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An Empirical Analysis of Weak Form Market Efficiency: Evidence from Chittagong Stock Exchange (CSE) of Bangladesh

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Abstract: Stock market efficiency is an important concept, for understanding the working of the capital markets particularly in emerging stock market such as Bangladesh. There is enough evidence on market efficiency and day of the week effect in the developed markets, however, the same is not true for the emerging stock markets. This paper provides empirical evidence on weak form efficiency which has been carried out to diagnose the random walk behavior of Chittagong Stock Exchange (CSE) by composing daily returns of three indices for the period of 2006 to 2015. Different non-parametric tests (Wald-Wolfowitz Runs Test, Variance Ratio Test and Kolmogorov Smirnov (K-S) Goodness of Fit Test) and parametric test (Augmented Dickey-Fuller (ADF) Test and Autocorrelation Function Test (ACF)) have been used to test the existence of Efficient Market Hypothesis (EMH) and provide evidences against random walk behavior in CSE in the Chittagong Stock Exchange. Thus the researcher found that the Chittagong Stock Exchange is not efficient in weak form. Therefore, there exist the opportunity of generating a superior return by the investors.

Keywords: Weak Form, Run test, Autocorrelation test, Variance Ratio Test, CSE.

1 Introduction

Living in 21st centuries our economy development mostly controlled and depends on the capital market which is a major vehicle of economic growth. Capital market helps to allocate the economics resources into the productive activities to the economy and to insure the pricing of securities treaded in the market. A strong and functioning of stock markets have considerable effect on growth of an economy in developing countries like Bangladesh.

On the subject of Efficient Market Hypothesis (EMH) there has been large number of studies, conducted around the globe by many researchers since last few decades. But results of these studies are controversial, which make us difficult to comment what is the status of different stock markets around the world. Now many theories have been developing to see the behavior of stock Market [8].

This paper contributes to the existing empirical literature on the weak-form efficiency of emerging Chittagong Stock Market (CSE). Our paper tries to find the evidence on Efficient Market Hypothesis (EMH) using various parametric and non-parametric tests using the experiences from past and recent studies what is the status of the Chittagong Stock Exchange (CSE).

2 Literature Review

A market is said to be efficient with respect to an information set if the price ‘fully reflects’ that information set, i.e. if the price would be unaffected by revealing the information set to all market participants. The efficient market hypothesis (EMH) asserts that financial markets are efficient. On the one hand, the definitional ‘fully’ is an exacting requirement, suggesting that no real market could ever be efficient, implying that the EMH is almost certainly false. On the other hand, economics is a social science, and a hypothesis that is asymptotically true puts the EMH in contention for one of the

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strongest hypotheses in the whole of the social sciences. Strictly speaking the EMH is false, but in spirit is profoundly true. Besides, science concerns seeking the best hypothesis, and until a flawed
hypothesis is replaced by a better hypothesis, criticism is of limited value.

There are a number of studies which supported weak form market efficiency like Sharma and Kennedy (1977), who evaluated the stock indices of Bombay, London and NYSE during the period 1963 to 1973 using run test and spectral analysis and both the tests confirmed the random movement of stock indices for all the three stock exchanges. Then, Barnes (1986) tested weak form market efficiency for Kaula Lumpur Stock Exchange (KLSE). Rahman et al. (2004) evaluated Dhaka Stock Exchange (DSE) for the existence of weak form for the period of January 31, 1990 to September 30, 2003 using monthly index time series. For such evaluation, unit root tests (ADF and PP) were used and the results supported the hypothesis that DSE index time series contains unit root which implies the existence of weak form market efficiency in DSE. Akinkugbe (2005) explored Botswana stock exchange (BSE) for weak form of efficient market hypotheses using 738 weekly observations for the period of June 1989 to December2003.

Autocorrelation and unit root (ADF and PP) were used to test the weak form efficiency in BSE. The autocorrelation test does not evidenced serial correlation and the result of both unit root tests indicated a stationary process for stock returns. Therefore, it implied that stock markets in Botswana were efficient in weak form. Omran et al. (2006) investigated the validity of the random walk hypothesis and tested for calendar effects in five major Middle Eastern emerging markets, by applying a range of statistical and econometrics techniques such as run test, autocorrelation function, box-pierce test and unit root test for testing the random walk and kruskal-wallis test for testing the calendar (day of the week) effect. The results confirmed that Israel's TA- 100 stock market shows greater support for the random walk hypotheses (RWH) compared with the other markets in the sample.

With regard to calendar effects, there were anomalies found related to day of the week effects which do not appear to be related to the pattern of trading days over the week, and which might be accounted for by other institutional factors specific to the countries in the sample. Asiri (2008) used cross sectional time series data for forty listed companies in Bahrain Stock Exchange (BSE) over the period from June 1, 1990 to December 31, 2000 to study the behavior of stock prices in BSE. Random walk models such as unit root and dickey fuller test were used as basic stochastic tests for nonstationarity of daily prices for all listed companies in BSE and autoregressive integrated moving average (ARIMA) and exponential smoothing method were also used. The results confirmed random walk for all daily stock prices and thus the market is considered efficient in weak form. Chigozie (2009) investigated whether the Nigerian stock market, from period 1984 to 2006, follows random walk.

Our study finds the evidence on Efficient Market Hypothesis (EMH) using various parametric and non-parametric tests using the experiences from past and recent studies what is the status of the Chittagong Stock Exchange (CSE).

3 Materials and Methods

3.1 Data and Methodology

This paper uses the daily data of Chittagong Stock Exchange (CSE) considering 2248 observations during the period 1st July, 2006 to 26th November, 2015. Here we use the index prices, rather than individual observations stock prices to provide market wide evidence. Therefore our prime investigative look is to find the evidence on weak form efficiency and we test the following hypothesis:

H_0: *Prices on the CSE follow a random walk*

H_1: *Prices on the CSE do not follow a random walk*

3.2 Unit Root Test (Augmented Dickey-Fuller (ADF) test)

It is a test to verify the presence of stationary properties in the time series data. A unit root test is a statistical test for the proposition that in an autoregressive statistical model of a time series, the autoregressive parameter is one. The presence of unit root in a time series is tested with the help of Augmented Dickey–Fuller test (ADF) test. It tests for a unit root in the univariate representation of time series. For a return series R_t, the ADF test consists of a regression of the first difference of the series against the series lagged *k* times as follows:

$$\Delta X_i = \alpha_1 + \alpha_2 t + \beta R_{t-1} + \sum_{i=1}^{k} \gamma_t \Delta R_{t-1} + \mu_t$$

The null hypothesis is $H_0: \beta = 0$ and $H_1: \beta < 1$. The acceptance of null hypothesis implies non-stationarity. Mackinnon's critical values are used to determine the significance of the test statistic. If the calculated absolute values of ADF statistics are higher than Mackinnon's critical Value, we can reject the null hypothesis of random walk in the series [15].

3.3 Autocorrelation Function Test (ACF)

Firstly, we employ autocorrelation function test (ACF) to disclose the validity of random walk hypothesis in CSE. Autocorrelation function (ACF) test measures the degree of correlation between the current stocks returns and its lagged observations or the degree of independence which given by:

$$\rho_k = \sum_{t=1}^{n-k}(RT_t - \overline{RT})(RT_{t+k} - \overline{RT}) \Big/ \sum_{t=1}^{n}(RT_i - \overline{RT})^2$$

Where k refers to the lags number, and r indicates to the real rate of return which calculated as follows:

$$RT_t = ln\left(\frac{Pr_t}{Pr_{t-1}}\right) \times 100 = \alpha + \mu$$

We apply this test to examine the significance of serial correlation coefficients, and if the stocks returns are serially correlated we will reject the null hypothesis which means that CSE is inefficient at weak form level. Ljung–Box (Q) statistic which given bellow to test the joint hypothesis that all autocorrelations are significantly different from zero:

$$Q_{LB} = n(n+2)\sum_{t=1}^{k}\left(\frac{{\rho_t}^2}{n-t}\right)$$

k : Refer to the lag length; n : refer to the sample size, under the null hypotheses of zero autocorrelation at the first k autocorrelations which is distributed as chi-squared. $(\rho_1 = \rho_2 = \cdots\cdots = \rho_n)$ [11].

3.4 Runs Tests

We use the Wald-Wolfowitz Runs Test for the randomness of the series. Runs testing is a strong test for randomness in investigating serial dependence in share price movements and compares the expected number of runs from a random process with the observed number of runs. The test is non-parametric and is independent of the normality and constant variance of data. A run is defined as a series of identical signs that are preceded or are followed by a different sign or no sign at all. That is given a sequence of observations, the runs test examines whether the value of one observation influences the values taken by later observations. If there is no influence (the observations are independent), the sequence is considered random [14].

Under null hypothesis, the successive price changes are independent and it is assumed that sample proportions of positive, negative and no price changes are unbiased estimates of the population proportions. Wallis and Roberts (1956) inferred the expected number of runs, *M,* and the standard error of runs, S_M as follows:

$$M = \left[\frac{n(n-1) - \sum_{i-1}^{3} {\eta_i}^2}{n}\right] and$$

$$S_M = \left\{\frac{\sum_{i-1}^{3} {\eta_i}^2 (\sum_{i-1}^{3} {\eta_i}^2 + n(n+1)) - 2n\sum_{i-1}^{3} {\eta_i}^3 - n^3}{n^2(n-1)}\right\}$$

Where n denotes the number of observations; $i = 1, 2, 3$ denotes the signs of plus, minus and no change; denotes the total number of changes of each category of signs. Fama (1965) suggested that when n is large, the expected number of runs, M, is approximately normally distributed. Furthermore, the standard normal statistic in the test of the actual number of runs being equal to the expected number of runs is as follows:

$$Z = \frac{A_c - M \pm \left(\frac{1}{2}\right)}{S_M} \approx N(0,1)$$

Where A_c denotes actual runs, ½ is the correction factor for continuity adjustment, in which the sign of the continuity adjustment is positive if $A_c \leq M$, and negative if $A_c \geq M.Z$ follows a standard normal distribution. For testing the significance of the difference between observed and expected number of runs, 'Z' statistic can be used, where A_c *total number of observed runs of all signs and* ½ *is* is the continuity adjustment. For large *N*, *Z* will follow normal distribution with mean zero and variance unity. $If\ |Z| \geq 1.96$, null hypothesis of random price changes will be rejected [29].

3.5 Variance Ratio Test

The robust variance ratio test, developed by Lo and Mackinlay (1988), shows that the variance ratio tests is more powerful than the well-known Dickey–Fuller unit root or the Box–Pierce *Q*-tests. The first null hypothesis is stated as follows:

Let Y_t denote a time series generated from the following equation:

$$Y_t = \mu + Y_{t-1} + \varepsilon_t$$

Where μ is an arbitrary drift parameter. The key properties of a random walk that we would like to test are $E(\varepsilon_t \varepsilon_{t-1}) = 0$, for all t, and $E(\varepsilon_t \varepsilon_{t-1}) = 0$, for any positive j. We may define estimators for the mean of first difference and variance:

$$\bar{\mu} = \frac{1}{T}\sum_{t=1}^{r}(Y_t - Y_{t-1}) = \frac{1}{T}(Y_t - Y_0)$$

$$\bar{\sigma}^2 = \frac{1}{T}\sum_{t=1}^{T}(Y_t - Y_{t-1} - \bar{\mu})^2$$

Where $\bar{\sigma}^2$ is an unbiased estimate of σ^2 based on the period difference $\Delta Y_t = Y_t - Y_{t-1}$. Alternatively, we may consider the $q - period$ difference of Y_t, $Y_t - Y_{t-q}$ from which we obtain an estimate of the variance of the *q*-period difference as follows:

$$\bar{\sigma}^2 = \frac{1}{Tq}\sum_{t=1}^{T}(Y_t - Y_{t-1} - q\bar{\mu})^2$$

The formula above has taken account of the degree of freedom adjustment suggested by Lo and MacKinlay (1989). Under H_0, the variance of the $q - period$ difference of Y_t is $q\sigma^2$. The corresponding variance ratio can be calculated as follows:

$$VR(q) = \hat{\sigma}^2(q) / \hat{\sigma}^2(1)$$

Lo and MacKinlay show that the variance ratio $z - statistic$: $Z(q) = \frac{Var(q)-1}{[\hat{s}^2(q)]^{-1/2}}$ is asymptotically $N(0,1)$ for appropriate choice of estimator $\hat{s}^2(q)$

Under the independent and identically distributed (iid) hypothesis, we have the estimator: $\hat{s}^2(q) = \frac{2(2q-1)(q-1)}{3qT}$ *(The asymptotic variance of the variance ratio under the condition of homoscedasticity).*

Lo and MacKinlay also outline a heteroscedastic RWH where they weaken the iid assumption and allow for fairly general forms of conditional heteroscedasticity and dependence. Under condition of heteroscedasticity, we may estimate the estimator as under:

$$\hat{s}^2(q) = \sum_{j=1}^{q-1}\left(\frac{2(q-j)}{q}\right)^2 . \hat{\delta}_j$$

Where,

$$\hat{\delta}_j = \left\{\sum_{t=j+1}^{T}(Y_t - Y_{t-1} - \bar{\mu})^2 \sum_{t=1}^{T}\left(Y_{t-j} - Y_{t-j-1} - \bar{\mu}\right)^2\right\} / \{\sum_{t=1}^{T}(Y_t - Y_{t-1} - \bar{\mu})^2\}^2$$

Where $T$the number of observations *is*, $\hat{\delta}_j$ is the heteroscedasticity-consistent estimator, Y_t is the price of the security at time t and $\hat{\mu}$ is the average return [15]

3.6 Kolmogorov Smirnov Goodness of Fit Test

The most popular nonparametric goodness-of-fit test is the Kolmogorov-Smirnov test (Chakravart, Laha and Roy, 1967). It is used to decide if a sample comes from a population with a specific distribution. For one dimensional probability distribution the K-S test can be used to compare a sample with a reference distribution (one-sample K-S test) or to compare two samples (two-sample K-S test). It is based on the empirical cumulative distribution function $(ECDF)$. Assume that we have a random sample $x_1 \cdots\cdots x_n$ from some continuous distribution with CDF $F(x)$.The empirical CDF is denoted by

$$F_n(x) = \frac{1}{n}[Number\ of\ observations\ \leq x]$$

The Kolmogorov-Smirnov test is defined by:

$H_0 = CSE\ indecies\ of\ returns\ series\ Follow\ the\ Normal\ Distribution.$

$H_1 = CSE\ indecies\ of\ returns\ series\ Follow\ the\ Normal\ Distribution.$

The Kolmogorov-Smirnov test statistic is defined as

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

Where ***F*** is the theoretical cumulative distribution of the distribution being tested 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. There are several variations of these tables in the literature that use somewhat different scaling's for the K-S test statistic and critical regions. These alternative formulations should be equivalent, but it is necessary to ensure that the test statistic is calculated in a way that is consistent with how the critical values were tabulated.

4 Empirical Results and analysis

4.1 Runs Tests

In this section we use the Run analysis to test and detect statistical dependencies (Randomness) in CSE share price movements which is may not be detected by the serial correlation test. The run analysis examines weather the value of one observation influences the values taken by later observations.

Table 1: Run Analysis

	CSE 30 Index	**CSCX Index**	**CASPI Index**
Test Value	.0658	.06404876662	.0697898770
Cases < Test Value	1154	1147	1141
Cases >= Test Value	1094	1101	1107
Total Cases	2248	2248	2248
Number of Runs	1016	1028	1022
Z	-4.568	-4.074	-4.336
Asymp. Sig. (2-tailed)	.000	.000	.000

In this case we use 0.01% level of significance which is shown in Table 1, the calculated z statistics of daily market return for every indexes is significantly negative. Thus the negative *z*-values is a dictation that the actual number of runs is less than the expected number of runs under the null hypothesis of return independence at the .01 level or lower for all indices. Our results reject the null hypothesis showing that CSE doesn't follow the random walk and therefore, the market is not efficient in weak form.

4.2 Kolmogorov Smirnov Goodness of Fit Test

The Kolmogorov Smirnov Goodness of Fit Test (KS) shows 0.0000 probability for the Z at the 5 percent level of significance, in case of normal as well as uniform distribution. The results clearly indicate that the frequency distribution of the daily values of CSE Indices does not fit either normal or uniform distribution. Table 2 shows the results of the KS Test:

Table 2: Kolmogorov Smirnov Goodness of Fit Test

	Distribution	Absolute	Positive	Negative	K-S Z	Z-Tailed P
CSE 30 Index	**Normal**	.071	.071	-.064	3.347	.000
	Uniform	.471	.471	-.234	22.321	.000
	Distribution	**Absolute**	**Positive**	**Negative**	**K-S Z**	**Z-Tailed P**
CSCX Index	**Normal**	.070	.063	-.070	3.340	.000
	Uniform	.470	.470	-.219	22.307	.000
	Distribution	**Absolute**	**Positive**	**Negative**	**K-S Z**	**Z-Tailed P**
CASPI Index	**Normal**	.074	.060	-.074	3.521	.000
	Uniform	.471	.471	-.224	22.353	.000

4.3 Result of Variance Ratio Test

The result of variance of ratio test for three returns series on CSE (CSE 30, CSCX and CASPI) are reported in Table 3.The Table 3 contains the value for variance ratio of the returns series of CSE using the intervals 2,4,8,12,16,20,24,28 and 30. The value of variance ratio is decreasing with increase in intervals such as the variance ratio falls from 0.516678 at lag 2 to 0.033210 at the interval of 30 lags in CSE 30 Index. This indicates the signs of weaker correlation with the increasing intervals. Also we can see from Table 3 the same result for the CSC X Index and CSSPI Index respectively. For CSC X Index the value of variance ratio is decreasing with increase in intervals such as the variance ratio falls from 0.510551 at lag 2 to 0.032832 at the interval of 30 lags. Also for the CSSPI Index Index the value of variance ratio is decreasing with increase in intervals such as the variance ratio falls from 0.510494 at lag 2 to 0.033044 at the interval of 30 lags.

Table 3: Variance Ratio Test

CSE 30 Index			
Period	Var.Ratio	z-Statistic	Probability
2	0.516678	-22.89030	0.0000
4	0.251981	-18.93623	0.0000
8	0.129466	-13.93786	0.0000
12	0.085419	-11.55348	0.0000
16	0.063443	-10.07692	0.0000
20	0.050717	-9.046109	0.0000
24	0.042642	-8.274231	0.0000
28	0.035673	-7.680690	0.0000
30	0.033210	-7.425538	0.0000

CSCX Index			
Period	Var. Ratio	z-Statistic	Probability
2	0.510551	-23.18045	0.0000
4	0.253247	-18.90418	0.0000
8	0.128975	-13.94573	0.0000
12	0.083824	-11.57363	0.0000
16	0.063010	-10.08158	0.0000
20	0.050410	-9.049034	0.0000
24	0.042513	-8.275344	0.0000
28	0.035733	-7.680216	0.0000
30	0.032832	-7.428445	0.0000

CASPI Index			
Period	Var.Ratio	z-Statistic	Probability
2	0.510494	-23.18315	0.0000
4	0.251836	-18.93988	0.0000
8	0.129162	-13.94273	0.0000
12	0.083728	-11.57484	0.0000
16	0.062533	-10.08672	0.0000
20	0.050231	-9.050737	0.0000
24	0.042456	-8.275836	0.0000
28	0.035598	-7.681290	0.0000
30	0.033044	-7.426816	0.0000

4.4 Result of Unit Root Test

The results of Augmented Dickey–Fuller (ADF) are presented in Table 4 In all the three return series of CSE the ADF test statistic in absolute term is found to be greater than absolute critical value at 1 per cent level of significance. Thus, the ADF test supports the presence of stationary in all the three return series of index markets, thereby rejecting the null hypothesis of unit root and providing the evidence in favor of RWH.

Table 4: Augmented Dickey–Fuller (ADF) Unit Root Test

	Intercept	Intercept and Trend
CSE30	-46.31005	-46.32348
CSCX	-46.53163	-46.54106
CASPI	-46.69192	-46.70342

Notes: The optimum lag length is indicated within parentheses determined by the Schwarz criteria.

5 Conclusion

This paper has examined the weak form of efficiency of Chittagong Stock Exchange in Bangladesh. Different statistical parametric and non-parametric tests were applied for analysis and results. Three important indices like CSE All Share Price Index, CSE Selective Index and CSE Selective Categories Index are verified by using both parametric and non-parametric techniques to test the existence of Efficient Market Hypothesis (EMH) in CSE. To make our paper feasible the Unit Root Test (Augmented Dickey-Fuller (ADF) test) is used to check the stationarity of the data. Also we use the Auto Correlation Function (ACF) test for the independence of stock price change, while non-parametric tests include Runs test, Variance Ratio Test and Kolmogrov-Smirnov (K-S) test to see the evidence on Efficient Market Hypothesis (EMH) in CSE. Therefore, CSE do not follow random walk hypothesis and it is inefficient in weak form in our study period. As far as the future implication of the present research work is considered, the research work on stock markets done in past may be functional for the researchers who wish to work on the same subject line in future because these type of studies are persistent in nature. The observations, which are drawn from such studies conducted in one time period, may be helpful in justifying the studies of future researchers. In addition, the results of the past studies are contradictory in nature which is an inspiring reason for future researches in the same area.

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