Is the Emerging Asian Stock Markets Really Predictable Based on the Operations and Information Management?

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***Abstract*—This paper examines the weak-form of market efficiency for six emerging Asian markets by using daily, weekly and monthly indices data based on the information management. The returns are not normally distributed, because they are negatively skewed and leptokurtic, and also found conditional heteroscedasticity. Findings suggest that none of the sample markets follow Random-walk and hence all are weak-form efficient markets except South Korean Markets. Additionally, short-term variants of the technical trading rules have better predictive ability than long-term variants. The results also reveal that these markets do not follow the same trend; the prices predictability is not analogous in all the sample markets.**

***Keywords*—** *Stock market efficiency, Operations and information management, Unit root tests, Variance-ratio tests, Emerging Markets*

1. Introduction

In recent global economy, stock markets have significant place which is acknowledged by governments and business organizations. Stock markets and information management system (IMS) can play a vital role in the economic growth of a country. It is found that in the history of stock markets, risk taking is allowed and the results show that most of the major stock markets have faced crashes. So, these occurrences have obvious side effect of any market where the significance of public attitudes is noticeable. In the stock market, shareholders get the profit which is constantly evaluated by the investors. Consequently, fluctuations are found in stock prices which are independent. Though these independent stock prices have the same prospect distribution, growing trend is retained by the prices. It is difficult to forecast the changes of stock prices but observing the charts and ups and downs of the past results, it can be identified. From the opinion of chartists and technical theorists, it is found that the project of upcoming prices can be made by the historical patterns. According to the Random Walk Hypothesis (RWH), these predictions cannot be right all the time.

IMS uses outputs from Transaction Processing system (TPS) to create reports on transpired operations in an organization. The level of data summarizing is higher. Statistical functions can be applied to the TPS data, such as variance and averaging. This is different than the way the data are processed in TPS. Another difference is that queries and reports cover longer period of time, such as quarters and half-year periods. An example of MIS outputs are a summary of sales in the last quarter, with a breakdown of totals per product/store, weekly and monthly averages, and variances from the corresponding sales targets. These capabilities cater to business needs of mid-level managers.

All the existing information is reflected by the prices of the securities and the new prices are adjusted to the prices which are essential characteristics of stock market. Consequently, investors can not

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generate excess returns by the use of such information. French mathematician Louis Bachelier upholds that in 1900, the stock prices are random, and therefore, these are unpredictable [1,2]. The main implication of RWH is analyzed in the 1960's. As in the efficient markets, prices are not expected, and so the irregular returns are not found. In brief, stock markets receive the unpredictable path. The future stock price can be gone up and down simultaneously. According to the RWH, it is impossible to outperform the market without risk and it is necessary to assume additional risk for outperforming. Efficient market hypothesis is formulated by Fama which has important place in financial market [10-12]. According to EMH, all the essential information is reflected by the stock prices where private, public or historical information cannot help the investors.

It is found that returns from emerging markets are usually higher than returns from developed markets [3]. The basic purpose of this study is predictability of returns in a number of emerging markets of Asia to help the investors in portfolio selection in which both the finance practitioners and academics have considerable interest. In the next section, it can be seen that there are many studies that test the predictability of returns of emerging stock markets. Though the outcomes are varied and spread over the numerous studies, different sample periods, methods and data frequencies are used by these studies. Kim et al., state that weak-form efficiency is illustrated by the developed or advanced emerging markets and the secondary emerging markets are originated to be inefficient. As there are lots of conflicts in this issue, so a comprehensive study is needed paying attention to the effects of the global financial crisis [13].

Two motivations for our study are indicated. Firstly, as it is found in the current studies, Asian emerging stock markets have secure place for the global financial investors [13]. Secondly, it is seen that emerging Asian markets are volatile, mostly small market capitalization (e.g. Bangladesh), that face a lot in crisis periods [3]. Among the global investors can invest emerging Asian stock markets for higher returns through a global portfolio diversification. So the emerging Asian stock markets have increased their strength and improved the rules and regulations for the global investors [8,9].

The main contribution of this study is found in the following three aspects: (1) the data cover very recent years, up to 2016, which have not been covered in previous studies of emerging Asian markets. Data frequency: daily, weekly and monthly data series used. The potential effect of white noise on weak-form efficiency is mitigated. Analyzed daily returns to detect violations of the random walk hypothesis likely to be obscured at longer sampling frequencies. (2) By breaking the ten years data set into two five years sub-periods, includes the global financial crisis. The results are obtained for 2007-2016 (full), 2007-2011 (sub periods -1), and 2012-2016 (sub periods -2) respectively. The comparison of different periods is useful to find out which markets are gradually becoming more efficient. (3) This study uses some of the most popular statistical techniques, which are more powerful. These include Lo and MacKinlay variance ratio (VR) tests, Wright VR tests, runs test, and model comparison: ranking by error statistics and BDS test [17,20].

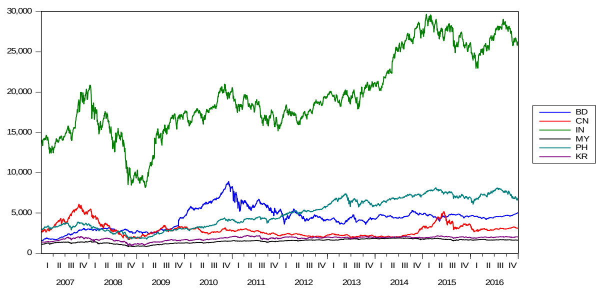
2. Data and Statistical Analysis based on the Operations and Information Management

The data consists of daily, weekly, and monthly closing prices of six emerging stock market indexes in Asian countries of- Bangladesh, Chinese, India, Malaysia, Philippine, and South Korea, chosen as representative for each of these markets. The stock indices are used for the study which is the most important benchmark index for each country, respectively, DSEX, SSE composite, BSE 30, FBMKLCI, PSEi, and KOSPI. As for the analysis purpose, the stock index of each market is converted into stock index return to avoid complications following the algorithm that express the difference in the logarithm between the yield of closing price of today and of yesterday's (equation 1), where R_t denotes t day's rate of return, p_t denotes today's closing price and p_{t-1} denotes yesterday's closing price.

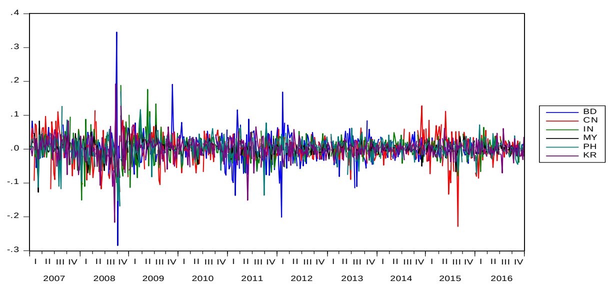
$$R_t = \log p_t - \log p_{t-1} \qquad (1)$$

Figure 1 shows the time-series behavior of the daily stock market indices and weekly market returns. Panel A reflects a general upward market trend in all stock markets during the study period while panel B is suggestive of mean-reversion for weekly stock returns in all six markets.

Panel A: Stock market indices (Daily market indices)



Panel B: Stock market returns (Weekly market returns



Note: The symbols BD, CN, IN, MY, PH, and KR denote the countries Bangladesh, China, India, Malaysia, Philippine, and South Korea respectively.

Figure 1. Time-series behavior of stock market daily indices and weekly market returns

The empirical tests are applied to the whole ten year period, the data are further divided into two sub groups for extending the analysis; from 2007-2011 (sub periods -1), and 2012-2016 (sub periods -2). The investigation of different sub periods has the advantage for allowing the structural changes, some periods accept the RWH while in other periods, and hypothesis is rejected. Daily closing index prices are used to figure out the weekly series data. The every Friday's (Thursdays only for Bangladesh) data is used to figure out the weekly series, in case, if data are missing, the previous day's data is used.

3. Methodology

In this study we basically follow a number of tests (i.e., unit root tests, serial correlation test, runs test, VR tests, ARMA, GARCH type models, and BDS test) in order to investigate whether emerging Asian stock markets are forecasting performance determined. The EMH in its weak form is tested on historical data for the daily, weekly, and monthly indices for the six emerging Asian stock markets. The methodology follows the following steps:

3.1 Unit Root Test

There is a common process, the unit root test, to define financial variable follows a random walk or not. The efficiency of markets is tested by the unit root test. The meaning of null hypothesis is found in the existence of a unit root for a particular series that means the series follow a random walk. In this study are used the Augmented Dickey-Fuller unit root tests; and Kwiatkowski, Phillips, Schmidt, and Shin (1992) stationarity test. The null hypothesis is tested by the Augmented Dickey-Fuller and Phillips-Perron tests in the presence of a unit root that shows the series follow a random walk [19]. The Kwiatkowski, Phillips, Schmidt, and Shin test is an alternative unit root test which mainly tests the null hypothesis of stationarity against the alternative of a unit root. Here, rejecting the null hypothesis that means the series follow a random walk. The Augmented Dickey and Fuller (ADF), estimate the following equation:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \delta_2 \Delta y_{t-2} + \cdots + \delta_p \Delta y_{t-p} + \varepsilon_t \qquad (2)$$

In the above equation, y_t is a series that follows as autoregressive (AR) p process, α is a constant, β the coefficient on a time trend and ε_t are assumed to be white noise. Imposing the constraints $\alpha = 0$ and $\beta = 0$ corresponds to modelling a random walk and using the constraint $\beta = 0$ corresponds to modelling a random walk with a drift.

Phillips-Perron (PP) unit root tests is based on the statistic:

$$\tilde{t}_\alpha = t_\alpha (\frac{\gamma_0}{f_0})^{\frac{1}{2}} - \frac{T(f_0 - \gamma_0)(se(\hat{\alpha}))}{2 f_0^{1/2} s} \qquad (3)$$

In this equation $\hat{\alpha}$ is the estimate, and t_α the t ratio of α, $se(\hat{\alpha})$ is a coefficient standard error, and s is the standard error of the test regression. Moreover, γ_0 is a consistent estimate of the error variance. The rest of the term, f_0 is an estimator of the residual spectrum at frequency zero.

Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) stationarity test is defined as:

$$y_t = r_t + \beta_t + \varepsilon_t \qquad (4)$$

The KPSS test statistic is constructed on the linear regression. Where y is a univariate time series, a random walk r_t, a deterministic trend β_t, and a stationary error ε_t.

3.2 Serial Correlation Test

Correlation coefficient between a series of returns and lagged returns in the same series is determined by serial correlation or autocorrelation tests. The positive result of the correlation between current return and previous return uphold the existence of certain trends in return series. So the non-randomness is found in data. The negative result of the correlation between current return and previous return uphold existence of the reverse relationship in return series and there is also non-randomness in data. Randomness in return series can be considered getting the zero result of the correlation between current return and previous return. The auto correlation is tested by a parametric auto correlation coefficient test and non-parametric run test where there is found the calculation of the correlation for rate of returns over time. It is analyzed that weather the rate of return on day *t* correlates with the rate of return on day *t*-1, *t*-2…. *t*-n. The efficiency of the market creates an insignificant relation between return on day *t* with the return on day *t*-1, *t*-2….*t*-n. The following equation is used to measure the serial correlation between current time period return and previous time period return.

$$\text{In } R_t = \alpha + \rho \text{ In } R_{t-1} + \varepsilon_t \qquad (5)$$

Where R_t is current time period return (dependent variable), R_{t-1} is previous time period return, α is constant term and ε is error term while ρ = estimated parameter (-1<ρ<1).

Ljung-Box Q-statistic test is selected to test the significance of the auto-correlation. As research data is time series and in statistics there are number of autocorrelation tests exist for times series data. Ljung-Box Q-statistic test is one of most famous serial correlation test. The Ljung-Box Q-statistic test has been proposed by Ljung-Box (1978). The reason is to use Ljung-Box Q-statistic test to find out whether the series contains autocorrelation or not. An autocorrelation analysis is subsequently performed with the serial correlation coefficient defined as:

$$\rho(k) = \frac{Cov(P_t, P_{t-k})}{Var\ (R_t)} \qquad (6)$$

Where k is the lag of the period and *P* is the logarithmic difference. The tests are conducted for 20 lags of daily, weekly, and monthly log differences. The basic formula of Ljung-Box Q-statistic test is as follow:

$$Q = T(T+2) \sum_{j=1}^{k} \frac{T_j^2}{T=J} \qquad (7)$$

Where T is the number of observations T_j is the *j* th autocorrelation. *Q* is asymptotically distributed as a x^2 with degrees of freedom equal to the number of autocorrelations.

3.3 Runs Test

To find out the successive price changes are independent or not, the runs test is used which is a non-parametric test. Runs test determines that events separate the quantity of similar events that are also different. Null hypothesis is tested by observing the number of runs where the successive price changes (or returns) with the same sign. A positive sign (+) is found in the return which is above the mean return and a negative sign (−) is found in below the mean return. All these series allow an ultimate time drift in the series of return. It can be noted that this is a non-parametric test. So it does not need the returns to be normally distributed like a martingale test. The runs test is based on the premise that if price changes (returns) are random, the actual number of runs (R) should be close to the expected number of runs (μ_R).

Let n_+ and n_- be the number of positive returns (+) and negative returns (−) in a sample with n observations, where $n = n_+ + n_-$. For large sample sizes, the test statistic is approximately normally distributed. Following equation was used.

$$Z = \frac{R-\mu_R}{\sigma_R} \approx \mathrm{N}(0,1), \quad (8)$$

Where $\mu_R = 2n_+n_-/n + 1$, and

$\sigma_R = \sqrt{2n_+n_-(2n_+n_- - n)/n^2(n-1)}$.

3.4 Variance Ratio (VR) Test

There is fourth method variance ratio test that has been selected for analysis which is a nonparametric test. This test has been proposed by Lo and MacKinlay considering both homoskedastic and heteroskedastic components [17]. There are Monte Carlo experiments where Lo and MacKinlay exhibit that the VR statistic is more powerful than unit root based tests or the autocorrelations based tests [18].

There is an alternative VR tests which is proposed by Wright (2000) and it is based on the ranks and signs of a time series to test the null. So the series is found as a martingale difference sequence. It is found that ranks and signs based tests are more powerful than the conventional variance-ratio tests among the several VR tests [20].

3.4.1 Lo an MacKinlay (L-M) VR

According to Lo and MacKinlay,the proportionality of the variance of k -differences are found from the first difference of the series [17]. They also calculate that for a random walk series, the variance of its k -differences is k times and the variance of its first difference. The VR of the k th difference is defined as follows:

$$VR(k) = \frac{\sigma^2(k)}{\sigma^2(1)} \quad (9)$$

Where $VR(k)$ is the variance ratio of the k th difference of the series; $\sigma^2(k)$ is the unbiased estimator of $1/k$ of the variance of the k th difference of the series under the null hypothesis; $\sigma^2(1)$ is the variance of the first difference of the series; and k is the number of days in the observation interval, or difference interval.

The estimator of the k -period difference, $\sigma^2(k)$, can be computed as followed by Lo and MacKinlay [17, 18]:

$$\sigma^2(k) = \frac{1}{Tk}\sum_{t=k}^{T}(X_t + \cdots + X_{t-k-1} - k\hat{\mu})^2 \quad (10)$$

Where $\hat{\mu} = (\frac{1}{T})\sum_{t-k}^{T} X_t$. The unbiased estimator of the variance of the first difference, $\sigma^2(1)$, is calculated as follows:

$$\sigma^2(1) = \frac{1}{T}\sum_{t=1}^{T}(X_t - \hat{\mu})^2 \quad (11)$$

The test statistic $M_1(k)$ is therefore defined as follows:

$$M_1(k) = \frac{VR(k)-1}{\emptyset(k)^{1/2}} \quad (12)$$

Under the assumption of homoskedasticity, $M_1(k)$ is asymptotically distributed to $N(0,1)$, with the asymptotic variance, $\emptyset(k)$, being defined as follows:

$$\emptyset(k) = \frac{2(2k-1)(k-1)}{3kT} \quad (13)$$

The test statistic $M_2(k)$ is robust under heteroskedasticity and defined as follows:

$$M_2(k) = \frac{VR(k)-1}{\emptyset^*(k)^{1/2}} \quad (14)$$

Where $\emptyset^*(k) = \sum_{i=1}^{k-1}\left[\frac{2(k-i)}{k}\right]^2 \delta(i)$ and $\delta(i) = \frac{(\sum_{t=i+1}^{T}(X_t-\hat{\mu})^2(X_{t-i}-\hat{\mu})^2)}{[\sum_{t=1}^{T}(X_t-\hat{\mu})^2]^2}$

3.4.2 Wright's alternative VR

From the opinion of Wright (2000) it is found that the rank and sign based tests are capable of decisively rejecting the martingale model of a financial series for which other variance-ratio tests give rather ambiguous results. He proposes ranks (R_1 and R_2) and signs (S_1 and S_2) as alternatives to standard VR tests (M_1 and M_2). The R_1 and R_2 proposed by Wright are defined as follows [20]:

$$R_1 = (\frac{\left(\frac{1}{Tk}\right)\sum_{t=k}^{T}(r_{1t}+\cdots+r_{1t-k+1})^2}{(1/T)\sum_{t=1}^{T}r_{1t}^2} - 1) \times \emptyset(k)^{-1/2} \quad (15)$$

$$R_2 = \left(\frac{\left(\frac{1}{Tk}\right)\sum_{t=k}^{T}(r_{2t}+\cdots+r_{2t-k+1})^2}{\left(\frac{1}{T}\right)\sum_{t=1}^{T}r_{2t}^2} - 1\right) \times \emptyset(k)^{-\frac{1}{2}} \quad (16)$$

Where

$$r_{1t} = (r(X_t) - \left(\frac{T+1}{2}\right))/\sqrt{(T-1)(T+1)/12}$$

$$r_{2t} = \emptyset^{-1}r(X_t)/(T+1).$$

$\emptyset(k)$ is as defined in Eq. (13); $r(X_t)$ is the rank of X_t among $X_t, \ldots, X_T$; and $\emptyset^{-1}$ is the inverse of the standard normal cumulative distribution function. The test based on the signs of the returns is defined as follows:

$$S_1 = (\frac{\left(\frac{1}{Tk}\right)\sum_{t=k}^{T}(s_t+\cdots+s_{t-k+1})^2}{(1/T)\sum_{t=1}^{T}s_t^2} - 1) \times (\frac{2(2k-1)(k-1)}{3kT})^{-1/2} \quad (17)$$

Where $s_t = 2\mu(X_{t,}0)$, $u(X_{t,}q) = \begin{cases} 0.5 & \text{if } X_t > q \\ -0.5 & \text{otherwise} \end{cases}$; S_1 therefore assumes a zero drift value.

Wright (2000) claims that the rank tests R_1 and R_2 always have better power than either of the M_1 and M_2 tests of Lo and MacKinlay [17]. Both R_1 and R_2 dominate the heteroskedasticity robust test M_2 in power. According to Wright (2000) it is also found that sign-based tests have more power than the L-M variance-ratio tests even though they usually have less power than the rank-based tests. In this paper demonstrates that this Lo and MacKinlay M_2 and, Wright R_1 and S_1 those are more powerful in VR tests [20].

3.5 ARMA Model

If the RWH, for a particular data series, is rejected on the basis of unit root, autocorrelation, runs test, or VR tests, the series is tested for possible ARCH effects procedure. At first, it is needed to identify the most appropriate ARIMA model. The Box– Pierce Q-statistic of the squared residuals is used to identify the (p, q) order of GARCH process with the best fit.

3.6 GARCH Models

There are some conditional heteroscedasticity models GARCH, GARCH-M, TARCH, and PARCH which are applied to the log return series. Different types of noticeable features of return volatility are captured by the each new model.

There is symmetric effect on volatilities of positive and negative error terms that is assumed by Standard GARCH models. It has been documented, however, that the price reaction of financial assets to new information tends to be asymmetric, while bad news increases volatility; good news increases volatility by a smaller amount or even decreases volatility. In emerging markets' return supply, the relative high level volatility and fat tails are pointed by Harvey [13].

3.7 Forecasting Error Statistics

Brailsford and Faff point out that there are three symmetric error statistics which compare the forecasting performance of the ARMA and GARCH-type models [6,7]. These error statistics are: (i) Root Mean Squared Error (RMSE), (ii) Mean Absolute Error (MAE), and (i) the Mean Absolute Percentage Error (MAPE). In addition, the Theil Inequality Coefficient (TIC), and the Bias as well as the Variance Proportions of the mean squared forecast error are presented. For the rolling one-day-ahead forecast of within-week volatility, the RMSE is

$$RMSE = \sqrt{\sum_{t=T+1}^{T+h} \frac{(\hat{y}_t - y)^2}{h}} \quad (20)$$

Where the forecasting sample $= T+1, T+2, \ldots, T+h,$ and denote the actual and forecasted value in period t as y_t and $\hat{y}_t$, respectively.

The MAE is

$$MAE = \sum_{t=T+1}^{T+h} \frac{|\hat{y}_t - y_t|}{h} \quad (21)$$

And the MAPE is

$$100 \sum_{t=T+1}^{T+h} \left| \frac{\frac{\hat{y}_t - y_t}{y_t}}{h} \right| \quad (22)$$

The TIC is

$$\frac{\sqrt{\sum_{t=T+1}^{T+h} \frac{(\hat{y}_t - y_t)^2}{h}}}{\sqrt{\sum_{t=T+1}^{T+h} \frac{y_t}{h}} + \sqrt{\sum_{t=T+1}^{T+h} \frac{\hat{y}_t^2}{h}}} \quad (23)$$

In addition, the squared forecast error can be decomposed as

$$\frac{\Sigma(\hat{y}_t - y_t)^2}{h} = \left(\left(\frac{\Sigma \hat{y}_t}{h}\right) - \bar{y}^2\right) + (S_{\hat{y}} - S_y)^2 + 2(1-r)S_y S_{\hat{y}} \quad (24)$$

measures the difference in variation between forecasted and actual values. Lower values for these proportions indicate better forecasting performance. It is also noticeable that based on these error statistics, relative forecasting performance is difficult to judge.

4. Results

4.1 Unit Root Test

In time series data analysis, it is a significant concern to find out if the data series are stationary or not stationary. The presence of a unit root in the six Asian countries emerging stock markets returns are tested using the ADF, PP, and KPSS tests. Cooray and Wickremasinghe apply the Ng and Perron tests and the Zivot and Andrew tests to detect unit root components. They find that the stock markets of India follow a random walk [21].

In Table 1(a) unit root tests for the full period and both sub periods (1, 2) are reported. The unit root tests for daily indices price data between index level and first differences are close to zero at all significance level. The ADF and PP tests indicate that the null hypothesis of the existence of a unit root in the levels of each of the six indices prices series cannot be rejected. The only exception is found in the second sub period in Bangladesh where the null hypothesis is rejected at the 1%-level in ADF and PP tests. The KPSS test statistics suggest rejecting the null hypothesis of stationarity for all market indices and data frequencies for the full period and the both sub periods.

In Table 1(b) illustrates the unit root tests for weekly indices prices which is largely consistent with the evidence from daily data, at levels, the ADF and PP statistics do not reject the null hypotheses of a unit root, with the exception of the Bangladesh and South Korea markets for the ADF and PP tests in the second sub period, where the null hypothesis is rejected at the 1%-level. The KPSS test is largely consistent with the evidence from daily data, which is rejecting the null hypothesis of stationarity for all market indices and data frequencies for the full period and the both sub periods.

In Table 1(c) the unit root tests results are clearly supported by evidence from weekly data, in the case of monthly indices prices, showing at levels, the ADF and PP statistics do not reject the null hypotheses of a unit root, with the exception of the Bangladesh and South Korea markets for the ADF and PP tests in the second sub period, where the null hypothesis is rejected at the 1%-level; another side, in ADF test for the first time in China where the null hypothesis is rejected at 5%-level in first sub period. For the KPSS test is not consistent with the evidence from daily and weekly data, in the second sub period, however, the null hypothesis of the existence of a unit root are rejected for Bangladesh and Malaysia; and China and India for first sub period; again China for full period data.

As a crucial condition for a RWH, the ADF and PP unit root tests cannot reject the essential null hypothesis in the situation of all six emerging markets with the exception of Bangladesh and South Korea in second sub period for all frequency, while the KPSS unit root tests reject the necessary null with the exception of monthly data.

Table 1(a). Unit Root Tests, Daily Data

Markets	Period	Levels			First Differences		
		ADF	PP	KPSS	ADF	PP	KPSS
	Full	-2.10	-2.06	1.72***	-52.13***	-52.19***	0.18
Bangladesh	1	-1.27	-1.26	3.41***	-27.25***	-34.44***	0.17
	2	-3.47***	-3.67***	0.66**	-14.20***	-35.70***	0.13
	Full	-2.15	-2.16	1.05***	-44.20***	-44.19***	0.12
China	1	-1.15	-1.21	1.39***	-35.97***	-35.99***	0.22
	2	-1.56	-1.37	2.27***	-15.97***	-32.76***	0.09
	Full	-1.16	-1.32	4.86***	-43.51***	-41.43***	0.07
India	1	-1.06	-1.15	1.16***	-32.64***	-31.95***	0.09
	2	-1.71	-1.72	3.65***	-34.09***	-34.04***	0.15
	Full	-1.51	-1.53	4.71***	45.80***	-45.86***	0.14
Malaysia	1	-0.96	-0.99	1.53***	32.29***	-32.27***	0.17
	2	-2.39	-2.23	1.03***	-32.44***	-32.30***	0.23
	Full	-0.77	-0.81	5.84***	-43.16***	-47.37***	0.11
Philippine	1	-0.74	-0.65	1.81***	-30.89***	-31.73***	0.21
	2	-2.50	-2.81	3.19***	-20.84***	-34.32***	0.25
	Full	-2.49	-2.52	3.39***	-43.69***	-43.68***	0.05

South Korea	1	-1.61	-1.63	1.45***	-36.36***	-35.36***	0.07
	2	-4.52	-4.58	0.72**	-32.27***	-35.48***	0.03

*Denote statistical significance at the 10% level.
** Denote statistical significance at the 5% level.
***Denote statistical significance at the 1% level

Table 1(b). Unit Root Tests, Weekly Data

Markets	Period	Levels			First Differences		
		ADF	PP	KPSS	ADF	PP	KPSS
	Full	-2.13	-2.10	0.78***	-23.68***	-23.61***	0.16
Bangladesh	1	-1.32	-1.35	1.54***	-17.03***	-16.97***	0.15
	2	-4.02***	-4.34***	0.39*	-9.14***	-16.01***	0.13
	Full	-1.88	-2.11	0.44*	-20.82***	-20.88***	0.07
China	1	-1.21	-1.35	0.68**	-14.77***	-14.81***	0.17
	2	-1.44	-1.65	1.14***	-14.51***	-14.58***	0.06
	Full	-1.24	-1.25	2.15***	-24.12***	-24.12***	0.05
India	1	-1.80	-1.73	0.56**	-16.97***	-16.96***	0.09
	2	-1.69	-1.67	1.65***	-16.99***	-17.11***	0.19
	Full	-1.52	-1.51	2.07***	-22.06***	-22.06***	0.14
Malaysia	1	-1.12	-1.12	0.69**	-15.71***	-15.71***	0.13
	2	-2.25	-2.26	0.51**	-15.22***	-15.22***	0.27
	Full	-0.87	-0.85	2.55***	-23.47***	-23.43***	0.12
Philippine	1	-0.78	-0.67	0.83***	-17.43***	-17.42***	0.20
	2	-2.39	-2.39	1.53***	-16.08***	-16.07***	0.28
	Full	-2.63	-2.57	1.45***	-22.26***	-22.33***	0.07
South Korea	1	-1.66	-1.65	0.71**	-15.38***	-15.40***	0.08
	2	-4.63***	-4.65***	0.50**	-16.53***	-17.11***	0.03

*Denote statistical significance at the 10% level.

** Denote statistical significance at the 5% level.
***Denote statistical significance at the 1% level.

Table 1(c). Unit Root Tests, Monthly Data

Markets	Period	Levels			First Differences		
		ADF	PP	KPSS	ADF	PP	KPSS
	Full	-2.28	-2.25	0.39*	-10.87***	-10.87***	0.14
Bangladesh	1	-1.36	-1.35	0.77***	-6.85***	-6.84***	0.13
	2	-5.07***	-5.23***	0.29	-11.57***	-22.40***	0.32
	Full	-2.06	-2.54	0.25	-9.61***	-9.65***	0.05
China	1	-3.48**	-1.69	0.32	-2.70*	-6.17***	0.12
	2	-1.64	-1.63	0.57**	-7.45***	-7.53***	0.07
	Full	-1.15	-1.26	1.05***	10.86***	-10.87***	0.05
India	1	-1.78	-1.91	0.29	-7.21***	-7.19***	0.08
	2	-1.58	-1.57	0.82***	-8.38***	-8.35***	0.17
	Full	-1.50	-1.55	0.99***	-10.63***	-10.64***	0.13
Malaysia	1	-1.13	-1.29	0.36*	-7.07***	-7.08***	0.11
	2	-2.24	-2.21	0.26	-8.34***	-8.35***	0.35*
	Full	-0.79	-0.78	1.19***	-11.88***	-10.86***	0.11
Philippine	1	-0.80	-0.81	0.40*	-7.60***	-7.59***	0.18
	2	-2.42	-2.45	0.78***	-7.65***	-7.68***	0.23
	Full	-2.52	-2.47	0.80***	-11.92***	-11.97***	0.07
South Korea	1	-1.64	-1.79	0.37*	-8.01***	-8.00***	0.07
	2	-4.61***	-4.69***	0.40*	-9.48***	-15.96***	0.22

*Denote statistical significance at the 10% level.
** Denote statistical significance at the 5% level.
***Denote statistical significance at the 1% level.

4.2 Serial Correlation Test

The presence of a unit root is necessary, nevertheless, this procedure is not sufficient on its own to assess RW. The serial correlation or autocorrelation test maybe the most widely used test to investigate the RWH. Autocorrelation test states that consecutive value changes are independent of each other. To find out the RWH, the serial autocorrelation and Ljung-Box Q-statistic tests have been used. In Table 3(a)-4(c) daily, weekly, and monthly returns, respectively, on the six Asian emerging stock markets indices are selected for the study full and both sub periods and the results for autocorrelation tests with lags up to 20 days.

Table 2(a) reports, the test for daily results for the full data period is exposed that South Korea stock markets do not have any serial correlation. Nevertheless, the Bangladeshi and Chinese stock markets show different lags that reject the null hypothesis which has no big numbers and the evidence indicates that those markets have significant serial correlation. However, the Philippine, Malaysia, and Indian stock markets suffers from positive serial correlation up to the 20th lag.

Table 2(b) presents the reports of weekly returns, and the full period presents that the Malaysian and South Korean have no serial correlation. However, the p-value of Bangladesh, China, India and the Philippine are less than 0.05 in most of different lags time which accepts the null hypothesis and meaning that those markets have serial correlation. All these indicate that those markets are not weak form efficient which means that the future returns can be predictable by the historical returns.

Table 2(a). Results of Autocorrelation, Daily data.

Lags	Full: 2007-2016											
	BD		CN		IN		MY		PH		KR	
	AC	Q-St	AC	Q-St	AC	Q-St	AC	Q-St	AC	Q-St	AC	Q-St
1	0.01	0.22	0.02	1.14	0.07*	12.54	0.12*	34.47	0.11*	33.35	0.02	0.75
2	0.00	0.24	-0.03	2.79	0.01*	12.72	0.03*	37.27	0.00*	33.37	-0.01	1.04
3	-0.01	0.52	0.02	4.04	0.03*	14.72	0.02*	38.01	0.05*	39.08	0.00	1.05
4	0.06	8.78	0.08*	19.24	-0.02*	15.33	0.02*	38.90	-0.07*	53.30	-0.04	4.36
5	0.03	11.08	-0.01*	19.78	0.03*	16.94	-0.01*	39.02	-0.06*	61.29	-0.05	10.57
6	-0.09*	29.91	-0.05*	27.04	-0.06*	26.20	-0.03*	40.97	-0.01*	61.69	0.00	10.60
7	0.02*	30.49	0.02*	27.90	0.00*	26.20	0.01*	41.52	0.01*	61.77	0.00	10.64
8	0.00*	30.49	0.02*	29.06	0.02*	27.37	0.00*	41.52	0.04*	66.20	0.01	11.13
9	0.04*	33.99	0.02*	29.73	0.07*	41.40	0.01*	41.71	0.01*	66.69	0.01	11.45
10	0.00*	34.01	0.01*	29.82	0.02*	42.84	0.04*	45.11	0.01*	67.04	0.01	11.81
11	0.00*	34.02	-0.01*	30.23	-0.06*	52.90	-0.01*	45.21	0.02*	67.61	-0.02	12.48

12	0.06*	42.32	-0.01*	30.39	0.02*	54.17	0.01*	45.35	0.01*	67.74	-0.01	12.97
13	-0.03*	45.18	0.07*	43.10	0.03*	57.25	-0.01*	45.79	0.05*	74.49	0.02	13.77
14	0.02*	45.76	-0.02*	44.63	0.01*	57.80	0.01*	45.93	0.00*	74.49	-0.02	14.78
15	0.02*	47.00	0.01*	45.14	0.01*	58.09	0.01*	45.98	0.00*	74.52	-0.03	16.48
16	0.01*	47.08	0.03*	47.94	0.03*	60.75	-0.02*	47.41	-0.02*	75.23	0.01	16.68
17	0.00*	47.13	0.00*	47.94	0.00*	60.78	0.00*	47.42	-0.02*	76.42	-0.03	18.99
18	-0.04*	50.41	0.01*	48.02	-0.02*	61.47	-0.05*	52.65	0.02*	77.23	0.03	20.62
19	0.07*	61.94	-0.02*	48.94	0.01*	61.92	0.02*	53.77	0.02*	78.27	0.04	24.14
20	0.00*	61.97	0.05*	54.86	-0.00*	61.93	0.01*	53.99	0.00*	78.28	0.00	24.14

Note: The symbols BD, CN, IN, MY, PH, and KR denote the countries Bangladesh, China, India, Malaysia, Philippine, and South Korea respectively.AC: Autocorrelation coefficient; Q: Box-Ljung statistics; Box-Ljung statistic based on the asymptotic Chi square approximation. If the P-value of the Q-Statistics is less than 0.05 i.e. P-value < 0.05 the null hypothesis is reject at 5% of level of significance. *Null hypothesis rejection significant at the 5% level.

Table 2(b). Results of Autocorrelation, Weekly data.

Lags	Full: 2007-2016											
	BD		CN		IN		MY		PH		KR	
	AC	Q-St	AC	Q-St	AC	Q-St	AC	Q-St	AC	Q-St	AC	Q-St
1	-0.12*	6.52	0.03	0.31	-0.10*	5.11	-0.02	0.23	-0.13*	7.56	-0.04	0.67
2	0.08*	9.62	0.06	1.76	0.05	6.24	0.04	0.99	0.09*	11.72	-0.07	2.77
3	0.02*	9.75	-0.01	1.82	0.11*	11.75	-0.06	2.84	-0.03*	12.03	-0.06	4.42
4	-0.01*	9.79	0.12	9.27	-0.13*	19.43	0.02	2.96	-0.02*	12.25	-0.01	4.44
5	-0.02	9.94	-0.08*	12.15	0.09*	23.41	0.07	5.64	0.08*	15.35	0.09	8.00
6	0.02	10.06	0.03*	12.63	-0.01*	23.45	0.02	5.87	-0.07*	17.71	-0.02	8.27
7	0.04	10.92	0.04	13.35	-0.02*	23.61	0.01	5.95	0.03*	18.00	0.02	8.47
8	-0.08	13.77	0.08*	16.85	0.06*	25.16	0.03	6.33	0.00*	18.01	-0.04	9.20
9	0.04	14.43	0.01	16.86	-0.11*	31.02	-0.03	6.67	-0.01*	18.04	-0.11	14.86
10	-0.10*	19.49	0.08*	19.68	0.03*	31.36	0.03	7.11	-0.05*	19.23	-0.03	15.17
11	0.03*	19.97	0.03*	20.06	-0.03*	31.94	-0.01	7.16	0.05	20.30	0.07	17.57

12	0.01	20.02	0.00	20.07	0.06*	33.86	0.03	7.66	0.02	20.54	0.12*	24.10
13	-0.05	21.21	-0.11*	25.60	0.07*	36.27	0.11	14.04	0.10*	25.77	0.03*	24.47
14	0.04	21.97	-0.03*	25.91	0.02*	36.49	0.01	14.10	-0.02*	25.96	0.04*	25.13
15	0.07	24.36	0.09*	29.47	0.10*	41.88	0.08	17.22	0.03*	26.30	-0.06*	27.13
16	0.00	24.36	0.13*	38.05	0.02*	42.00	-0.01	17.32	0.06*	28.24	0.04*	27.99
17	-0.01	24.39	0.07*	40.51	-0.03*	42.35	-0.02	17.46	-0.07*	30.34	0.03*	28.43
18	0.00	24.39	0.08*	43.32	0.06*	44.12	0.01	17.55	0.06*	32.14	0.04	29.29
19	0.06	25.91	0.07*	45.41	-0.08*	47.10	-0.04	18.45	-0.07*	34.50	-0.03	29.60
20	-0.01	25.98	0.06*	46.97	0.08*	50.14	0.07	20.88	0.10*	39.50	-0.08*	32.88

Note: The symbols BD, CN, IN, MY, PH, and KR denote the countries Bangladesh, China, India, Malaysia, Philippine, and South Korea respectively.AC: Autocorrelation coefficient; Q: Box-Ljung statistics; Box-Ljung statistic based on the asymptotic Chi square approximation. If the P-value of the Q-Statistics is less than 0.05 i.e. P-value < 0.05 the null hypothesis is reject at 5% of level of significance. *Null hypothesis rejection significant at the 5% level

4.3 Runs Test

The runs test results do not depend on normality of returns. To assess the independence between successive price changes, the runs test is used. The runs test results are presented in Table 3, for daily, weekly, and monthly returns.

Panel A (daily returns) presents the results for all periods. In full data period, the results expose that all countries stock markets indices Z-values are negative and statistically significant (therefore the closing prices are not random). This phenomenon indicates that the actual number of runs falls short of the expected number of runs, under the null hypothesis of return independence. These produce a positive serial correlation for negative Z-values. The only exception is South Korean stock market Z-value which is negative but statistically insignificant. The results for the first sub period data is similar to the full period results. Again, exceptional results are found in South Korean stock market that display more runs than it is expected, statistically not significant, and Z-value is positive which indicates the negative serial correlation. The results for the second sub period data support the full period results. Some exception are noticeable here, Chinese, Indian, and South Korean stock markets Z-values are negative and statistically not significant.

Panel B (weekly returns) presents the results for all periods. The number of runs with full period data is above expected in India and the Philippine, and below expected in other four countries stock markets that the number of runs is close to the expected. Only Bangladeshi stock markets Z-value is negative and statistically significant. However, Indian and the Philippine stock markets Z-values are positive, and the opposite outcomes are found in Chinese, Malaysian, and South Korean stock markets where Z-values are negative but all of those countries stock markets are statistically insignificant. In first sub period, the number of runs is above expected in China, India, and the Philippine. The results expose that Z-values are negative in Bangladesh, Malaysia, and South Korea; nevertheless, statistical significant is found only in Bangladesh and the Philippine stock markets. The results for the second sub period data is similar to the full period results.

Table 3. Results of runs test

Countries	Bangladesh			China			India			Malaysia		
	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2	Full period
R	1075	549	529	1250	605	651	1231	604	623	1208	612	597	1161
μR	1305.5	625.1	653.4	1301	649.6	652.6	1305.2	653	652.9	1305.5	653	653.4	1305.5
Z	-9.027**	-5.721**	-6.893**	-2.005*	-2.485*	-0.092	-2.907**	-2.715**	-1.662	-3.818**	-2.271*	-3.122**	-5.658**
p-Value	0.000	0.000	0.000	0.045	0.013	0.927	0.004	0.007	0.097	0.000	0.023	0.002	0.000
R	208	104	105	239	122	115	254	121	133	239	118	120	257
μR	240.9	120.9	121	240.4	121	120.2	239.8	118.8	121	240.1	120.2	120.8	240.6
Z	-3.007*	-2.191*	-2.070*	-0.128	0.129	0.673	1.305	0.281	1.554	-0.097	-0.282	-0.103	1.503
p-Value	0.003	0.028	0.038	0.898	0.897	0.501	0.192	0.779	0.120	0.922	0.778	0.918	0.133
R	52	23	31	61	27	37	67	31	32	61	26	32	57
μR	60.9	30.9	30.2	60.4	30.5	31	58.6	28.3	30.9	60.4	30.9	28.9	60.6
Z	-1.648	-2.077*	0.223	0.111	-0.919	1.562	1.605	0.774	0.296	0.111	-1.295	0.880	-0.662
p-Value	0.099	0.038	0.823	0.912	0.358	0.118	0.109	0.439	0.767	0.912	0.195	0.379	0.508

Notes: The runs test tests for a statistically significant difference between the expected numbers of runs (μR) vs. the actual number of runs (R). A run is defined as sequence of successive returns with the same sign. We define as a positive/negative return any return above/below the mean return in the period. The null hypothesis is that the successive returns follow a martingale.

*Null hypothesis rejection significant at the 5% level.

**Null hypothesis rejection significant at the 1% level.

4.4 Variance Ratio Test

A series has a unit root component and the uncorrelated series (or a series has a martingale property) which are implied by the random walk. The financial series follow a random walk when both the properties are found to exist in a financial market. Nevertheless, martingale property and vice versa are not present in a series but unit root can be found in a series. The unit root tests and autocorrelation test are identifying the first property of the random walk; the variance-ratio (VR) tests identify the uncorrelated increments or martingale property. Lo and MacKinlay mention that the VR test is more consistent than the unit root tests. To investigate the random walk behavior of the financial markets, these tests supplement each other [14-18]. The VR tests results are shown in Table 4(a), (b) statistics in daily, weekly, and monthly data. For making conjecture decisions using these statistics, the null of RWH (martingale property) is rejected if there are more than one rejection at 5%-level of significance.

Table 4(a) displays the Lo and MacKinlay ratio test statistics; during full period and both sub periods, and variation ratio for 2, 4, 8, and 16. Panel A presents the results of the Lo and MacKinlay ratio test in daily data. In full period data, it is discernible that the null of RWH or martingale is rejected for the Asian six separate emerging markets at the 5% level of significance. Only exception is found in South Korean stock markets that shows weaker evidence against the RWH. Also in this case, the joint test results for Bangladesh and China, do not reject Z-statistics. In first sub period results evaluation, the RWH is rejected for all countries markets, except Bangladesh and South Korean stock markets. The Chinese and Indian stock markets accept joint test hypothesis. The results for the second sub period data suggest that Chinese and Philippine stock markets have improved results compared to the previous sub period. China, the Philippine, and South Korea stock markets do not reject RWH. Indian and Malaysian stock markets do not reject joint test.

Panel B presents the results for weekly data. The results show remarkable differences between daily data and weekly based results. In full period that the null of RWH and joint test (Z-statistic) are not rejected for the Asian six separate emerging markets at the 5% level of significance. Only exception is found in Indian stock markets that show that the null of RWH is rejected. Nearly parallel results are found in first and second sub periods, however in first sub period Chinese stock markets and in second sub period South Korean market shows evidence that reject the null of RWH when VR is 16 for both markets.

Panel C presents the results for monthly data. In full period results of weekly data are clearly supported by full period results of monthly data. In first sub period China, Malaysia, and the Philippine reject the null of RWH. In second sub period, only South Korean market rejects the null of RWH when VR is 4 and 8.

Table 4(b) displays the Wright ratio test statistics; based on ranks during full period and both sub periods, and variation ratio for 2, 5, 10, and 30. For data series that are found to be i.i.d. in the existence of heteroscedasticity, the test types tend to yield different outcomes. Based on rank tests results in panel A (daily data), it is apparent that the RWH is rejected for all six emerging countries, except South Korean stock markets that follows a RW process. In first sub period, results support clearly to the full period results. Results of second sub period are discernible that the null of RWH is rejected for the Asian six separate emerging markets (e.g. Bangladesh, India, Malaysia, and the Philippine) at the 5% level of significance.

Panel B presents the results for weekly data. In full period results evaluation, the RWH is rejected for all countries markets, except Indian and South Korean stock markets. The results for the first sub period data suggest that Bangladesh and Philippine stock markets have improved results compared to the full period results. In second sub period results present that China, Malaysia, and the Philippine stock markets do not reject RWH or martingale property. The Bangladeshi Indian and South Korean stock markets do not reject joint test.

In Table 4(b) ranks tests findings are clearly supported by the results of the more robust signs tests. Based on signs tests results in panel A (daily data), in full period data, it appears that the null of RWH is rejected for the Asian six separate emerging markets at the 5% level of significance, except South Korean stock markets follow a RW process. Bangladeshi and Malaysian stock markets do not reject joint test. In first sub period, results are discernible that the null of RW or martingale is rejected for all the six separate emerging markets, nevertheless, South Korean stock markets demonstrate the evidence that reject the null of RWH when VR is 30. The results from the second sub period indicate that the null of RWH is rejected for the Asian six separate emerging markets (e.g. Bangladesh, Malaysia, and the Philippine). However, Chinese and Indian stock markets show the evidence that reject the null of RWH when VR is 30 and 2, respectively.

Panel B presents the results for weekly data. In full period, the null of RWH is not rejected for the Asian six separate emerging markets at the 5% level of significance. The exception is found in Bangladeshi and Chinese stock markets that show the null of RWH which is rejected. The results from the first sub period support that the Chinese stock market has improved results compared to the full period. Chinese and Indian markets show the evidence that reject the null of RWH when VR is 30 and 10, respectively. Only Bangladeshi and Malaysian stock markets reject the null of RWH.

Table 4(a). Results of variance ratio test [17]

Countries	Bangladesh			China			India			Malaysia		
	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2
VR (2)	1.039	1.046	1.023	1.036	1.003	1.096	1.073*	1.083*	1.058*	1.109*	1.108*	1.107*
VR (4)	0.994	0.952	1.127	1.027*	1.014	1.061	1.101*	1.129	1.059	1.203*	1.219*	1.182*
VR (8)	0.970*	0.865	1.294*	1.105	1.087*	1.166	1.039	1.048	1.025	1.246*	1.340*	1.162
VR (16)	1.017	0.874	1.463*	1.194	1.175	1.299	1.032	1.062*	0.984	1.253*	1.382*	1.077
Z	0.531	0.573	2.108*	1.336	1.015	1.578	3.116*	2.388	2.079	3.590*	2.660*	2.833
VR (2)	0.922	0.903	0.966	1.051	1.048	1.066	0.902*	0.906	0.902	0.992	0.984	1.015
VR (4)	1.012	0.970	1.120	1.126	1.126	1.159	0.909	0.965	0.831	0.970	1.002	0.931
VR (8)	1.104	1.164	0.942	1.270	1.280	1.338	0.893*	1.018	0.718	0.976	1.069	0.841
VR (16)	1.075	1.287	0.533	1.478	1.719*	1.322	0.931	1.138	0.726	1.068	1.289	0.731
Z	0.779	0.722	1.035	1.591	1.903	1.050	1.909	1.333	1.377	0.284	0.889	0.899
VR (2)	1.007	1.126	0.673	1.132	1.224	1.038	0.999	1.068	0.891	1.027	1.094	0.916

VR (4)	0.892	1.118	0.361	1.273	1.591*	0.971	1.023	1.166	0.884	1.112	1.282	0.799
VR (8)	0.928	1.239	0.215	1.583	2.262*	1.062	1.174	1.456	1.011	1.289	1.735	0.741
VR (16)	1.246	1.293	0.233	0.956	1.318	0.936	0.956	1.103	1.234	1.416	2.152*	1.306
Z	0.460	0.542	1.594	1.556	2.763*	0.170	0.598	1.167	0.786	0.984	2.098	0.810

Note: Z is the heteroskedasticity-robust Chow-Denning joint VR test and VR is the individual test results. Test statistics under heteroskedasticity assumption. Statistical significance approximation using studentized maximum modulus. A * indicate statistical significance at 5% level.

Table 4(b). Results of variance ratio test [20]

Countries	Bangladesh			China			India			Malaysia		
	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2	Full period	Sub-period 1	Sub-period 2
VR (2)	1.150*	1.129*	1.166*	1.033	1.032	1.024	1.087*	1.090*	1.071*	1.123*	1.133*	1.106*
VR (5)	1.391*	1.311*	1.436*	1.118*	1.137*	1.067	1.179*	1.199*	1.120*	1.223*	1.291*	1.120*
VR (10)	1.637*	1.514*	1.670*	1.201*	1.252	1.079	1.182*	1.209*	1.087	1.221*	1.322*	1.050
VR (30)	2.055*	1.885*	1.877*	1.742*	1.894	1.343*	1.171	1.313	0.831	1.313*	1.571*	0.844
Z	9.643*	5.498*	7.190*	6.145*	5.235*	2.010	4.427*	3.289*	2.582*	6.268*	4.801*	3.831*
VR (2)	1.079	1.043	1.103	1.003	1.010	0.998	0.938	0.951	0.907	1.043	1.073	0.976
VR (5)	1.267*	1.153	1.308*	1.177	1.159	1.136	0.944	1.022	0.764*	1.119	1.213	0.893
VR (10)	1.372*	1.238	1.292	1.360*	1.385	1.188	0.864	0.997	0.597	1.256	1.443*	0.716
VR (30)	1.483	1.339	0.719	1.880*	2.083*	1.192	0.922	1.143	0.477	1.638*	1.922*	0.546

Z	2.664 *	1.092	2.176	3.122 *	2.717 *	0.960	1.363	0.752	1.843	2.264	2.311 *	1.301
VR (2)	1.168	1.155	1.080	1.117	1.124	1.059	0.942	0.988	0.923	1.057	1.079	0.990
VR (5)	1.122	1.106	0.531	1.203	1.451	0.886	0.909	0.972	0.703	1.090	1.261	0.629
VR (10)	1.236	1.123	0.268	1.309	1.49	0.829	0.941	0.939	0.573	1.260	1.505	0.602
VR (30)	1.012	0.085	0.027 *	0.524	0.176	0.229	0.235	0.098	0.185	0.597	0.357	0.290
Z	1.837	1.193	1.666	1.280	1.581	0.961	1.353	1.123	1.040	0.840	1.149	1.300

Note: Z is the heteroskedasticity-robust Chow-Denning joint VR test and VR is the individual test results. Test statistics under heteroskedasticity assumption using ranks. Statistical significance approximation using studentized maximum modulus. A * indicate statistical significance at 5% level.

4.5 ARMA Model

A large number of data forecasts across a variety time series are produced with a variety of challenges. Building a forecasting model with the best possible fit for each country market index starts with the ARMA (p, q) model selection. One of the most challenging jobs is considered as forecasting the stock market data due to its random walk characteristic. Forecasting the stock market data and behavior of financial time series analysis researchers and financial specialists need to consider a lot of attention and time. Stock markets of six emerging countries indices start the ARMA (p, q) model selection to build the forecasting model with the best possible fit. In the ARMA (p, q) model selection process AR (autoregressive) and MA (moving average) terms are ascertained on the basis of the AIC (akaike information criterion) and the BIC (schwarz bayesian information criterion). The evaluation results for the appropriate ARMA (p, q) model for all of the six stock markets are found in Table 5.

Table 5. ARMA (p,q) model estimation, full period data.

	Bangladesh			China			India	
Variable	Coeff.	Prob.	Variable	Coeff.	Prob.	Variable	Coeff.	Prob.
C	0.0003	0.2275	C	0.0002	0.6016	C	0.0005	0.1432
AR(3)	0.8552	0.0000	AR(1)	0.6910	0.0001	AR(1)	-0.2814	0.0000
MA(3)	-0.8655	0.0000	MA(1)	-0.6774	0.0003	MA(2)	-0.0483	0.0177
AIC	-5.5733		AIC	-5.2952		AIC	-4.5098	
BIC	-5.5665		BIC	-5.2884		BIC	-4.5031	

Variable	Malaysia		Variable	Philippine		Variable	South Korea	
	Coeff.	Prob.		Coeff.	Prob.		Coeff.	Prob.
C	0.0002	0.2382	C	0.0004	0.1080	C	0.0002	0.3490
AR(3)	-0.7886	0.0000	AR(2)	-0.9763	0.0000	AR(1)	0.8273	0.0000
MA(3)	0.8152	0.0000	MA(2)	0.9849	0.0000	MA(1)	-0.8403	0.0000
AIC	-6.9483		AIC	-5.8993		AIC	-5.8383	
BIC	-6.9415		BIC	-5.8926		BIC	-5.8316	

4.6 GARCH Models

In all the six emerging countries stock markets, the presence of ARCH effect is confirmed in sample data. In an earlier study, Bhowmik et al. mention that, the serial correlation tests for IMS are found in squared residuals confirming that the data might better is modeled as a GARCH process [3]. Table 6 presents the results for the GARCH (1, 1) family type models that show the AIC and BIC results. Therefore, conducting the GARCH (1, 1), GARCH-M (1, 1), TGARCH (1, 1), EGARCH (1, 1), and PARCH (1, 1) models that are applied to all six stock markets daily return series. The values, that are shown in bold in the table, confirm that the model with the best fit for the Asian six separate emerging stock markets. The results appear that different models fit for forecasting the individual countries stock market indices.

Table 6. GARCH model selection, Daily data.

Country	Variable	GARCH	GARCH-M	TGARCH	EGARCH	PARCH
Bangladesh	AIC	-6.1677	**-6.1671**	-6.1690	-6.1874	-6.1697
	BIC	-6.1586	**-6.1559**	-6.1578	-6.1762	-6.1562
China	AIC	-5.5920	**-5.5913**	-5.5916	-5.5958	-5.5940
	BIC	-5.5830	**-5.5801**	-5.5804	-5.5845	-5.5805
India	AIC	**-5.5626**	-5.5863	-5.7057	-5.6685	-5.7082
	BIC	**-5.5536**	-5.5750	-5.6945	-5.6572	-5.6947
Malaysia	AIC	**-7.2857**	-7.2873	-7.2969	-7.2946	-7.2972
	BIC	**-7.2768**	-7.2760	-7.2856	-7.2834	-7.2837
Philippine	AIC	-6.1683	**-6.1686**	-6.1894	-6.1945	-6.1940
	BIC	-6.1593	**-6.1574**	-6.1782	-6.1833	-6.1805
	AIC	**-6.2674**	-6.2694	-6.2946	-6.2935	-6.2966

South Korea	BIC	**-6.2584**	-6.2582	-6.2834	-6.2823	-6.2831

Note: Values in bold identify the model with the best fit for each individual market.

4.7 Forecasting Error Statistics

In forecasting performance of the Asian six separate emerging stock markets indices returns are compared to all error terms (so called "error statistic measurements") through Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Mean Abs. Percent Error (MAPE), and Theil Inequality Coefficient (TIC) which are discussed in this part. Table 7 presents the error terms test results for ARMA and GARCH type models. The whole model types are selected by the best fitting model for each separate stock market. The values in bold identify that the model with the best fit for the six separate emerging stock markets in Asia. Finally, the overall results indicate that the GARCH family type models appear to generate a marginally better acceptable than ARMA model alternatives across the Asian six emerging stock markets indexes.

Table 7. Forecasting error statistics

Country	Model	RMSE	MAE	MAPE	Theil	Bias Prop.	Var. Prop.	Cov. Prop
Bangladesh	ARMA(3,3)	0.0149	0.0092	112.31	0.9606	0.0021	0.9897	0.0602
	GARCH-M	**0.0148**	**0.0093**	**102.30**	0.9333	0.0019	0.9520	0.0461
China	ARMA(1,1)	**0.0171**	**0.0116**	**101.52**	0.9550	0.0006	0.9154	0.0446
	GARCH-M	0.0171	0.0116	104.42	0.9757	0.0001	0.9765	0.0834
India	ARMA(1,2)	0.0253	0.0120	227.02	0.7556	0.0005	0.5715	0.4284
	GARCH	**0.0263**	**0.0103**	**147.92**	0.9603	0.0004	0.5694	0.3847
Malaysia	ARMA(3,3)	0.0075	0.0050	111.27	0.9665	0.0009	0.9509	0.0491
	GARCH	**0.0075**	**0.0049**	**105.36**	0.9546	0.0006	0.9153	0.0754
Philippine	ARMA(2,2)	0.0127	0.0087	156.03	0.9688	0.0098	0.9945	0.0158
	GARCH-M	**0.0126**	**0.0087**	**130.39**	0.9101	0.0047	0.9901	0.0052
South Korea	ARMA(1,1)	0.0131	0.0087	119.32	0.9697	0.0010	0.9484	0.0516
	GARCH	**0.0130**	**0.0087**	**116.63**	0.9735	0.0001	0.9236	0.0319

Notes: In error statistic measurements through Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Mean Abs. Percent Error (MAPE), and Theil Inequality Coefficient (TIC) are discussed. Values in bold identify the model with the best fit for each individual market.

6. Conclusion

This paper examines the weak form efficiency in the six Asian emerging countries (e.g. Bangladesh, China, India, Malaysia, the Philippine, and South Korea) stock markets. In this study, there has been used the daily, weekly, and monthly closing stock market indices data for the ten years, from 02 January, 2007 to 30 December, 2016. This analysis is performed for three data set; full period (2007-2016), by breaking the ten years data making two five years sub period data set- first sub period (2007-2011), and second sub period (2012-2016). To test the RWH, a battery of econometric tests are used and employed in all cases.

The Operations and Information Management (O&IM) has a long tradition of developing, applying and teaching theoretical developments to support the practice of effective decision making in extremely complex environments. Our battery of econometric tests provides mixed evidence on the basis of different period. Nevertheless, during the full periods and first sub period, six Asian emerging countries stock markets experienced significant positive serial correlation in daily returns, however declined in the second sub period. In first sub period, strong positive serial correlation exists in all six countries individually because of global financial crisis, the exception is found in Bangladesh and South Korean stock markets. Using daily data in all periods, in overall, it is discernible that the null of RWH is rejected for the six Asian emerging countries stock markets. The results show remarkable differences between daily data and specifically weekly based results, and predictable behavior exist in six of those countries weekly returns series. Nevertheless, Chinese and South Korean stock markets are mostly unpredictable patterns in the same series. In case of Bangladesh, random-walk has found both in weekly and monthly data but noticeably in all the sub periods of monthly data. Unlike Bangladesh random-walk has been found in some separate sub periods in Philippine. Different VR tests with exact heteroscedasticity assumptions get the evidence of nonlinear dependence for the daily series, supporting the evidence of not to accept the random walk process. However, the evidence that VR and runs tests provide the superior outcomes than the serial correlation and the unit root test that take into consideration on the bias in the data distribution; this finding is also steady with the evidence of Bley [4,5].

GARCH type models procedures also follow the same path an ARCH based model building procedure, GARCH type models are applied to the return series of any market that is found not to follow a random walk process. It deals with such an issue, applying a battery of serial correlation, runs, and variance ratio tests. The best fitting model for each market is then used to take a dynamic forecasting approach. In forecasting performance of the ARMA and GARCH family type models of the Asian six separate emerging stock markets are compared based on three symmetric error statistics. Overall, the GARCH family type models appear to have the best fit across the Asian emerging countries market indices. It is found that, none of the analyzed models produce greater forecasts, nevertheless, appear to be producing higher forecasts, as the values of the error statistics are fairly close.

Finally, the paper focuses on the RWH for stock markets predictability and it is important to mention that other financial markets that also offer potentiality for diversification of financial stability. In dealing with such an issue, applying a comparative forecasting performance method cannot identify noteworthy forecasting performance variances. Thus, some similar studies are commended to be done for financial markets in order to complement the current study for the ways to improve investment strategies and market predictability. To enhance the study, it is also needed to include the newly developed very promising method for the model explanatory power as an empirical mode decomposition (EMD) based neural network ensemble forecasting paradigm can be used.

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References

[1] Alagidede, P., & T. Panagiotidis. Modelling stock returns in Africa's emerging equity markets. I*nternational Review of Financial Analysis***18(1)**, 1-11, 2009.

[2] Bachelier, L., Theorie de la Speculation, Reprinted in Paul H. Cootner (ed). The random character of stock market prices. *Cambridge, Mass, The M.I.T. Press***1964:** 17-78, 1900.

[3] Bhowmik, R., Chao, W., Roy, J. K., & S. Wang. A Study on the Volatility of the Bangladesh Stock Market—Based on GARCH Type Models. *Journal of Systems Science and Information***5(3),** 193-215, 2017.

[4] Bley, J., Are GCC stock markets predictable?. *Emerging Markets Review***12(3)**, 217-237, 2011.

[5] Brock, W., Notes on nuisance parameter problems in BDS type tests for IID. Unpublished manuscript. *Madison: University of Wisconsin*, 1987.

[6] Borges, M. R., Efficient market hypothesis in European stock markets. *The European Journal of Finance***16(7)**, 711-726, 2010.

[7] Brailsford, T.J., &R.W. Faff, An evaluation of volatility forecasting techniques. *Journal of Banking and Finance***20(3),** 419–438, 1996.

[8] Cheong, C. W.,&Z.Isa, Tests of random walk hypothesis under drift and structural break-a nonparametric approach. *World Applied Sciences Journal***2(6),**674-681, 2007.

[9] Chow, K.V.,&K.C. Denning, A simple multiple variance ratio test. *Journal of Econometrics***58(3),**385-401, 1993.

[10] Dsouza, J. J., & T. Mallikarjunappa, Does the Indian stock market exhibit random walk?. *Paradigm* **19(1),** 1-20, 2015.

[11] Fama, E. F., Efficient capital markets: a review of theory and empirical work. *J. Finance***25,** 383–417, 2017.

[12] Harvey, C. R., Predictable risk and returns in emerging markets. *Review of Financial Studies***8(3),** 773-816, 1995.

[13] Kim, S., Lee, J. W., & C. Y. Park, Emerging Asia: decoupling or recoupling. *The World Economy* **34(1),** 23-53, 2011.

[14] Levy, R. A., The theory of random walks: A survey of Findings. *The American Economist***11(2),** 34-48, 2016

[15] Worthington, A. C., &H. Higgs, Random walks and market efficiency in European equity markets. *Global Journal of Finance and Economics***1(1),** 59-78, 2004.

[17] Lo, A. and MacKinlay, A., "Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test", The Review of Financial Studies, 1, 41-66, 1988.

[18] Lo, A. and MacKinlay, A., "The size and power of the variance ratio test in finite samples: A Monte Carlo investigation", Journal of Econometrics, 40 (2), 203-238, 1989.

[19] David A. Dickey & Wayne A. Fuller, Distribution of the Estimators for Autoregressive Time Series with a Unit Root, Journal of the American Statistical Association, Volume 74, 1979 - Issue 366a, 1979.

[20] D. L. Wright, R. McGraw, C. M. Benkovitz, S. E. Schwar, Six-moment representation of multiple aerosol populations in a sub-hemispheric chemical transformation mode, GEOPHYSICAL RESEARCH LETTERS, 27(7), 1, 967-970, 2000.

[21] Arusha Cooray and Guneratne Wickremasinghe, "The Efficiency of Emerging Stock Markets: Empirical Evidence from the South Asian Region", The Journal of Developing Areas, 41(1), pp. 171-183 , 200