Determining the Efficiency of Dhaka Stock Exchange (DSE): A Study based on Weak Form Efficient Market Hypothesis

1 author:

Kawser Ahmed Shiblu
Jagannath University - Bangladesh

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Determining the Efficiency of Dhaka Stock Exchange (DSE): A Study based on Weak Form Efficient Market Hypothesis

Kawser Ahmed Shiblu*
Nowrin Ahmed**

Abstract: *This paper is aimed to measure the weak form efficiency of Dhaka Stock Exchange (DSE) using DSE General (DGEN) Index price and DSE All Share (DSI) Index price for the period of January 2002 to July 2013 and April 2005 to January 2013 respectively. In analyzing the efficiency of DSE, we first tried to determine whether the index return series are normal or not. In the process of normality test, we used Descriptive Statistics (firmly Skewness, Kurtosis and Jarque-Bera statistics), Quantile-Quantile (Q-Q) plot and Kolmogrov-Smirnov goodness of fit test and all of these test can't accept the null hypothesis of normal distribution. Later on, we moved* to *Ljung-Box Test and Correlogram to measure the serial dependency of return series but insignificant non-zero autocorrelations indicates the non-randomness of data series. Finally the Random Walk Model hypothesis was tested by Run test, Augmented Dickey-Fuller (ADF) test and the most modern Variance- Ratio test. The rejection of null hypothesis of randomness in Run test was further confirmed by ADF test and Variance-Ratio test. So the investors can easily use the past security market information to predict the future price and trading based on information on past prices and trading volumes will give some advantages to investors.*

Keywords: Efficient Market Hypothesis, Kolmogrov-Smirnov goodness of fit test, Ljung - Box test, Augmented Dickey-Fuller test, Variance-Ratio test.

Introduction

Capital market is an engine of economic growth of a country. It transfers saving of surplus unit to deficit unit where savings turns into investment and thus ensure optimum allocation of resources. But such economic development or social welfare by capital market highly depends on market efficiency. That is, market efficiency ultimately determines the effectiveness of the stock market in economic development. The term 'informational efficiency' denotes the speed of adjustment of new information to the price of financial assets. In an informationally inefficient market, investor faces difficulty in choosing the optimal investment as information on corporate performance is less available and as a result, investors either want to withdraw their money from the market or become discouraged to invest funds for long term until this uncertainty is resolved. Moreover, if they are not rewarded for taking higher risk by investing in the stock market or if excess volatility weakens their confidence, they will not invest their savings in the stock market and thus economic growth becomes sluggish. So it is essential to ensure a stock market which is efficient and where investors feel confident to invest their savings. This market helps reduce the risk of investors through diversification and thus reducing the cost of capital which in turn spurs investment and economic growth.

* Lecturer, Department of Finance, Jagannath University, Dhaka-1100, Bangladesh.
** Assistant Director, Head Office, Bangladesh Bank, Dhaka-1000, Bangladesh.

Efficient-Market Hypothesis (EMH) is a cornerstone of modern financial theory. It maintains that all stocks are perfectly priced according to their fundamentals and all information is readily available to all market participants equally. So there is no way to find any mispriced securities and for this reason, return are always according to securities' associated risk. The EMH exists in various degrees: weak, semi-strong and strong form of efficiency. In the weak-form efficient market, all past information is reflected on current prices and trading based on information on past prices and trading volumes won't give any advantage. But investor may find mispriced securities as price does not reflect all publicly available information. When prices fully reflect all publicly available information then it is considered as semi-strong form efficient market. Again some information still available only to some group of investors, not to all general investors. This information asymmetry gives some group of investors a room for getting some unjustified profit which is also an indication of market inefficiency and strong form efficient market prevent any group of these investors who have access to information which is not publicly available and consistently enjoy abnormal returns. These groups are normally corporate insiders, security analysts, stock exchange specialists and professional asset managers. So, due to increased concerns regarding robustness of the EMH, now-a-days it is important to test the efficiency of the local stock market.

Dhaka Stock Exchange (DSE) is the first and leading stock market of Bangladesh and plays a vital role in the economy. But since its inception, DSE faces tremendous ups and down, two market crashes and so on. So regulators tried to improve its condition by imposing different rules and regulation because the degree of efficiency of Dhaka Stock Exchange affects all those who are either individual investors or professional managers. But along with recent crashes in capital market, DSE is not considered as efficient market and investors tend to lose their confidence on it (Chaity and Sharmin).

It is usually believed that, the markets in developing and less developed countries are not efficient in semi-strong form or strong form. So the study seeks evidence of weak form efficient market hypothesis in a less developed emerging market like DSE (Mobarek and Keasey). Thus it is realistic to test the weak-form efficiency of DSE rather than semi-strong form and strong-form efficiency as there is insufficient information, structural problems, syndicate acting together to artificially influence the prices, lack of supervision and so on. Again corporate insiders with privileged information, weak regulatory framework, poor corporate governance, lack of accountability, poor institutional infrastructure, lack of transparency of market transactions, misrepresentation of corporate key performance indicators, uneducated investors (those trade only depends on rumors, not on fundamental), prior availability of annual report information etc. take the market far away from semi-strong and strong form market hypothesis. Moreover, the market moved dramatically over a period of time to become a speculation market and then a gamble market. That means there is a trend of market movement and most of the investors in the market become speculators. Again, share price indices data are available and reliable to test the weak form efficiency of the market (Mobarek and Keasey). So the purpose of this paper is to determine empirically whether DSE is efficient at weak form or not and this study is useful for a number of reasons. For example, different modern performance evaluation techniques is applied to a unique daily data series to determine the efficiency of DSE, the results of this study will help all of its stakeholders in their respective fields, international organizations (such as the World Bank, IMF) and foreign governments who are interested in the development of capital markets in the emerging countries can get some understanding about the market.

This paper is organized under seven sections. The rationale and objectives of the study are enumerated respectively in section 1 and 2. A review of the prior researches those are related to the subject of this paper is presented in Section 3. The data and research techniques used in this study are detailed in Section 4. The findings as well as the interpretation of findings are described in Section 5 and finally the paper is concluded in section 6.

1. Rationale of the study

Stock market works as an intermediary between surplus and deficit units to turn savings into investments. The Dhaka Stock Exchange (DSE) is the oldest and prime stock exchange of Bangladesh .There is a huge number of investors in this market and most of these investors don't have enough knowledge but invest their most of all savings. Their limited knowledge sometimes results in the loss of their entire savings. Again, some people take investment in the market as career and try to make money overnight. So huge amount of money come to market and DSE had started to play a vital role in the economy. Whenever such huge investment had occurred, DSE experienced market crashes e.g. in 1996 and in 2010. So whether DSE is an efficient market or not becomes a burning question. To find out the answer, an analysis on DSE became very important and we felt motived to do such research where we tried to analyze DSE under weak form efficiency hypothesis.

2. Objectives of the study

The main objectives of this research work is to test the efficiency of the DSE whether it is weak form efficient or not as well as to identify the behavior of index returns over time.

3. Prior researches on EMH of DSE

Efficient Market Hypothesis (EMH) becomes an essential part of the modern Economics and Finance. The investment strategy is more or less dependent on market efficiency because in an efficient market, trying to get any abnormal return is totally a wastage of time as there is no existence of undervalued securities in such market. On the other hand, existence of undervalued securities in inefficient market gives opportunities to investor to get higher return than expected for a given level of risk. So market efficiency has become one of the most attractive topics in the field of research and a volume of study on the test of efficient market hypothesis has already been conducted and the findings range from acceptance to complete rejection of the hypothesis.

There are many studies which completely reject the null hypothesis of weak form efficiency of DSE. One group of researchers, Rayhan, Sarker & Sayem (2011), Alom & Raquib (2014) etc. tested the pattern in return and reasons behind the volatility of the monthly stock returns of DSE using only parametric tests and concluded non-random monthly DSE returns whereas other group, Mobarek & Keasey (2000), Ahmed & Samad (2008), Chaity & Sharmin (2012), Hosain & Uddin (2013) and Salam (2013) etc. used both non-parametric test and parametric tests to test the weak-form efficiency of DSE. Their results also indicated the non-normal and non-randomness of return series meaning inefficiency in the weak-form.

On the other hand, using Dockery and Kavussanos' Multivariate model with a set of panel data, Nguyen & Ali (2011) showed that, the DSE is not informationally efficient and the null hypothesis of the efficient market hypothesis is rejected when the number of stocks included in the sample is more than 3. There are still some other researchers like Hussain, Chakraborty & Kabir (2008), who used Moving Average rule (Technical Trading rule) to test the weak form efficiency and confirmed the previous results of weak form inefficiency.

Again, Hasan, Kamil, Mustafa & Azizul (2012) used Stochastic Frontier Production Function approach (Cobb-Douglas Stochastic Frontier Model) using variables like market return, market capitalization, book to market ratio and market value to test the technical efficiency of 94 companies of the stock market over the period 2000-2008 and the final outcome was gradually decreasing technical efficiency and above variables have a significant influence on share returns which ultimately reject the null hypothesis of weak form efficiency of DSE.

In contrast, some researchers performed a comparative efficiency analysis. Maxim Miti & Arifuzzaman (2012) did a comparison and analysis of the efficiency of the market before and after of the market crash December, 2010 using DGEN index daily closing values for year 2009-2010 (before crash) and 2011-2012 (after crash) with the analysis tools of Kolmogorov-Smirnov test and the Shaprio-Wilk test and Run test. The result showed non-randomness before crash and randomness after crash. Between two stock markets of Bangladesh, DSE & CSE, a comparative efficiency analysis was also done by Ali (2012) and concluded that DSE and CSE stock price are non-stationary time series at level but stationary at first difference and both DSE and CSE stock prices does not follow Random Walk Hypothesis (RWH) for daily and weekly data series but monthly series follow RWH indicated by multiple variance ratio test.

There still are a very few studies like; Hassan & Chowdhury (2008), Uddin & Shakila (2008) etc. which found the existence of weak form efficiency in Bangladesh stock market. Again, some other studies were performed on DSE to see whether DSE is efficient at semi-strong or not. Cooray and Wickremasinghe (2007) concluded the absence of semi-strong efficiency. Again, Arefin and Rahman (2011) used the excess return market model to test the semi-strong form efficiency of DSE and got excess return for many stocks listed in DSE and confirmed the rejecting of the null hypothesis of semi-strong form. But very recently, Bose, Uddin & Islam (2014) tested the relationship between the past information and the share price to see the randomness of prices and concluded that both DSE and CSE belong to the 'semi strong' form of efficiency and CSE is more efficient.

These disagreements regarding the efficiency market hypothesis of weak and semi-strong form has generated research interest in this topic. Thus this paper will fill the gap in the capital market literature by studying the weak form market efficiency of DSE in very recent year, given that failure to prove weak form efficiency indicates the rejection of both semi-strong and strong form efficiency.

4. Methodology of the Study

4.1 Data

In measuring the efficiency of Dhaka Stock Exchange (DSE), we have used the leading two indices i.e. DSE General Index (DGEN) and DSE All Share Index (DSI). In case of DGEN, observations collected for the period of January 2002 to July 2013 and observations collected for the period of April 2005 to January 2013 in case of DSI. Then returns, R_t, are computed as follows-

$$R_t = ln\left(\frac{P_t}{P_{t-1}}\right)$$

Here, P_t and P_{t-1} are the index value at time 't' and 't-1' respectively. All the data used in the study collected from the secondary sources. Secondary data were collected from DSE library, different websites, annual reports, journals, articles etc. For processing and analyzing the data, we have used software: Eviews 7, SPSS (Statistical Package for Social Science) 20 and MS Excel 2013.

4.2 Research Tools and Techniques

In an efficient markets, profiting by forecasting price movements is very difficult as well as almost impossible and the main reason of price changes is the arrival of new information. If prices quickly reflect new information without any bias then the market can be considered as “efficient”. Thus the current prices ‘fully reflect’ all the available information and there is no reason to believe that prices are too high or too low. In this paper, tests of normality, tests for serial dependency and tests for random walk are conducted to measure the efficiency of DSE.

4.2.1 Tests of Normality

Normal distribution of return is an essential criteria for market to be considered as efficient. The test of normality is done here through Descriptive statistics, Q-Q probability chart and Kolmogrov-Smirnov goodness of fit test.

4.2.1.1 Descriptive Statistics:

Numbers used to summarize and describe the basic features of the data in a study are known as Descriptive statistics. It contains Mean (the simple average of all data), Median (middle value), Maximum (highest) and minimum (lowest) value, standard deviation (spread among the data), skewness, kurtosis, Jarque-Bera statistics with probability, sum (addition of all value) and the number of observations. The value of skewness can be positive or negative or zero or even undefined. Like skewness, kurtosis is also an indicator of the shape of a probability distribution and the degree of kurtosis is measured by (β2 – 3) which is alternatively known as excess kurtosis and excess kurtosis can have positive, negative or zero value. But zero value of skewness and excess kurtosis indicates normal distribution. Another indication of normal distribution can be found from Jarque-Bera (JB) statistics with the null hypothesis of the data are from a normal distribution. Any deviation from zero value of skewness and excess kurtosis leaves a significant test statistic for the JB statistic. The Jarque-Bera statistic is calculated as follows:

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

where *S*, *K* and *N* denoting the skewness, kurtosis, and size of the sample respectively.

4.2.1.2 Quantile-Quantile (Q-Q) Plot:

The quantile-quantile (q-q) plot is a graphical technique for determining whether or not a dataset follows a given distribution e.g. normal distribution. In q-q plot, observed cumulative percentage and expected cumulative percentage are plotted on X axis and Y axis respectively along with a 45° reference line. The points fall approximately along this reference line indicates that the two data sets come from the same distribution. The more scattered the points from this reference line, the greater the evidence that the two data sets have come from different distributions. On the other hand, arced or "S" shaped q–q plots indicates that one of the distributions is more skewed or has heavier tails than the other.

4.2.1.3 Kolmogrov-Smirnov Goodness of Fit Test:

Kolmogrov-Smirnov goodness of fit test is a non-parametric test and is used to determine how well a random sample of data fit to a particular distribution (Chaity and Sharmin). In case of testing for normality, samples are standardized and compared with a standard normal distribution and Kolmogorov-Smirnov test hypothesis and its test statistic, *D*, can be defined as follows:

H_0: The data follow a specified (normal) distribution

H_1: The data do not follow the specified (normal) distribution

$$D = \max_{1 \le i \le N} \left(F(Y_i) - \frac{i-1}{N}, \frac{i}{N} - F(Y_i)\right)$$

Here, F is the theoretical cumulative distribution of the distribution being tested e.g. normal distribution which must be a continuous distribution (i.e. no discrete distributions such as the binomial or poisson). The hypothesis regarding the distributional form is rejected if the test statistic, D, is greater than the critical value obtained from a table for a stipulated **α,** significance level.

4.2.2 Tests for Serial Dependence

The presence of a dependence structure need to be tested in analysing time series. If some pair of values is correlated then it can be said that time series has serial dependency. Ljung-Box Test and Correlogram are used here to measure the serial dependency.

4.2.2.1 Ljung–Box test:

To test the quality of fit of a time series model, the Ljung-Box test (1978) is commonly used. It tests the "overall" randomness based on a number of lags instead of testing randomness at each distinct lag. This test is sometimes known as the Ljung–Box Q test. The Ljung–Box test hypothesis and its test statistic, Q, can be defined as follows-

H_0: The data series is independently distributed

H_1: The data series is not independently distributed.

$$Q = n(n+2)\sum_{k=1}^{h} \frac{\rho_k^2}{n-k}$$

Here, *n* is the sample size, ρ_k is the sample autocorrelation at lag *k*, and *h* is the number of lags being tested. For significance level α, the critical region for rejection of the hypothesis of randomness is $Q > \chi^2_{1-\alpha,h}$; where $\chi^2_{1-\alpha,h}$ is the α-quantile of the chi-squared distribution with *h* degrees of freedom.

4.2.2.2 Correlogram:

Correlogram is the graphical presentation of correlation statistics. In case of time series analysis, Correlogram is known as autocorrelation plot which shows the sample autocorrelations in an image view. The Correlogram is an excellent way of checking for randomness. By visualizing the autocorrelations at different lags, the randomness of data can be tested. For a random data series, autocorrelations should be zero or near zero for any and all time-lag. But one or more of significant non-zero autocorrelations indicates the non-randomness of data.

4.2.3 Tests for Random Walk

The idea of 'Random Walk' not necessarily indicates the whimsical and chaotic price movement. It states the future price cannot be forecasted from the previous changes and period-to-period price changes are statistically independent and unforecastable. So the chance of a stock's future price going up and going down is the same and it is impossible to outperform the market without assuming additional risk. In this paper the randomness is tested with the help of Run Test, Augmented Dickey-Fuller test and Variance Ratio Test.

4.2.3.1 Run test:

Run test is used to judge the randomness of returns or statistical dependency of returns over time. That is, run test determines whether the succeeding price changes are independent and moves randomly or not. A sequence of the price changes of the same sign (e.g. ++, _ _, 0 0) is used to compute the number of runs. If price changes or returns are random then actual number of runs and the expected number of runs are almost equal. Run test hypothesis and test statistics can be defined as follows-

H_0: The observed series is a random series;

H_1: The observed series is not a random series;

$$\mu_\omega = \frac{2n_+ n_-}{n} + 1; \qquad \sigma_\omega = \sqrt{\frac{(2n_+ n_-)(2n_+ n_- - n)}{n^2(n-1)}}; \qquad Z_{cal} = \frac{\omega - \mu_\omega}{\sigma_\omega}$$

Here, n, n_+ and n_- are the total number of the data or cases, the returns or prices that are equal or more than the mean value and the returns or prices that are below the mean respectively where $n=n_++n_-$ .Again, ω and Z_{cal} indicates respectively the number of runs and the test statistic i.e. calculated value. If the TS within the critical region (table value of Z) of the distribution then null hypothesis cannot be rejected. Another way of hypothesis test is- if the expected and actual number of runs are significantly different then null hypothesis is rejected. Above all, this method was thought to be the least restrictive method for the test of the random walk and market efficiency and also it was one of the earliest methods used for the randomness tests by scholars. However it is still just a necessary condition for the certification of random walk characteristic and it is not sufficient (Khandoker , Siddik and Azam).

4.2.3.2 Augmented Dickey-Fuller (ADF) test:

Data which are non-stationary in nature biases the results in scientific experiments. Unit root test is one of the method to test whether data is stationary or not and Augmented Dickey-Fuller test is a test of unit root in a time series sample. The following model is used in case ADF test.

$$\Delta y_t = \alpha + \beta t + \Upsilon y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t$$

Here, Δ, α, β and p are the first difference, constant, coefficient on a time trend and the lag order of the autoregressive process respectively. If we impose both zero-constant $(\alpha=0)$ and zero-time trend coefficient $(\beta=0)$ constraints then it corresponds to modelling a random walk and again if only impose zero-time trend coefficient $(\beta=0)$ constraint then it corresponds to modelling a random walk with a drift. Then the following hypothesis of ADF test is tested against test statistics (τ).

H_0: Stock return series has a unit root i.e. non-stationary or $\Upsilon = 0$;

H_1: Stock return series has no unit root i.e. stationary or $\Upsilon < 0$;

$$\text{Test Statistics}, \tau = \frac{\widehat{Y}}{\sigma_{\widehat{Y}}}$$

Here, $\widehat{Y}$ and $\sigma_{\widehat{Y}}$ are respectively the estimated coefficient and standard error in the coefficient estimate. Then the test statistics value *(τ)* is compared to the relevant critical value for the Dickey-Fuller test and if the test statistic is less (as this test is non symmetrical so an absolute value is not considered) than the (larger negative) critical value, then the null hypothesis is rejected and no unit root is present.

4.2.3.3 Variance-Ratio test:

Martingale model belongs to the earliest models of financial asset prices. It follows the principle of a fair game i.e. knowledge of past returns never helps predict the mean of the future returns. It is an essential criteria for a market to be efficient at weak form. So in efficient market it is impossible to make profit by trading on the information contained in the asset's price history. Thus martingale became the basis for the development of an efficient market model known as random walk and the test of martingale can be conducted with the help of Variance Ratio test proposed by Lo and MacKinlay (1988).

The variance-ratio test is used to test the behavior of the index return series i.e. whether the series follow random walk or not. It tests the proportionality of the variance of k-differences of the returns series with the first difference *k*. It assumes that the variance of its *k*-differences is *k* times the variance of its first difference for a random walk series i.e. the variance of increments is directly proportional to the length of time interval. For example, for a series follows a random walk, if weekly increments are considered, their variance should be 7 times the daily increments. The variance ratio of the *k*-th difference can be defined as follows:

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

Here, $VR\ (k), \sigma^2(k), \sigma^2(1)$ and k are respectively the variance ratio of an index's k^{th} difference, 1/ k of the variance of the k-differences, variance of the first differences and the number of days of base observations interval, or the difference interval. The hypothesis to be tested is-

H_0: The index return series is a martingale i.e. follows a random walk;

H_1: The index return series is not a martingale i.e. does not follows a random walk.

The null hypothesis for a random walk series require that $VR\ (k)$ cannot be significantly different from 1. Following Lo and Mackinlay (1988, 1989), the recommended two test statistics, *Z (k)* and *Z*(k)* are as follows:

$$Z\ (k) = \frac{VR\ (k) - 1}{\pi_0(k)}$$

which, under the assumption of homoscedasticity, is asymptotically distributed as *N(0,1)*. The asymptotic variance, $\pi_0(k)$, is given by:

$$\pi_0(k) = \left[\frac{2(2k-2)(k-1)}{3k(mk)}\right]^{1/2}$$

The test statistic, *Z*(k)* which is robust under heteroscedasticity, is given by:

$$Z^*(k) = \frac{VR\ (k) - 1}{\pi_0(k)}$$

Where,

$$\pi_0(k) = \left[4\sum_{t=1}^{k}(1-\frac{t}{k})\hat{\sigma}_t\right]^{1/2} \quad \text{and} \quad \hat{\sigma}_t = \frac{\sum_{i=t+1}^{mj}(R_t - R_{t-1} - j\hat{\mu})^{2}(R_{i-t} - R_{i-t-1} - j\hat{\mu})^2}{\left[\sum_{i=1}^{mj}(R_t - R_{t-1} - j\hat{\mu})^2\right]^2}$$

The above procedure is developed by Lo and MacKinlay (1988) to test single variance ratio tests for an explicitly k-difference and for the random walk hypothesis, there must have $VR\ (k)$ equal to 1 for all k. For more details about the variance formulae and the test, Lo and Mackinlay (1988), Franch et al. (2007), Hamid et al. (2010) can be used.

5. Findings and Analysis

5.1 ***Findings from tests for normal distribution***

Normal return series is one of the fundamental criteria for a market to be considered as efficient. So testing of EMH should be started by testing the return series whether they are normal or not. In this paper, Descriptive statistics, Q-Q probability chart, and Kolmogrov-Smirnov Goodness of Fit test are used to test the normality of return series.

5.1.1 Descriptive statistics

Table-1 and 2 show the descriptive statistics of daily return series for a period of Jan 2002 – Jul 2013 for DGEN index and Apr 2005 – Jan 2013 for DSI index.

Table-1: Descriptive statistics of the DGEN index daily return (2002-2013)

Period	Mean	Median	Max.	Min.	Std. Dev.	Skew.	Kurt.	J-B stat.	Prob.	Sum	Obs.
2002-2013	0.057%	0.0005	20.38%	-9.33%	1.52%	0.87	21.46	41597.78	0.00	1.66	2904

Here, in Table-1, the mean and standard deviation of DGEN index price over the period of 2002-2013 are 0.057% and 1.52% respectively. On the other hand, we know that, the skewness and excess kurtosis (i.e. kurtosis minus three) of a distribution must be zero to be considered as normal. But in the above table, the value of skewness and excess kurtosis is not zero. Again, the kurtosis is greater than three which indicates that the distribution consisting of daily return series for a period of Jan 2002 – Jul 2013 for DGEN index is a leptokurtic distribution meaning fatter tails and less risk of extreme returns. Jarque-Bera statistics (J-B stat.) also confirm the non-normality of return series by zero p-value.

Table-2: Descriptive statistics of the DSI index daily return (2005-2013)

Period	Mean	Median	Max.	Min.	Std. Dev.	Skew.	Kurt.	J-B stat.	Prob.	Sum	Obs.
2005-2013	0.046%	0.0006	19.22%	-9.13%	1.70%	0.82	17.42	16492.36	0.00	0.87	1878

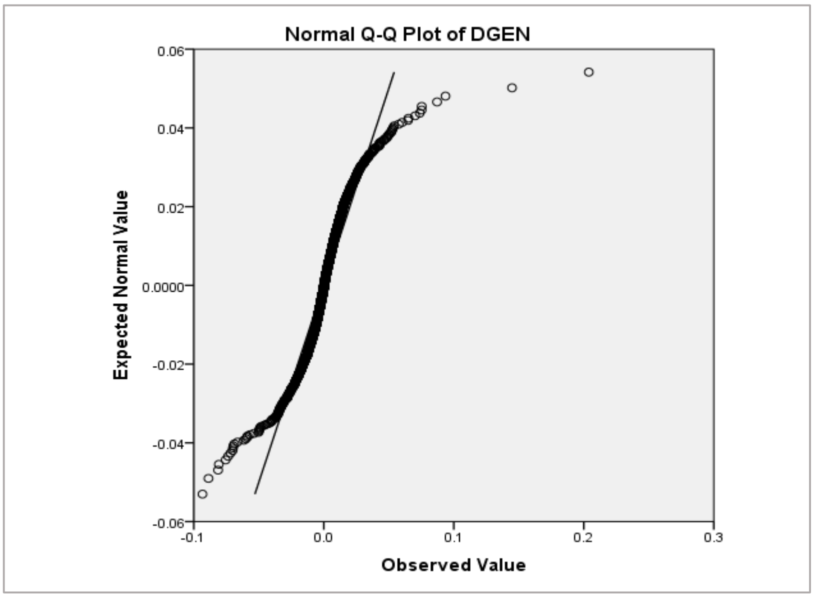
Similarly, in the Table-2, mean and standard deviation of DSI index price are 0.046% and 1.70% respectively. Again, skewness, kurtosis and Jarque-Bera statistic (J-B stat.) draw the conclusion of non-normal return series for a period of Apr 2005 – Jan 2013 for DSI index and represent a leptokurtic distribution.

So, Skewness, kurtosis and Jarque-Bera statistics draw the same conclusion that, neither of the above distributions are normal; rather they are leptokurtic in nature.

5.1.2 Q-Q Probability Chart

In the Figure-1 and 2, Q–Q plot and detrended Q–Q plot are drawn for both indices (DGEN and DSI) to test whether or not the return series follow the normal distribution. The point patter is not linear in Q–Q plot for both the indices. Here left end of the pattern is above the reference line (i.e. straight line) and the right end of the pattern is above the reference line which indicates that the return series do not follow the normal distribution. The detrended Q–Q plots also confirm the above conclusion of non-normality by plotting the deviation between observed and expected values in Y-axis which produce S" shaped curve indicating that the distributions have non-zero skewness.

Figure-1: Q-Q plots of Daily Market Return Series of DGEN Index



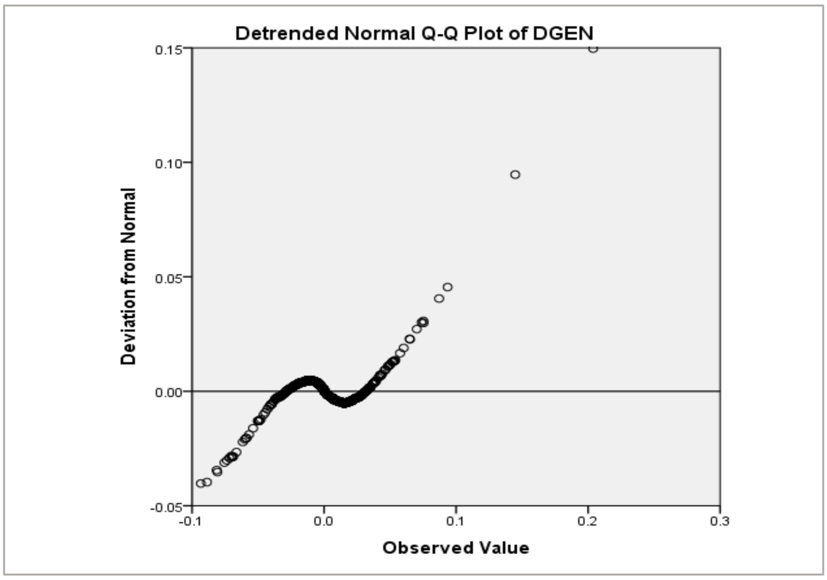
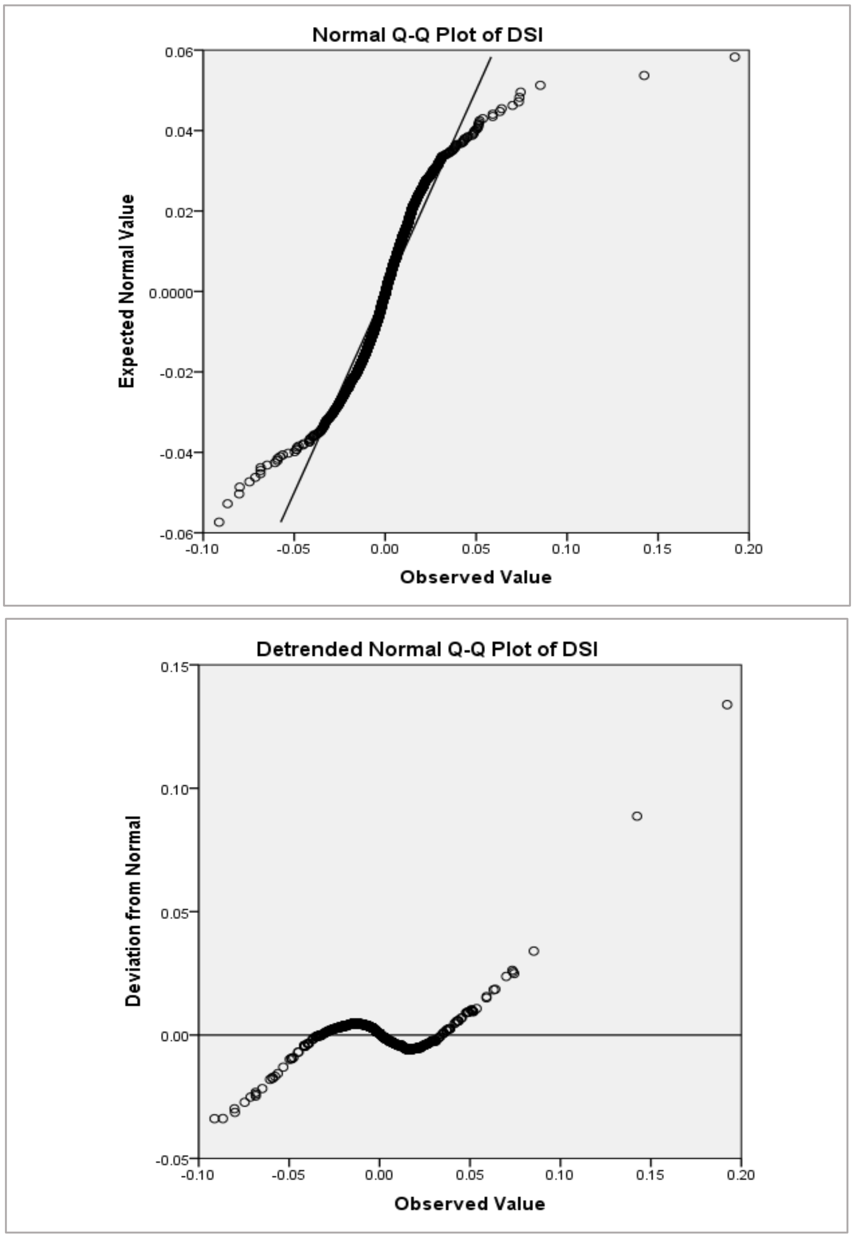


Figure-2: Q-Q plots of Daily Market Return Series of DSI Index



5.1.3 *Kolmogrov-Smirnov goodness of fit test*

In the Table-3, Kolmogrov-Smirnov goodness of fit test or one sample Kolmogrov-Smirnov test is done to test whether the return series used in this paper come from a normally distributed population.

Table-3: Kolmogrov-Smirnov goodness of fitness test of DGEN & DSI Indices.

Index Name		**DGEN**	**DSI**
N		2904	1878
Normal Parameters[a]	Mean	.000570	.000462
	Std. Deviation	.015224	.016991
Most Extreme Differences	Absolute	.095	.082
	Positive	.086	.082
	Negative	-.095	-.082

Kolmogorov-Smirnov Z	5.130	3.559
Asymp. Sig. (2-tailed)	0.000	0.000

[a.] Test distribution is Normal.

For both the indices, the p-value of 0.00 (< 0.05) indicates that the null hypothesis i.e. the return series fit to normal distribution, is rejected. Another way to test the hypothesis is: taking the most extreme difference, D_{cal}, (the highest value from Absolute, Positive and Negative extreme differences) and compare it with the critical value, D_{cri} from K-S table for a level of significance. If D_{cal} is greater than D_{cri}, then reject the null hypothesis. Here, in case of DGEN, 0.095 (D_{cal})>0.0009 (D_{cri}) and in case of DSI, 0.082 (D_{cal}) > 0.001(D_{cri}) at 5% level of significance. So we can reject the null hypothesis. Thus by accepting the alternate hypothesis, it can be reassured that the return series do not fit to normal distribution for the both indices.

5.2 *Findings from tests for serial dependence*

The Serial correlation, commonly termed as "autocorrelation" or "lagged correlation" measures the relationship between a variable and itself over various lagged periods. So to be an efficient market, the return series must not be correlated over it lagged time period. Here, we use Autocorrelation and Ljung-Box Q-Statistics and Correlogram, a graphical plot of autocorrelation, to see whether the return series for both indices show presence of non-zero auto correlation or not.

5.2.1 Ljung–Box test

Whether autocorrelation of the return series of DGEN and DSI indices are different from zero is tested here with the help of Ljung–Box test.

Table-4: Autocorrelation and Q-Statistics for Return

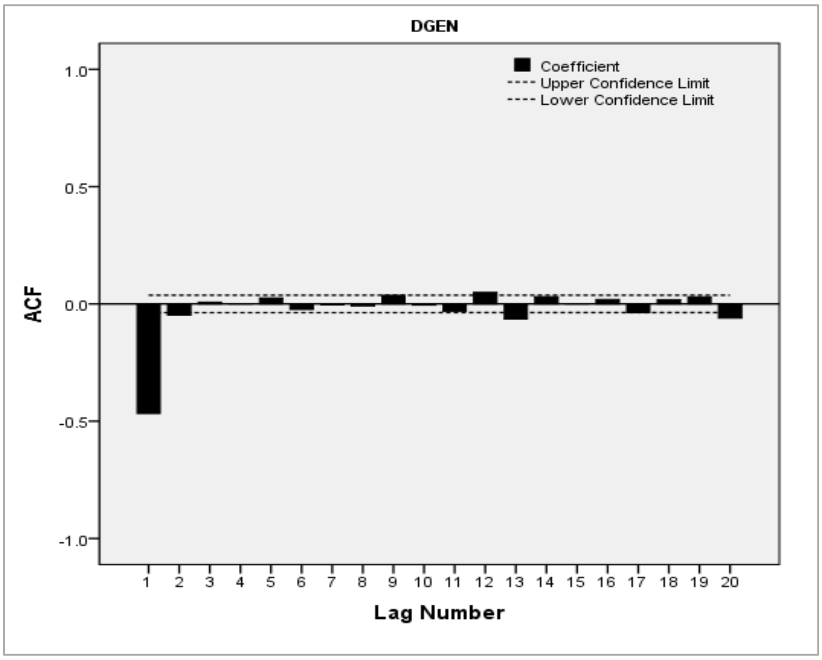
Return Series: DGEN						**Return Series: DSI**					
Lag	Autocorrelation	Std. Error	Box-Ljung/Q Statistic			Lag	Autocorrelation	Std. Error	Box-Ljung/Q Statistic		
			Value	Df	Sig.				Value	df	Sig.
1	-.467	.019	634.102	1	.000	1	-.471	.023	416.847	1	.000
2	-.048	.019	640.868	2	.000	2	-.038	.023	419.532	2	.000
3	.007	.019	641.022	3	.000	3	-.011	.023	419.744	3	.000
4	.001	.019	641.029	4	.000	4	.017	.023	420.295	4	.000
5	.025	.019	642.836	5	.000	5	.019	.023	420.951	5	.000
6	-.024	.019	644.462	6	.000	6	-.023	.023	421.914	6	.000
7	-.004	.019	644.498	7	.000	7	-.011	.023	422.130	7	.000
8	-.008	.019	644.702	8	.000	8	.009	.023	422.278	8	.000
9	.037	.019	648.711	9	.000	9	.023	.023	423.305	9	.000
10	-.005	.019	648.793	10	.000	10	.002	.023	423.317	10	.000
11	-.031	.019	651.535	11	.000	11	-.035	.023	425.629	11	.000
12	.049	.019	658.608	12	.000	12	.059	.023	432.157	12	.000
13	-.065	.019	670.868	13	.000	13	-.084	.023	445.426	13	.000
14	.031	.019	673.585	14	.000	14	.032	.023	447.382	14	.000
15	.001	.019	673.591	15	.000	15	.028	.023	448.826	15	.000
16	.019	.019	674.612	16	.000	16	-.009	.023	448.973	16	.000
17	-.037	.018	678.681	17	.000	17	-.029	.023	450.529	17	.000
18	.018	.018	679.640	18	.000	18	.024	.023	451.665	18	.000
19	.030	.018	682.263	19	.000	19	.030	.023	453.317	19	.000
20	-.061	.018	693.038	20	.000	20	-.069	.023	462.231	20	.000

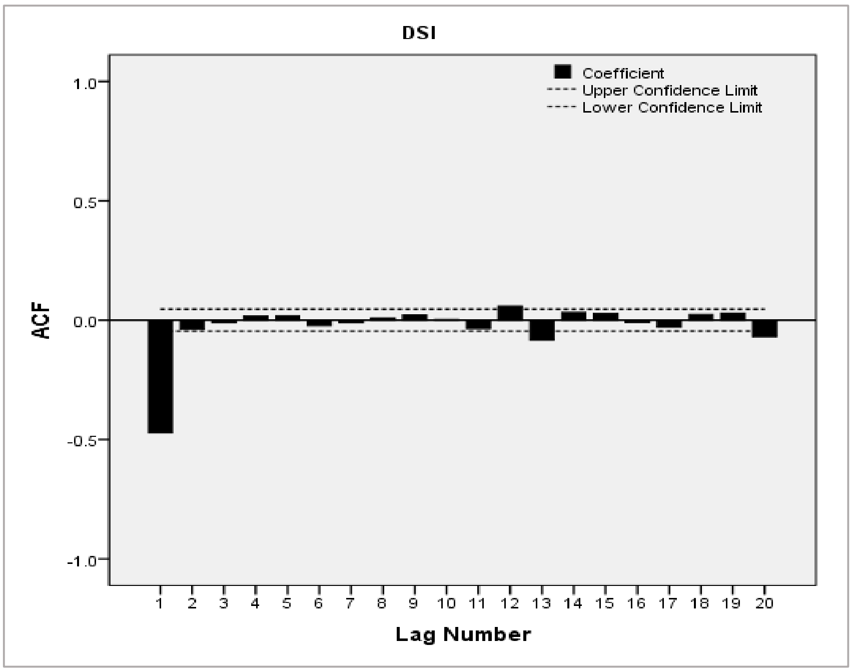
In the Table-4, Ljung-Box Q statistics indicates that the null hypothesis, i.e. the return series independently distributed, is failed to be accepted at 5% significance level at first difference with degrees of freedom of 20 (lags) as all the probability falls below the level of 0.05 for the both indices. Thus by rejecting the null hypothesis, we can conclude the historical returns can be a good predictor future returns and technical analysis can give some abnormal return which ultimately conclude that the weak form of market efficiency does not exists in DSE.

5.2.2 Correlogram

Now, if we visualize the autocorrelations at different lags, we can see DGEN index has negative values for first two lag and then it shows positive values for few lags again it shows negative values and continue this wavelike pattern. The DSI index also shows the same pattern for autocorrelation. This wavelike pattern of autocorrelation values is clearly shown in Correlogram in the Figure-3. The coefficient close to plus or minus one indicate the presence of strong correlation between the return series and the lags having coefficient outside the upper and lower confidence limits also conclude the presence of non-zero auto correlation. As we know if non-zero auto correlations are exist in the return series, then the series do not follow the random walk hypothesis.

Figure-3: Correlogram of market return Series for DGEN & DSI





5.3 ***Findings from tests for random walk***

We have already tested that the trend of future stock return series can be predicted from previous return series. It also can be reassured by Random Walk Hypothesis (RWH). According to the Random walk hypothesis, the log price series must have a unit root whereas the returns series must be stationary (Hamid , Suleman and Akash). To test whether return series of DGEN and DSI indices follow random walk i.e. non-stationary or not, we have used Run test, Augmented Dickey-Fuller test and Variance Ratio test.

5.3.1 Run Test

The result of Run test conducted for both DGEN and DSI return series is shown in Table-5. A deep look into the table shows a huge difference between total cases and number of runs for the both indices. The differences are 1667 and 1068 for DGEN and DSI return series respectively. These differences clearly rejects the random walk hypothesis.

Table-5: Run tests of DSE General Index and DSI (All Share) Index

Index	**DGEN**	**DSI**
Test Value = Mean	.00057	.00046
Cases < Mean	1466	927
Cases >=Mean	1438	951
Total Cases	2904	1878
Number of Runs	1237	810
Z	-8.014	-5.995
P-value	.000	.000
95% Confidence	Randomness Rejected	Randomness Rejected

Again, at 95% confidence level, the absolute calculated test statistics (calculated absolute z value) are outside the critical region of distribution indicating the rejection of the null hypothesis. The confirmation of above conclusion i.e. the return series do not follow the random walk, is also reassured by zero p-value which is smaller than the significance level of 5%. As run test is the least restrictive rules for judging the random walk and judge market efficiency so further analysis is done by Augmented Dickey-Fuller unit root test.

5.3.2 Augmented Dickey-Fuller unit root test

For a meaningful and reliable results, the return series must be stationary. Otherwise the results will lead to poor understanding and forecasting. For this purpose, the Augmented Dickey-Fuller (ADF) unit root test is used to test the stationary of the return series. In The Table-6 and 7, the results of Augmented Dickey-Fuller unit root test for both indices with trend and without trend are shown respectively.

Table-6: Output for ADF unit root test on DGEN & DSI indices return (without trend)

Lag	**ADF Calc. Value (DGEN)**	**ADF Calc. Value (DSI)**	**ADF Crit. Value (1%)**	**ADF Crit. Value (5%)**	**H_0**
1	-65.75814	-52.47897	-3.43241	-2.86234	Rejected
2	-54.55175	-44.32604	-3.43241	-2.86234	Rejected
3	-47.84904	-38.65689	-3.43241	-2.86234	Rejected
4	-41.58058	-33.65655	-3.43241	-2.86234	Rejected
5	-37.97022	-30.75753	-3.43241	-2.86234	Rejected
6	-35.60013	-29.25297	-3.43241	-2.86234	Rejected
7	-34.53048	-28.05233	-3.43241	-2.86234	Rejected
8	-32.02399	-26.11765	-3.43241	-2.86234	Rejected
9	-29.45074	-23.86418	-3.43241	-2.86234	Rejected
10	-28.27774	-22.88312	-3.43241	-2.86234	Rejected

From the Table-6 (ADF without trend), the ADF calculated value is less than the critical value for all the degrees of freedom (10 lags) at both 1% and 5% level of significance indicating the rejection of null hypothesis. So alternate hypothesis is accepted that is the return series has no unit root. So we can easily say that the series is stationary and thus does not follow the random walk.

Table-7: Output for ADF unit root test on DGEN & DSI indices return (with trend)

Lag	**ADF Calc. Value (DGEN)**	**ADF Calc. Value (DSI)**	**ADF Crit. Value (1%)**	**ADF Crit. Value (5%)**	**H_0**
1	-65.74680	-52.46498	-3.962944	-3.412207	Rejected
2	-54.54233	-44.31421	-3.962944	-3.412207	Rejected
3	-47.84075	-38.64654	-3.962944	-3.412207	Rejected
4	-41.57340	-33.64755	-3.962944	-3.412207	Rejected
5	-37.96365	-30.7493	-3.962944	-3.412207	Rejected
6	-35.59397	-29.24512	-3.962944	-3.412207	Rejected
7	-34.52449	-28.04493	-3.962944	-3.412207	Rejected
8	-32.01852	-26.11085	-3.962944	-3.412207	Rejected
9	-29.44589	-23.85803	-3.962944	-3.412207	Rejected
10	-28.27300	-22.87726	-3.962944	-3.412207	Rejected

Again the Table-7 (ADF with trend) also reject the null hypothesis for all the degrees of freedom (10 lags) at both 1% and 5% level of significance for the both return series of DGEN and DSI. From the above results, non-randomness of return series is confirmed thus the inefficiency of DSE is reassured.

5.3.3 Variance Ratio

Knowledge of past returns never helps predict the mean of the future returns, called martingale, is an essential criteria for a market to be efficient at weak form. Test of martingale can be conducted with the help of Variance Ratio test introduced by Lo and MacKinlay (1988). The results got from autocorrelation and Ljung-Box Q-Statistics is tested by this modern analytical tool. The Variance Ratio equal to 1 indicates a pure random walk series that is any positive and negative difference between Variance Ratio and 1 rejects the randomness of the return series.

Table-8: Variance Ratio test for DGEN and DSI return series.

Index	**Period**	**2**	**4**	**8**	**16**
DGEN	Var. Ratio	0.53319	0.25510	0.12685	0.06363
	z-Statistic	-8.51334	-8.34831	-7.39040	-5.90621
	Prob.	0.000	0.000	0.000	0.000
DSI	Var. Ratio	0.52956	0.25132	0.12400	0.06423
	z-Statistic	-7.57929	-7.39836	-6.53212	-5.15814
	Prob.	0.000	0.000	0.000	0.000

In the Table-8, variance ratio for all period (2 4 8 16) shows a negative value (Variance Ratio - 1) for both indices meaning negative autocorrelation. This results are also significant at 1% and 5% level. Again the absolute z-value for all the period for both indices is not within the critical region indicating the rejection of null hypothesis (H_0: Return series is a martingale). Let's take a deeper look. Variance ratio of DGEN at period 2 is 0.54 so the difference is - 0.46 (0.54 -1). This negative value -0.46 is also reflected at table -5 at lag 1of DGEN series. In the same way, variance ratio 0.53 for DSI leave a negative value of -0.47 as same as at table -5 at lag of DSI series which ultimately reflects the authenticity of results.

6 Conclusion

This research paper is designed to investigate evidence on weak form of efficiency of Dhaka Stock Exchange by following the random walk model, autocorrelation and normality behavior of DGEN and DSI indices. Overall results from the empirical analysis suggest that the Dhaka Stock Exchange is not efficient in weak-form. The results of this study conclude that the return series of both indices of Dhaka Stock Exchange do not follow the normal distribution as DSE returns show positive skewness, excess kurtosis and deviation from normality. The result is also confirmed by Q- Q probability chart and Kolmogrov-Smirnov goodness of fit test. The results of Ljung - Box Test and Correlogram display significant serial correlation, implying DSE inefficiency. The study also indicates that stock returns in DSE are not entirely random as the hypothesis of randomness of the stock returns is rejected for both index returns in case of Runs test, Augmented Dickey –Fuller test and Variance Ratio test. Such non-normality, non-zero autocorrelation and non-randomness of index returns confirms that Dhaka Stock Exchange is not efficient at weak form. A summary of these findings is shown in the Table-9.

Table-9: Is DSE efficient at weak form?

Test	**Technique**	**Findings in DSE**	**Is weak-form efficient?**
Normality	Descriptive Statistics	Non- normal distribution	No
	Q-Q Plot	Non- normal distribution	No
	K-S Test	Non- normal distribution	No
Serial Dependency	Correlogram	Non-zero auto correlation	No
	Ljung–Box Test	Non-zero auto correlation	No
Random Walk	Run Test	Non-random	No
	ADF Test	Non-random	No
	Variance Ratio Test	Non-random	No

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