Empirical Investigation of the Nature of Returns of Stock Prices of three Prominent South Asian Markets using Parametric and Non Parametric Techniques

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Abstract

The present study makes an attempt to test whether the returns of the three major indices of the prominent South Asian Markets namely BSE Sensex, CSE ASPI and Pakistan KSE 100 follow aStationary Process.The month wise closing data has been collected for the above indices and period of the study is eleven years, April 1, 2005 –March 31, 2016, The data has been log transformed to first difference (ln.P_t - ln. P_{t-1})and all the tests have been applied on log transformed data.Both Parametric and Non Parametric tests have been employed for testing the hypothesis of Stationarity. The parametric tests include Augmented Dickey Fuller test which has been traditionally used for checking the non-random character of time series, Dickey Fuller Generalized Least Squares (DF GLS of Elliott, Rothenberg, and Stock (1996) test,Box Pierce(1970) 'Q' statistics, &Variance Ratio technique of Lo and Mac Kinlay(1988). The non-parametric tests include turning point test, the difference of the runs test & KPSS(1992)test. The hypothesis has also been tested graphically using autocorrelation and partial autocorrelation techniques The variance ratio tests for randomness is applied first by assuming homoscedasticity or constant variance, &later by making it robust after incorporatingheteroscedasticity in time series.

The results of our study as revealed by parametric tests (ADF, 'Q' Statistics & Lo and Mac Kinlay Variance Ratio tests) confirm that the returns of, CSE ASPI is stationary, KSE is found to be stationary in three out of four tests, while BSE Sensex is stationary in only two of the four tests.. Coming to non-parametric results, runs test and KPSS test support stationarityof returns of all our indices. The present study shows that testing of stock returns for stationarity using only one single test is not at all conclusive &a good research must combine two-three parametric and one-two non parametric tests to get the satisfactory result w.r.t. stationarityof a variable.

Keywords: *Variance Ratio Test, Random Walk, Homoscedasticity, DF GLS test, South Asian Markets*

I. Introduction

The phrase, *Stock Prices are Non- Stationary or simply random in nature*actually implies that the probability or the chance of stock prices going up in future is equal to that of going down i.e. stock prices are expected to take an unpredictable path. This behavior of Stock Prices was first examined by Kendall (1953) where he laid down that the stock price fluctuations are independent of each other but maintain an upward trend over a period

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of time. The concept was however discussed in detail by Paul Cootner in his book ;*The Random Character of Stock Market Prices (1964)*, the book actually was an English Translation of Bachelier's (1900) research work that stock prices reflect all available information. The random walk was eventually confirmed by Fama (1965) &Fama (1970) where he discussed in detail Efficient Market Hypothesis (EMH) and split this hypothesis into three layers/forms; namely the weak, semi strong and strong forms. The lowest layer or the weak form of EMH would signify the random walk behavior of stock prices.

In general we can easily divide the theoretical and empirical research in this area into two distinct groups , one which supports the hypothesis that the stock prices are not predictable or are in favour of Efficient Market Hypothesis (EMH) in weak form & this group includes Kendell (1953), Fama(1965, 1970, 1995),Cootner (1964) while the second group which includes the group of researchers who do not support this hypothesis and conclude that stock prices are predictable using historical patterns ; studies by Lucas (1978) and Lo & Mac Kinlay (1988) support non-random behavior of the stock prices.The concept itself is not new in the sense that randomness has been tested in physical sciences where the researchers are interested in knowing path traced by a molecule. Bachelier (1900) in his Mathematics Dissertation had recognized this aspect by using Brownian Motion more than hundred years back.

In 1988, Wall Street Journal tested the RWH by Dart Board Game where the two types of investors were chosen, one set of investors were financial experts while the second set selected stocks by throwing darts. The analysis which was made after some time showed that dart throwers were winners for 39 rounds while financial experts were winners in 61 rounds, showing expert knowledge was helpful in getting a better score on stock markets. However Malkiel, B. G. (1999) was the foremost in challenging these results and he contested that the stocks picked by experts enjoyed superior publicity which lead to their rise in prices.

Over the years, testing of financial markets for a stationaryprocess has become one of the most popular areas of research on Financial Markets. However it has been found that most researches do care about testing the randomness using a simple tool of Dickey Fuller Unit Root&once the desired result is achieved, they proceed with further research like Causality, Co-integration, error correction in time series.

The present study shows that testing of stationarity using only one single test is not at all conclusive&therefore one needs to combine with two-three parametric and one-two non parametric tests to get a satisfactoryresult w.r.t. stationarityof the variable.

II. About the Sample & Scope of the Study

The present study is an attempt to test stationarity of stock returns of three major South Asian Markets namely India, Pakistan & Sri Lanka. The three countries account for 92 % of the GDP and 94 % of the exports arising out of the South Asian region (www.imf.org). In all the three countries financial institutions, banks and stock markets are fairly developed. We have chosen the three major indices; Bombay Stock Exchange's Sensex, Karachi Stock Exchange's KSE 100 & and Colombo's CSE ASPI Index as our sample.The period of our study is eleven years, April 1, 2005 –March 31, 2016. The month-wise closing data has been collected for the above indices for the sampled period. Other countries of the region were not considered due to either non availability of statistics on the country's stock index or due to lack of consistency and regularity of data.

To test the hypothesis of stationarity,we have applied both Parametric&Non Parametric tests. Besides applying these tests we have also tested the hypothesis of random walk with the help of Bar Charts and popular Lo &Mac Kinlay (1988) Conventional Variance Ratio Test. For applying the various tests, the data on monthly closing prices has been converted to log returns by applying the following formula $ln(P_t / P_{t-1})$, where P_t is the index at time t &P_{t-1} is the index at time t-1 and therefore the analysis focuses on random walk of returns and not the closing prices. The sources of data from where information has been collected include the websites : *www.bseindia.com, in.finance.yahoo.com, www.kse.com,www.cse.lk.*

III. Review of Literature

Different methodologies have been used by researchers to test thestationarycharacteristics in financial markets. Whereas the use of parametric and non-parametric tests is quite common; other tests like using graphic representation of random walk, variance ratio tests have also been applied by many researchers for testing the hypothesis of Random Walk. Other type of tests include the test of linearity in time series, calendar effect tests (day of the week or month of the year effect) etc. Further the random walk studies have been carried out by researchers on all types of markets viz. Stock Markets, Foreign Exchange Markets, Commodities and so on with focus on both Developed & Emerging Markets including Indian Markets. In our study since we have restricted our sample to South Asian Markets, we try to review the literature of those studies which have a focus onStationary Characteristics of South Asian Markets. However since only a few researchers have focused on these markets from the angle of verifying the efficiency of these markets we shall extend our review of literature study to other Asian Markets as well.

Chopra K et.al (2015) applied both Parametric and Non Parametric tests to test the Random Walk Hypothesis on three South Asian Markets for a ten year period & the results showed that parametric tests rejected the random character of the indices. On the other hand the non parametric tests clearly showed that the behavior of these markets was random. *Sunal G et.al (2014)*applied ADF, day of the week & runs test on Indian Markets to test for Random Walk. The results failed to give a complete and concrete picture on weak form of market efficiency in Indian Markets i.e. the results were mixed with respect to weak form efficiency in Indian Markets. *Nisar, S., &Hanif, M. (2012)*studied weak form efficiency for four South Asian markets ; India, Pakistan, Bangladesh and Sri-lanka using different time interval data i.e. daily, weekly and monthly returns data for a period of 14 years (1997-2011) using both parametric and non parametric tests and found that none of the markets were weak form efficient. *Arora H (2013)* tested for random walk on Indian Markets &the results showed that the Random Walk could not be rejected in Indian Markets.*Nikunj R. Patel, NiteshRadadiaand JuhiDhawan (2012)* selected Asian markets which included India, China, Hong Kong and Japan for 11 year period & applied ADF, auto-correlation and variance ratio test. The results showed mixed picture in terms of Random Walk & Weak Form Efficiency of these markets.

Nikunj R. Patel, Bhavesh K. Patel & Darshan Ranpura (2011) got contradictory about random walk hypothesis when they conducted their study on BSE & NSE under different time frames during the period (1998-2010). The tests applied were ADF, runs test & autocorrelation. *Madhusoodanan, T. P. (1998)*applied the variance ratio tests on Indian Markets, these were applied bothindividual stock wise and for the entire market. The tests were carried out both under the assumption of homoscedasticity & with robust heteroscedastic error term. The findings revealed that Indian markets do not follow random walk at the aggregate index level, while at the individual stock level only 16 out of 120 stocks which were studied showed random behaviour. *Lim, K. P., Brooks, R. D., & Kim, J. H. (2008)* tried to study the effects of 1997 financial currency crisis on Asian Markets by dividing the sample into three parts, pre crisis, during crisis and post crisis. The results showed that the crisis did impact Asian Markets, however their efficiency improved post crisis. The methodology used was rolling Bi-Correlation (H) Statistics.

*Kim, J. H., & Shamsuddin, A. (2008)*examined for a fifteen year period using new multiple variance ratio tests whether Selected Asian stock market returns follow a martingale process/weak form market efficiency. The results showed that market efficiency was directly related to level of equity market development i.e. in Asia advanced markets like S Korea, Hong Kong, Japan& Singapore showed that they were weak efficient, while other markets were found to be inefficient. Moreover few markets did become efficient after Asian currency crisis of 1997. *Cooray, A., &Wickremasinghe, G. B. (2007)*examined four markets of the South Asian Region namely India, Pakistan, Bangladesh and Srilanka for their efficiency. The weak form efficiency was tested by Unit root tests (ADF, GLS ADF) while semi strong was tested by causality and co-integration The results showed all markets to be weak form efficient using ADF and all except Bangladesh were efficient using GLS ADF. The semi strong was not proved in any market.*SunilPoshakwale (1996)* conducted calendar effect studies on Bombay Stock Exchange (1987-1994), results did provide some evidence of 'day of the week effect' reflecting market inefficiency. *Ayadi, O. F and C.S. Pyun (1994)* tested RWH on Korean Markets using the conventional Lo & Mac Kinlay Variance Ratio test (1988) & found that the hypothesis was rejected with the assumption of homoscedasticity but was accepted when the error term was made robust.

IV. Methodology Adopted

The Hypothesis of Non Stationary (Random walk) tracksthe following model :

$$ln.P_t = ln.P_{t-1} + u_t$$

We test this Hypothesis in Returns of Select South Asian Markets using parametric and non parametric tests. Whereas the parametric tests would make an assumption about the parameters of population or the underlying distribution, the non-parametric tests make no such assumption or are distribution free tests. We also try to test the hypothesis graphically with the help of Bar Charts through autocorrelation and partial autocorrelation function.

(A) Parametric Tests

1. Augmented Dickey Fuller Test

This test is one of the more popular tests &commonly applied to test whether time series data follows a stationary process. For the three indices for which we are carrying out these tests we develop three equations as under :

Δ Ret Sensex $_t$ =β_1+(β_2 – 1)Ret Sensex $_{t-1}$ + $\sum_{i=1}^{m} \beta_{3i}$ Δ Ret Sensex $_{t-i}$ + u_{1t} ...... eq(i)

Δ Ret KSE$_t$ = π_1 + (π_2 – 1)Ret KSE $_{t-1}$ + $\sum_{i=1}^{m} \boldsymbol{\pi}_{3i}$ Δ Ret KSE $_{t-i}$ + u_{2t} ...... eq(ii)

Δ Ret CSE ASPI $_t$ = α_1 + (α_2 – 1)Ret CSE ASPI$_{t-1}$ + $\sum_{i=1}^{m} \boldsymbol{\alpha}_{3i}$ Δ CSE ASPI $_{t-i}$ + u_{3t} ... eq(iii)

(For the equation (i) ; Δ Ret Sensex$_t$ is change in Sensex return in period t,. (β_2 – 1) is the coefficient of the Random Walk for variable Ret Sensex $_{t-1}$, $\sum_{i=1}^{m} \beta_{3i}$ Δ Ret Sensex$_{t-i}$ denotes change in Sensex return in period t-1 & is the augmented variable which has been added to take care of autocorrelation and the term sums up 'm' times till the autocorrelation is removed. Finally u_{1t} is random error term. Similarly we test for the random walk of our rest of the two other equations; equation (ii) & (iii))

The testable hypothesis (H_0) for our test for random walk would be

β_2 – 1 =0 Or β_2 = 1 (the stock returns follow a non-stationary process)

Alt Hypothesis (H_a): β_2 – 1 <0, (Nifty IT is stationary*)*

Note: We are testing at one tail only as we want to avoid the explosive process

2. Dickey Fuller Generalized Least Squares (DF GLS)

A test given by Elliott, Rothenberg, and Stock (1996) stated that it is important to first transform the time series via a generalized least squares (GLS) regression. Next on this data we perform the usual ADF test but we must exclude intercept i.e. we get

$$\Delta y_t^d = \alpha_1 y_{t-1}^d + \beta_1 \Delta y_{t-1}^d + \beta_2 \Delta y_{t-2}^d + \beta_3 \Delta y_{t-3}^d + \ldots + \beta_p \Delta y_{t-p}^d$$

The above equation is similar to ADF except the variable (y_t^d) has been GLS de-trended.

3. Box Pierce 'Q' statistics (1970)

The test is performed by making a Joint Hypothesis for correlations between residual return and residual lag returns & whether or not these are simultaneously equal to zero. The Null if proved shows that there is no serial correlation or there is random walk behavior of our time series. The formulafor 'Q' is as under:-

Q Statistic (Q_m) =n $\sum_{k=1}^{m} \rho_k^2$

The Statistic ''Q Computed Value is compared with Chi Square Value with 'm' degrees of freedom, where m = no. of lags, where 'p' is estimator of autocorrelation.

Null Hypothesis (H_o): Time series is without serial correlation.

4. Lo & Mac KinlayVariance Ratio test (1988)

According to this test :*if a stock follows a random walk, then the increments in the variance as 't' changes have been proved to be linear.*

Let us further assume the lag difference between two variables is '2'(q=2), then if we consider one variable returns as R_{t-2}, R_{t-3}, R_{t-4},R_{t-5},....., the second set of variable shall have returns ; R_{t-4}, R_{t-5}, R_{t-6}, R_{t-7},..... Next we find out the Š or the difference between the returns of these two variable's, & for this new time series we compute variance. Now for a random series the above variance so computed i.e. Var. (q) must be equal to 'q' x one period difference variance.

e.g. if we consider one series as lag 10 and second as lag 13, then 'q' which is '3'multiplied by variance of *one* period difference between the two time series i.e. $\boldsymbol{\sigma^2 (R_t - R_{t-1})}$ =

σ^2{R_{10} -R_{11},R_9- R_{10},R_8–R_9, R_7-R_8,............. }must be equal to Variance of *three* period difference in time series i.e.ό²{R_{10} -R_{13},R_9- R_{12},R_8–R_{11}, R_7–R_{10},............. }

(On the same ground we may say that the variance of annual returns should be equal to 12 x variance of monthly returns.)

Thus we get :-

$$\mathbf{Var\ (q) = q \times \sigma^2 (R_t - R_{t-1}),}$$

where 'q' is the q^{th} difference in lag of the return of two time series. This can easily be developed in random walk formula by putting the two in a ratio i.e.

Null Hypothesis (H_o) : $\frac{\sigma^2(R_t - R_{t-q})}{q\ \sigma^2(R_t - R_{t-1})} = 1$ showing non stationary time series

To test the above hypothesis we have to make an assumption about the behavior of the error term :If we assume this to be homoscedastic (constant variance), then we compute (Z_1) as under :-

Z_1=[Var (q) -1] / $\sqrt{\lambda(q)}$ $\rightarrow$ N(0,1)

where $\lambda(q)$ is defined as homoscedasticity variance ratio and is given by the formula :

$\lambda(q)$ = [2(2q-1)(q-1)] / [3q (nq)]

However if the assumption of homoscedasticity is relaxed then we have to define the heteroscedasticity variance ratio; $\lambda^*(q)$, however the test is also follows N(0,1) after the necessary changes are made in the formula& we compute (Z_2) as under :-

Z_2 = [Var (q) -1] / $\sqrt{\lambda^*(q)}$, $\rightarrow$ N(0,1)

(where, $\lambda^*(q)$ is defined as = $\sum_{j=1}^{q-1}[\ 2(q-j/q)\ ]^2\ \delta_j$)

Further δ_j is defined as

$$\frac{\sum_{t=j+1}^{nq}(R_t - R_{t-1} - \mu)^2(R_{t-j} - R_{t-j-1} - \mu)^2}{\left(\sum_{t=1}^{nq}(R_t - R_{t-1} - \mu)^2\right)^2}$$

(B) Non Parametric Tests

1. Runs Test of Successive Differences

A Run (r) is a sequence of alternate signs where we add up the no. of times the signs change e.g. if the stock's return is '+' on Monday, '-' on Tuesday, Wednesday &Thursday, '+' on Friday, the total no. of runs for the above week are three i.e. two '+' **(say n^+)** and one '-'**(say n^-)** totaling *'three'***(n).** This test does not assume that the positive and negative 'runs' have equal probabilities of occurring*(therefore it is a non-parametric test)*. However the test does assume that these 'runs' are independent and their distribution is identical.

Null Hypothesis (H_o): Observations are Non Stationary.

Alt Hypothesis (H_a) : Non Random Nature of Observations

The two critical values of upper and lower limit are constructed using normal distribution as

(C_1) = $\mu - 1.96\ \sigma$ & (C_2) = $\mu + 1.96\ \sigma$,

Decision Criteria: Accept the Null if the computed 'n' lies within the limits

where μ & μ^2 is defined in specific terms as $\mu = \left[\frac{2(n^+n^-)}{n} + 1\right]$

& σ^2 is defined as $\frac{(\mu-1)(\mu-2)}{n-1}$

(Note : 'n' is total no. of runs and not total no. of observations)

2. Turning Point (Trough & Peak) Test for Randomness (1874)

A turning Point is defined as that value which is different from both preceding & succeeding values; if this value is lower than both preceding and succeeding values it is called *trough* turning point, if it is higher than both preceding and succeeding values it is called *Peak*turning point. The sum of the total no. of peaks and troughsis denoted by ***'p'***.Turning Point test was first used by BienaymeIrenee Jules (1874) and is one of the earliest testfor testing randomness of a variable.

The Null Hypothesis (H_o): Variation in time series is independent (or Series is non stationary).

Alt Hypothesis (H_a) :Stationary time series

For 'n'>30, the turning points are expected to be normally distributed therefore we can easily apply 'Z' test &'z' statistic shall be= | |

(Mean is defined as (μ)= $\frac{2}{3}$ (n-2), n is no. of observations and standard deviation defined as = $\sqrt{\frac{16n-29}{90}}$)

3. KPSS Kwiatkowski–Phillips–Schmidt–Shin (KPSS) (1992)

KPSStest follows a different set of hypothesis i.e. here the Null Hypothesis is presence of a trend while theAlternative Hypothesis must be absence of trend, however rejection of Null would also mean it is quite possible that the stochastic root may still exist. Therefore acceptance of Null simply means that the trend existsor is trend stationary. It is to be noted that trend-non-randomness is mean-reverting, while time series with a stochastic root is not (it has a permanent impact on the mean)

Under this test we first we regress the variable (which is being tested for randomness) against the constant and trend, using OLS to obtain the residuals. These residuals are added to get partial sum of residuals (S_t) ; which is nothing sum at each stage e.g. S_3 would mean sum of first three residuals, S_4 as sum of first four residuals and so on giving $S_t = \sum_{i=1}^{t} u_t$ (i=1,2,3,...). Also we compute an estimate of the variance of the residuals (S^2 {k}), which we then put these in the formula as under :-

KPSS(u) = $n^2 \sum S_t^2 / S^2$ (k), *n is the no. of observations in the sample*

KPSS(u)follows a non-standard distribution, if KPSS (u) is larger than critical then the Null is rejected.

(C) Graphic Representation through Correlogram

Under this test many researchers try to prove the stationarityof a variable graphically using correlogram (or autocorrelation plot), which is simply an image or bar chart of coefficient of correlation statistics. However this is only a test of serial correlation which is only a partial and not a conclusive test of stationarity of a variable.We compute two types of Bar Charts ; the autocorrelation function (ACF) &Partial Autocorrelation function (PACF). Whereas ACF would measure how a time series is correlated with itself at various lags& if different autocorrelations computed are near '0' then the time series is random, if any one or more of the autocorrelations are non-zero & also significant then randomness of the variable must be rejected.On the other hand PACF would give partial correlation of a series with its own lagged values, however here the difference is that it controls for the values obtained at all other lags, this helps in identifying the no. of lags in an autoregressive model. *(ACF does not enjoy control for other lags; ACF at lag3 would mean average combined autocorrelation of the time series with lag1,2&3).*

V. Results & Discussion

The results of our study are given in tabular format in appendices. These results are divided into three segments, the first segment deals with the Statistical Description of the Returns for all the three indices **(Table 1 (a to c)),** second segment discusses the results of testing of the Random Walk Hypothesis on South Asian Markets using Parametric tests **(Table 2-4)** while the third segment deals with Non Parametric testresults(**Table 5 to 7).**

The Statistical Description of the three indices **(Table 1(a to c))** show that highest mean monthly return is seen in case of KSE (1.175 %) followed by BSE (1.08 %) while the CSE gives the lowest mean return at 0.916 %,. CSE on the other hand has reported lowest risk (as measured by standard deviation) at 6.6 % while KSE has the highest Standard Deviation at 7.35 %. As far as skewness is concerned, the BSE & KSE returns are skewed to the left while CSE to the right. This is evident from the sign of skewness and also the Histogram which is represented along with statistical description. Kurtosis is exhibited by all the three indices with KSE and BSE showing highest deviation from normal distribution. In terms of normality of the three indices, only CSE appears to be normal (it has a JB value of 5.89 which is lower than 5.99 ; Chi Square at 2 df))

Considering the parametric tests, the first result is the ADF test results **(Table 2 a)** & since the absolute computed 't' value is higher than absolute critical value at 1 % for all the three indices, we reject the Null of Non Stationarity (for returns) and come to the conclusion that all our index returns are Stationary. The **Table 2 b** which gives the results for return by using DF Generalized Least Squares developed by Elliot Rothenberg & Stock accepts the results of ADF but only for CSE & KSE (these two returns are stationary) however it accepts the Null of non stationary returns for BSE index. Clearly this test where we first de-trend the time series& on the de-trended variable we perform the usual ADF test, is shown by researchers to have a much larger power than the traditional unit root ADF.

The results of the ACF & PACF Plots &'Q' Statistics are given in **Table 3**. The Plots of ACF & PACF clearly show no serial correlation for BSE & KSE stock index returns, however for CSE there is positive serial correlation at 1st Lag. The same hypothesis can be seen by observing the 'p' values of 'Q' Statistics which is again accepting the Null of No Serial Correlation for BSE & KSE indices and rejecting the null for CSE.

The result of the Variance Ratio tests are given in **Table 4.** Now for a non stationary time series, the Variance ratio value for Individual tests must be 1 or close to 1, while if it is less than one then the results are stationary or it is a case of mean reversion. The results of Individual Variance Ratio tests can also be confirmed by applying **Max |z|** or **Wald Chi Square** whose probability **must be more than 0.05 to accept the Null of Randomness of the time series**. Our results clearly show that all our index returns (BSE, CSE & KSE) are having a variance ratio as below 1 for all the periods both for homoscedastic and hetroscedastic robust cases showing non-random character (mean reversion) of our time series.

Coming to the Non Parametric tests **(Table 5-7),** the results of the runs test show that returns of all our indices are stationary, however a different story appears for turning point test which accepts the non randomness of all our index returns. Finally we have the KPSS test results which clearly show that all our indices are non-random*(trend non-randomness to be specific, here the Null is trend non-randomness against the alternative of Stochastic randomness)*as the computed value is lower than the table value in all the three index returns resulting in acceptance of null of trend non-random time series.

VI. Conclusion

The present study made an attempt to test whether the returns of the three major indices of the prominent South Asian Markets namely BSE Sensex, CSE ASPI and Pakistan KSE 100 have stationary characteristics by using monthly closing log transformed data for these indices for eleven year period, April 1, 2005 –March 31, 2016. Parametric and Non Parametric tests have been employed for testing the hypothesis of Random Walk. The parametric tests included ADF, Dickey Fuller Generalized Least Squares Elliott, Rothenberg, and Stock (1996) test,Box Pierce (1970) 'Q' statistics, &Variance Ratio technique of Lo and Mac Kinlay(1988) with both homoscedasticity and hetroscedasticity assumptions. The non parametric tests include turning point test, the difference of the runs test & KPSS (1992) test.

The results of our study as revealed by parametric tests (ADF, DF GLS,'Q' Statistics & Lo and Mac Kinlay Variance Ratio tests) confirm that the returns of CSE indexisstationaryas given by the above four tests while KSE is stationary in three out of these four tests. On the other hand the BSE Sensex return has a 50 % chance of being stationary. Coming to non-parametric results, runs test and KPSS test support stationarity of returns of all our indices. On the other hand turning point test gives a different viewpoint altogether, however many researchers usually ignore the results of turning point test as this 140 year old test gives correct results only under very strong assumptions.

Thus we may conclude by saying that the stationary character of returns is strongly proved in case of CSE returns, to a great extend for KSE returnsbut surprisingly it is not proved for BSE returns.

VII. Policy Implications

The study has important implications for all investors especially the institutional investors coming from abroad as they have the liberty to pick and choose their market from the whole universe of markets. Now if the markets of South Asia also behave in a similar manner (i.e. are weak efficient in their prices and stationary at first difference (or returns) just like the many markets in the west, then they can think of investing in these markets. This is so because these foreign institutions have a strong tradition of investing their funds in efficient and mature markets. Further since the South Asian Markets also have demonstrated that these can grow at a much faster rate than some of the developed markets especially during the last decade, theforeign investors who are attracted to any market by the growth potential it offers, can increase the investment in these markets in a big manner.

On the domestic side, government too should be a lot less worried if markets are efficient in prices as this also implies that any individual or group of people shall not be able to influence the markets, as efficient markets are traditionally known to bounce back to realistic levels fairly quickly. For retail investors investing in these markets, this would be a good signas they shall be able to buy stocks which are appropriately priced with the future prices being largely driven by the corporate performance.

There are some policy implications for the researchers working in the area of financial markets; not to rely on one single test for testing of the stationarity of any stock market, but to go for multiple tests and if possible a combination of parametric and non- parametric tests.

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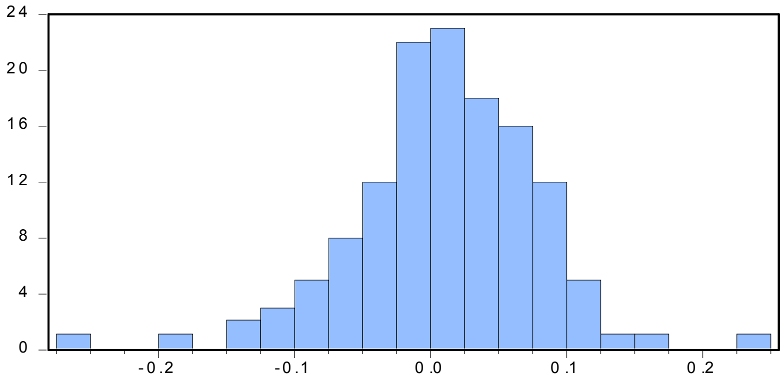
IX. Appendices

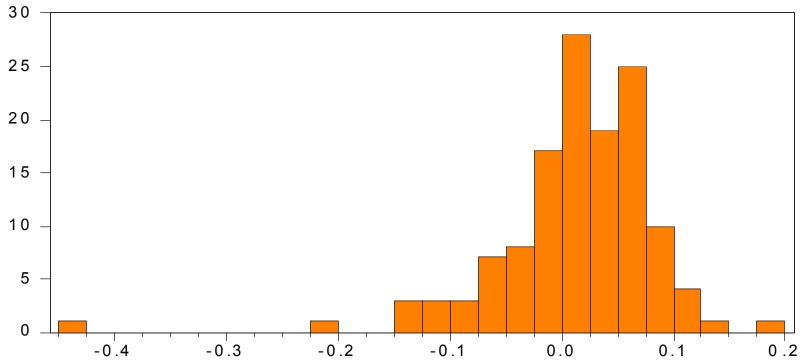
Table 1(a to c) : Statistical Description of returns (mean, median skewness, kurtosis and histogram of returns) for the period April 1, 2005 – March 31 2016 for three indices (BSE Sensex, KSE 100& CSE ASPI) is given below

(a) BSE Sensex Returns



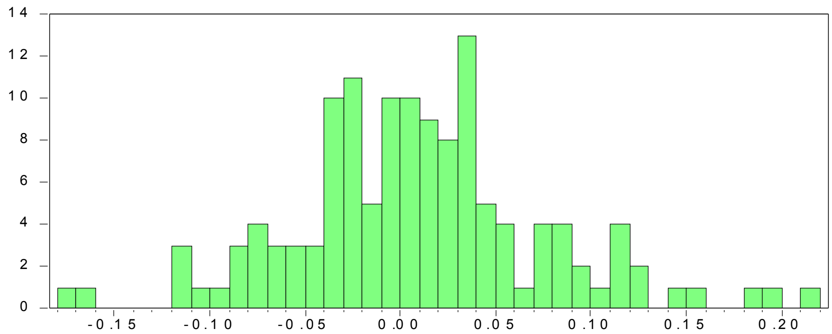
Series: SENSEX_LOG_RET	
Sample 2005M04 2016M03	
Observations 131	
Mean	0.010804
Median	0.011941
Maximum	0.248851
Minimum	-0.272992
Std. Dev.	0.069153
Skewness	-0.526436
Kurtosis	5.408043
Jarque-Bera	37.70185
Probability	0.000000

(b) KSE Index Returns



Series: KSE_LOG_RET	
Sample 2005M04 2016M03	
Observations 131	
Mean	0.011755
Median	0.020202
Maximum	0.180467
Minimum	-0.448796
Std. Dev.	0.073530
Skewness	-2.261489
Kurtosis	14.05295
Jarque-Bera	778.4948
Probability	0.000000

(c) CSE Index Returns



Series: CSE_LOG_RET	
Sample 2005M04 2016M03	
Observations 131	
Mean	0.009157
Median	0.006373
Maximum	0.212441
Minimum	-0.176150
Std. Dev.	0.066114
Skewness	0.286098
Kurtosis	3.867495
Jarque-Bera	5.894761
Probability	0.052477

The no. of Observations are 131 as the description is based upon returns

$$JB = \frac{N}{6}\left(S^2 + \frac{1}{4}(K-3)^2\right)$$

Table 2(a): Results for Testing of the Randomness using ADF Test

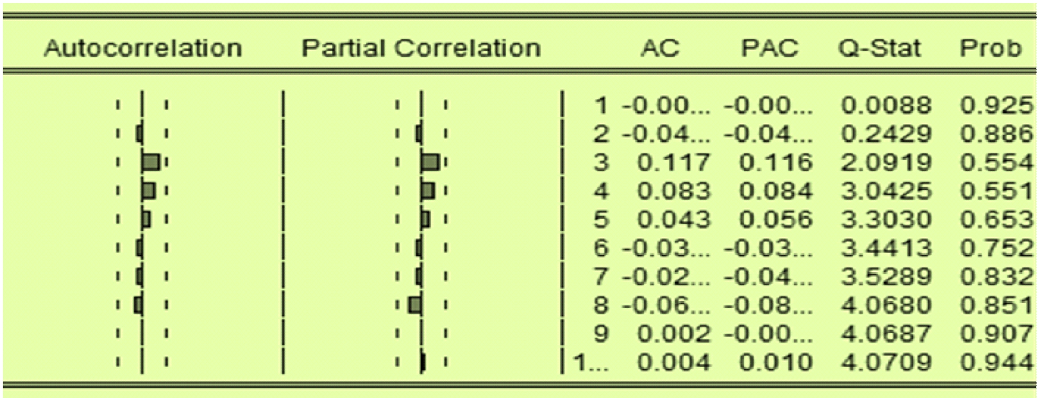
Null Hypothesis	Augmented Dickey-Fuller test statistic computed 't' values	Test critical values for ADF test 1% level	Test critical values for ADF test 5% level
D(CLOSING_SENSEX) has a unit root	-11.23096	-3.481217	-2.883753
D(CLOSING_KSE) has a unit root	-12.64653	-3.481217	-2.883753
D(CLOSING_CSE) has a unit root	-10.29551	-3.481217	-2.883753

Table 2(b): Results for Testing of the Randomness Using Elliott-Rothenberg-Stock Test Statistic

Null Hypothesis	Elliott-Rothenberg-Stock test statistic (Computed)values	Test critical values: 1% level	Test critical values 5% level
D(CLOSING_SENSEX) has a unit root	1.801037	4.194900	5.646200
D(CLOSING_KSE) has a unit root	11.85087	4.194900	5.646200
D(CLOSING_CSE) has a unit root	8.444730	4.194900	5.646200

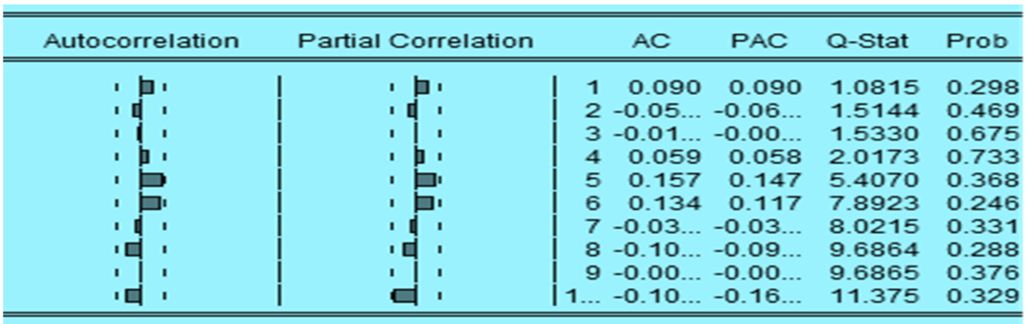
Table 3: Results for Testing of the Random Walk Using ACF, PACF & 'Q' Statistics

3(a) Results from Correlogram of BSE Sensex (at returns)



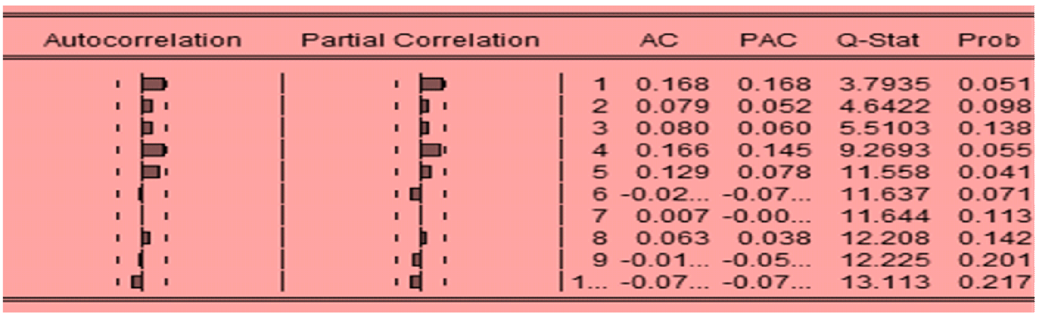
Lag	AC	PAC	Q-Stat	Prob
1	-0.00...	-0.00...	0.0088	0.925
2	-0.04...	-0.04...	0.2429	0.886
3	0.117	0.116	2.0919	0.554
4	0.083	0.084	3.0425	0.551
5	0.043	0.056	3.3030	0.653
6	-0.03...	-0.03...	3.4413	0.752
7	-0.02...	-0.04...	3.5289	0.832
8	-0.06...	-0.08...	4.0680	0.851
9	0.002	-0.00...	4.0687	0.907
1...	0.004	0.010	4.0709	0.944

3(b) Results from Correlogram of KSE 100 (at returns)



Lag	AC	PAC	Q-Stat	Prob
1	0.090	0.090	1.0815	0.298
2	-0.05...	-0.06...	1.5144	0.469
3	-0.01...	-0.00...	1.5330	0.675
4	0.059	0.058	2.0173	0.733
5	0.157	0.147	5.4070	0.368
6	0.134	0.117	7.8923	0.246
7	-0.03...	-0.03...	8.0215	0.331
8	-0.10...	-0.09...	9.6864	0.288
9	-0.00...	-0.00...	9.6865	0.376
1...	-0.10...	-0.16...	11.375	0.329

3(c) Results from Correlogram of CSE ASPI (at returns)



Lag	AC	PAC	Q-Stat	Prob
1	0.168	0.168	3.7935	0.051
2	0.079	0.052	4.6422	0.098
3	0.080	0.060	5.5103	0.138
4	0.166	0.145	9.2693	0.055
5	0.129	0.078	11.558	0.041
6	-0.02...	-0.07...	11.637	0.071
7	0.007	-0.00...	11.644	0.113
8	0.063	0.038	12.208	0.142
9	-0.01...	-0.05...	12.225	0.201
1...	-0.07...	-0.07...	13.113	0.217

Table 4: Variance Ratio Test (Lo &Mc. Kinley) results of Return on BSE Sensex, Pakistan KSE 100 & Sri Lanka's CSE ASPI for the none year period April 1, 2005- March 31, 2016

Table 4(a) Variance Ratio Test Results for BSE SENSEX

(i) Homoscedastic Assumption

Joint Tests		Value	df	Probability
Max |z| (at period 2)		5.081152	130	0.0000
Wald (Chi-Square)		27.42348	4	0.0000
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.554353	0.087706	-5.081152	0.0000
4	0.234769	0.164083	-4.663695	0.0000
8	0.146280	0.259437	-3.290660	0.0010

(ii) Heteroscedastic Robust Results

Joint Tests		Value	df	Probability
Max |z| (at period 2)		4.254763	130	0.0001
Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.550089	0.105743	-4.254763	0.0000
4	0.229351	0.196137	-3.929130	0.0001
8	0.138403	0.308311	-2.794570	0.0052

Table 4(b): Variance Ratio TestResultsPakistan's KSE Markets

(i) Homoscedastic Assumption

Joint Tests		Value	df	Probability
Max |z| (at period 2)		4.752513	130	0.0000
Wald (Chi-Square)		24.43648	4	0.0001
Individual Tests				
Period	**Var. Ratio**	**Std. Error**	**z-Statistic**	**Probability**
2	0.583177	0.087706	-4.752513	0.0000
4	0.261258	0.164083	-4.502256	0.0000
8	0.156592	0.259437	-3.250915	0.0012

(ii) Heteroscedastic Robust Results

Joint Tests		Value	df	Probability
Max |z| (at period 4)		2.875578	130	0.0160
Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.578691	0.158363	-2.660407	0.0078
4	0.255229	0.258999	-2.875578	0.0040
8	0.148160	0.350823	-2.428121	0.0152

Table 4(c): Variance Ratio Test Results Srilanka's ASPI Markets

(i) Homoscedastic Assumption

Joint Tests		Value	df	Probability
Max |z| (at period 2)		5.051895	130	0.0000
Wald (Chi-Square)		26.44493	4	0.0000
Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.556919	0.087706	-5.051895	0.0000
4	0.252247	0.164083	-4.557177	0.0000
8	0.137816	0.259437	-3.323287	0.0009

(ii) Heteroscedastic Robust Results

Joint Tests		Value	df	Probability
Max |z| (at period 2)		3.933494	130	0.0003
Individual Tests				
Period	Var. Ratio	Std. Error	z-Statistic	Probability
2	0.552635	0.113732	-3.933494	0.0001
4	0.246426	0.195648	-3.851683	0.0001
8	0.130395	0.286771	-3.032402	0.0024

Table 5: Results of the Runs Test of Successive Differences for Testing the Randomness of our Sampled Stock Indices

Stock Index	n+	n-	Total No. of Runs (n)	μ	σ	C1(μ-1.96σ)	C2 (μ+1.96σ)	Random/Not Random
Sensex Return	32	33	65	33.49231	3.99855	25.65514963	41.32946376	Not Random
KSE 100	31	31	62	32	3.9046	24.34698388	39.65301612	Not Random
CSE ASPI	28	28	56	29	3.707486	21.73332688	36.26667312	Not Random

Table 6: Results of Turning Point (Trough & Peak) Test for Randomness

Stock Index	N	P	Mean	Std Deviation	|zcal|	|ztable|	Random/Non-Random
Sensex Return	131	92	86	4.79	1.2526	1.96	Random
KSE 100	131	77	86	4.79	-1.8789	1.96	Random
CSE ASPI	131	84	86	4.79	-0.4175	1.96	Random

Table 7: Results of KPSS Test for Randomness

Null Hypothesis	Kwiatkowski-Phillips-Schmidt-Shin test statistic computed LM values	Null Accept/Reject
D(CL_SENSEX) is trend non-random	0.062955	Accept*
D(CL_KSE) is trend non-random	0.315045	Accept*
D(CL_CSE) is trend non-random	0.101627	Accept*

Critical Values for KPSS test: 5% : 0.463000 & 1% 0.739000

* Acceptance of Null would mean that there is no trend but still it is quite possible that the stochastic root may still exist