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Are There Benefits From Sectoral Diversification in the Indian BSE Market?

Evidence from Non-Parametric Test

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ABSTRACT

This paper tests the weak form of stock market efficiency using data on eight sectoral indices from the Bombay Stock Exchange (BSE, India). The aim is to examine if portfolio diversification strategy can be used by investors to make financial gain. For this purpose we implement the Breitung's (2002) non-parametric unit root test and the Bierens's (1997) and Breitung's (2002) non-parametric cointegration test. Based on the results, we find that the BSE sectoral indices satisfy the weaker form of efficiency. The cointegration tests suggest that there is no common trend which can bring these BSE indices together in the long run. This implies that the benefits of diversification are enormous within these indices.

Keywords: Bombay Stock Indices, India, Structural Breaks, Non-parametric Cointegration Test

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1. INTRODUCTION

Since publication of the seminal work by Fama (1970), a large body of literature in finance has emerged to test market efficiency. The Efficient Market Hypothesis (EMH) defines an efficient market as one in which new information is quickly and correctly reflected in the current security prices. Depending upon the type of information used, Fama (1970) divided the EMH into three categories viz., weak, semi-strong and strong forms. The strong form of EMH deals with all available information –public and private; while semi strong form deals with the information that is publicly available. The weak form of EMH, which is the focus of this study, asserts that past prices, volumes and other market statistics are not relevant in predicting future stock prices. In its weak form, we assume that the price changes follow "Random walk", i.e. prices change randomly with the arrival of new information. In other words, stock prices are characterized by unit root. The process has no memory and the volatility in stock markets increases without bounds (Chaudhuri and Wu, 2003). The instantaneous price changes caused by new information reduce the possibility of earning excess profits persistently. As observed by Evans (2006), "the more efficient the market is, the more random the sequence of price changes generated by such a market would be" (p. 1274). Kim *et al*. (2009) observed, "if stock prices are mean reverting, then short-selling assets that have performed well and buying assets with relatively poor performance in the past (i.e., contrarian strategies) should provide higher returns" (p. 347). Thus, the stock prices act as signals for investors' assessment of the profitability of firm's investment opportunities wherein market efficiency turns out to be a necessary condition for economic efficiency (Dow and Gorton, 1997).

The objective of this paper is to test the random walk hypothesis for the Bombay Stock Exchange (BSE) in India, an emerging stock market. The research has been motivated by the need to address questions about the assumption of linearity in financial time series. The recent developments in time series econometrics have provided ammunition to the critics and even provided evidence in favor of nonlinearities in the data generating process (DGP) of stock indices [See for example, Hsieh (1989, 1991), Scheinkman and LeBaron (1989), De Grauwe *et al*. (1993), Abhyankar *et al.* (1995), Abhyankar *et al.* (1997), Steurer (1995), Brooks (1996), Barkoulas and Travlos (1998) and Opong *et al.* (1999)]. Thus, to avoid methodological challenges and to finesse potential pitfalls, the paper applies nonlinear unit root and cointegration test. In particular, the paper examines the linkages between sectoral indices of BSE in India using the non-parametric unit root and cointegration techniques to allow for nonlinearity in the analysis. The results of the study not only provide evidence in favor of the (weak form) efficiency of the BSE sectoral indices (i.e., random walk hypothesis) but also offer insight into the potential benefit to investors from sectoral diversification. The evidence will help foreign and Indian investors to understand the functioning of the BSE sectoral market and make informed decision. In terms of the asset allocation theory, portfolio efficiency (higher returns per unit of risk) can be achieved by forming a portfolio with different asset categories so as to eliminate unsystematic risk. It is widely accepted that a sound portfolio requires minimum positive co-movement between the security prices. Minimum co-movements among international stock markets make international portfolio diversification possible [Wong *et al.* (2004), Phylaktis and Fabiola (2005) and Onour (2010)].

This study contributes to the literature by examining the informational efficiency aspect and sectoral diversification opportunities in the Indian stock market, more specifically the BSE. Although there are a few studies that examine the stock markets of Athens, China and Amman, the authors are not aware of any similar study on India. The application of nonparametric unit root test and cointegration techniques makes this paper significantly different from other studies. The procedure has several advantages. (a) It ensures that the results are robust to the underlying distributional assumptions. (b) The test statistics are not affected by any nonlinearity in the DGP, which is also the focus of the present study. The results can help investors exploit portfolio diversification opportunities in the BSE. The findings, based on rigorous academic research, can better serve the interest of investors in the Indian stock market in general and BSE in particular.

The rest of the study is organized as follows. Section 2 offers logical justification for non-linearity in the financial data. Section 3 briefly reviews the literature. Section 4 describes data and methodology. Section 5 discusses the results; while Section 6 draws conclusion arising out of the paper.

2. NON-LINEARITY IN THE FINANCIAL DATA

In this section we briefly describe the sources of nonlinearities in financial data. Much of the nonlinearities or nonlinear adjustments in economic time series arise from market frictions and transaction costs. Another source may simply be non-linear causal relationship between the two series due to, for example, (a) asymmetry in the investors'/ agents' reaction to a positive shock, compared to a negative shock of the same absolute magnitude in the financial markets. That is, asymmetric information can cause asymmetric causality. (b) The presence of bid-ask spread; short selling; borrowing constraint; and other transaction costs make arbitrage unprofitable which causes small deviations from the fundamental equilibrium. Subsequent reversion to equilibrium takes place only if the deviations from the equilibrium price are large enough to set the stage for arbitrage activities to become profitable again.

The standard cointegration tests e.g., the Johansen approach is based on linear autoregressive model which implicitly assumes that the underlying dynamics are all linear. So, if nonlinearity in the series is present, the standard tests are not reliable. Using Monte Carlo simulation, Bierens (1997) shows that the Johansen approach is misspecified when the true adjustment process is non-linear. In addition, the speed of adjustment varies with the magnitude of disequilibrium. Balke and Fomby (1997) argue that there is a potential loss of power in standard cointegration tests under the threshold autoregressive DGP. Motivated by the above noted considerations, this paper uses non-parametric cointegration tests proposed by Bierens (1997) and Breitung (2000) to examine the sectoral stock markets integration, with particular focus on a long run relationship[2]. In general, this non-parametric test is similar in spirit to the Johansen and Juselius (1990) approach. However, in obtaining the Bierens' (1997) and Breitung's (2000)[3] test statistics, it is not necessary to specify a DGP. This makes these tests completely non-parametric even though under both approaches the test statistic is obtained from the solutions of a generalized eigenvalue problem. In principle, both approaches should generate similar outcomes. The choice of Bierens' (1997) and Breitung's (2000) methods is dictated by its claimed superiority in detecting cointegration when the error-correction mechanism is non-linear. However, there are other advantages too. (a) The short-run component does not affect the asymptotic null distribution of the test statistic (b) The outcome does not depend on the lag length or the inclusion of a trend or a constant, while the Johansen procedure is sensitive to both. This is supported by the empirical works of Ma and Kanas (2000), Coakley and Fuertes (2001), Lee *et al*. (2009).

3. A BRIEF REVIEW OF LITERATURE

Samuelson (1965) and Fama (1965) are the earliest notable authors to have worked on random walk hypothesis. Since then, several authors have empirically examined the weak form stock

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[2] Similar methodology has been use by Kanas (1998) for the U.S. and European stock markets.

[3]Breitung's (2000) unit roots and cointegration test employ variance ratio as the test statistic. This approach can eliminate the problem of specification of the short run dynamics and the estimation of nuisance parameters.

market efficiency using a variety of empirical approaches, but the evidence is mixed for the emerging markets (see Lim and Brooks, 2011). Based on the approaches taken, the literature can be grouped in different categories. However, we focus on four types of studies namely; those using (a) unit root test (b) cointegration test (c) Long Memory test. Finally because the study relates to Indian stock market, we added a fourth category: (d) studies relating to the Asian/ south east Asian economies. As noted earlier, in this paper we apply the unit root tests and the cointegration tests.

3.1 Unit Root

The conventional ADF unit root test has been a popular statistical tool to test the weak-form of EMH in the literature. Some of the other studies have used other advanced time series and panel unit root tests that incorporate either one or multiple structural breaks in the DGP. Within the time series framework, quite a few studies have also used nonlinear unit root tests such as the threshold model of Caner and Hansen (2001) and/or test proposed by Kapetanios *et al*. (2003) formally known as KSS test. In such studies, non-stationarity in the log-levels of stock prices has been interpreted as weak-form-efficient. Narayan and Smyth (2004) examined the efficiency of South Korean stock market using a battery of unit root tests to investigate the random walk hypothesis. Based on the evidence on unit root, they conclude that the South Korea's stock market is efficient. Lean and Smyth (2007) find that stock price indices in eight Asian countries follow a random walk process which is also supported by the panel Lagrange Multiplier (LM) unit root test with one break. When allowed for two breaks, the panel results suggest stock prices are mean reverting. The Istanbul Stock Exchange, an emerging market is found to be weakly efficient because the major index is characterized by a unit root with two structural breaks (Ozdemir, 2008). Stationarity in stock prices is found when a panel LM unit root test with two structural breaks is employed (Lean and Smyth, 2007; Narayan, 2008). Caner and Hansen (2001) propose a unit root test built on an unrestricted two regime threshold autoregressive model. This test has been adopted by Narayan (2005, 2006) and Qian et al. (2008). The consensus is that stock price indices exhibit threshold nonlinearity. Narayan (2005) and Qian et al. (2008) report unit roots in both regimes, while Narayan (2006) finds partial unit root regime in the US stock price index. Koustas et al. (2008) re-examine the US stock market data using a three-regime self-exciting threshold autoregressive (SETAR) process. Their results show that the inner regime is characterized by unit root process but the two outer regimes are well captured by a stationary autoregressive process. This body of literature also employs unit root tests that allow the alternative hypothesis to incorporate nonlinear dynamics (Hasanov, 2009a, b) and a transitional autoregressive process (Kim et al., 2009). The applications of these tests show strong mean reversion tendency in stock prices. Despite all the methodological advances, Rahman and Saadi (2008) suggest that unit root is a necessary pre-requisite for the validity of the random walk hypothesis; but not sufficient because the return series must also be serially independent. Rahman and Saadi (2008) comment, *"Essentially, these papers use tests that are only designed to show whether a series is difference-stationary or trend-stationary, and to investigate whether stock price index series are unpredictable or at the least, uncorrelated. However, a time series can be stationary and at the same time predictable, and therefore unit root tests are not appropriate for testing the random walk hypothesis"* (p. 206).

3.2 Cointegration

Much of the extant literature that examines the inter linkages among markets actually tests the interdependence using the Johansen-Juselius cointegration (or VAR) techniques. These studies use daily/ weekly data from developed and emerging economies. Under this approach, if stock prices indices of two or more countries are found to be cointegrated, the claim is: these stock markets are interdependent and there are no benefits from portfolio diversification. In this section we briefly review the recent studies.

Husain and Saidi (2000) examine the integrating behavior of stock markets in the US, UK, France, Germany, Japan, Hong Kong and Singapore with the Pakistan stock market. After accounting for the structural shift, they found one co-movement path. Siklos and Ng (2001) investigated the integrating behavior of five stock markets in the Asia-Pacific region with US and Japan. They find one co-integrating vector among seven stock markets. Ng (2002) applied several approaches to examine linkages among five stock markets in the South-East Asian region. Although the co-integration test did not support any co-movement, the correlation matrix and the time varying model showed signs of gradual integration of the markets. Johnson and Soenen (2002) investigate the degree to which twelve stock markets in Asia are integrated with that of Japan. Based on the results of a Geweke measure of feedback, they conclude that some of the markets are highly integrated with Japan's market. Ibrahim (2003) investigated the long-run relationship and dynamic interactions between the Malaysian stock market and major stock markets in US and Japan, and found cointegration. Yang et al. (2003) examined the European Monetary Union (EMU) and European stock market integration and found two co-integrating relations that are converging fast to the long run path following the EMU. Darrat and Benkato (2003) investigated the impact of liberalization of the Istanbul stock exchange (ISE) on its integration opportunities with the major world stock markets (US, UK, Japan, Germany); and whether as a result the ISE has become more prone to spillovers. The answer to both was yes. Cooray (2004) found three cointegrating vectors among the four stock prices lending support to the weak form efficiency in Sri Lanka, India, Bangladesh and Pakistan. Wong et al. (2005) studied the integrating behavior and short-run dynamic linkage between the stock markets in India and major developed countries (U.S., U.K. and Japan) and found that the former not only integrates with mature stock markets but is also sensitive to the external dynamics. Fraser and Oyefeso (2005) examined convergence between the US, UK and seven European stock markets and found a common trend. Gunasinghe (2005) examined the integration behavior and volatility spillover transmissions across the stock markets of Sri Lanka, India and Pakistan for the post 1990 liberalization period but did not find any long-run relation. Ahmad et al. (2005) examined the inter linkages and causal relationship between the Nasdaq composite index in the US, the Nikkei in Japan with that of National Stock Exchange (NSE) Nifty and BSE Sensex in India. They failed to find cointegration. Granger causality test shows unidirectional causality from Nasdaq and Nikkei to Indian stock markets. Hoque (2007) explored the dynamics of stock price movements in Bangladesh with that of USA, Japan and India. The results showed cointegration among the markets. Madhusoodanan and Kumar (2008) examined cointegration and causality between the BSE and the NSE and found market integration suggesting information dissemination between them. K.G. and Tiwari (2012) analyzed the short term and long term linkages between the sectoral indices of BSE and found that most of the indices in India are cointegrated with at least one other, indicating that the sectoral indices possess useful information about co-movements. Such co-movements indicate that the BSE is not weak form efficient. That is, the opportunity from sectoral portfolio diversification might be limited.

3.3 Long Memory

The rescaled variance statistic (V/S) a la Giraitis et al. (2003) has emerged as a competing tool to test long memory (see Cajueiro and Tabak, 2005b; Assaf, 2006, 2008). However, the evidence in favor of significant long memory in stock return series is far from persuasive. Cheung and Lai (1995) and Hiemstra and Jones (1997) extend Lo's model (1991) but the modified rescaled range statistic failed to reject the null hypothesis of no long memory at any reasonable significance level. Their conclusion is further reinforced by the Geweke and Porter-Hudak (GPH) spectral regression. Using a battery of four different statistical tests, Sadique and Silvapulle (2001) find evidence of long memory in the weekly stock returns for four of seven markets in their sample. Similar mixed results are also reported for stock markets in the Middle East region (Assaf, 2006; Maghyereh, 2007). Some researchers also find evidence of long memory (see Barkoulas et al., 2000; Limam, 2003; Cajueiro and Tabak, 2005b; Christodoulou-Volos and Siokis, 2006; Kyaw et al., 2006; Serletis and Rosenberg, 2009; Tiwari and Chaudhari, 2012).

3.4 Asia

The literature on the Asian economy is sizeable (see, discussion in section 3.2 above). In the Indian context a number of studies have tested the random walk hypothesis. Earlier works in this area include Sharma and Kennedy (1977). They examined the validity of random walk hypothesis in Bombay, London and New York stock markets and found that the BSE is efficient in its weak form. Gupta (1990) used data from 1979 to 1987 to examine the hypothesis. Using the Runs test for serial correlation he found that the market follows a random walk. Using post 1990 reform data, Poshakwale (1996) and Gupta and Basu (2007) found that the Indian stock market is informationally inefficient. Sumanta (2004) analysed monthly data for the BSE 100 index from 1993 to 2001 and found that the extent of informational efficiency of Indian stocks was different during 18 sub periods. However, Fuss (2005) observed that the BSE exhibits a weakly efficient market following liberalization policies of the 1990's. Recently, Mishra and

Pradhan (2009) examined the efficiency characteristics of the market, in light of the recent economic crisis and observed that the Indian stock market is informationally inefficient.

Some studies, especially those in the emerging market context, examine the short- and long-run relationship between stock indices to explore the validity of random walk hypothesis. Buguk and Brorsen (2003) suggested that stock indices can be used to test efficiency and performance of market in emerging economies. Al-Fayoumi, and Al-Thuneibat (2009) also examined the dynamic linkages between the stock indices in Amman market and found support for informational inefficiency. These results show that the diversification of portfolio across sectors may not produce high returns as noted by Wang et al. (2005). The authors examined the linkages between Chinese sectoral stock indices.

Squalli (2006) examined the weak-form efficiency for the Dubai Financial Market (DFM) and the Abu Dhabi Securities Market (ADSM) in the United Arab Emirates. The Variance Ratio (VR) tests results show that most of the economic sectors are inefficient. Similar results were found by Hassan and Chowdhury (2008) and Chakraborty (2006) with respect to stock returns in Bangladesh and Pakistan. The recent improvements in VR methodology rekindled interest in Asian stock markets. Hoque et al.(2007); Kim and Shamsuddin (2008) find weak-form efficiency for emerging stock markets [see Al-Khazali et al. (2007) for Bahrain, Jordan, Kuwait, Oman, Saudi Arabia; Smith (2007) for Israel, Jordan and Lebanon; Kim and Shamsuddin (2008) for South Korea, Taiwan and Thailand; Smith (2009) for Turkey].

K.G. et al. (2012) examine the weak form efficiency in stock returns for Brazil, Russia, India and China (BRIC). The study uses Lee and Strazicich (2003, 2004) and Narayan and Popp (2010) unit root tests. Subsequently, the test proposed by Brock, Dechert, and Scheinkman (BDS) (1987) and K2K test (as an alternative to BDS) also has been used to check the i.i.d properties of stock returns. They found unit root among the stock returns of the BRIC economies. However, these stock returns do not follow the i.i.d property indicated by the K2K test, a requirement for fulfillment of the weak form efficiency (Rahman and Saadi, 2008).

4. DATA AND VARIABLES

The test of weak form of efficiency of BSE sectoral indices is carried out by using daily data from August 23rd 2004 to June 31st 2010.[4] The BSE has eleven sectoral indices e.g., capital goods, consumer durables, fast moving consumer goods **(**FMCG), banking, metal, oil and gas, healthcare, auto and information technology. Of these, capital goods, consumer durables, FMCG, and healthcare indices[5]data was launched in 1999 (based on full market capitalization method), banking index in 2003, auto metal and oil and gas in 2004, and power and realty indices in 2007. All indices were shifted to floating market capitalization method[6] on 23rd August 2004. The daily index data has been collected from the "Prowess" database provided by Center for Monitoring Indian Economy (CMIE). Power and realty indices are not available prior to 2007 so we have excluded them from the study. This leaves us with a total of eight indices to consider. All the variables have been converted in to natural logarithm before conducting the statistical analysis.

[4]We accept the argument that in time series analysis number of observations does not matter while it is the time duration which plays a crucial role. However, there are numerous studies which have used daily data for analysis particularly in stock market and for shorter period of time. Therefore, we have followed them in our work. Of course, our results will be subjected by the time duration. Further, in order to minimize the subjectivity of our results we also provided simulated critical values for our data.

[5] IT sector was also introduced in the same year however, we have excluded from our analysis because of its extreme volatile nature.

[6] Free-float market capitalization takes into consideration only those shares issued by the company that are readily available for trading in the market. It generally excludes promoters' holding, government holding, strategic holding and other locked-in shares that will not come to the market for trading in the normal course.

5. METHODOLOGY

To establish the stationary property of the series (i.e., to test the weak form of efficiency) we applied Breitung's (2002) nonparametric unit root test. The null hypothesis under test is, H_0: y(t) is a unit root process with drift, against the alternate, H_1: y(t) is a trend stationary process.

To test the possibilities of portfolio diversification in BSE sectoral indices, we utilized the Bierens' (1997) and Breitung's (2002) non-parametric cointegration test. The Bierens' (1997) method is based on the generalized eigenvalues of matrices A_m and $(B_m + n^{-2}A_m^{-1})$ where A_m and B_m are defined as the following matrices:

$$A_m = \frac{8\pi^2}{n}\sum_{k=1}^{m} k^2 \left(\frac{1}{n}\sum_{t=1}^{n} \cos(2k\pi(t-0.5)/n) z_t\right) \times \left(\frac{1}{n}\sum_{t=1}^{n} \cos(2k\pi(t-0.5)/n) z_t\right)'$$

$$B_m = 2n\sum_{k=1}^{m} \left(\frac{1}{n}\sum_{t=1}^{n} \cos(2k\pi(t-0.5)/n)\Delta z_t\right) \times \left(\frac{1}{n}\sum_{t=1}^{n} \cos(2k\pi(t-0.5)/n)\Delta z_t\right)' \quad (2)$$

which are computed as sums of outer-products of weighted means of z_t and Δz_t, where z_t is the observable q-variate process for $t = 0,1,2,3...n.$ and n is the sample size. To ensure invariance of the test statistics to drift terms, the weight functions of $\cos(2k\pi(t-0.5)/n)$ is suggested here. Note that the condition $m \geq q$ must be satisfied and the optimal value of m can be chosen based on Table 1 of Bierens (1997).

Similar to the properties of the Johansen and Juselius (1990) likelihood ratio method, the ordered generalized eigenvalues of this non-parametric method are obtained as solution of the problem $\det[P_n - \lambda Q_n] = 0$ when the pair of random matrices $P_n = A_m$ and $Q_n = (B_m + n^{-2}A_m^{-1})$ are defined. This approach can be used to test the hypothesis about cointegration rank r.

To estimate r, two test statistics are proposed by Bierens (1997). First, Bierens (1997) derives the 'lambda-min' $(\lambda_{\min}), \hat{\lambda}_{q-r,m})$ which corresponds to the Johansen's maximum likelihood method to test the null hypothesis of $H_0(r)$ against the alternative of H_1(r+1) and tabulates the critical values for this test. Second, Bierens' (1997) approach also provides the $\hat{g}_m(r)$ which is computed from the Bierens'(1997) generalized eigenvalues:

$$\hat{g}_m(r) = (\prod_{k=1}^{q} \hat{\lambda}_{k,m})^{-1} \qquad \text{if r = 0,}$$

$$= (\prod_{k=1}^{q-r} \hat{\lambda}_{k,m})^{-1}(n^{2r} \prod_{k=q-r+1}^{q} \hat{\lambda}_{k,m}), \qquad \text{if r = 1,2,3,4,….,q-1.}$$

$$= n^{2q} \prod_{k=1}^{q} \hat{\lambda}_{k,m}, \qquad \text{if r = q.}$$

where *m* is chosen for $r<q$, and $m = q$ is chosen when $r = q$ (Bierens, 1997; Table 1) It is noted in Bierens (1997) that $\hat{g}_m(r)$ converges in probability to infinity if the true number of cointegrating vector is unequal to *r*, and $\hat{g}_m(r) = O_p(1)$ if the true number of cointegrating vector is equal to *r*. Therefore, we have we have $\lim_{n\to\infty} P(\hat{r}_m = r) \approx 1$, when $\hat{r}_m = \arg\min_{0\le r\le 1}\{\hat{g}_m(r)\}$. Thus, this test statistic is useful as a tool to double-check on the test results of *r*.

Finally, a linear restriction on the cointegrating vectors is needed because not all of the series will enter the cointegrating vector system. To address this, Bierens (1997) proposed the trace and lambda-max statistics. The critical values of trace ($m = 2q$, F (x) k = cos($2k\pi x$)) and lambda-max tests ($m = 2q$, F (x) k = cos($2k\pi x$)) are given in Bierens (1997, Tables 3 and 4).

Breitung's (2002) nonparametric cointegration test is based on the following rationale:

Let y(t), t=1,...,n, be a 8-dimensional unit root process, such that: y(t) = y(t-1) + m + u(t), where u(t) is a zero-mean stationary 8-dimensional time series process, and m is a 8-dimensional vector of drift parameters. If m = 0 (i.e., no drift), let z(t) be the demeaned vector time series y(t), otherwise let z(t) be the detrended vector time series y(t). Compute the partial sums

Z(t) = z(1) + z(2) + ... + z(t),

and then the matrices

A = Z(1)Z(1)' + Z(2)Z(2)' + ... + Z(n)Z(n)'

B = z(1)z(1)' + z(2)z(2)' + ... + z(n)z(n)'.

Let c(1), ... , c(8) be the increasingly ordered generalized eigenvalues of A with respect to B. If y(t) is cointegrated with rank r then (n^2).[c(1)+...+c(8-r)] converges in distribution to a function of a standard Wiener process, which is free of a nuisance parameters, whereas for k > 8-r, $[(n^2)*c(k)]$ converges to infinity. Therefore, the Breitung's (2002) test is conducted right-sided, starting from the null hypothesis r = 0. The cointegration rank r corresponds to the null hypothesis that is not rejected first. If none is accepted the cointegration rank is r = 8, which implies that y(t) is a (trend) stationary process.

6. Empirical results

As noted, we apply two types of empirical test namely unit root tests and Bierens's (1997) and Breitung's (2002) nonparametric cointegration test. The unit root tests serve as preliminary step to determine the order of integration for each of the stock price indices which are needed for cointegration test. We require that each series has the same order of integration[7], preferably I(1), for a cointegrating relationship. Then we proceed with the Bierens's (1997) and Breitung's (2002) non-parametric cointegration test for a long run relationship among the eight BSE sectoral stock indices. If we find cointegration, then further investigation will be needed to determine which of the price indices will enter the cointegrating vector system. This can be done by imposing the restriction test on each of the cointegrating parameter. Results of Breitung's

[7]This is not however, necessary either in Pesaran's bounds testing approach, or the fractional cointegration tests.

(2002) unit root analysis (along with conventional unit root tests- e.g. PP and DF-GLS)[8] are presented in Table 1.

<Insert Table 1 about here>

The unit root tests results (Table 1) suggest that all stock indices are nonstationary in their level. This provides clue for the presence of weak form of efficiency in BSE sectoral market. Further, these results are also robust under the random walk model using the Breitung's (2002) non parametric unit root test**.** The BSE sectoral indices thus are weakly efficient. To examine the potential for portfolio diversification from these indices we test cointegration among them. The pretest done for autoregressive (AR) order shows that the series are AR(1) process.[9]

4.1 Testing for Cointegration and Restrictions

In this section, we employ the Bierens's (1997) and Breitung's (2002) non-parametric cointegration test to determine whether the eight BSE sectoral indices are cointegrated. First, we present the results of Bierens' (1997) non-parametric cointegration test. This method uses both the $\lambda_{\min}$ and $\hat{g}_m(r)$ statistics to determine the cointegrating rank *r*. Results of Bierens' (1997) $\lambda_{\min}$ test statistics are reported in Table 2.

< Insert Table 2 about here >

Results fail to reject the null hypothesis, *r*= *i*, where *i*=0,1,…8. This implies complete absence of even a single cointegrating vector among the eight indices. To confirm the findings, we report the results of $\hat{g}_m(r)$ test statistics inTable3.

[8] The PP tests correct for any serial correlation and hetroskedasticity in the errors. Under the null hypothesis, the PP test statistics have the same asymptotic distributions as the Augmented Dickey-Fuller (ADF) test. PP tests are robust to general forms of heteroskedastic error term. For appropriate lag length the default procedure is that of Newey-West using the Bartlet kernel method. Elliott *et al*. (1996) proposed to extract the constant and trend effects from the series of interest using the GLS method, before estimating the Dickey and Fuller (1979) test, yielding the so-called DF-GLS test. The latter has the best overall power in small-sample, (Baum 2001; Vougas 2007).

[9] Results of first difference analysis are not reported but can be accessed from the author upon request.

< Insert Table 3 about here >

Results in Table 3 show that the smallest $\hat{g}_m(r)$ statistics is 30.90836959E-001 which appears in the cointegrating rank of $r = 0$. The Breitung's (2002) non-parametric test reported in Table 4.

< Insert Table 4 about here >

It is clear from Table 4 that in none of the cases our null hypothesis could be rejected even at the 10% level of significance. Further, we also simulated the P-values with 10,000 replications and found the same result in each case.[10] This implies that the shocks from any of these eight BSE indices are unlikely to spillover to the other markets within the indices. International investors who are looking for portfolio diversification can stand to gain from these markets. We conclude that there are opportunities for investors to gain from portfolio diversification in BSE sectoral indices in the long run are enormous.

7. Conclusions

The paper tests the random walk hypothesis using data from the BSE, the linkages among the sectoral indices by implementing the non-parametric unit root and cointegration test. We choose tests that are capable of incorporating nonlinearity in the model. Recently developed time series

[10] We also conducted cointegration test in linear framework using the Johansen and Juselius (1990) procedure to compare results, and bootstrapped the trace statistic distribution (the trace statistic is more powerful in the Johansen and Juselius' procedure) with 10,000 replications to get simulated P-values for modes with constant and trend. Our findings are similar to those reported in the two non-parametric cointegration tests. Results available upon request.

technique questions the assumption of linearity in financial time series[11], and provides evidence to the contrary in the DGP of the stock indices. As such, the paper applies nonlinear unit root and cointegration test. Our results support random walk hypothesis. The results might help investors to benefit from sectoral diversification. The evidence offers insights in to the functioning of the BSE sectoral markets. The knowledge can help to attract investors in India and those from across the globe to take advantage from the market, as per predictions of the asset allocation theory.

The main contribution of this study is methodological, as applied to the sectoral indices of BSE market. Given solid evidence for non-linearity in stock returns series, this study re-examines the weak form efficiency and integration using a more robust test - the Breitung's (2002) non-parametric unit root test and Bierens's (1997) and Breitung's (2002) non-parametric cointegration test which are more appropriate for stock market data. The potential superiority over the linear Johansen and Juselius (1990) method in detecting cointegration when the DGP is non-linear is novel in the Indian case.

The Breitung (2002) test indicates that BSE sectoral indices are weakly efficient. Results of Bierens's (1997) and Breitung's (2002) tests indicate that there is no common force which brings these BSE sectoral indices together in the long run. This provides support to the view that even if these eight BSE indices are part of a single stock market they are highly independent and non-integrated. This suggests that the potential for benefits from portfolio diversification is enormous within these BSE indices. Although, based on the results of eight BSE sectoral indices the market can be considered risk free as there is no evidence of spillover of shock in one sector to the other; it is important to note that there is always an element of risk in integrated financial

[11] Theoretically, there is no reason to believe that economic systems must be intrinsically linear (see, for example, Pesaran and Potter 1993, Campbell *et al.* 1997, Barnett and Serletis 2000).

markets. The heterogeneous nature of these indices is often cited as reasons that restrict the spillover effect. We feel that future research in the area will help investors assess market risk and opportunity of return. In light of the forces generating the BSE sectoral stock indices market independence, more studies are needed for further robust result.

Our results are in line with Sharma and Kennedy (1977), Gupta (1990), Poshakwale (1996), and Gupta and Basu (2007) and Sumanta (2004). Fuss (2005) found a weakly efficient BSE only for the post 1990 liberalization policies. The Indian stock market is informationally inefficient in light of the recent economic crisis. Among other Asian markets, Al-Fayoumi, and Al-Thuneibat (2009) found support for informational inefficiency for Amman market; suggesting that strategy of diversification of portfolio across sectors may not yield high returns as noted by Wang *et al*. (2005).

Our findings are different from those of K.G. and Tiwari (2012) who also analyzed the short term and long term linkages among the sectoral indices of BSE using the daily data on nine sectoral indices for the period 23rd August 2004 to 31st June 2010, but implemented linear cointegration test that incorporate structural breaks in the data set. Their study found that most of the sectoral indexes in India are cointegrated with at least one other indicating that the sectoral indexes possess useful information about the movements of other indices. The co-movements among the sectoral indices indicate that the BSE is not weak form efficient and the possibility of sectoral portfolio diversification is limited.

Our finding that BSE sectoral indices are weakly efficient should guide investors in their investment decisions with regard to portfolio diversification in the Indian stock market. The results are relevant and useful for both fundamental and technical analysis of stock markets.

Since stock markets are a barometer for the economy, the results can also help us examine the overall economic situation, and help to identify potential problems in the financial market.

It should be kept in mind that the use of daily closing stock indices would mean that the limits for daily price could be affected by the closing price of the previous day. It is plausible that the data would have hit a circuit breaker and thus be contaminated. Even so, daily price data is crucial to the understanding of the behavior of the series. It should be pointed out that relations among stock markets are also affected by macroeconomic variables such as trade and levels of foreign exchange. Future research should incorporate relevant macroeconomic series which might provide more insight in to the working of equity market.

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Table 1. Univariate unit root tests

	Level#		
	Breitung's nonparametric unit root test- statistic: B(n)/n	PP (k)	DF-GLS (k)
Durable	0.01199	-2.071114 (13)	-0.946576 (1)
FMCG	0.00743	-2.623222(4)	-1.282842 (2)
Bankex	0.00647	-2.304821(12)	-1.604284(1)
Metal	0.00481	-1.921836 (12)	-1.644317 (1)
Oil and Gas	0.00877	-1.831476 (6)	-1.631303 (1)
HC	0.00562	-2.051351(13)	-1.648985 (1)
Capital goods	0.01050	-1.652361(6)	-0.897087 (1)
Auto	0.00902	-1.364646(12)	-1.167698(1)

Note: (1) 0.00450 and 0.00355 are critical values at the 1% and 5% respectively.

(2) Critical values for PP are -3.964, -3.413and -3.1284 at 1%, 5% and 10%and. critical values for GF-GLS are -3.48, -2.89 and -2.57 at 1%, 5% and 10%, respectively.

(3) "k" in parenthesis represents the chosen lag length. For PP test lag length is chosen by Newey-West method using Bartlett kernel and in case of GF-GLS lag length is determined on the basis of SIC because of its superior performance in Monte-Carlo simulations.

(4) #We have not presented results of first difference form of the variables for brevity however, results can be accessed from the author upon request.

(5) Results reported for PP and DF-GLS are based on constant and trend both in regression equation. We have analyzed the case when only constant term is present in the equation (in level and first difference). These results are also available upon request.

Table 2: Bierens's non-parametric Cointegration Test Results (λ_{min}statistics)

H0	H1	λ_{min}
$r = 0$	$r = 1$	0.08640
$r = 1$	$r = 2$	0.08794
$r = 2$	$r = 3$	0.15477
$r = 3$	$r = 4$	0.46393
$r = 4$	$r = 5$	1.69493
$r = 5$	$r = 6$	2.67499
$r = 6$	$r = 7$	3.44171
$r = 7$	$r = 8$	15.63051

Source: Author's calculation

Table 3: Bierens's non-parametric Cointegration Test Results $\hat{g}_m(r)$ statistics	
Cointegration rank (*r*)	$\hat{g}_m(r)$
$r = 0$	30.90836959E-001
$r = 1$	32.02369916E+003
$r = 2$	13.12328206E+008
$r = 3$	89.63297745E+012
$r = 4$	40.62978621E+018
$r = 5$	15.10487234E+025
$r = 6$	26.40799309E+032
$r = 7$	12.33031709E+040
$r = 8$	12.76949528E+049
Source: Author's calculation	

Table 4: Breitung's cointegration test

H_0	H_1	Test-statistics	10%critical value	5% critical value	Simulated p-values
$r = 0$	$r > 0$	7679.72	8830.00	9388.00	0.32740
$r = 1$	$r < 1$	3964.66	6484.00	6984.00	0.93830
$r = 2$	$r < 2$	2147.82	4572.00	4954.00	0.99820
$r = 3$	$r < 3$	1326.19	3107.00	3429.00	0.99790
$r = 4$	$r < 4$	708.97	1972.00	2184.00	0.99880
$r = 5$	$r < 5$	341.91	1158.00	1330.00	0.99980
$r = 6$	$r < 6$	136.65	596.20	713.30	0.99990
$r = 7$	$r < 7$	49.75	222.40	281.10	0.95420
Conclusion			$r = 0$	$r = 0$	$r = 0$

Note: (1) Test results for the case that y(t) has drift; (2) P values are based on 10,000 replications of Gaussian random walks with length n = 1454.

Source: Author's calculation