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An Empirical Test of Weak Form Market Efficiency on an Emerging Market: Evidence from Dhaka Stock Exchange

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Abstract: *Efficient Market Hypothesis is the cornerstone of modern financial theories. As the tests of market efficiency firstly started from developed markets, the studies on these markets are more in numbers compared with that of on emerging markets. Dhaka Stock Exchange (DSE) is an emerging market of South Asia. The current study has tested this market against weak form market efficiency by using a set of Parametric (serial correlation coefficient test, unit root test, ARIMA) and Non-parametric tests (runs test, Kolmogorov Smirnov test, Shapiro Wilk test) on DGEN and DSE 20 index (two indices of DSE) for the period of 2002-2010 and has concluded that the market is not weak form efficient.*

Keywords: *Dhaka Stock Exchange, Efficient Market Hypothesis, Parametric tests, Non-parametric tests.*

1. Introduction

Efficient Market Hypothesis (EMH) is an integral part of finance. The importance of EMH is not required to discuss to a further extent as we know that the assumption of market efficiency is directly used in so many essential financial models and theories, e.g., Capital Asset Pricing Model (CAPM), Black-Scholes-Merton Model, etc. There are several researchers like Dimson & Mussavian (1998); Beechey, Gruen & Vickery (2000) and Sewell (2011), who have conducted study on the history of efficient market hypothesis. And from their studies this is quite clear that Efficient Market Hypothesis is one of the ancient ideas in Finance discipline. The first distinct idea about EMH came from Louis Bachelier in the year 1900. After that so many scholars and researchers have worked on it and have refined the concepts of EMH. But it was the year 1965 when a complete definition of EMH was given for the first time by Eugene Francis Fama.

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EMH defines a market as an efficient one if all of its available information is fully reflected on its prices of securities (Fama 1970). In an efficient market if an investor wants to earn additional return then that person must bear an additional amount of risk. No one is able to earn an abnormal return by beating the market. The general idea behind the efficient market hypothesis can be explained with the help of the following equation:

$$E(\hat{P}_{i,t+1}) = [1 + E(\hat{r}_{i,t+1} | I_t)] \times P_{i,t} \tag{1}$$

Here, $E(\hat{P}_{i,t+1})$ is the expected price of a security i at time period t+1, $P_{i,t}$ is the price of that security at time period t. And, $E(\hat{r}_{i,t+1} | I_t)$ is the expected return conditional on I_t, which is the available information at time period t. The variables with hat (^) indicate they are random variables at time period t. The market will be efficient if the actual price equals to the expected price of that security, $E(\hat{P}_{i,t+1})$. That is to say no body can be able to use the information available in the market at time period t to gain a return in excess of the actual return at time period t+1, so that the following equation can hold:

$$E(\hat{R}_{i,t+1} | I_t) = 0, \text{and}, R_{i,t+1} = r_{i,t+1} - E(\hat{r}_{i,t+1} | I_t) \tag{2}$$

Here, $R_{i,t+1}$ is the excess return at time period t+1 predicted at t and $r_{i,t+1}$ is the actual return at time period t+1. So, in an efficient market the expected excess return from a security will always be zero, as the current price will reflect all the previous information in an efficient manner.

According to EMH the efficiency level can be classified into three degrees of efficiency (Fama 1970). A market is assumed to be **Weak Form Efficient** if all the historical information is reflected on the current market price. In **Semi Strong Form of Efficiency** all the historical and publicly available information will be reflected on the current price of the securities. **Strong Form of Efficiency**, which is the highest level of efficiency possible in a market, denotes that all the historical, public and private information is reflected in the current market price of securities. The test of market efficiency has always been an interesting area of study to the researchers, scholars and academician, because of its great importance in asset pricing, formulation of theories and developing trading strategies. Among the tests of the three levels of market efficiency, test of weak form market efficiency is the widely performed test throughout the world, as we know that a market cannot move toward the semi-strong form of efficiency unless being efficient in the weak form. The Weak Form Efficient Market Hypothesis (WFEMH) test examines whether the future price or return series of the security can be predicted with accuracy from the past price or return series. If the prediction becomes unsuccessful then the price or return series is assumed to be random and weak form efficient. On the other hand if it becomes successful then by developing some suitable trading strategies investors or speculators can earn abnormal profit which is a contra evidence of WFEMH. But this profitability also depends upon some other factors, i.e., trading cost. Again the fact is if we look at the literature then we will find that most of the test of market efficiency has been performed on the developed market like the stock markets in USA or Europe. Comparing to this, less studies have been performed on emerging markets. Moreover it is found that in most of the cases developed markets are weak form efficient and emerging markets are weak form inefficient. So this proposed study on test of weak form market efficiency is going to be conducted on Dhaka Stock Exchange (DSE) of Bangladesh, which is an emerging market of South Asia. The number of studies on test of market efficiency on DSE is really meagre and before the year 2000 there was no formal paper regarding this issue on this market (Mobarek & Keasey 2000). There are a few papers on the WFEMH test on DSE and nearly all of those have found that the market is weak form inefficient, still the current study is going be a comprehensive one as it will use some more research tools compared with the recent studies and it can be able to give the latest conclusion as the very recent data set will be used here. Finally this study will enhance some literature in the area of emerging market.

2. Literature Review

Thousands of papers have been published on test of efficient market hypothesis on different country markets throughout the world, though this is true that studies on emerging markets are less and studies on Bangladesh would be few. In this part basically some selected and relevant findings and evidence of Weak Form Efficient Market Hypothesis (WFEMH) will be presented. At the end of this part the gaps in the literature and the justification of the present study will be discussed.

Several interesting findings can be noted from the literature. Most of the tests up to year 1970 were found in line with efficient market hypothesis and supporting the random walk theory (Kendall 1953; Fama 1965; Fama & Blume 1966; James 1968; Jensen & Benington 1970; etc.). But after 1970 there were so many studies which came up with findings contradictory to efficient market hypothesis or random walk (Lo & MacKinlay 1988; Sweeny 1988; Brock et al. 1992; etc.). But it is quite apparent that the developed markets generally tend to be weak form efficient (Kendall 1953; Fama 1965; Fama & Blume 1966; James 1968; Jensen & Benington 1970; Hudson, Dempsey & Keasey 1996; etc.) on the other hand emerging markets tend to be weak form inefficient (Poshakwale 1996; Mobarek & Keasey 2000; Hassan et al. 2007; Chion & Veliz C. 2008; Metghalchi et al. 2008; etc.).

Hence this is quite apparent that market efficiency is still a debatable topic because review from literature shows mixed results. At the same time development of testing methods in this field has become an obvious phenomenon. So scope of study in this field is always open. Here some of the major test methods for testing weak form of market efficiency which have been successfully applied by previous researchers in their studies are given below:

- Serial Correlation Coefficient Test: Autocorrelation and Partial Autocorrelation tests, etc. (Kendall 1953; Fama 1965; Vaidyanathan & Gali 1994; Poshakwale 1996; Mobarek & Keasey 2000; Akhtar & Misir 2005; Mollah, Rahman & Islam 2005; Hassan, Abdullah & Shah 2007; Mobarek, Mollah & Bhuyan 2008; Chaity & Sharmin 2012; Rehman et al. 2012).

- Runs Test (Vaidyanathan & Gali 1994; Poshakwale 1996; Mobarek & Keasey 2000; Moustafa 2004; Akhtar & Misir 2005;Mobarek, Mollah & Bhuyan 2008; etc.).

- Test of Normality: Kolmogorov-Smirnov (K-S) test and Shapiro-Wilk test, etc. (Poshakwale 1996; Mobarek & Keasey 2000; Hassan, Abdullah & Shah 2007; Chaity & Sharmin 2012; Khan & Huq 2012; etc.).

- Test of Stationarity or Unit Root Test: Augmented Dickey Fuller (ADF) test, Phillips-Perron test, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, etc. (Cooray & Wickremasinghe 2007; Hassan, Abdullah & Shah 2007; Uddin & Khoda 2009; Khandoker, Siddik & Azam 2011; Gupta & Yang 2011; Rehman et al. 2012; etc.).

- Dynamic Time Series Model: ARMA and ARIMA models, etc. (Fama & French 1988; Poterba & Summers 1988; Mobarek & Keasey 2000; Gilmore & McManus 2001; Mollah, Rahman& Islam 2005; Mobarek, Mollah & Bhuyan 2008; Bepari & Mollik 2009; Chaity & Sharmin 2012; etc.).

- Variance Ratio Test (Lo & MacKinlay 1988; Hassan, Abdullah & Shah 2007; Ntim, Opong and Danbolt 2007; etc.).

- Test of Technical Trading Rules: Moving Averages rules, K% Filter rules, Relative Strength Index, Trading Range Break, Moving Averages with Stochastic Oscillator, etc. (Alexander 1961; 1964; Fama & Blume 1966; Vanhorne & Parker 1967; James 1968; Jensen & Benington 1970; Sweeny 1988; Brock, Lakonishok & LeBaron 1992; Hudson, Dempsey & Keasey 1996; Mills 1997; Kader & Rahman 2005; Loh 2007; Hussain, Chakraborty & Kabir 2008; Metghalchi et al.

2008; Milionis &Papanagiotou 2008; Metghalchi, Chang & Du 2011; Chen & Metghalchi 2012; etc.).

A brief review of some of the studies on this issue which have been performed earlier on the capital market of Bangladesh can be presented here.

Mobarek & Keasey performed test of weak form market efficiency on Dhaka Stock Exchange (DSE) of Bangladesh in the year 2000. They claim this study to be the first one of its kind on this market. Here they took all the daily price of listed securities of Bangladesh during 1988 to 1997 as a sample and tested a set of both parametric and non-parametric tests. In non-parametric test they performed Kolmogorov-Smirnov test, runs test and in parametric test they did Auto-correlation test, Auto-regression and ARIMA model. Finally they reached at the conclusion that the market was not weak form efficient. Mollah, Rahman & Islam (2005) particularly worked on DSE-20 index of Dhaka Stock Exchange. They used various tests like ARMA, ARIMA, ACF, PACF and Dimson's Market model and finally found that return behaviour of DSE-20 can be predicted. A bit different argument was raised by Islam & Khaled (2005). They presented that from using heteroscedasticity-robust Box-Pierce test on Dhaka Stock Market data could give a different result other than typical weak form inefficiency. But on the other hand Akhter & Misir (2005) came up with a contradictory finding. They took a sample of monthly return series from DSE for the year 2003 and divided the securities into ten different segments. Then they applied serial correlation coefficient and runs test. At the end they have found that the monthly return series from industry wise classification was random and there was no serial dependence. So they concluded the market as weak form efficient. Again, Mobarek, Mollah & Bhuyan (2008) did a study on DSE by taking the daily price index of listed securities for the period of 1988 to 2000 and applied some parametric and non-parametric tests. They also rejected the null hypothesis of weak form market efficiency. Uddin & Khoda (2009) and Khandoker, Siddik & Azam (2011) concluded Dhaka Stock Exchange as weak form inefficient after testing it with Augmented Dickey-Fuller test. A different set of tests were executed by Bepari & Mollik (2009). They used combined regression time series model and found seasonality in Dhaka Stock Exchange monthly series. Evidence of 'April Effect' also came up from their study. So market is not an efficient market and by using investment timing investors can earn higher return without bearing any additional risk. Chaity & Sharmin (2012) concluded that DSE is not weak form efficient. They used Kolmogoro-Smirnov test, Q-Q probability plot, Serial correlation coefficient test and ARIMA model and took DSE All Share Price Index (1993-2011) and DSE General Index (2002-2011) as their sample. Khan & Huq (2012) used the three market indices of DSE All share price index, General Index and DSE-20 to test the normality of return series calculated on a daily, weekly, monthly and annual basis. They concluded that market return series is not normally distributed hence the return may be predictable and market was not following random walk model. Rahman & Uddin (2012) found stationarity in three South Asian markets- Dhaka Stock Exchange, Bombay Stock Exchange and Karachi Stock Exchange monthly data. They found some common stochastic trend by using co-integration test. From the results of Granger causality test they concluded that one market's past return cannot improve the predictability of another.

The gaps in the literature from some major studies on Dhaka Stock Exchange are discussed below in a tabular format:

Table 2.1
Gaps in the Literature

Researcher's Name (Year)	Data	Tests applied	Findings	Gaps in the literature
Mobarek & Keasey (2000)	All daily price of listed securities in DSE (1988-1997)	Kolmogorov-Smirnov test, runs test, Auto-correlation test, ARIMA model	Market is weak form inefficient	• Data set is old comparing to recent times. • They have not included DSE20 index. • They have not tested trading strategies. • No unit root test.
Akhter & Misir (2005)	Monthly return series of ten industry segments of DSE (2003)	Serial correlation coefficient test and runs test	Market is weak form efficient	• Excluded daily return series. • Sample for one year is a very small sample size to draw a conclusion. • They have not tested the trading rules.

Mobarek, Mollah & Bhuyan (2008)	Daily price of index of listed securities in DSE (1988-2000)	Kolmogorov-Smirnov test, runs test, Auto-correlation test, ARIMA model	Market is weak form inefficient	• Data set is old comparing to recent times. • They have not included DSE20 index. • No unit root test.
Chaity & Sharmin (2012)	DSE All Share Price Index & DSE General Index (2002-2011)	Kolmogorov-Smirnov test, Q-Q Probability plot, Serial Correlation Coefficient test and ARIMA model	Market is not weak form efficient	• They have not included DSE20 index. • No unit root test.
Rahman & Uddin (2012)	DSE General Index (2002-2010)	Jarque-Bera normality test, Autocorrelation test, Unit Root test, Cointegration test, Granger-Causality test	Market is not weak form efficient	• Excluded daily return series. • They have not included DSE20 index.

Considering the gaps in the literature the current study can be justified by fulfilling the gaps in the following ways:

- The current study is going to perform a research by taking the very recent samples from Dhaka Stock Exchange so that the latest status of efficiency can be revealed.
- Along with Kolmogorov-Smirnov test, Shapiro-Wilk test and Kolmogorov-Smirnov test with Lilliefors Significance correction are going to be used as these are proven to be more robust test (Razali & Wah 2011).
- The current study will be more comprehensive as it will apply most of the popular testing methods, i.e. Unit Root Test, Runs Test, ARIMA, etc.

- Daily return series calculated form both DSE General Index and DSE20 Index will be used.
- Returns calculated from twelve individual listed securities will be taken into account to avoid thin trading bias.

3. Research Questions, Objectives and Hypothesis

At this stage the following research questions for the present study can be formulated:

- Can the security prices be predicted in Dhaka Stock Exchange (DSE)?
- Can the investors in DSE be able to earn abnormal profit from their investment?
- Do the security prices follow the random walk model?
- Is the return series of DSE normally distributed?
- Is Dhaka Stock Exchange weak form efficient?
- Has there any change been occurred from the past studies on DSE in WFEMH?

From the above research questions the following research objectives can be derived:

- To find out whether the securities return can be predicted in DSE.
- To reveal the behaviour of security return in DSE, i.e., follows random walk model.
- To find out whether there has occurred any shift of efficiency level from the previous status.
- To conclude about the recent status of weak form market efficiency of DSE.

By incorporating all the research questions and objectives the following two null hypotheses can be formulated:

$H0_1$: Dhaka Stock Exchange complies with random walk model.

$H0_2$: Dhaka Stock Exchange is efficient according to Weak Form of Market Efficiency Hypothesis.

4. Data and Research Methodology

Dhaka Stock Exchange Limited (DSE) is the biggest stock exchange of Bangladesh and one of the emerging markets in South Asia. Currently DSE has 235 listed actively traded companies as on May 2012. In DSE there are three listed indices- DSE General Index (DGEN), DSE All Share Price Index (DSI) and DSE20 index. The daily closing prices of DGEN and DSE 20 from the year 2002 to 2010 (nine years) will be considered as the sample period. As a discontinuity is found in DSI, it has been excluded from sample.

According to this sample period the sample size will be 2289 observations for each of DGEN and DSE 20. All required data set will be collected from the Dhaka Stock Exchange.

Considering sub-periods while testing weak form market efficiency is often found within the previous studies (Mobarek & Keasey 2000; Loh 2007; Hussain et al. 2008; Kumar & Dhankar 2011; Khan & Huq 2012). The current study has also considered three sub-sample periods 2002-2004, 2005-2007 and 2008-2010. These will help to test the robustness of the empirical findings. Besides, the study has also considered the index prices from November 2009 to December 2010 as outlier. Because, after the IPO (Initial Public Offering) of Grameen Phone Ltd. (Country's biggest telecom operator) share in DSE on 16 November 2009 the index reached at a record high. As a result the market showed about 20 per cent return on a single day. From that day the price series soared abnormally. The Financial Express, a famous newspaper of Bangladesh reported on 17th November 2009 in the following way:

'The DSE benchmark index gained more than 20 per cent minutes after the Grameen Phone shares hit the floors....At the end of the day, the benchmark DGEN surged 22.60 per cent or 764.87 points, the highest ever single day rise'.

Moreover the study includes daily price from the year 2002 to 2010 of twelve individual listed and actively traded companies, by selecting those randomly from twelve respective major industry segments of DSE. This sample will be used in Autocorrelation test and runs test only. This inclusion beyond the indices has been made to avoid thin trading bias.

Daily return series calculated from the prices of the indices (DGEN and DSE 20) and twelve individual randomly selected companies will be considered as the variables of this study. In all the cases natural logarithmic return is used. The main argument is logarithmic returns tend to be normally distributed, which is very important for so many statistical tests (Strong 1992, cited in Mobarek et al. 2008). The formula for calculating the log return is given below:

Return on index at time period t = Ln (IN_t / IN_{t-1}), where Ln denotes to natural logarithm, IN_t is the index price at time period t and IN_{t-1} is the price of index at time period previous of t. In this study only the changes in stock price have been considered. Because some of the previous studies have confirmed that the inclusion and exclusion of dividend will not have any impact on the conclusion (Lakonishok and Smidt 1988; Fishe et al. 1993, cited in Mobarek et al. 2008).

Fama (1991) suggested that the test of weak form of market efficiency basically denotes to the test of return predictability, which means to find out whether the past return series can predict the future return series. Fama (1965a) described two approaches for test of return predictability for the researchers. The first approach denotes to find out by using some statistical techniques like Serial Correlation Coefficient test, Runs test, Normality tests, Unit Root test, etc. whether the return series is random and independent and the second approach denotes to the formulation of some trading rules to find out whether these have any return predictability to generate abnormal return. Reilly & Brown (2004, p. 180) has named these two test approaches as firstly, Statistical Tests of Independence, and secondly, Tests of Trading Rules. In the literature review part evidence of different test methods from earlier studies has been showed. The scope of the present study will be limited to Statistical Tests of Independence only.

In choosing the test methods the study has adopted triangulation or multi-approach technique. So it is going to conduct the test of weak form market efficiency on DSE by using several test methods. By using this triangulation technique the results can be cross-checked.

To find out whether the return series is statistically independent, two sets of tests are available here:

4.1 Parametric Tests

This test generally assumes that the dataset conforms to a particular distribution (normal or t-distribution). These tests are often robust but if the dataset does not conform to a predefined distribution or the dataset is rank based then the result may be erroneous.

4.1.1 Autocorrelation Test

By using Autocorrelation test it can be identified whether returns are correlated with its lag or past returns. The value of the coefficient can be ranged between +1 to -1, where -1 denotes to the perfectly negative relationship and +1 means perfectly positive relationship. If the coefficient significantly differs from zero then there would be a dependency in the return series. The following equation is used for calculating autocorrelation coefficient ‘r’ for lag n:

$$r_n = \frac{\sum_{t=n+1}^{T} (X_t - \overline{X})(X_{t-n} - \overline{X})}{\sum_{t=1}^{T} (X_t - \overline{X})^2} \quad (3)$$

Here, X is the time series, X is the sample mean and T is the end of the time period. There will be the existence of autocorrelation if r_n is found to be significantly different from zero.

In this study Autocorrelation is used to find out whether the daily return series calculated from the indices is random and statistically independent.

4.1.2 Unit Root Test

This test can be used to find out whether a time series is non-stationary. Non stationarity is an important assumption for random walk model. To conduct a unit root test firstly a simple AR1 (Auto Regressive) model can be considered:

$X_t = \alpha X_{t-1} + \beta t + \varepsilon_t$, here in this model X_t is the time series, β is the coefficient of a trend in time and ε is the error term. If $/\alpha/ \geq 1$then the variance of X increases with time and approaches to infinity and the time series will be non-stationary and it will be random walk model. But if $/\alpha/ <1$then X is a stationary series, which can be predicted by using time series model. One of the famous tests for testing unit root is Augmented Dickey Fuller (ADF) test. Mainly this is an extension of Dickey Fuller (DF) test. Dickey Fuller test is held valid only if the series follows an AR (1) process, like in our previous equation. If the series is correlated with its higher order lags then the assumption of white noise disturbance terms ε_t will be violated.As a solution of this problem ADF test considers a parametric correction for higher order correlation, where X series assumes an AR(n) process. ADF test basically uses the following regression equation if we suppose here it will consider n-number of lagged difference terms:

$\Delta X_t = \Phi X_{t-1} + \beta t + \delta_1 \Delta X_{t-1} + ... + \delta_n \Delta X_{t-n} + u_t$, here Φ, β, and δ are the coefficients, $\Delta$is the first difference operator, u_t is the error term. ADF test is used to find out whether $H_0{:}\Phi = 0$ and the hypothesis of non-stationarity will be rejected if $\Phi < 0$.

4.1.3 ARIMA model

Auto Regressive Integrated Moving Average model (ARIMA) denotes to a univariate time series model. Basically this model has three parts for predicting autocorrelation in the disturbance:

i. The first part of this model is Auto Regressive (AR) model. AR (1) model, which is discussed earlier, helps to forecast a residual by using one lag residual. Higher order AR model is also possible which includes more lag values of residual (v) as the independent variable in the model. An n-order of AR model can be given below, AR(n):$v_t = \alpha_1 v_{t-1} + \alpha_2 v_{t-2} + ... + \alpha_n v_{t-n} + \varepsilon_t$

ii. The second part of this model is integration order. It denotes to the order of differentiation of the series to be forecasted. First order integration denotes to the first order differentiation.

iii. The third part of this model is Moving Average (MA). It is used to improve the forecasting by incorporating the lag values of the error term of forecasting. If it is first order moving average then it means that the most recent error term will be used as the independent variable in the forecasting model. An n-order MA model is given below: $v_t = \delta_1\ \varepsilon_{t-1} + \delta_2\ \varepsilon_{t-2} + \delta_n\varepsilon_{t-n} + \varepsilon_t$

The current study will apply different ARIMA models to find out the best fitted model. If a model becomes significant or valid then it will show the evidence of return predictability.

4.2 Non-Parametric Tests

The main advantage of these tests is, there is no previously assumed distribution of the observations. These tests are rank based test and virtually applicable universally, but less powerful test than the parametric tests.

4.2.1 Runs test

In this test the number of runs is computed as the sequence of change of price, e.g., +++----+++ denotes three runs. The null hypothesis of randomness is rejected when the observed numbers of runs differ from the expected runs. The decision is taken in the following way (Gujarati 2003):

Here,

N = Total number of observations = $N_1 + N_2$

N_1 = Number of + symbols

N_2 = Number of – symbols

R = number of runs

$$\text{Expected number of runs } E(R) = \frac{2\,N_1N_2}{N} + 1 \tag{4}$$

$$\text{Variance } \sigma^2_R = \frac{2\,N_1N_2\,(2\,N_1N_2 - N)}{(N)^2\,(N-1)} \tag{5}$$

Now, if it is assumed that the level of confidence is 95 per cent then there will be 95per cent probability that the Number of Runs (R) will be expected to fall like below in order to be proven random:

$$[\ E(R) - 1.96\ \sigma_R\ ] \le R \le [\ E(R) + 1.96\ \sigma_R\ ] \tag{6}$$

Basically by using the statistical software i.e. SPSS these numbers and P-value are generated, if the P-value is less than fiveper cent then $R \neq E(R)$ and the null hypothesis of randomness will be rejected at 95 per cent level of confidence (Poshakwale 1996).

4.2.2 Kolmogorov-Smirnov and Shapiro Wilk test

These tests generally compare the sample data distribution with a particular distribution i.e. normal distribution. Suppose, in one sample Kolmogorov-Smirnov test, F(X) is the empirical cumulative probability distribution of the sample. On the other hand $F_0(X)$ is the cumulative probability distribution of the hypothesized population. Then F(X) is compared with $F_0(X)$ for all the values of X. By using statistical software a test statistic and P-value are generated. If the P-value is less than five per cent (at five per cent level of significance) then $F(X) \neq F_0(X)$ and the null hypothesis of randomness will be rejected (Poshakwale 1996; Sheskin 2000; Pallant 2005, p. 57). Shapiro-Wilk test is another test of normality. But this is a more powerful test compared with Kolmogorov-Smirnov test, because it can detect non-normality for either skewness or kurtosis or both and it also works better even if the sample size is low (Razali & Wah 2011). If the statistical software generated P-value for Shapiro-Wilk test is less than five per cent then the null hypothesis of normality will be rejected.

The robustness of the test results of this study is evaluated in various ways. Firstly, as mentioned earlier the study has adopted triangulation technique. So it will test weak form of market efficiency by using both parametric and non-parametric tests. So, all the test results can be cross checked to reach at a precise conclusion. Secondly, the study has considered sub-sample period and outlier to check extremities in the observation. Finally the study has considered return series of actively traded individual companies in order to avoid thin trading bias.

5. Test Results and Empirical Findings

This part will focus on the results and empirical findings from the tests conducted. At the end of this part a summary of the result will be provided.

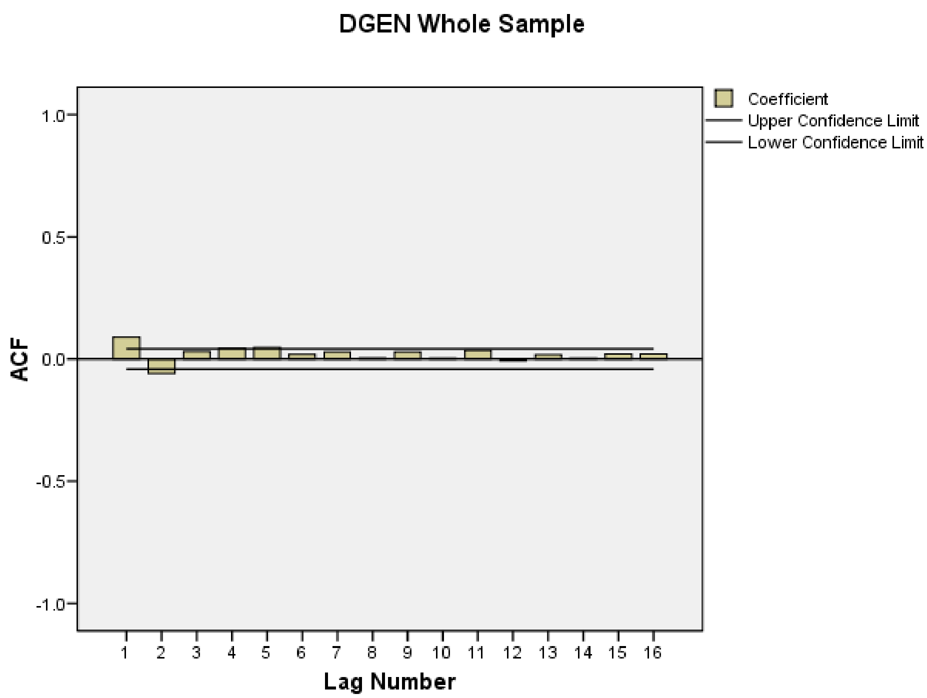
5.1 Tests of Autocorrelation

At this stage of the current study the statistical independence will be examined by finding whether the return series is correlated with its previous lags.

Table 5.14
Results from the Test of Autocorrelation (DGEN)

Lag	DGEN							
	Autocorrelation coefficient (Whole sample)	Standard Error	Q-stat	Sig.	Autocorrelation coefficient (Without Outlier)	Standard Error	Q-stat	Sig.
1	0.089	0.021	18.043	0.000	0.116	0.022	26.840	0.000
2	-0.060	0.021	26.239	0.000	-0.031	0.022	28.710	0.000
3	0.031	0.021	28.388	0.000	0.020	0.022	29.549	0.000
4	0.045	0.021	32.989	0.000	0.026	0.022	30.883	0.000
5	0.048	0.021	38.185	0.000	0.048	0.022	35.451	0.000
6	0.018	0.021	38.945	0.000	0.016	0.022	35.964	0.000
7	0.029	0.021	40.879	0.000	0.019	0.022	36.697	0.000
8	0.004	0.021	40.907	0.000	-0.003	0.022	36.711	0.000
9	0.029	0.021	42.851	0.000	0.039	0.022	39.769	0.000
10	0.003	0.021	42.868	0.000	-0.004	0.022	39.806	0.000
11	0.035	0.021	45.648	0.000	0.030	0.022	41.565	0.000
12	-0.007	0.021	45.757	0.000	-0.013	0.022	41.886	0.000
13	0.017	0.021	46.397	0.000	0.025	0.022	43.120	0.000
14	0.003	0.021	46.419	0.000	0.007	0.022	43.215	0.000
15	0.021	0.021	47.391	0.000	0.015	0.022	43.658	0.000
16	0.021	0.021	48.361	0.000	0.005	0.022	43.718	0.000

Graph 5.1: Correlogram (DGEN)

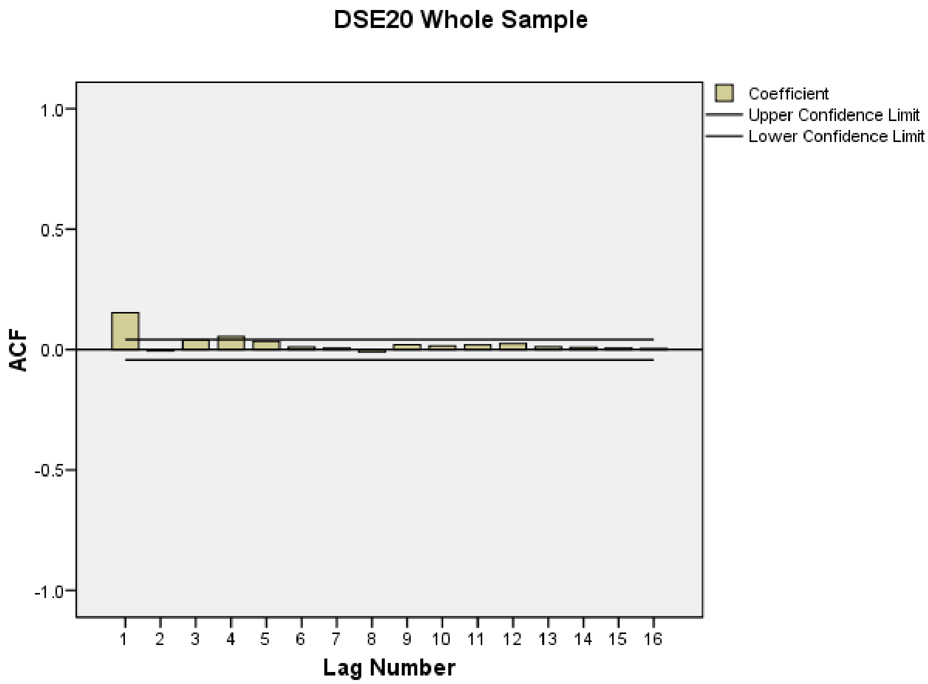


From the Table 5.1 and Graph 5.1 it is quite clear that DGEN daily return is correlated with its lagged values. All the autocorrelation coefficients are significant at one per cent level of significance. Considering two standard error limit current return is positively correlated with its first, fourth and fifth lag and negatively correlated with its second lag.

Table 5.2
Results from the Test of Autocorrelation (DSE20)

Lag	DSE 20							
	Autocorrelation coefficient (Whole sample)	Standard Error	Q-stat	Sig.	Autocorrelation coefficient (Without Outlier)	Standard Error	Q-stat	Sig.
1	0.153	0.021	53.336	0.000	0.154	0.022	47.508	0.000
2	-0.006	0.021	53.415	0.000	0.005	0.022	47.564	0.000
3	0.040	0.021	57.129	0.000	0.034	0.022	49.823	0.000
4	0.055	0.021	63.990	0.000	0.035	0.022	52.262	0.000
5	0.034	0.021	66.672	0.000	0.042	0.022	55.756	0.000
6	0.011	0.021	66.949	0.000	0.006	0.022	55.821	0.000
7	0.006	0.021	67.028	0.000	-0.002	0.022	55.831	0.000
8	-0.010	0.021	67.245	0.000	-0.007	0.022	55.935	0.000
9	0.020	0.021	68.158	0.000	0.033	0.022	58.103	0.000
10	0.016	0.021	68.727	0.000	0.008	0.022	58.241	0.000
11	0.019	0.021	69.572	0.000	0.021	0.022	59.097	0.000
12	0.025	0.021	71.010	0.000	0.025	0.022	60.386	0.000
13	0.012	0.021	71.326	0.000	0.006	0.022	60.461	0.000
14	0.009	0.021	71.525	0.000	0.008	0.022	60.587	0.000
15	0.006	0.021	71.599	0.000	-0.001	0.022	60.591	0.000
16	0.005	0.021	71.650	0.000	0.000	0.022	60.591	0.000

Graph 5.2: Correlogram (DSE20)



Evidence of non-randomness is also found in respect of DSE20 return series, as it is observed from Table 5.2 and Graph 5.2 that the first and fourth lagged returns are positively correlated with its current return. In both DGEN and DSE20, the without outlier series shows significant autocorrelation coefficient which supports the rejection of the hypothesis of randomness. The results are also consistent with some of the previous studies (Mobarek & Keasey 2000; Mollah, Rahman & Islam 2005; Mobarek, Mollah & Bhuyan 2008)

5.2 Runs Test

In this part runs test, a non-parametric test will be applied to find out the randomness status of DSE. Runs test will be conducted on whole sample, sub-sample period, without outlier and also on twelve randomly selected shares from twelve major industries of DSE.

Table 5.3
Results of Runs Test (DGEN and DSE20)

Indices	Number of Runs	Z	Asymp. Sig. (2-tailed)
DGEN			
Whole Sample	951	-7.789	0.000
2002-2004	341	-5.309	0.000
2005-2007	301	-4.559	0.000
2008-2010	310	-3.485	0.000
Without Outlier	833	-7.476	0.000
DSE20			
Whole Sample	910	-9.764	0.000
2002-2004	312	-7.491	0.000
2005-2007	303	-4.421	0.000
2008-2010	297	-4.718	0.000
Without Outlier	796	-9.250	0.000

In all the cases (Table 5.3) Asymptotic P-value is less than five per cent. So the hypothesis of randomness for the entire cases- whole sample, sub-samples and sample without outlier of DGEN and DSE20 is rejected. From runs test it is proven that the return series of DSE is not random and hence the market is weak form inefficient (Mobarek & Keasey 2000; Mobarek, Mollah & Bhuyan 2008).

Table 5.4
Results of Runs Test (twelve randomly selected individual stocks listed in DSE)

Company Name	Number of Runs	Z	Asymp. Sig. (2-tailed)
DBBL	939	-2.224	0.026*
Heidelberg	1024	-3.300	0.001*
Fuwang	1027	-1.966	0.049*
Atlas	1014	-1.316	0.188
IDLC	927	-3.437	0.001*
Bangas	925	0.109	0.914
Padma	695	-1.152	0.249
Pragati	940	-0.528	0.598
Glaxo	740	0.777	0.437
Bata	1073	-0.375	0.707
Apex	956	-0.241	0.809
Eastern	1008	-2.688	0.007*

*Significant at 5% level

From the Table 5.4, five out of 12 shares are found to be significant at five per cent level as asymptotic P-value is less than 0.05. So these returns are found to be non-random, but others show randomness. But still it should be kept in mind 12 companies out of 235 listed companies may not be a very good sample to conclude.

5.3 Tests of Normality

Now the DGEN and DSE20 will be tested for normality by using two renowned tests-Kolmogorov-Smirnov test and Shapiro-Wilk test. The main intuition behind this test is normally distributed return series tends to be efficient.

Table 5.5
Results from Tests of Normality (DGEN and DSE20)

Indices	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
DGEN (Whole Sample)	0.072	2288	0.000	0.878	2288	0.000
DSE20 (Whole Sample)	0.068	2288	0.000	0.945	2288	0.000
DGEN (Without Outlier)	0.063	2004	0.000	0.955	2004	0.000
DSE20 (Without Outlier)	0.074	2004	0.000	0.939	2004	0.000

Table 5.6
Results from Tests of Normality (sub-sample periods)

Indices		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
DGEN	2002-04	0.068	840	0.000	0.950	840	0.000
	2005-07	0.055	723	0.000	0.960	723	0.000
	2008-10	0.087	725	0.000	0.801	725	0.000
DSE20	2002-04	0.077	840	0.000	0.926	840	0.000
	2005-07	0.065	723	0.000	0.951	723	0.000
	2008-10	0.053	725	0.000	0.963	725	0.000

From both the tables (Table 5.5, 5.6) it is evident that the return series of DGEN and DSE20 is not normally distributed, as in all the cases for both Kolmogorov-Smirnov test and Shapiro-Wilk test statistic is found to be significant at five per cent level. Hence the normality hypothesis is rejected for DSE which further supports weak form market inefficiency (Mobarek & Keasey 2000; Mobarek, Mollah & Bhuyan 2008; Chaity & Sharmin 2012; Khan & Huq 2012)

5.4 Unit Root Test

To test unit root this study has conducted Augmented Dickey Fuller test, which is a famous test to draw inference on stationarity. In order to be consistent with random walk model a time series must exhibit non-stationarity, otherwise, if it is stationary then by using some time series model it can be predicted.

Table 5.7
Unit Root Test on DGEN (2002-2010)

Null Hypothesis: DGEN has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-34.52855	0.0000
Test critical values:	1% level	-3.433015	
	5% level	-2.862603	
	10% level	-2.567382	

*MacKinnon (1996) one-sided p-values.

From Table 5.7 the ADF test statistic is found to be less than all the given critical values (at one per cent, five per cent and ten per cent), hence, the null hypothesis about DGEN's having a unit root is rejected. Therefore on the basis of the given sample DGEN is concluded as a stationary series which can be forecasted by using time series models.

Table 5.8
Unit Root Test on DSE20 (2002-2010)

Null Hypothesis: DSE20 has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-40.98818	0.0000
Test critical values:	1% level	-3.433013	
	5% level	-2.862603	
	10% level	-2.567381	

*MacKinnon (1996) one-sided p-values.

In the same way DSE20 can also be concluded as a stationary series, as it is observed to have a less t-statistic value than the test critical values. Finally on the basis of the unit root test on the given sample it is evident that DSE is not consistent with random walk hypothesis as well as weak form efficient market hypothesis (Cooray & Wickremasinghe 2007; Uddin & Khoda 2009; Khandoker, Siddik & Azam 2011).

5.5 Test of ARIMA Model

As it has already been evident that DGEN and DSE20 exhibit stationarity, it can be predicted by using time series models. In this part whether the return is predictable by using ARIMA (Autoregressive Integrated Moving Average) model will be illustrated with appropriate statistical significance.

Table 5.9
ARIMA (1,0,1) on DGEN (2002-2010)

Dependent Variable: DGEN

F-stat: 15.512

Prob (F-stat): 0.000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001002	0.000261	3.838000	0.0001
AR(1)	-0.544740	0.116324	-4.682962	0.0000
MA(1)	0.642598	0.106266	6.047100	0.0000

Table 5.10 ARIMA (4,0,1) on DSE20 (2002-2010)

Dependent Variable: DSE20

F-stat: 30.952

Prob (F-stat): 0.000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000697	0.000288	2.418380	0.0157
AR(4)	0.045254	0.020927	2.162458	0.0307
MA(1)	0.158121	0.020686	7.643858	0.0000

After some trial ARIMA (1.0.1) and ARIMA (4.0.1) have been found significantly applicable on DGEN and DSE20 respectively. Both the models have become statistically significant at five percent level as in both the cases P-value (F-stat) is found to be less than five per cent. Besides, coefficients of all the variables are also significant at five per cent level. Therefore it has become evident that return series of DSE can be predicted by using time series model like ARIMA, hence it is found weak form inefficient (Mobarek & Keasey 2000; Mollah, Rahman & Islam 2005; Mobarek, Mollah & Bhuyan 2008; Chaity & Sharmin 2012).

5.6 Summary of Findings

- From the statistical tests of independence conducted in this study, it is quite evident that Dhaka Stock Exchange does not follow random walk model.
- Results from serial correlation coefficient test, runs test, test for normality, unit root test, application of ARIMA model, unanimously suggest that DSE is not consistent with Weak Form Efficient Market Hypothesis.
- Results from parametric tests (autocorrelation test, unit root test, ARIMA), non-parametric tests (runs test, Kolmogorov-Smirnov test, Shapiro-Wilk test), results from subsamples, without outlier and individual companies coincide at the same point that DSE does not follow random walk, and DSE is Weak form Inefficient. So it can be said that the findings are robust as well.

6. Recommendations and Conclusion

Findings from the previous sections and also from the previous studies confirm that Dhaka Stock Exchange is suffering from weak form market inefficiency, which is alarming for the general investors of this market. The following recommendations can be considered for the improvement of this market:

- Policies should be taken to remove information asymmetry, so that all the investors can get the information immediately to take prompt investment decisions.
- Proper measures should be taken by the regulatory authority to control the opportunities of making abnormal return by violating the market structure.
- There are so many capital market investors in Bangladesh who do not have sufficient investment education. So some training initiatives can be taken to train them about how to take investment decision rationally.
- The number of actively trading securities should be increased in DSE. Besides initiatives to encourage IPOs should be taken.
- Finally the regulatory commission should conduct quality research on DSE on a regular basis to find out the loop holes, and take corrective measures accordingly.

Though this study on DSE is a comprehensive one and has covered most of the renowned testing methods, scope for further studies can be found in the area of data ranges and variations in testing methodology. In this study only twelve individual listed shares from twelve major industries have been used, which is very low as a sample from 235 listed shares. So by including more shares in the sample further studies can be conducted. Test of EMH is a complex issue. Stock market anomalies, Behavioural Finance, Joint Hypothesis problem, etc. have lifted up the complexity to a further extent. So more and more quality studies can refine this field and standardize it.

The findings of the current study are consistent with some of the prior studies on Emerging Markets (Poshakwale 1996; Cooray & Wickremasinghe 2007; Hassan, Abdullah & Shah 2007; Ntim, Opong & Danbolt 2007; Metghalchi et al. 2008; Kumar & Dhankar 2011; Gupta & Yang 2011), on the other hand some of the studies show findings contradictory to current study (Gilmore & McManus 2001; Aly, Mehdian & Perry 2004; Moustafa 2004; Chen & Metghalchi 2012). Therefore the capital market of Bangladesh is found to be very adjacent to some emerging capital markets like in India, Ghana, and Pakistan. This has happened because these markets have some common features like-thin trading, information asymmetry, investors' tendency to outperform the market, less actively traded security, lack of market monitoring, regulatory loop holes, etc. In order to improve the capital market efficiency the regulatory authority must take steps very urgently otherwise the general investors of these markets will be deprived and their confidence will be broken down.

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