3.2.1 Chow and Denning (1993) Multiple Variance Ratios Test:

The variance ratios test of Lo and MacKinlay (1988) estimates individual variance ratios where one variance ratio is considered at a time, for a particular holding period (k). Empirical works examine the variance ratio statistics for several k values. The null of random walk is rejected if it is rejected for some k value. So it is essentially an individual hypothesis test. The variance ratio of Lo and MacKinlay (1988) tests whether variance ratio is equal to one for a particular holding period whereas the random walk hypothesis requires that variance ratios for all holding periods should be equal to one and the test should be conducted jointly over a number of holding periods. The sequential procedure of this test leads to size distortions. To overcome from this problem, Chow and Denning (1993) proposes multiple variance ratio test procedure where a set of multiple variance ratios over a number of holding periods can be tested to determine whether the multiple variance ratios (over a number of holing periods) are jointly equal to one. The test is based on the idea that the decision regarding the null hypothesis can be made according to the maximum absolute value of the individual variance ratio statistics. RWH is rejected if any one of the estimated variance ratios is significantly different from one (Chow and Denning, 1993).

3.2.2 Portmanteau Bicorrelation Test:

Hinich and Patterson (1995), propose a procedure of dividing full sample period into equal-length non-overlapped windows to capture episodic dependencies in stock returns. The present study divides whole sample into a set of non-overlapped window of 50 observations in equal length (Note 2). Then, Hinich (1996) bicorrelation test is applied. The portmanteau bicorrelation test of Hinich (1996) is a third order extension of the standard correlation tests for white noise. The null hypothesis for each window is that the transformed data are realizations of a stationary pure white noise process that has zero correlation (C) and bicorrelation (H). Thus, under the null hypothesis, the correlation (C) and bicorrelation (H) are expected to be equal to zero. The alternative hypothesis is that the process in window has some non-zero correlation (second order linear) or bicorrelations (third order non-linear dependence).

4. Empirical Analysis:

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.

The empirical results of Chow and Denning (1993) test are provided in table 2. For a comparison purpose, the individual variance ratios (Lo and MackKinlay variance ratios) and corresponding homscadasticity and hetroscadasticity roubst test statistics for various investment horizons like 2, 4, 8, and 16 are presented in the table. It is evident from the table that with the sole exception of BSE 100, variance ratios for all other indices at all investment horizons are greater than unity.

The variance ratio tests offer conflicting results. The indices such as Nifty Junior, BSE 500, BSE Midcap and BSE Smallcap reject the RWH at all investment horizons or holding periods. The CNX IT and BSE 200 support null of random walk. However, random walk behaviour is observed in CNX Defty, BSE Sensex, CNX Bank Nifty, BSE100, CNX 100 indices at certain horizons and rejections of the same at certain other investment horizons. The variance ratio for Nifty Junior, BSE Midcap, BSE Smallcap, CNX 500 and BSE 500 are far from unity indicating the presence of significant positive autocorrelations.

The conflicting results from the LMVR test reveals the fact that the individual variance ratio tests of LMVR do not give definite answer since the null of random walk requires variance ratios for all holding periods should be equal to one. In this context, the Chow and Denning (1993) multiple variance ratio test assumes importance. The Chow and Denning (1993) maximum heteroscadasticity robust statistic given in the last column of table 2, shows that CNX Nifty Junior, CNX 500, CNX Bank Nifty, BSE 500, BSE Midcap and BSE Small cap resoundingly reject the null of random walk. On the other hand, return indices such as CNX Nifty, CNX Defty, CNX IT, BSE Sensex, BSE 100, BSE 200, CNX100, CNX Infrastructure, validate RWH as the Chow-Denning statistic values are less than the critical values.

It may be noted that five indices out of eight indices traded at National Stock Exchange (NSE) and three out of six indices traded in Bombay Stock Exchange (BSE) support RWH. This indicates inter market and intra market variations in the behaviour of stock returns.

The Hinich (1996) correlation (C) and bicorrelation (H) test statistics covering the full sample period are presented in table 3. The null of pure noise is tested. Rejection of the null of pure white noise for all indices except CNX IT and BSE 200 is evident from the table as the p values are close to zero. It may be inferred that the return series for these indexes are not generated by strong stationary pure noise process. However, we cannot reject the null of pure noise for CNX IT and BSE 200 since the p values are almost close to 1. In other words, the stock returns may not be correlated and hence follow random walk hypothesis. It is to be noted that Chow-Denning test also shows that these two indices follow a random walk. It can be inferred that these two indices are weak form efficient. The Chow-Denning test results for other indices are in contrast to findings of bicorrelation test which reject the pure noise process.

The presence of dependence either linear or non-linear or both, throughout the sample period or confined to certain period within the sample is an interesting issue to explore. To examine the episodic dependence in returns series, Hinich and Patterson (1995) suggest dividing the sample into different windows and then testing the null of pure noise. Following Lim *et al* (2008), the sample is divided into a set of non-overlapped widow of 50 observations in equal length and then C and H statistics of Hinich (1996) are computed to detected serial dependencies in each window.

Table 4 presents total number of significant H and C windows with percentage in parenthesis. A window is significant if the H or C statistics reject the null hypothesis at pre determined level of p value. The results show that the number of significant H and C windows is less. Specifically, the percentage of significant H windows on an average is 15.6 percent while that of C windows is around 5 per cent. The rejection of null hypothesis in these significant windows may be due to either significant correlation or bi-correlation or both. In other words, total number of significant windows indicates presence of serial dependencies in those time periods of windows. The highest significant H windows is for CNX Infrastructure (46.1) followed by BSE Midcap and BSE Smallcap (53.8 %) and CNX Nifty Junior (33.9 %). It is to be noted that the Chow- Denning test also shows presence of linear dependencies in return series of these indices. The CNX Bank Nifty and CNX Nifty have lowest significant H windows while the CNX 100 has only one significant C window which is lowest among all indices.

The evidences presented above from the bi-correlation test for full sample and sub-sample may throw lights on the behaviour of stock return series. The resounding rejection of null hypothesis of pure noise for all most all indices in full sample period may be because of linear or non linear dependence or both in return series driven by the activity during the small number of significant window periods.

5. Conclusion:

The present study examines the stock return behaviour in two premier Indian stock markets using Chow-Denning (1993) multiple variance ratio and Hinich (1996) bicorrelation tests. The multiple variance ratio tests show that CNX Nifty Junior, CNX 500, CNX Bank Nifty, BSE 500, BSE Midcap and BSE Small cap reject the random walk hypothesis and return series are characterized by the presence of linear dependencies. On the other hand, the bicorrelation test rejects the hypothesis of pure white noise process for the full sample period. However, the results for sub-periods show that those serial dependencies are not consistent across the sample period for all indices. This indicates presence of episodic dependencies in stock returns surrounded by long

periods of pure noise. In other words, the Indian s tock markets are weak form efficient but not all the time. This conclusion is consistent with Bonilla *et al* (2006) for Latin America. The events occurred during the periods of serial dependencies and peculiarity of particular indices can be investigated in future research

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Notes

Note 1. For a comprehensive survey of literature on market efficiency hypothesis for India, see Amanulla and Kamaiah (1996).

Note 2. Hinich and Patterson (1995) suggest that the window length should be sufficiently large to validly apply bicorrelation test and yet short enough for the data generating process to have remained roughly constant.

Table 1. Descriptive Statistics for Stock Index Returns

Indexes	Mean	Minimum	Maximum	Std.Dev	Skewness	Kurtosis	Jarque-Bera	P value
CNX Nifty	0.000340	0.079691	0.017438	0.017438	-0.519211	4.475148	2566.928	0.0000
CNX Junior	0.000456	-0.131333	0.082922	0.020527	-0.678203	3.807871	1987.318	0.0000
CNX Defty	0.000233	-0.141131	0.089858	0.018438	-0472041	4.698742	2792.704	0.0000
CNX IT	0.000175	-2.365839	0.145567	0.052223	-32051150	1449.945	2327.864	0.0000
BSE Sensex	0.000342	-0.150214	0.102127	0.021883	-0.767701	6.057552	2064.842	0.0000
BSE 100	0.000395	-1.473311	0.552934	0.023958	-1.473311	244.0782	66926.37	0.0000
BSE 200	0.000407	-1.037087	1.084561	0.033690	1.394998	712.4875	5085.416	0.0000
CNX 500	0.000427	-0.128847	0.076945	0.017731	-0.772766	4.533660	2327.864	0.0000
CNX Bank	0.000657	-0.151380	0.114014	0.021577	-0419269	4.193256	1731.887	0.0000
BSE 500	0.000255	-0.249828	0.075327	0.018640	-1.727030	17.37390	2973.094	0.0000
CNX 100	0.000654	-0.130494	0.080065	0.017992	-0.859112	5.926253	2414.447	0.0000
CNX Infra	0.000676	-0.150214	0.102127	0.021883	-0.767701	6.057552	2064.842	0.0000
BSE Midcap	0.000145	-0.120764	0.078359	0.017902	-1.373015	7.010821	3002.329	0.0000
BSE SMallcap	0.000233	-0.108357	0.064767	0.018712	-1.234866	4.141240	1232.220	0.0000

Std.Dev = Standard deviation, CNXInfra = CNX Infrastructure.

Table 2. Lo and MacKinaly Variance-Ratio and Chow Denning Statistics for Index Returns

Indexes	Variance Ratios For Different Investment Horizons				ChowDenning
	2	4	8	16	
CNX Nifty	1.062	1.053	1.036	1.087	
	(3.35)*	(1.53)	(0.65)	(1.07)	1.93554
	(1.93)	(0.92)	(0.41)	(0.72)	
CNX Nifty Junior	1.143	1.209	1.231	1.072	
	(7.75)*	(6.04)*	(4.22)*	(4.96)*	4.26921*
	(4.26)*	(3.46)*	(2.59)*	(3.29)*	
CNX Defty	1.072	1.094	1.091	1.163	
	(3.89)*	(2.72)*	(1.66)	(2.00)*	2.22679
	(2.22)*	(1.62)	(1.04)	(1.32)	
CNX IT	1.008	1.016	1.026	1.113	
	(0.43)	(0.47)	(0.48)	(1.39)	0.53818
	(0.33)	(0.43)	(0.44)	(1.20)	
BSE Sensex	1.070	1.069	1.037	1.093	
	(3.66)*	(1.94)	(0.61)	(1.10)	2.34265
BSE 100	0.840	0.769	0.719	0.770	
	(-8.37)*	(-6.46)*	(-4.98)*	(-2.74)*	0.76055
	(-075)	(-0.72)	(-0.75)	(-0.56)	
BSE 200	1.011	1.014	1.023	1.058	
	(0.61)	(0.40)	(0.42)	(0.69)	0.82037
	(0.81)	(0.54)	(0.57)	(0.95)	
CNX 500	1.138	1.189	1.221	1.380	
	(6.81)*	(4.98)*	(3.68)*	(4.25)*	3.62379*
	(3.63)*	(2.16)*	(0.50)	(0.34)	
CNX Bank Nifty	1.123	1.146	1.049	1.047	
	(5.90)*	(3.73)*	(0.80)	(0.51)	3.23927*
	(3.21)*	(2.16)*	(0.50)	(0.34)	
BSE 500	1.123	1.173	1.217	1.396	
	(5.91)*	(4.42)*	(3.50)*	(4.29)*	3.37238*
	(3.39)*	(2.66)*	(2.24)*	(2.96)*	
CNX 100	1.093	1.096	1.054	1.126	
	(3.65)*	(2.01)*	(0.71)	(1.12)	1.85454
	(1.85)	(1.06)	(0.40)	(0.68)	
CNX 100	1.093	1.096	1.054	1.126	
	(3.26)*	(1.49)	(0.38)	(0.49)	1.60863
	(1.85)	(1.06)	(0.40)	(0.68)	
CNX Infrastructure	1.091	1.078	1.0316	1.061	
	(3.26)*	(1.49)	(0.38)	(0.49)	1.60863
	(1.63)	(0.78)	(0.21)	(0.30)	
CNX Midcap	1.220	1.350	1.464	1.688	
	(7.85)*	(7.85)*	(5.59)*	(5.57)*	3.42666*
	(3.43)*	(3.10)*	(2.90)*	(3.29)*	
BSE Smallcap	1.279	1.504	1.733	2.069	
	(9.96)*	(9.60)*	(8.84)*	(8.65)*	5.27285*
	(5.28)*	(5.42)*	(5.45)*	(5.86)*	

The variance ratios VR (q) are reported in the main rows and variance test statistic Z(q) for homoskedastic increments and, for heteroscedasticity- robust test statistics z*(q) are given in the second and third row parentheses . The Chow and Denning (1993) statistics, Z*(q) is given in the last column. Asterisked values reject random walk hypothesis at 5% level significance.

Table 3. Hinich Correlation (C) and Bicorrelation (H) Statistics for Full Sample Data

Indexes	Number of lags	Number of bicorrelations	Correlation (C)	Bicorrelation(H)
CNX Nifty*	24	276	0.00000000	0.00031967
CNX Nifty Junior*	24	276	0.00000000	0.00000000
CNX Defty*	24	276	0.00000000	0.00086180
CNX IT	24	276	1.00000000	0.74625165
BSE Sensex*	23	253	0.00000000	0.00000514
BSE 100*	23	253	0.00000000	0.00000514
BSE 200	23	253	1.00000000	0.99648407
CNX 500*	22	231	0.00000000	0.00000000
CNX Bank Nifty*	22	231	0.00000000	0.00000000
BSE 500*	22	231	0.00000000	0.00000046
CNX 100*	18	153	0.00000000	0.00094372
CNX Infrastructure*	17	136	0.00000000	0.00020523
BSE Midcap*	17	136	0.00000000	0.00000000
BSE Smallcap*	17	136	0.00000000	0.00000000

The table reports probability values of correlations (C) and bicorrelations (H) statistics. Asterisked indices reject null of pure noise at all conventional significance level.

Table 4. Widowed Test Results of Hinich H and C Statistics

Index	Total Number of Windows	Total Number of Significant H Windows	Total Number of Significant C Windows
CNX Nifty	59	9 (15.25)	3 (02.08)
CNX Nifty Junior	59	20 (33.89)	7 (11.86)
CNX Defty	59	15 (25.42)	4 (06.77)
CNX IT	59	15 (25.42)	8 (13.55)
BSE Sensex	56	11 (18.64)	8 (13.55)
BSE 100	56	16 (28.57)	6 (10.71)
BSE 200	56	18 (32.14)	5 (08.92)
CNX 500	49	15 (30.16)	5 (10.20)
CNX Bank Nifty	46	7 (15.21)	4 (08.69)
BSE 500	46	9 (19.56)	5 (10.86)
CNX 100	31	8 (25.80)	1 (03.22)
CNX Infrastructure	26	14 (46.15)	5 (19.23)
BSE Midcap	26	10 (38.46)	5 (19.23)
BSE Smallcap	26	10 (38.46)	5 (19.23)

The number of significant windows is reported in main rows with percentage in parenthesis.
A window is defined as significant if C or H statistics reject null of pure noise at 5 % significance level.

Appendix: Sample Indexes – Time Period Covered

S.No	Index	Time Period	% of Market Capitalization
01	CNX Nifty	02/06/1997 – 30/01/2009	61.70
02	CNX Junior	02/06/1997 – 30/01/2009	9.89
03	CNX Defty	02/06/1997 – 30/01/2009	-
04	CNX IT	02/06/1997 – 30/01/2009	14
05	BSE Sensex	01/01/1998 – 30/01/2009	46.53
06	BSE 100	01/01/1998 – 30/01/2009	75.67
07	BSE 200	01/01/1998 – 30/01/2009	85.24
08	CNX 500	07/06/1999 – 30/01/2009	84.24
09	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 Infrastructure	01/01/2004 – 30/01/2009	18.84
13	BSE Midcap	01/01/2004 – 30/01/2009	12.80
14	BSE Smallcap	01/01/2004 – 30/01/2009	3.7

Note: The values of market capitalizations are as on 30/01/2009.