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Do Stock Returns in India Exhibit a Mean-Reverting Tendency? Evidence from Multiple Structural Breaks Test

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ABSTRACT

This paper re-examines the issue of mean-reversion in Indian equity market. Unlike earlier studies, the present paper carries out multiple structural breaks test and uses new and disaggregated data set. The study found significant structural breaks in the returns series of all selected indices and thus provide evidence of mean-reverting tendency in the Indian stock returns. This implies violation of efficient market hypothesis in India. The endogenously searched significant structural breaks occurred in the years 2000, 2003, 2006, 2007 and 2008 for most of the indices indicating respectively rise in international oil prices, global recession, erratic fluctuations in exchange rates, and sub-prime crisis followed by global meltdown. The evidences of structural breaks and mean-reverting tendency indicate possibility to predict the future returns. Further, it is observed that small indices with less liquidity and lower market capitalization are more vulnerable to external events than the liquid indices. The results call for appropriate policy and regulatory measures particularly external shocks to improve the efficiency of the market.

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Keywords: Multiple Structural Breaks; Mean Reversion; Random Walk; Global Economic Crisis; External Shocks; NSE; BSE.

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1.INTRODUCTION

Two extreme views are popular in the literature about stock return behavior. One view is that returns are generated by a random walk process so that it is not possible to predict their future movements based on past information. This is formally stated as random walk hypothesis (RWH). The other view is the mean-reversion view, according to which there exists a tendency for the stock returns to return to its trend path. Hence, it is possible to predict future price movements based on history of prices. The earlier studies supported the stylized fact that stock return series follows a random walk. This was challenged by many later studies which documented mean-reverting tendency in stock returns [Fama and French, 1988; Poterba and Summers, 1988]. Some later studies, however[see Richardson and Stock, 1989; Kim *et al,*1991; McQueen, 1992;Richardson, 1993)reported evidences against mean-reversion.

The mean reverting tendency in stock returns points out possibility of prediction of futures returns and consequent abnormal returns. This violates the efficiency market hypothesis (EMH) which states that currency prices fully and instantly reflects information and therefore futures returns are unpredictable. The issue of mean-reversion of stock returns in India was examined using conventional unit root tests only. These tests are known to be less powerful in the presence of structural breaks. The objective of present study is to re-examine the issue of mean-reversion and structural breaks in Indian equity market using more sophisticated test on new disaggregated data.Thus, present study is first of its kind which examines multiple

structural breaks in the Indian context. In the past decade, several structural changes took place such as second-generation financial sector reforms[1], screen based trading, introduction of derivatives etc. The available studies refer to the 1980's and 1990's and hence could not capture the nature of microstructure of Indian stock markets, which has undergone various changes in the initial years of 21st century. This study uses updated and disaggregate data set covering the periodof such structural changes and hence is in order. In addition, the study also covers the period of recent financial crisis. Earlier studies in India focused only on Bombay Stock Exchange(BSE) (mostly confined to BSE Sensex index) with the belief that every stock exchange in India follows BSE Sensex. However, in the last few years, National Stock Exchange (NSE) emerged as the largest stock exchange in India. The data set of fourteen indices from both BSE and NSE used in the present study has another advantage as it helps to measure relative efficiency represented by different indices traded at the same exchange[2]. The rest of the paper divided into following sections for convenience. Section – 2 provides review of previous work. Section – 3 describes the data and methodology of the study. Discussion on results presented in Section -4 and the last section presents conclusion of the study.

2. REVIEW OF PREVIOUS WORKS

Nelson and Plosser (1982) pointed out that the random shocks have permanent effect on the underlying series. Empirical studies have employed largely conventional unit root tests to examine the issue. However, in the presence of a structural break, power of a unit root test decreases when stationary alternative is true (Perron 1989). Thus, inference concerning effect of shocks on long-term impact on series, employing conventional unit root tests is likely to go wrong when structural break is ignored. An appropriate way would be to test for the presence of structural break while employing such tests.In this context, Perron (1989) proposed an alternative testwhere break point is known before hand. Perron (1989) included dummy variables to account for one known or exogenous structural break in the framework of Dickey-Fuller (1979) unit root test. The test allows for a break under the null and alternative hypothesis. Perron (1989) proposed three models namely, model A which allows for break in mean, model B thatallows for break in slope, and model C allows for break both in mean and slope. He treated Great Depression and Oil shock of 1973 solely as exogenous events, which altered the long run movement of stock prices. Perron (1989) provided evidence of trend stationarity for ten of the thirteen series of Nelson and Plosser (1982). A limitation of this test is that it requires knowledge of break point beforehand, which is more often difficult to ascertain, and also involves subjectivity in the determination of break point.

To overcome this limitation, Christiano (1992), Banerjee *et al* (1992), Zivot, and Andrews (1992) among others proposed tests procedures based on different methods. Zivot and Andrews (1992) test is most popularlyemployed in empirical studies. Zivot-Andrews developed a sequential test procedure, which endogenously searches for a break point and tests for the presence of unit root when the process has a broken trend. The test selects the break date where t-statistics testing the null of unit root is minimum (most negative). They provided evidence in support of findings of Nelson and Plosser (1982) as they reject null of unit root for three out thirteen series.

Further, Wu (1997), Chaudhuri and Wu (2003), Narayan and Smyth (2005) and Chancharat and Valadkhani (2007) tested for presence of structural break using Zivot-Andrews test. Wu (1997) employed the test on a sample of eleven OECD countries during the period 1979-1994. While the conventional unit root test namely,augmented Dickey and Fuller (1979) supported the null of unit root (except for Finland and the UK), the Zivot-Andrews test showthat eightout of eleven countries characterize by trend-stationarity. Further, using monthly data from 1985-1997 for seventeen emerging countries including India, Chaudhuri and Wu (2003) found evidences of mean-reversion intenout of seventeen emerging markets. In contrast to evidences from emerging countries, the OECD countries documented evidences against mean-reversion and supported unit root process of underlying stock prices (Narayan and Smyth, 2005). Chancharat and Valadkhani (2007) who used data from seven developed and nine emerging markets found,with the exception of Malaysia and Russia that all the countries rejected mean-reversion hypothesis.

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As mentioned earlier, Perron (1989) pointed out that ignoring a structural break may lead to loss of power of unit root test. Similarly, ignoring breaks more than one may also lead to loss of power of a test. Motivated by this concern, Lumsdaine and Papell (1997)proposed two breaks unit root test where they extended the endogenous break test methodology of Zivot and Andrews(1992) test, to allow for two breaks under the alternative hypothesis of unit root test[3]. The endogenous break tests such as Zivot-Andrews (single break) and Lumsdaine-Papell (two breaks) tests do not assume break(s) under unit root null and derive their critical values. This may potentially biases test and leads to size distortions and incorrect inferences (Nunes *et al,* 1997; Lee and Strazicich, 2003). Lagrange Multiplier (LM)unit root multiple breaks test developed by Lee and Strazicich (2003)incorporates breaks under both null and alternative. Therefore, rejection of null clearly indicates trend stationarity process. Empirically, Lee and Strazicich (2003) showed potential for over rejection using Lumsdaine-Papell test. Galip (2005), Cook (2005), Bruggemann and Trenkler (2005) employed Lee-Strazicich test on macroeconomic series, while Hooi and Smyth (2005), Payne*et al* (2005) applied the same test to examine the presence of breaks in exchange rates of different countries. Narayan and Smyth (2007)using Lee-Strazicich test found evidences against mean-reversion in six out of seven stock returns of G7 countries.

The quest for study of stock returns behaviour in India began with early work of Rao and Mukherjee (1971). Later, Sharma and Kennedy (1977), Barua (1981), Gupta (1985), Amanullah(1997) and Amanullah and Kamaiah (1998) concluded that Indian stock returns follow random walk[4]. In contrast, Hiremath *et al* (2009) and Hiremath and Kamaiah (2010) rejected random walk.The most of the studies on Indian data used data of 1980's and early 1990's and carried out conventional tests of random walk.A plethora of changes in structure and functioning of the equity market took place in post Asian financial crisis. Therefore, the present study assumes importance as it uses latest data covering market microstructure changes and world's worst financial crisis. The paper also used more sophisticated test of mean reversion with multiple breaks. This is the first study, which examines multiple structural breaks in stock returns of India. India is second fastest growing economy and considered as one of the important destination for investment. The results, therefore, will have implications for investors and policy makers. This is the first study on India of its kind.

3. DATA AND METHODOLOGY

Data

Data of daily stock returns of five indices from the NSE and six indices from the BSE for the period January 1997 to March 2009 are considered for the present study. In addition, considering growing importance of information technology, banking and infrastructure sectors in the Indian economy, three sectoral indices from NSE are also chosen for the study. The data coverage is different for different indices (see Appendix - A), because of the fact that these indices were launched at different points of time. However, the indices considered have the track record of at least five years. The daily index values of the NSE and the BSE are collected from the official website of NSE and CMIE Prowess respectively. Unlike the earlier studies, the present study has the advantage of covering the period during which major structural changes have taken place. The data set of fourteen indices has another advantage as it helps to understand how highly liquid and less liquid indices respond to changes.

Methodology

The present study employs the Zivot and Andrews (1992) sequential trend break and Lee-Strazicich (2003) LM Unit root (with two structural breaks)tests. A brief description of thesetwo tests is presented below.

Zivot- Andrews (1992) Test

Zivot-Andrews developed three models namely, model A which allows for a break in intercept only, model B that allows for a break in trend only, and model C which allows for a break each in intercept and trend. Since model C allows single break each in mean and intercept, the present study considered model C

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as appropriate, as it accommodates both model A and model B. Besides, Sen (2003) demonstrated through Monte Carlo simulation that model C yields more reliable breakpoints than model A when the break is unknown. Model C is given in the following equation:

$$\Delta P_t = \mu + \theta\, DU_t(\lambda) + \beta t + \gamma DT_t(\lambda) + \alpha p_{t-1} + \sum_{j=1}^{k} \phi_j\, \Delta p_{t-j} + \epsilon_t \qquad (1)$$

In equation (1), ΔP_t is the first difference of the process P_t,DU_t is a dummy variable that captures shift in the intercept, and DT_tanother dummy that represents a shift in the trend occurring at time T_B. $\mu, \theta, \beta, \gamma, \alpha$ and ϕ sare constants, 'λ' representslocation of the break point and ε_t , the shock. These dummy variables are defined as follows:

$$DU_t(\lambda) = \begin{bmatrix} 1 \text{ if } t > TB \\ 0 \text{ otherwise,} \end{bmatrix}$$

$$DT_t(\lambda) = \begin{bmatrix} 1 \text{ if } t > TB \\ 0 \text{ otherwise,} \end{bmatrix}$$

Zivot-Andrews tests the null that trend (return) variable contains a unit root with drift that excludes any structural break against the alternative hypothesis of trend-stationarity process with a one-time break in the trend variable.The model allows for a one-time break both in intercept and trend. The test allows testing for a unit root against the alternative of stationarity with structural change at some unknown point. To determine the break point and compute the test statistics for a unit root, an ordinary least square regression is run with a break at T_B, where T_B rangesfrom 1 to T-2. For each value of T_B, the number of extra regressors*k*, is chosen following a sequential downward t-test on all lags as suggested by Campbell and Perron (1991).Furthermore, Ng and Perron (1995) showed that general to specific approach provides test statistics which have better properties than information based criteria[5].

Lee-Strazicich (2003) LM Unit Root Test with two Structural Breaks

Let thedata generatingprocess (y_t) be given by

$$\{y_t\} = \delta' Z_t + e, \qquad e_t = \beta e_{t-1} + \varepsilon_t \qquad (2)$$

where Z_t a vector of exogenous variables, e_ta vector of (first order auto-correlated) errors, δ'a vector of parameters, β a constant, and ε_t an error term with zero mean and constant variance. Lee-Strazicich by extending the LM unit root test of Schmidt and Phillips (1992), developed two models namely, model AA and model CC. In the present study, model CC is employed because model AA allows for two shifts in intercept only, and model CC allows for two shifts each in intercept and trend. In other words, model CC includes model AA. The model CC is as follows:

Let

$$Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}] \qquad (3)$$

where Z_ta vector of variables, t is time trend, D_{jt} and DT_{jt} (j = 1, 2) are dummy variablesdefined as follows:

$$D_{jt} = \begin{bmatrix} 1 \text{ for } t > TB_j + 1 \\ 0 \text{ otherwise,} \end{bmatrix}$$

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$$DT_{jt} = \begin{bmatrix} 1 \text{ for } t > TB_j + 1 \\ 0 \text{ otherwise,} \end{bmatrix}$$

In the above equation (3), T_{Bj} is the time period when a break occurs. For model CC, the following null ($\beta = 1$) and alternative ($\beta < 1$) hypothesis in which the process y_t includes two trend breaks each in intercept and slope may be formulated as follows:

$$\text{Null}: y_t = \mu^{(N)} + d_{11}^{(N)} B_{1t} + d_{12}^{(N)} B_{2t} + d_{21}^{(N)} BT_{1t} + d_{22}^{(N)} BT_{2t} + y_{t-1} + \nu_{1t} \quad (4a)$$

$$\text{Alternative}: y_t = \mu^{(A)} + d_{11}^{(A)} + D_{1t} + d_{12}^{(A)} D_{2t} + d_{21}^{(A)} DT_{1t} + d_{22}^{(A)} DT_{2t} + \nu_{2t} \quad (4b)$$

In (4a) and (4b), the superscripts 'N' and 'A' denote null and alternative respectively, $\nu_{1t}$and $\nu_{2t}$are stationary error terms, and B_{jt} and BT_{jt} are defined as follows:

$$B_{jt} = \begin{bmatrix} 1 \text{ for } t > TB_j + 1 \\ 0 \text{ otherwise,} \end{bmatrix}$$

$$BT_{jt} = \begin{bmatrix} 1 \text{ for } t > TB_j + 1 \\ 0 \text{ otherwise,} \end{bmatrix}$$

Under the null hypothesis, it is assumed that

$$d_{11}^{(N)} = d_{12}^{(N)} = 0$$
$$d_{21}^{(N)} = d_{22}^{(N)} = 0$$

The two breaks LM unit root test statistics is obtained from the following regression:

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \mu_t \quad (5)$$

where $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \tilde{\delta}, t = 2, \ldots, T$; $\hat{\delta}$ are coefficients in the regression of Δy_t on ΔZ_t; $\tilde{\psi}_x$ is given by$y - Z\tilde{\delta}$; and y and Zrepresent the first observations of $y_t$and Z_t respectively. The unit root null is described by $\phi = 0$, and the LM test statistics are given by$\hat{\rho} = T\hat{\phi}$ and$\tilde{\tau}$ = t-statistic for testing the unit root null hypothesis that ϕ=0. The location of the structural break (T_B) is determined by selecting all possible break points for the minimum t-statistics given by:

$$inf\ \hat{\rho}(\lambda) = inf\ \hat{\tau}(\lambda)$$
λ $\lambda(6)$

The search is carried out over the trimming region (0.15T, 085T), where T is the sample size. As in case of Zivot-Andrews test, the numbers of lagged augmentation terms in this test, are determined by the general-to specific procedure suggested in Ng and Perron (1995). Starting from a maximum of k = 8, lagged terms, the procedure looks for significance of the last augmented term.

4. EMPIRICAL RESULTS

The basic statistics for the fourteen indices are given in table 1. The highest average returns are registered by CNX 100, followed by CNX Infrastructure. This reflects the performance of this index owing to considerable growth of infrastructure sector in India. This also indicates that the small size indices

commonly have higher returns. CNX Bank Nifty is the other index which shows higher mean returns. However, the CNX 500 registers negative mean returns. Further, the BSE 200 has the highest standard deviation, followed by CNX IT indicating high volatility, and lowest is of CNX Nifty and BSE Sensex (see table 1). The returns of all indices are negatively skewed implying the returns are flatter to the left compared to normal distribution. The significant kurtosis indicates that stock returns are leptokurtic, that is, returns have fatter tails than a normal distribution. Further, significant Jarque-Bera statistic rejects the null of normality and thus confirms that stocks returns are non-normally distributed. This corroborates the stylized fact (non-normality) of recent financial data.

As noted earlier, the conventional unit root tests give spurious results if the presence of structural breaks is ignored. Hence, it is vital to see whether there is a unit root in the returns process while simultaneously taking into account possible structural break. Trends Break tests possess advantage over unit root tests and therefore are statistically powerful thanthe latter tests. Considering this, Zivot-Andrews sequential break (model C) test, which searches for a break endogenously, is employed and results are reported in table 2. The general specific procedure is followed to choose extra k regressors. Further, fraction of data range to skip at either when examining possible break is fixed as 0.15T (trimming region). Table 2showsthat Zivot-Andrews test statistic for all the indices is significant at 1 % level. Thus, this test provides evidence of mean-reversion in Indian stock returns.

The plot of stock returns for fourteen indices is depicted in Figure 1. The structural break points for all indices identified by Zivot-Andrews test are significant as it is evident from the minimum t-statistics on vertical axis corresponding break point of each index as shown in figure 1. The structural break for CNX IT and BSE 100 in the year 2000 is associated with global economic slowdown and dot-com internet bubble. The structural break for CNX Nifty, BSE Sensex, BSE 200, and BSE 500 occurred in 2003, the period, which witnessed rise in international oil prices. The break points for CNX Bank Nifty and CNX Defty coincides with unprecedented slide of rupee in 2006. The break point for CNX 100, CNX 500, and less liquid and having lower market capitalization indices namely, CNX Infrastructure, BSE Midcap and BSE Small cap structural break point associated with global economic meltdown of 2008 precipitated by sub-prime crisis in US.

It may be pertinent to note that ignoring a structural break may leads to bias and loss of power of unit root test. In the same fashion, ignoring more than one break, results in reduction of power of the test. Motivated by this concern, the present study applied Lee-Strazicich two structural breaks test. The model CC of the Lee-Strazicich test is employed which allows for two shifts each in intercept and trend. The test has advantage over Zivot-Andrews and Lumsdaine-Papell multiple breaks test since it includes breaks both under null and alternative hypothesis. The rejection of null in this test, unlike Zivot-Andrews, and Lumsdaine and Papell without any ambiguity implies trendstationarity and not difference stationarity. Table 3provides the Lee-Strazicich test statistics along with break dates.It is clearly evident from the table that LM statistic is statistically significant at 1 % level, thus rejecting the null of unit root. This unambiguously implies trend stationarity process in returns.In other words, the evidences are in support of mean-reverting tendency in Indian stock returns.

The break dates identified by Zivot-Andrews and Lee-Strazicich, (though strictly not comparable) suggest different break points. The possible reason may be the different methods of specification and identification of the break point. While structural break points identified by Zivot-Andrews for BSE 100, CNX Bank Nifty and BSE 500 are identical to first break point of Lee-Strazicich, and for indices namely, CNX Defty, CNX 500, CNX 100, CNX Infrastructure, BSE Midcap and BSE Smallcap are identical to second break point identified by Lee-Strazicich test. The break points for rest of the indices (CNX Nifty, CNX Nifty Junior, BSE Sensex, BSE 200) are entirely different.This indicates the importance of considering two structural breaks, as single break test ignores the other structural breaks which are important and such ignorance leads to wrong inferences. Besides, it also points out importance of incorporation of breaks both under null and alternative hypothesis. In other words, multiple breaks test is preferable to Zivot-Andrews's single break test. Further, Lee-Strazicich test results are preferable to other

multiple structural breaks tests such as Lumsdaine-Papell which do not assume breaks under null and thus leads to incorrect inferences.

Lee-Strazicich test results show that the break points identified around break dates for various indices are different. Most of the break dates seem to have occurred during 2000-03 and 2006-08.The first break point for CNX Nifty, CNX Nifty Junior, BSE Sensex, BSE 100, BSE, 200, CNX 500falls in between 1999 and 2001. This was a period of global economic recession originated in the US, dot-com bubble burst and Air India hijack followed by war hysteria between India and Pakistan.It may also benoted that in March 2000, the government notified to removethe ban on future trading to pave way for derivative trading in India.

The sluggishness in foreign institutional investors (FIIs), slip in consumer spending and bad monsoon during 2003 made the market to move in a narrow range. This is the year when the first break point for CNX Defty, BSE 500, CNX 100, detected. The rise in international oil prices during March-May, 2003 is one of the possible factors for the break in these indices. The first structural break for BSE Midcap and BSE Smallcap occurredin 2007 is associated with notorious sub-prime mortgage crisis broke out and many investments banks collapsed in a short span of time and there was sustained pull out of investment by FIIs from Indian markets.

The second structural break point identified by Lee-Strazicich test for BSE 100 and BSE 500 falls between 2003-2004, which coincides with bad monsoons, and international oil shock. There was sustained pull out of FIIs from the market and unprecedented slide of rupee in 2006.The second break points for CNX Defty, CNX IT, and BSE Sensex occurred during this year. The second break occurred in case of most indices such as CNX Nifty, BSE 200, CNX Bank Nifty, CNX 100, CNX InfrastructureBSE Midcap and BSE Smallcap during 2008. This is the period of global meltdown triggered by sub-prime crisis, which spread to financial sector and resulted in economic crisis. It is to be noted here that in late 2007 Securities and Exchange Board of India (SEBI) banned P-Notes meant for FIIs. The BSE Midcap, BSE Smallcap, CNX Infrastructure, CNX Bank Nifty were more vulnerable to financial crisis and market meltdown as they have low capitalization and compress less liquid stocks than other indices.

Since the trend break test is powerful than conventional unit root tests, the former test is better than latter. However, the multiple structural breaks test is preferable to single structural break test because ignorance of multiple breaks leads to spurious results. Further, Lee-Strazicich test is preferable than other multiple breaks tests such as Lumsdaine-Papell as the former includes breaks both under null and alternative hypothesis and therefore the rejection of null clearly indicates trend-stationarity process. In other words, the results of Lee-Strazicich are unambiguous and reliable. The results of the present study indicated trend stationarity process in stock returns of BSE and NSE. The different indices have different structural breaks. The difference in liquidity and market capitalization of indices is one of the explanations for such differences. The study observes that less liquid and lower cap indices were quick in responding to external shocks such as financial crisis, oil prices fluctuations, and global economic meltdown than their more liquid and high cap indices.

5. CONCLUSION

The present study re-examines the issue of mean reversion and structural break in NSE and BSE. Zivot and Andrews (1992) sequential break test,and Lee and Strazicich (2003) are employed on a sample of 14 indices of BSE and NSE between 1997 and 2009. The conventional unit root tests find evidences against random walk process. Zivot and Andrew (1992) test provides the mean-reverting tendency as the test strongly rejects null of unit root for all indices. However, since the test assumes breaks only in alternative hypothesis, the rejection of the null not necessarily implies trend stationarity. It may be only difference stationarity and inferences would not be reliable. Therefore, the Lee and Strazicich (2003) LM unit root test is performed, which assumes breaks both under null and alternative hypothesis. The test results clearly provide evidence of trend stationarity in Indian stock returns. This suggests that the shocks trigged by structural or policy change may have only a temporaryimpact on stock returnsand there is tendency for the

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returns to return to trend path. The breaks occurred in 2000, 2003, 2007, and 2008are associated with structural reforms, global economic recession,ban on P notes, sub-prime crisis and economic meltdown. The study also suggests that the less liquid indices are more vulnerable to external shocks.

The substantial evidence of mean-reversion in Indian stock returns across indices has important theoretical, practical and policy implication. The observed mean-reverting tendency indicate possibility of prediction of stock returns based on past history of returns and thus clearly rejects efficient market hypothesis in the context of Indian equity market. The financial sector reforms and changes in market microstructure, which aimed at improving efficiency of market have not brought desired results. The external events have always created panic in the Indian equity market. The events identified around trend breaks in the present study were mostly external events. Whenever there were some shocks, it was found that there was net outflow of FIIs. This calls for an appropriate regulation of external sector and FIIs and further disclosure from them. It is found in the study that smaller indices were more vulnerable to shocks than large indices. To improve the performance of small indices having lesser liquidity, it is important to improveliquidity of such indices. This can be achieved by encouraging retail trading in the market. Because, presently BSE and NSE together constitute 99.9 per cent of Indian market while trade is not taking place in other 17exchanges in India. The further study can be focused considering the breaks in forecast modelling and comparing profits generated by constructing portfolios during structural breaks detected by multiple trend breaks with other models of forecast.

Foot notes:

1. The major structural changes include new industrial policy, competition act, greater role to private sector, liberalization of banking & financial sector from bureaucratic controls, establishment of SEBI, opening stock market for foreign portfolio investment etc.

2. Campbell *et al* (2007) emphasis relative efficiency of one market measures against another which is more useful concept than the view of traditional market efficiency literature. They pointed out that market efficiency in an ideal though unrealizable serves as useful benchmark for measuring relative efficiency.

3. Clemente *et al,* (1998), Ohara (1999), Papell and Prodan (2003) also introduced multiple breaks tests.

4. For a detailed review on Indian market behavior, see Amanulla and Kamaiah (1996), Hiremath *et al* (2009) and, Hiremath and Kamaiah (2010).

5. The sequential procedure suggests first to start with $k_{\max}$ and then estimate the model with $k_{\max}$ lags. If the coefficient of the last included lag is significant at the 10 % level, select $k=k_{max}$. Otherwise, reduce the lag order by one until the coefficient of the last included lag becomes significant. For details, see Campbell and Perron (1991).

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APPENDIX A

Table 1. Summary Statistics

Index	Mean	Std.Dev	Skewness	Kurtosis	Jarque-Bera
CNX Nifty	0.000352	0.017484	-0.51921	4.47514	0.0000
CNX Junior	0.000458	0.020527	-0.67820	3.80787	0.0000
CNX Defty	0.000234	0.018531	-0.47204	4.69874	0.0000
CNX IT	0.000187	0.051938	-32.05115	1449.94	0.0000
BSE Sensex	0.000345	0.017809	-0.39940	6.05755	0.0000
BSE 100	0.000400	0.023933	-1.47331	241.078	0.0000
BSE 200	0.000412	0.063972	-0.06899	12.487	0.0000
CNX 500	-0.00005 2	0.030893	-27.32103	4.53366	0.0000
CNX Bank	0.000614	0.021784	-0.42328	4.19325	0.0000
BSE 500	0.000273	0.018658	-1.69004	17.3739	0.0000
CNX 100	0.000667	0.018059	-0.83520	5.92625	0.0000
CNX Infra	0.000659	0.021825	-0.75894	6.05755	0.0000
BSE Midcap	0.000144	0.018377	-1.26659	7.01082	0.0000
BSE Smallcap	0.000171	0.019092	-0.87443	4.14124	0.0000

Note: Basic statistics for 14 indices are given in the table. The null of skewness and kurtosis =0, is significantly rejected. CNX Infra = CNX Infrastructure. Std.Dev = Standard deviation

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Table 2. Zivot and Andrew (1992) Sequential Trend Break Test Statistics

Index	Trend Break	K	Minimum T statistic
CNX Nifty	2003:04:25	7	-19.286*
CNX Nifty Junior	2003:03:31	2	-29.698*
CNX Defty	2006:06:14	7	-19.038*
CNX IT	2000:02:21	5	-22.037*
BSE Sensex	2003:05:12	7	-18.674*
BSE 100	2000:02:21	0	-62.221*
BSE 200	2003:04:29	6	-27.186*
CNX 500	2007:08:23	0	-48.288*
CNX Bank Nifty	2006:07:19	5	-22.125*
BSE 500	2003:04:01	1	-33.143*
CNX 100	2008:01:09	5	-17.652*
CNX Infrastructure	2008:01:09	5	-16.647*
BSE Mid Cap	2008:01:08	2	-19.528*
BSE Small Cap	2008:01:08	2	-18.169*

*Note: The table reports Zivot test statistics for Model C which allows for break both in intercept and trend. The critical values are -5.57 and -508 for 1% and 5% respectively. *, ** denote statistical significance at 1 % and 5 % respectively.*

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Table 3. Lee and Strazicich (2003) LM Unit root Two Structural Breaks Test Statistics

Index	LM Statistic	Trend	Break Date	Trend	Break Date
CNX Nifty	-23.81*	19.66*	1999:01:15	-19.41*	2008:01:09
CNX Nifty Junior	-18.65*	16.83*	2000:03:13	-18.07*	2002:02:27
CNX Defty	-19.79*	17.86*	2003:10:24	-18.23*	2006:07:06
CNX IT	-25.97*	-19.51*	2004:05:20	11.69*	2006:06:14
BSE Sensex	-19.53*	-17.68*	2000:03:14	18.40*	2006:07:06
BSE 100	-18.67*	17.62*	2000:02:25	18.21*	2003:09:12
BSE 200	-36.47*	-27.82*	1999:12:29	27.93*	2008:01:22
CNX 500	-27.91*	1.98	2001:07:09	-10.50*	2007:09:03
CNX Bank Nifty	-22.58*	21.83*	2006:07:19	16.99*	2008:01:02
BSE 500	-27.91*	18.29*	2003:05:08	3.40	2004:06:18
CNX 100	-18.17*	14.72*	2003:10:24	-16.17*	2008:01:09
CNX Infrastructure	-17.56*	17.16*	2006:06:08	-15.56*	2008:01:15
BSE Mid Cap	-30.19*	-4.50	2007:08:27	-0.73	2008:07:18
BSE Smallcap	-18.44*	15.48*	2007:08:21	-13.37*	2008:03:17

*Note: The table reports Lee and Strzicich (2003) two breaks test statistics. The null is unit root with breaks. * indicates significance level at 1 % level. The critical values of the test are given in Lee and Strazicich (2003)*

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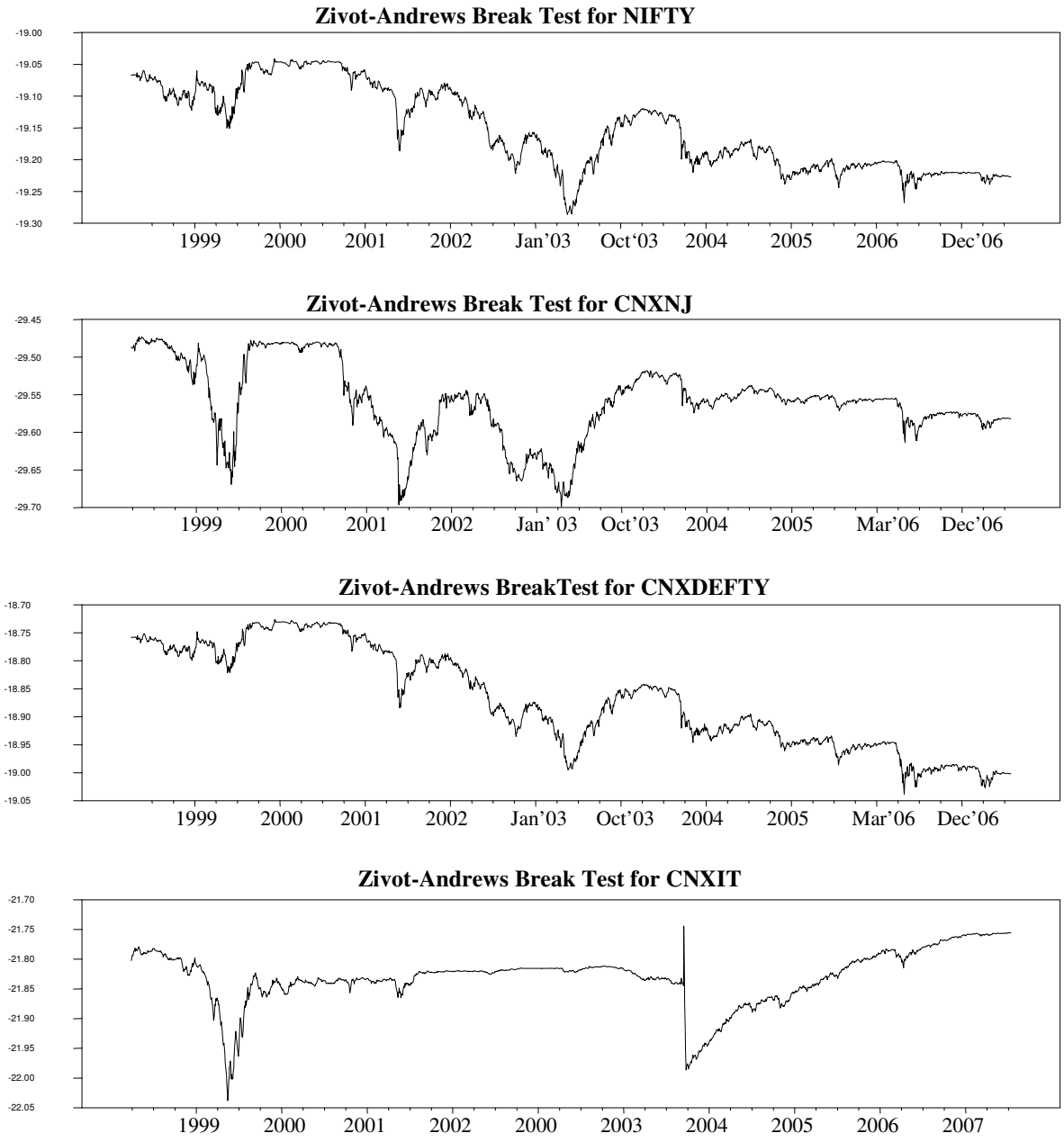
Figure 1. Plot of Stock Returns Indices with Structural Break



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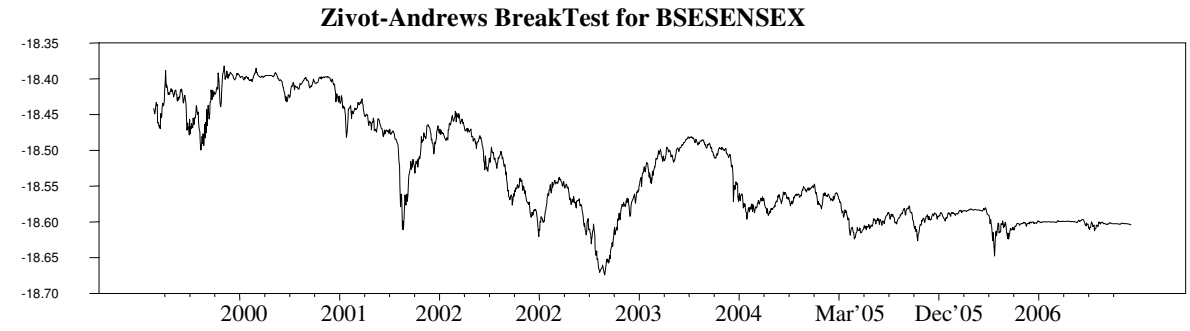
Zivot-Andrews BreakTest for BSESENSEX
-18.35
-18.40
-18.45
-18.50
-18.55
-18.60
-18.65
-18.70
2000
2001
2002
2002
2003
2004
Mar'05
Dec'05
2006

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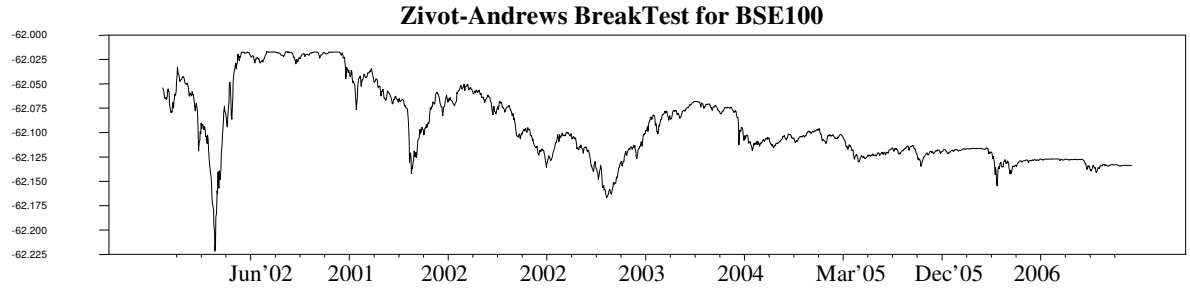
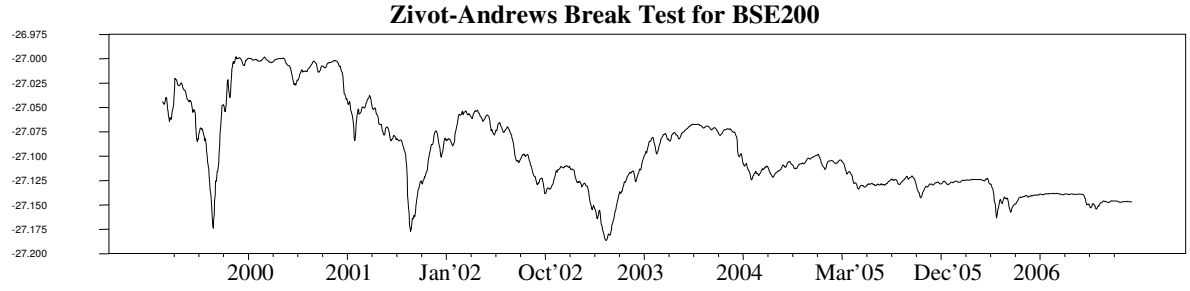
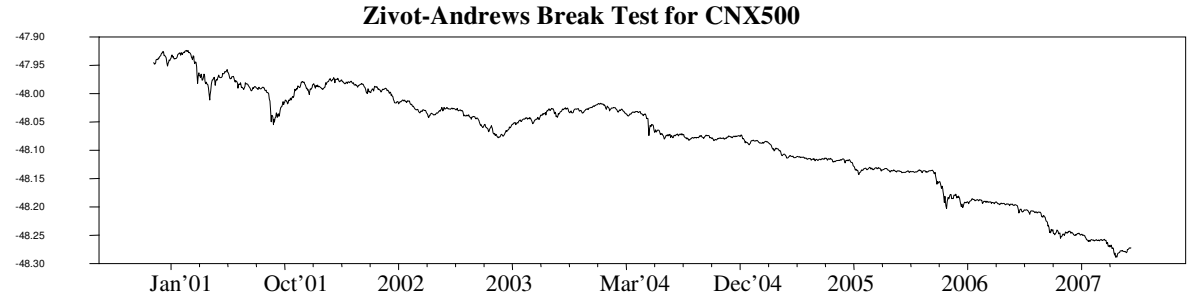

Zivot-Andrews BreakTest for BSE100
-62.000
-62.025
-62.050
-62.075
-62.100
-62.125
-62.150
-62.175
-62.200
-62.225
Jun'02
2001
2002
2002
2003
2004
Mar'05
Dec'05
2006


Zivot-Andrews Break Test for BSE200
-26.975
-27.000
-27.025
-27.050
-27.075
-27.100
-27.125
-27.150
-27.175
-27.200
2000
2001
Jan'02
Oct'02
2003
2004
Mar'05
Dec'05
2006


Zivot-Andrews Break Test for CNX500
-47.90
-47.95
-48.00
-48.05
-48.10
-48.15
-48.20
-48.25
-48.30
Jan'01
Oct'01
2002
2003
Mar'04
Dec'04
2005
2006
2007

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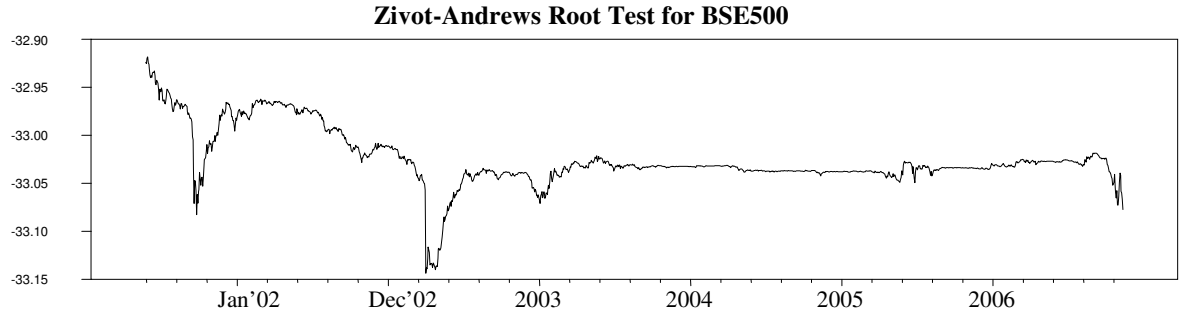
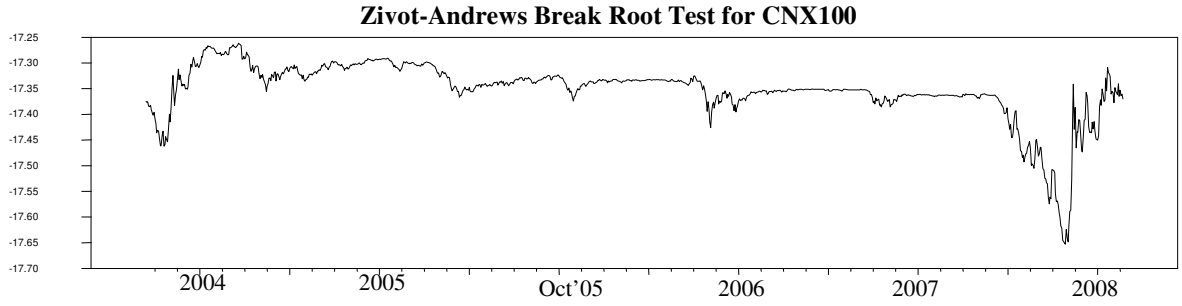
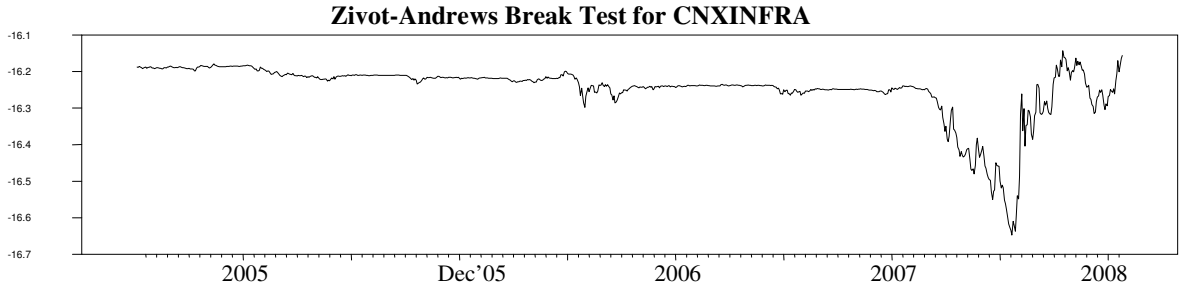
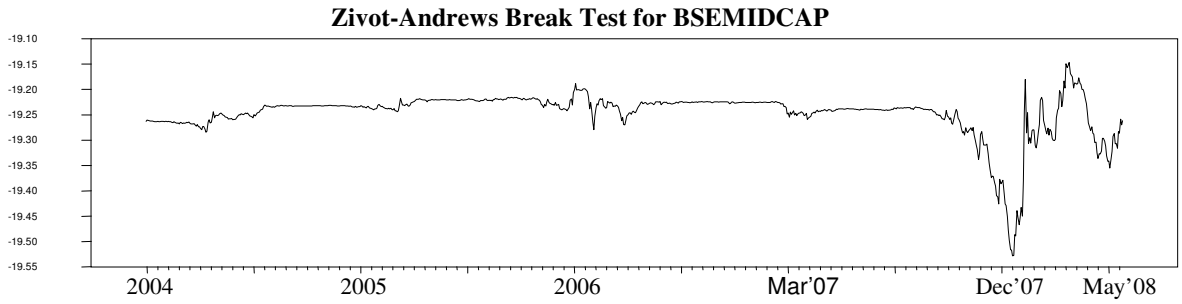
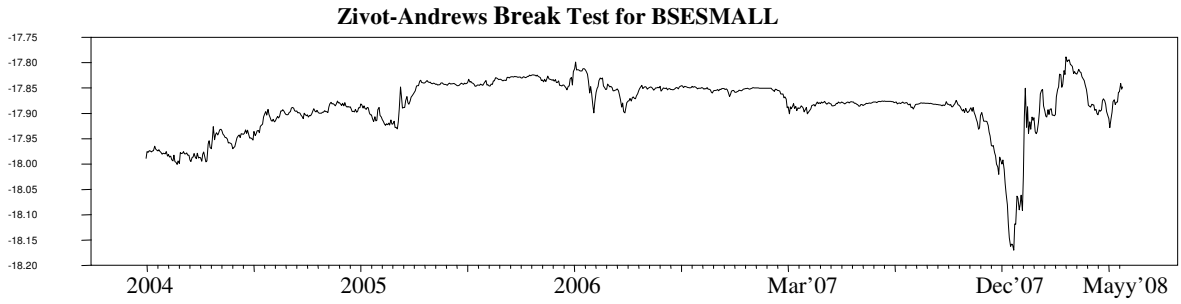

Zivot-Andrews Root Test for BSE500
-32.90
-32.95
-33.00
-33.05
-33.10
-33.15
Jan'02
Dec'02
2003
2004
2005
2006


Zivot-Andrews Break Root Test for CNX100
-17.25
-17.30
-17.35
-17.40
-17.45
-17.50
-17.55
-17.60
-17.65
-17.70
2004
2005
Oct'05
2006
2007
2008


Zivot-Andrews Break Test for CNXINFRA
-16.1
-16.2
-16.3
-16.4
-16.5
-16.6
-16.7
2005
Dec'05
2006
2007
2008


Zivot-Andrews Break Test for BSEMIDCAP
-19.10
-19.15
-19.20
-19.25
-19.30
-19.35
-19.40
-19.45
-19.50
-19.55
2004
2005
2006
Mar'07
Dec'07
May'08

.


Zivot-Andrews Break Test for BSESMALL
-17.75
-17.80
-17.85
-17.90
-17.95
-18.00
-18.05
-18.10
-18.15
-18.20
2004
2005
2006
Mar'07
Dec'07
Mayy'08

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APPENDIX B

A brief description of the selected indices is as follows:

Indices Traded at NSE

CNX Nifty(02/06/1997 to 31/03/2009)
It represents most liquid and well diversified 50 stocks traded at NSE representing 22 sectors of the economy. Its percentage to total market capitalization is about 65 percent on NSE

CNX Defty (02/06/1997 to 31/03/2009)
CNX Defty is nothing but CNX Nifty, measured in dollars. This index launched by NSE to facilitate FIIs and off-shore fund enterprises.

CNX Nifty Junior (02/06/1997 to 31/03/2009)
CNX Nifty Junior consists of next 50 liquid stocks excluded from CNX Nifty and represents about 10 percent of total market capitalization on NSE.

CNX 100(01/01/2003 to 31/03/2009)
Diversified 100 stocks representing 35 sectors of the economy constitute CNX 100 index. It represents 75 percent of total market capitalization on NSE

CNX 500 (07/06/1999 to 31/03/2009)
CNX 500 equity index is broad based index and accounts 95 percent of total market capitalization. The companies included are disaggregated into 72 industry indices.

Indices Traded at BSE

BSE Sensex (01/01/1998 to 31/03/2009)
BSE Sensex represents large and financially sound 30 companies across key sectors. It accounts for about 45 percent of total market capitalization on BSE.

BSE 100(01/01/1998 to 31/03/2009)
BSE 100 was formerly known as BSE National Index. BSE 100 index is made up of 100 companies listed on 5 important stock exchanges in India. The scripts included are of those companies that have been traded more than 95 percent trading days and figured in final 200 ranking. BSE 100 stocks represent about 73 percent of market capitalization. BSE arrives at this ranking base on three months full market capitalization of stock and liquidity which are given 75 and 25 percentage of weight respectively.

BSE 200(01/01/1998 to 31/03/2009)
Equity shares of 200 selected companies from the specified and non-specified lists of BSE constitute BSE 200 index. It represents 82.70 percent of market capitalization on BSE.

BSE 500 (03/01/2000 to 31/03/2009)
BSE 500 constitutes about 94 percent of market capitalization on BSE. It covers major 20 industries of the company. The stocks which are included in BSE 500 are those which have traded 75 per cent days and figured in top 750 companies in final ranking.

BSE Midcap (01/01/2004 to 31/03/2009)
This index constitutes medium sized stocks and represents about 16 percent of total market capitalization on BSE.

BSE Smallcap (01/01/2004 to 31/03/2009)
It accounts for about 6 percent of market capitalization and made up of small sized stocks.

Sectoral Indices

CNX IT (02/06/1997 to 31/03/2009)
Companies that have more than 50 percent of their turnover from IT related activities are compressed in CNX IT. The CNX IT Index stocks represent about 80.33 percent of the total market capitalization of the IT sector as on March 31, 2009. Companies included in 19 CNX IT have at least 90 percent trading days and ranked less than 500 based on market capitalization. This index accounts 14 percent of total market capitalization on NSE.

CNX Bank Nifty (01/01/2000 to 31/03/2009)

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The most liquid and large market capitalized 12 Indian Banking stocks traded on NSE comprises CNX Bank Nifty. The CNX Bank Index stocks represent about 87.24 percent of the total market capitalization of the banking sector and about 8 percent of the total market capitalization on NSE.

CNX Infrastructure (01/01/2004 to 31/03/2009)

CNX Infrastructure index includes 25 stocks of companies belonging to Telecom, Power, Port, Air, Roads, Railways, shipping and other Utility Services providers. CNX Infrastructure Index constituents represent about 21.43 percent of the total market capitalization on NSE.