Test Of Weak Form Efficiency Of The Emerging Indian Stock Market Using The Non-Parametric Rank And Sign Variance Ratio Test

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Abstract
This study has used the Wright (2000) rank and sign variance ratio test along with the traditional variance ratio test and the multiple variance ratio extension to examine the weak form market efficiency of the major stock indices in the Indian stock market. The empirical results have rejected the null hypothesis of random walk / martingale behavior for all the tested indices, namely large-capitalisation, mid-cap and small-cap indices, for both the daily and weekly data, under conditions of both homoskedasticity and heteroskedasticity. There is also no evidence of evolving market efficiency in the Indian stock market. The results show that the Indian stock market is not weak form efficient and investors can make abnormal profits by analyzing past prices.

Keywords: Indian stock market, random walk, martingale difference, variance ratio, ranks, signs.

JEL Classification: G12, G14

I INTRODUCTION
One of the most debated concepts in the area of Financial economics is the ‘Efficient Market Hypothesis’ (EMH). The EMH has dominated economics and finance in the past decades and is central to both theoretical and empirical finance. The weak form EMH in particular has been extensively researched and investigated in the existing literature. The weak form EMH stipulates that the information contained in the past sequence of prices of a security is fully reflected in the current market price of that
security. If the weak form EMH does not hold, the past prices can be used to implement trading strategies. The implications are that chartists and fundamental analysts can add value or earn consistent excess profits and more importantly market is not always right. Secondly, all the asset pricing theories in finance are based on probability assumptions like ‘uncorrelatedness’. Further, due to the importance given to informational efficiency in allocation of resources, the predictability of the security prices and market efficiency assumes importance. It also has implications on the market structure, cost of capital and financial policy.

According to Fama (1970) definition of EMH, in an efficient market, any new information is quickly and completely reflected in the stock prices. This along with the requirements of weak form efficiency implies the stock price changes to be random and unpredictable. The martingale model of EMH requires only the uncorrelatedness of stock price changes as measured by its serial correlation. The Lo and Macinlay (1988) ‘Variance ratio test’ (VR test) is one of the most used techniques to test if stock returns are serially correlated. The basic premise of the VR test is that under random walk the variance of the n\textsuperscript{th} period return is equal to ‘n’ times the variance of the one period return. The later innovations in the VR test are the more powerful non-parametric Wright (2000) rank and signs VR tests and the multiple variance ratio tests. The seminal paper by Lo and Macinlay (1988) empirically tested the non-overlapping VR statistic (M\textsubscript{2} in this study) using weekly data of the large, middle and small capitalization US stocks and evidenced stronger departures from the random walk hypothesis for the middle and small capitalization indices compared to the large cap index.

Though there have been extensive studies on the weak form efficiency of the developed markets based on the VR test, the emerging markets have come into focus in the recent years. In the Asian markets, Hoque et al (2007) examined the random walk hypothesis for eight emerging equity markets in Asia, namely Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand. They used the Wright's rank and sign and Whang–Kim subsampling tests–as well as the conventional Lo–MacKinlay and the multiple variance ratio Chow–Denning tests. They evidenced that except for Taiwan and Korea, the random walk assumption was rejected for all the stock market indices of the other six countries. They also asserted that the Wright's and Whang–Kim's tests report far less ambiguous results compared to other tests. Kim and Shamsuddin (2008) tested the Asian markets for the period 1990 to 2006 using the variance ratio tests based on the non-parametric wild bootstrap and signs as they are finite sample tests, which do not rely on large sample theories for statistical inference. They found that while the Hong Kong, Japanese, Korean and Taiwanese markets have been efficient in the weak-form, the markets of Indonesia, Malaysia and Philippines have shown no sign of market efficiency. Lima and Tabak (2004) analysed the Hong Kong and Singapore markets using variance ratio of Lo and MacKinlay and multiple variance ratio methods for the 1992–2000 period. They evidenced that only the Hongkong stock market was weak form efficient. Charles and Darne (2009) examined the random walk hypothesis for the Shanghai and Shenzhen stock markets for both A and B shares, using daily data over the period 1992–2007 using the multiple variance ratio tests including the conventional multiple Chow-
Denning test. They evidenced that while the Class B shares for Chinese stock exchanges do not follow the random walk hypothesis the Class A shares seemed more efficient.

Al Khazali et al (2007) studied the Middle East and North African stock markets using the Wright’s (2000) rank and sign test evidenced mixed results but most importantly suggested that the non-parametric rank and sign tests are more suited for the emerging markets. Jorg (2011) analysed the Gulf stock markets using daily, weekly, and monthly index data for the 10-year period between 2000 and 2009. Various variance ratio tests with homo and heteroskedasticity assumptions rejected random walk for the daily data, but differences appeared across markets for the weekly and monthly data. Smith (2009) tested the martingale hypothesis in the European emerging stock markets of the Czech Republic, Estonia, Hungary, Malta, Poland, Russia, the Slovak Republic, Slovenia, Turkey and the Ukraine, using joint variance ratio tests based on signs and the wild bootstrap, for the period 1998-2007. Among the tested stock markets, the results rejected martingale difference sequence (MDS) for Malta, the Slovak Republic and Slovenia. He opined that size, liquidity and the quality of the market are important for MDS returns.

In the Indian stock market, Hiremath(2010) studied the weak form efficiency of the major stock indices using the conventional Lo–MacKinlay and the multiple variance ratio Chow–Denning extension and concluded that generally the large cap indices are efficient compared to the mid-cap and small-cap indices. However, the research in these areas are few and far in between in the Indian stock markets. The increasing international portfolio investment and participation provides a perfect platform for gathering information about the market structure, efficiency and evidence of the integration mechanism with the developed markets. The Indian stock market differs from the developed markets in the following ways; the Indian stock market is characterized by less informational efficiency, higher costs, smaller investor base and lower liquidity compared with the stock markets of developed countries. Given the differences between an emerging market like India and the developed markets in policy, structure and institutional settings, the comprehensive study of the stock market efficiency will provide an invaluable insight into an economy in transition.

The aim of this paper is to examine the weak form EMH of the major stock indices in the Indian stock market in a comprehensive manner using the non-parametric Wright (2000) rank and sign variance ratio test and its multiple variance ratio extension for both the, recent twelve year, daily and weekly data. The second section explains the Indian stock market. The third section describes the methodology while the fourth section reports and discusses the results. The fifth section concludes.

**II THE INDIAN EQUITY MARKET:**

The Indian stock market is one of the oldest in Asia with the Bombay stock exchange (BSE) dating back to the end of the 18th century. The liberalization and the market reform process, started in 1992, brought about far reaching changes in the Indian capital market. The National stock Exchange (NSE) was started trading in 1994. A new governance model was created for financial infrastructure such as exchanges,
depositories, electronic order books and clearing corporations. The reduction of entry level barriers, dematerialization and the influx of foreign institutional investors increased participation in the Indian equity market. A number of significant reforms have been implemented both in the cash and derivatives markets with the aim of removing direct government control and replacing it by a regulatory framework based on transparency and disclosure. The cost of transaction and the risk of settlement are being minimized. These, along with the recent attempts to improvement in accounting standards and corporate governance have put the Indian stock markets in the path of development. The NSE premier index ‘NIFTY’ became the underlying for one of the world's biggest index derivatives contracts, with onshore trading at NSE and offshore trading in Singapore and Chicago.

Over the current decade, India progressed from being a medium sized developing country to be ranked 10th in terms of market capitalization as on October 2014. The National stock exchange (NSE) is the market leader in the Indian stock market with 77.8% of total turnover (volumes in cash market, equity derivatives, and currency derivatives) in 2013–2014. Source: NSE fact book 2014: http://www.nse-india.com/content/us/ismr2014ch1.pdf

III METHODOLOGY:
Let \( X_t \) be a stochastic process satisfying the following condition,
\[
X_t = \mu + X_{t-1} + \xi_t, \quad E(\xi_t) = 0 \quad \text{for all} \quad t,
\]
(1)

Where, drift \( \mu \) is an arbitrary parameter. According to the random walk hypothesis, the innovations \( \xi_t \) are independently and identically distributed Gaussian increments. The martingale hypothesis requires only the uncorrelatedness of stock price changes and includes weakly dependent and possibly heteroskedastic increments.

\( X_t \) is a martingale if,
\[
E\{X_{t+1} | \{X_t, X_{t-1}, \ldots\}\} = X_t
\]
(2)
The behavior of the major indices in the Indian stock market is examined by the parametric Lo and Macinaly (1988) tests, non-parametric Wright (2000) rank and sign tests and the Chow Denning (2003) multiple variance ratio (VR) tests. The basic premise of the VR test is that under random walk the variance of the \( n \)th period return is equal to ‘n’ times the variance of the one period return.
The hypothesis to be tested is \( H_0 \): The index series follow a random walk.
\( H_1 \): The index series do not follow a random walk.

Let \( \{y_t\} \) denote a time series consisting of \( T \) observations \( y_1, \ldots, y_T \) of asset returns.
The variance ratio of the \( k \)-th difference is defined as:
\[
VR(k) = \frac{\sigma^2(k)}{\sigma^2(1)}
\]
(3)

\( VR(k) \) : is the variance ratio of the index \( k \)-th difference
\( \sigma^2(k) \) : is the unbiased estimator of 1\( k \) of the variance of the Index \( k \)-th difference, under the null hypothesis
\( \sigma^2(1) \) : is the variance of the first-differenced index series
\( k \) : is the number of days of base observations interval or the difference interval.
Following Lo and Mackinlay (1988), the estimator of the $k$-period difference, $\sigma^2(k)$, is calculated as:

$$
\sigma^2(k) = \frac{1}{k(T - k + 1)(1 - k/T)} \sum_{t = k}^{T} (y_t + \ldots + y_{t-k+1} - k\hat{\mu})^2
$$

(4)

where

$$
\hat{\mu} = \frac{1}{T} \sum_{t = 1}^{T} y_t
$$

The unbiased estimator of the variance of the first difference, $\sigma^2(1)$, is computed as follows:

$$
\sigma^2(1) = \frac{1}{T} \sum_{t = 1}^{T} (y_t - \hat{\mu})^2
$$

(5)

Lo and Macinlay (1988) show that under IID assumptions:

$$
M_1(k) = \frac{VR(k) - 1}{\phi(k)^{1/2}} \text{ (asymptotically distributed as } N(0,1) \text{) (6)}
$$

The asymptotic variance, $\phi(k)$, is given by:

$$
\phi(k) = \frac{2(2k - 1)(k - 1)}{3kT}
$$

(7)

Lo and Macinlay (1988), in order to account for asset returns empirical departures from normality, used the approach developed by White and Domowitz (1994) to develop a statistic robust to many forms of heteroskedasticity,

$$
M_2(k) = \frac{VR(k) - 1}{\phi^*(k)^{1/2}} \text{ (asymptotically distributed as } N(0,1) \text{) (8)}
$$

Where

$$
\phi^*(k) = \sum_{j=1}^{k-1} \left[ \frac{2(k - j)}{k} \right] \hat{\sigma}(j)
$$

(9)

$$
\hat{\sigma}(j) = \sum_{t \neq j} \frac{(y_t - \hat{\mu})^2}{\left( \sum_{j=1}^{T} (y_j - \hat{\mu})^2 \right)^2}
$$

(10)

Charles and Darne (2009) note that the Lo-MacInlay tests being asymptotic tests, whose sampling distribution is approximated based on its limiting distribution, are biased and right skewed in finite samples. Wright (2000) proposed the use of signs and ranks where ranks and signs and substituted in place of the differences in the Lo and MacKinlay tests and has an exact distribution. Wright showed that his nonparametric variance ratio tests, based on ranks ($R_1$ and $R_2$) and signs ($S_1$ and $S_2$), have better size and power properties to examine the random walk / martingale hypothesis than the tests suggested by Lo and MacKinlay for many processes. Wright’s proposed $R_1$ and $R_2$ are defined as:
\[
R_1 = \left( \frac{1}{T_k} \sum_{t=k}^{T} (r_{1,t} + \ldots + r_{1,T-k+1})^2 - 1 \right) \times \phi(k)^{-1/2}
\]
\[
R_2 = \left( \frac{1}{T_k} \sum_{t=k}^{T} (r_{2,t} + \ldots + r_{2,T-k+1})^2 - 1 \right) \times \phi(k)^{-1/2}
\]

Where
\[
r_{1,t} = \left( r \left( y_{t - \frac{T + 1}{2}} \right) \right) / \sqrt{(T - 1)(T + 1) / 12}
\]
\[
r_{2,t} = \Phi^{-1} (r(y_t) / (T+1)).
\]

\(\phi(k)\) is defined in (5), \(r(y_t)\) is the rank of \(y_t\) among \(y_1, \ldots, y_T\), and \(\Phi^{-1}\) is inverse of the standard normal cumulative distribution function. The test based on the signs of returns rather than ranks is given by:
\[
S_I = \left( \frac{1}{T_k} \sum_{t=k}^{T} (S_t + \ldots + S_{T-k+1})^2 - 1 \right) \times \phi(k)^{-1/2}
\]

where \(\phi(k)\) is defined in (5), \(s_t = 2u(y_t, 0), s_t(\bar{\mu}) = 2u(y_t, (\bar{\mu})\), and
\[
u(x, q) = \begin{cases} 
0.5 & \text{if } x > q, \\
-0.5 & \text{otherwise}
\end{cases}
\]

Thus, \(S_I\) assumes a zero drift value.


Chow Denning (1993) (CD) proposed the multiple VR test incorporated with Studentized Maximum Modulus (SMM) critical values to control overall test size for the VR test statistics under different time period \(q\). Under the null hypothesis, for a single VR test, \(VR(q) = 1\), and \(M_j(q) = VR(q) - 1 = 0\). Now consider a set of \(m\) VR tests \(\{M_j(q)\}_{j=1, \ldots, m}\), where \((q_i, q_j) \in [1, \ldots, m]\) and \(q_i \geq 1, q_i \neq q_j, q_i \in N\), \(\forall i \neq j\). Under the specification, the random walk null hypothesis consists of \(m\) sub-hypotheses:
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\[ H_{0i} : M_i(q_i) = 0 \text{ for } i = 1, \ldots, m \]
\[ H_{ai} : M_i(q_i) \neq 0 \text{ for any } i = 1, \ldots, m \]  

(14)

Rejection of any sub-hypothesis \( H_{ai} \) will lead to the turndown of RWH. Consider five sets of above mentioned test statistics, \( \{Z\}_{i}^{(q_i)} \big| i = 1, \ldots, m \), \( \{R\}_{i}^{(q_i)} \big| i = 1, \ldots, m \} \) for \( j=1,2 \) and \( \{S\}_{i}^{(q_i)} \big| i = 1, \ldots, m \} \). Since the RWH is rejected if any of the estimated VR ratios is significantly different from one, Chow and Denning (1993) reconstructed the test statistics under the multiple specifications. The multiple VR test is based on the following inequality:

\[
P_{\alpha} = \max \left( \left| z_{1} \right|, \ldots, \left| z_{m} \right| \right) \leq \text{SMM} (\alpha; m; N) \geq (1-\alpha) \]

(15)

Where, \( \{z_{i} \big| i = 1, \ldots, m \} \) is a set of \( m \) standard normal variates, SMM \( (\alpha; m; N) \) is the upper \( \alpha \) point of the SMM distribution with parameter \( m \) and \( N \) (sample size) degrees of freedom. Asymptotically, when \( N \) goes infinite, SMM \( (\alpha; m; \infty) = Z_{\alpha/2} \), where \( \alpha+ = 1 - (1 - \alpha)^{1/m} \).


\[
Z_{j}^{*} (q) = \max_{1 \leq i \leq m} \left| Z_{j}^{(q_i)} \right|, \text{ for } j = 2
\]

(16)

\[
R_{j}^{*} (q) = \max_{1 \leq i \leq m} \left| R_{j}^{(q_i)} \right|, \text{ for } j = 1, 2
\]

(17)

\[
S_{j}^{*} (q) = \max_{1 \leq i \leq m} \left| S_{j}^{(q_i)} \right|, \text{ for } j = 1
\]

(18)

where the critical values of \( Z_{j}^{*} (q) \) are based on above mentioned SMM distribution.

Under the iid assumption 0 (i.i.d. first differences) in Wright (2000), the test statistics of \( R_{j}^{*} (q) \) are distributed as:

\[
\max \left\{ \left| R_{j}^{\dagger} (q_1) \right|, \left| R_{j}^{\dagger} (q_2) \right|, \ldots, \left| R_{j}^{\dagger} (q_m) \right| \right\}
\]

(19)

where \( R_{j}^{\dagger} (q_i) \) is the ranks-based test computed with any random permutation of the elements \( \{y_{i}\}_{i=1}^{T} \), each element is 1 with probability \( 1/2 \) and -1 otherwise. Therefore, the exact sampling distribution of \( R_{j}^{\dagger} (q) \) and \( S_{j}^{*} (q) (j = 1, 2) \) can be simulated with any arbitrary degree of accuracy. The CD modified VR statistics under multiple specifications are \( M^{\text{cd},2} \), \( R^{\text{cd},1} \), \( R^{\text{cd},2} \) and \( S^{\text{cd},1} \) for \( M_{2} \), \( R_{1} \), \( R_{2} \) and \( S_{1} \) respectively.
IV RESULTS AND DISCUSSION

4.1 Data description and descriptive statistics:

Table 2: Basic Statistics

<table>
<thead>
<tr>
<th>INDEX</th>
<th>Nifty</th>
<th>Defty</th>
<th>Mid-cap</th>
<th>Small-cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.000453</td>
<td>0.000362</td>
<td>0.000684</td>
<td>0.000617</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.015539</td>
<td>0.017404</td>
<td>0.015103</td>
<td>0.015797</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.28708</td>
<td>-0.16108</td>
<td>-0.91153</td>
<td>-1.09</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>11.35411</td>
<td>10.93457</td>
<td>10.39621</td>
<td>10.28478</td>
</tr>
<tr>
<td>Jarque Bera</td>
<td>10918.4**</td>
<td>9819.162**</td>
<td>8585.648**</td>
<td>6740.893**</td>
</tr>
<tr>
<td>Ljung Box Q(10)</td>
<td>39.471**</td>
<td>35.602**</td>
<td>109.568**</td>
<td>184.116**</td>
</tr>
<tr>
<td>Ljung Box Q(20)</td>
<td>65.626**</td>
<td>65.531**</td>
<td>135.882**</td>
<td>209.102**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INDEX</th>
<th>Nifty</th>
<th>Defty</th>
<th>Mid-cap</th>
<th>Small-cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.002283</td>
<td>0.001807</td>
<td>0.003241</td>
<td>0.003021</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.034474</td>
<td>0.039759</td>
<td>0.037659</td>
<td>0.042142</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.38129</td>
<td>-0.2714</td>
<td>-0.6054</td>
<td>-0.7174</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>5.312469</td>
<td>5.30513</td>
<td>6.685229</td>
<td>6.073903</td>
</tr>
<tr>
<td>Jarque Bera</td>
<td>192.941**</td>
<td>182.034**</td>
<td>463.948**</td>
<td>273.782**</td>
</tr>
<tr>
<td>Ljung Box Q(10)</td>
<td>30.314**</td>
<td>35.971**</td>
<td>38.439**</td>
<td>50.011**</td>
</tr>
<tr>
<td>Ljung Box Q(20)</td>
<td>40.932**</td>
<td>49.724**</td>
<td>47.862**</td>
<td>69.735**</td>
</tr>
</tbody>
</table>

Notes: Returns are computed as log return of closing prices.** represents significance at 5% level.

Under normal distribution, skewness = 0 and kurtosis = 3.

The NIFTY and DEFTY indices of the NSE are chosen as the large cap indices. The CNX 100 index of the NSE and the BSE (Bombay stock exchange) small-cap index are chosen as the mid-cap and the small-cap indices respectively. The large capitalization index NIFTY\(^1\) represents the fifty large, liquid stocks in the Indian stock market. The ‘DEFTY’ index, the dollar denominated NIFTY index, is more relevant for the foreign institutional investors and off-shore funds. The Mid-cap index CNX 100 represents the next level of stocks which are large, liquid 100 stocks excluding the NIFTY stocks. The BSE small-cap index represents the smaller capitalization stocks. The sample period for the NIFTY and DEFTY index runs from 01 April 2000 to 31 March 2015. While the sample period for the CNX Mid-cap index runs from 01 April 2001 to 31 March 2015, it is from 01 April 2003 to 31 March 2015 for the BSE small-cap index. The weekly data represents the Wednesday closing prices. If Wednesday is a holiday, the Thursday closing prices are used (or Tuesday, if Thursday is also a holiday). Only the publicly available data from the NSE and BSE official websites\(^2\) are used in this study.
Table 2 reports the descriptive statistics of all the return series for both the daily and weekly data. The large-cap indices exhibit the least skewness and kurtosis. Though, all the return series are negatively skewed and leptokurtic, the skewness is more negative for the mid and small cap indices compared to the large cap index. However, the Jarque bera statistics indicate that none of the tested return series, both daily and weekly data, follow normal distribution. Though the Ljung Box tests suggest that all the tested indices are characterized by serial correlation, Lo and Macinalay (1989) showed that VR tests are more powerful and robust tests.

4.2 Single and Multiple VR test – Daily data:
The Table 3 reports the results of the single VR statistics namely, M₂, R₁, R₂ and S₁ using daily data. The time intervals representing day, week, fortnight and month (q = 2, 5, 10 and 20) are studied as in many other similar studies. The Lo and Macinlay (1988) M₂ is reported as it is robust to conditional heteroskedasticity. The results in panel A indicate that, based on M₂, the null of random walk cannot be rejected for both the Large-cap indices Nifty and Defty. Wright (2000) has shown that R₁ and R₂ have better size and power properties than M₁ for many alternatives and Further, sign based S₁ is exact and robust to many forms of conditional heteroskedasticity. The rank based tests R₁ and R₂ reject the null of random walk for q = 2 and 5 for both the large-cap indices at 5% level of significance. For the Nifty index, the sign based test S₁ has rejected the null of MDS at 5% level for q = 2, 5, 10 and 20. In the case of Defty index, the null of MDS is rejected at all the tested intervals at 5% level. The rejection by the heteroskedasticity robust sign based test has confirmed that the rejection, based on rank based tests, is not due to conditional heteroskedasticity.
The results, reported in Table 3, Panel B for the Mid-cap and small-cap indices, show that the null of random walk / MDS is rejected for all the tests (M₂, R₁, R₂ and S₁) for all the intervals at 1% level of significance. Though the rejections are stronger in the case of mid-cap and small-cap indices than the large-cap indices, the single VR tests reject the null hypothesis for all the indices using daily data. Chow and Denning (1983), and others have argued that single VR tests lead to over-rejection of the null hypothesis when the joint test size is not controlled. Chow and Denning (1993) had shown that failing to control the joint test size for these estimates results in very large Type I errors and suggested the multiple VR test incorporated with Studentized Maximum Modulus (SMM) critical values to control overall test size for the VR test statistics. Franch and Conteras (2004), Collatez (2005) and Kim and Shamsuddin (2008) proposed their extension of the Chow-Denning (1993) multiple variance ratio test to Wright (2000) rank and sign based tests. We also use the multiple variance-ratio extension to the Wright (2000) rank and sign based tests as the existing literature has shown that these tests are more powerful and robust for testing weak form market efficiency. The statistics M^{cd}_2, R^{cd}_1, R^{cd}_2 and S^{cd}_1 represent the CD extension to M₂, R₁, R₂ and S₁ respectively.
The results for the multiple VR statistics for Large-cap indices are reported in the Table 4, Panel A. The CD multiple VR statistics R^{cd}_1, R^{cd}_2 reject the null hypothesis for the Nifty and the Defty indices at 5% level. The sign based S₁ also rejects the null at 5% level for both the Nifty and the Defty index. The multiple VR results support
the individual VR results that the tested large cap indices are not weak form efficient. Table 4 Panel B reports the results for the mid-cap and small-cap index. All the multiple VR tests $M_{cd}^2$, $R_{1cd}$, $R_{2cd}$ and $S_{cd}^1$ reject the null of random walk / MDS at 1% level for both the mid-cap and small-cap indices except for $M_{cd}^2$ which rejected the null at 5% level for the mid-cap index.

**Table 3:** VR tests using daily data for the Major stock Indices of the NSE

<table>
<thead>
<tr>
<th>Panel A-The Large cap of the NSE</th>
<th>Defty Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NIFTY Index</strong></td>
<td><strong>Defty Index</strong></td>
</tr>
<tr>
<td>$q$</td>
<td>$M_2$</td>
</tr>
<tr>
<td>2</td>
<td>2.773**</td>
</tr>
<tr>
<td>5</td>
<td>1.358</td>
</tr>
<tr>
<td>10</td>
<td>0.521</td>
</tr>
<tr>
<td>20</td>
<td>0.783</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B-Mid-cap and Small-cap index of the NSE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mid-cap Index</strong></td>
</tr>
<tr>
<td>$q$</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

**Table 4:** CD Multiple VR tests using daily data for the Major stock Indices of the NSE

<table>
<thead>
<tr>
<th>Panel A-The Large cap of the NSE</th>
<th>Defty Index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NIFTY Index</strong></td>
<td><strong>Defty Index</strong></td>
</tr>
<tr>
<td>$M_{cd}^2$</td>
<td>$R_{1cd}$</td>
</tr>
<tr>
<td>2.773**</td>
<td>5.380**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B-Mid-cap and Small-cap index of the NSE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mid-cap Index</strong></td>
</tr>
<tr>
<td>$M_{cd}^2$</td>
</tr>
</tbody>
</table>

The VR statistic based on LoMac $M_2$, Wright (2000) Rank and Sign $R_1$, $R_2$ and $S_1$ using daily data of the major indices of NSE for the period 2000-2015 in the Indian stock market. The BSE Small-cap index is used. Table 3 reports the individual VR statistics and Table 4 reports the Chow-Denning multiple VR statistics. The statistics $M_{cd}^2$, $R_{1cd}$, $R_{2cd}$ and $S_{cd}^1$ represent the CD extension to $M_2$, $R_1$, $R_2$ and $S_1$ respectively. Significance at 5% level are indicated by **.
Though the null of random walk / MDS is rejected for all the tested daily index time series, the results are consistent with the conclusions of Lo and Macinlay (1988) in that the rejections for the mid-cap and small-cap indices were stronger than the rejections of the large-cap indices. However, the result that large-cap indices are not weak form efficient is different from that of the results in the developed markets.

4.3 Single and Multiple VR test – Weekly data:

Table 5: VR tests using weekly data for the Major stock Indices of the NSE

<table>
<thead>
<tr>
<th>Panel A</th>
<th>The Large cap of the NSE</th>
<th>Defy Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NIFTY Index</td>
<td></td>
</tr>
<tr>
<td>q</td>
<td>M2</td>
<td>R1</td>
</tr>
<tr>
<td>4</td>
<td>0.442</td>
<td>0.480</td>
</tr>
<tr>
<td>8</td>
<td>0.074</td>
<td>0.164</td>
</tr>
<tr>
<td>16</td>
<td>0.102</td>
<td>1.316</td>
</tr>
<tr>
<td>32</td>
<td>0.548</td>
<td>2.429**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B</th>
<th>Mid-cap and Small-cap index of the NSE</th>
<th>Small-cap Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mid-cap Index</td>
<td>Small-cap Index</td>
</tr>
<tr>
<td>q</td>
<td>M2</td>
<td>R1</td>
</tr>
<tr>
<td>4</td>
<td>1.828</td>
<td>2.560**</td>
</tr>
<tr>
<td>8</td>
<td>1.797</td>
<td>2.678**</td>
</tr>
<tr>
<td>16</td>
<td>1.546</td>
<td>3.109**</td>
</tr>
<tr>
<td>32</td>
<td>1.754</td>
<td>3.712**</td>
</tr>
</tbody>
</table>

Table 6: CD Multiple VR tests using weekly data for the Major stock Indices of the NSE

<table>
<thead>
<tr>
<th>Panel A</th>
<th>The Large cap of the NSE</th>
<th>Defy Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NIFTY Index</td>
<td></td>
</tr>
<tr>
<td>M(_{t}^d)</td>
<td>R(_{t}^d)</td>
<td>R(_{t}^d)</td>
</tr>
<tr>
<td>0.548</td>
<td>2.429**</td>
<td>1.416</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B</th>
<th>Mid-cap and Small-cap index of the NSE</th>
<th>Small-cap Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mid-cap Index</td>
<td>Small-cap Index</td>
</tr>
<tr>
<td>M(_{t}^d)</td>
<td>R(_{t}^d)</td>
<td>R(_{t}^d)</td>
</tr>
<tr>
<td>1.828</td>
<td>3.712**</td>
<td>2.984**</td>
</tr>
</tbody>
</table>

The VR statistic based on LoMac M\(_{t}^d\) Wright (2000) Rank and Sign R\(_{t}^d\) and S\(_{t}^d\) using weekly data of the major indices of NSE for the period 2000-2015 in the Indian stock market. The BSE Small-cap index is used. Table 5 reports the individual VR statistics and the Table 6 reports the Chow-Denning multiple VR statistics. The statistics M\(_{t}^d\), R\(_{t}^d\) and S\(_{t}^d\) represent the CD extension to M\(_{t}^d\), R\(_{t}^d\) and S\(_{t}^d\) respectively. Significance at 5% level are indicated by **.
The single VR results for the weekly data of all the tested indices are reported in Table 5. The VR tests are studied at intervals $q = 4, 8, 16,$ and 32. The null hypothesis of the large-cap indices, reported at Panel A, is not rejected by the $M_2$ statistic at any level of significance for all time intervals. The rank based test $R_1$ reject the null of random walk for $q = 32$ for both the large-cap indices at 5% level of significance. For the Nifty index, the sign based test $S_1$ has rejected the null of MDS at 5% level for $q = 16$ and 32. However the rejection is stronger for the Defty index with rejection at $q = 2, 16$ and 32. Though the weak form efficiency of the Nifty index is rejected by the single VR statistics, the mid-cap and the small-cap indices evidenced stronger rejections by all the test statistics at various time intervals as reported in the Panel B. The multiple VR results for the weekly data are reported in Table 6. The multiple VR test results reported in Panel A for the Nifty index gives unambiguous results compared to the single VR tests. The null is rejected at 5% level by the rank based $R^{(d)}$ and sign based $S^{(d)}$ tests for both the Nifty and Defty indices.

The Panel B reports stronger rejections for the mid-cap and small-cap index at 5% level for all the non-parametric multiple variance ratio tests. We can safely conclude that the null of random walk / martingale hypothesis is clearly violated for not only the mid-cap and small-cap indices but also the large-cap Nifty and the Defty indices for both the daily and weekly data. The results are different from that of the developed markets in that even the large-cap indices are not weak form efficient. But, similar to most studies in the developed markets and some studies in the developing markets, rejections for the mid-cap and small-cap indices are stronger than the rejections for the large-cap indices. Lo and Macinlay (1988) observed that the rejection in the daily data might be due to non-trading, bid-ask spread, non-synchronous trading, etc. and recommended the use of weekly data to minimize them. Though the large-cap NIFTY and the DEFTY indices, by construction, do not suffer from the mentioned deficiencies for daily data, we have evidenced significant rejections across all the tested indices for both the daily and weekly data.

This study also used the static non-overlapping samples based on predetermined break points. Consequently, the daily data of the Large cap Nifty index was further subdivided into three sub-periods namely 2000-2005, 2006-2010 and 2011-2015 as structural and market environmental changes might have had impact on the market efficiency. Further, it also helps in analysing the issue of evolving market efficiency. Table 7 lists the single and multiple VR tests respectively of the chosen three sub periods. It is seen that both the single and multiple VR tests have rejected the null of no serial correlation at 5% level of significance for both the 2000-2005 and 2011-2015 periods. The results show that there is no evidence of evolving market efficiency as the latest period data also suffers from significant serial correlation. The results contradict Mobarek and Firante (2014) results suggesting improved market efficiency in the later period. This is due to the choice of period as their study had used 1996-2010 period data whereas this study has used 2000-2015 data. In order to avoid the bias that the choice of periods might have impacted the three sub period results, the data was divided into two sub-periods namely, 2000 – Sep 2007 and Oct 2007 – 2015 periods (not shown in Table 7). It is seen that both the single and multiple VR tests
have rejected the null of no serial correlation at 5% level of significance for both the tested periods.

**Table 7: VR tests using Daily data for the Large Cap Nifty index**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>q</td>
<td>M₂</td>
<td>R₁</td>
<td>R₂</td>
</tr>
<tr>
<td>2</td>
<td>1.887</td>
<td>4.598**</td>
<td>4.660**</td>
</tr>
<tr>
<td>5</td>
<td>1.017</td>
<td>3.783**</td>
<td>3.189**</td>
</tr>
<tr>
<td>10</td>
<td>0.838</td>
<td>3.332**</td>
<td>2.553**</td>
</tr>
<tr>
<td>20</td>
<td>0.653</td>
<td>2.524**</td>
<td>1.585</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M₂²</td>
<td>R₁²</td>
<td>R₂²</td>
</tr>
<tr>
<td>1.887</td>
<td>4.598**</td>
<td>4.660**</td>
<td>4.149**</td>
</tr>
</tbody>
</table>

The VR statistic based on LoMac M₂, Wright (2000) Rank and Sign R₁, R₂ and S₁ using daily data of the Nifty index of NSE for the period 2000-2015 using three sub periods in the Indian stock market. Table 5 reports the individual VR statistics and the Table 6 reports the Chow-Denning multiple VR statistics. The statistics M₂, R₁, R₂ and S₁ represent the CD extension to M₂, R₁, R₂ and S₁ respectively. Significance at 5% are indicated by **.

**V CONCLUSION:**

This study examines the weak form market efficiency in the Indian stock market using both the daily and weekly data for the 1999-2010 period. The large cap NSE indices Nifty and Defty along with NSE mid-cap and the BSE small cap indices were examined using parametric and non-parametric variance ratio tests. Further, in order to increase the power of the single VR tests, Chow Denning (1993) multiple ratio tests to Wright (2000) rank and sign test have been extended as in Franch and Contreras (2004), Collatez (2005) and Kim and Shamsuddin (2008). The null hypothesis of random walk / martingale behavior is rejected for all the tested indices for both daily and weekly data. The results of the study show that, unlike some studies in the developed markets, the weak form market efficiency is not supported for the large cap indices for both the daily and weekly data. The rejections are stronger for the daily data compared to the weekly data. The mid-cap and small cap indices evidenced stronger rejection of weak form market efficiency compared to the large cap indices. There is no evidence of evolving market efficiency in the Indian stock market. The rejections for the large cap indices are interesting as they represent the large and most liquid stocks in the Indian stock market which are normally held by institutional investors and enjoy informational superiority. The stronger rejections for the mid-cap and small cap indices suggest that further research is needed to study the impact of liquidity on such tests.
Notes:

3. If the number of lags ‘q’ is restricted to 16, the null of martingale hypothesis is rejected at 5% level. Further, the number of lags as per the AIC criterion for Nifty daily index series is 14.

References

Test Of Weak Form Efficiency Of The Emerging Indian Stock Market


