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Tests of Weak-Form Efficiency of the Dhaka Stock Exchange

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Abstract: Conflicting evidence on weak form efficiency of the Dhaka Stock Market appears to stem from the use of monthly versus daily data, structural changes after the 1996 market crash, and the use of tests with or without heteroscedasticity adjustment. Heteroscedasticity-robust tests indicate short-term predictability of share prices prior to the crash, but not afterwards. Although a heteroscedasticity-robust Box-Pierce test was used by Lo and MacKinlay (1989) in their simulations, our study appears to be the first to apply this test to stock prices. Typical rejection of weak-form market efficiency by the usual autocorrelation tests may be reversed by a heteroscedasticity-robust test.

Keywords: efficient market, variance ratio, Dhaka stock exchange

1. INTRODUCTION

The securities market is a crucial institution in the financial system of any country. The activities of buying and selling of shares on the securities market are extremely important for the efficient allocation of capital through proper pricing of capital and risk. In a capital starved economy like Bangladesh, efficient allocation of scarce resources and encouragement of foreign

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private investment are both of vital importance. Success of an increasing privatisation of the economy, now under way in Bangladesh, will depend crucially on the presence of an active and efficient share market. The role of such markets in harnessing domestic saving takes on an extra dimension in a country like Bangladesh with a predominantly Muslim population. According to the Islamic faith, *riba* (usury) is prohibited. The correct interpretation of *riba* is a highly contested matter in Islamic economic discussions, but there are many Muslims who consider any fixed interest saving instruments as being unacceptable. For such people, a well functioning stock market can provide an ideal alternative investment mechanism. At present, there are two stock exchanges in Bangladesh, namely, the Dhaka Stock Exchange (henceforth DSE) and the Chittagong Stock Exchange.[1] For the purpose of this study we will concentrate on the DSE, as this is the country's oldest stock exchange, and according to Standard and Poor's *Emerging Stock Markets Fact Book 2000*, the DSE is one of the frontier emerging markets of South Asia.

Compared to the stock markets in developed countries, the emerging stock markets are in many cases characterised by a lower volume and frequency of trading ('thin trading'), ease of manipulation by a few large traders, weaker disclosure and accounting requirements, settlement delays, and a generally less than smooth transmission of financial information. If correct information on business performance and prospects fail to be quickly and fully reflected in the stock prices, those who are privy to such information can benefit by anticipating the course of such prices. Stock markets are said to be efficient when all information are reflected in the stock prices. Any abnormal price changes should not be predictable in an efficient market. When any random components in the changes of a share price are not correlated, unpredictability (or efficiency) of such a price is also known as a 'random walk'. Emerging stock markets may not be efficient in this sense owing to the imperfections mentioned above.

1 Dual listing of companies is allowed. For example, most of the companies listed on the Dhaka Stock Exchange are also listed on the Chittagong Stock Exchange.

A stock market is said to be weak-form inefficient if stock prices and/or returns are predictable given their history. The findings of market efficiency tests (mostly weak-form efficiency tests) on emerging markets are rather varied. Some researchers find evidence in favour of weak-form efficiency (e.g. Alam et al., 1999; Cheung and Coutts, 2001; and Abrosimova and Linowski, 2002), but some other researchers find evidence of predictability of stock prices (e.g. Lee et al., 2001; Smith et al., 2002; and Mobarek and Keasey, 2002).

There have been only two studies (Alam et al., 1999; and Mobarek and Keasey, 2002) testing the market efficiency of the DSE. The results are conflicting. Applying a variance ratio test, Alam et al. (1999) found that the monthly stock price index series of the DSE (during 1986 to 1995) followed a random walk. This implies the existence of weak-form efficiency. However, by applying runs and autocorrelation tests, Mobarek and Keasey (2002) concluded that the daily price index series of the DSE (for the period of 1988 to 1997) did not follow a random walk.

Besides making a contribution to the literature on the assessment of efficiency of an emerging stock market with more recent information, the aim of this paper is to revisit the Dhaka Stock Market data to determine if the conflicting results reported by the two studies on this market stem from different test methods employed and/or from the use of monthly versus daily data. We offer a more comprehensive study by considering data at the three commonly used intervals – daily, weekly and monthly. The remainder of the paper is structured as follows. The next section outlines the various methods typically employed in testing for stock market efficiency. Information on the size of the DSE and a description of the data are presented in Section 3. This is followed by a presentation and discussion of the results in Section 4. The conclusions are presented in Section 5.

2. METHODOLOGY

Efficiency in financial markets is generally represented as a lack of predictability of returns in excess of normal returns. According to the weak form of the efficient market hypothesis

(EMH), the current rate of return cannot be predicted by past rates of return. The rate of return is $R_t = \ln P_t - \ln P_{t-1}$ where P_t is the price. Consider the multiple regression:

$$R_t = \beta_0 + \beta_1 R_{t-1} + \beta_2 R_{t-2} + \ldots + \beta_k R_{t-k} + \varepsilon_t \qquad (1)$$

where ε_t is a random error. Here, the weak-form efficiency is the hypothesis H_0: $\beta_1 = 0$, $\beta_2 = 0, \ldots, \beta_k = 0$. Under this hypothesis, $R_t = \beta_0 + \varepsilon_t$, that is:

$$\ln P_t = \beta_0 + \ln P_{t-1} + \varepsilon_t \qquad (2)$$

which is known as a 'random walk' or a 'unit root' process. Thus, weak EMH can be tested in two alternative ways, either by testing H_0: $\beta_1 = 0, \beta_2 = 0, \ldots, \beta_k = 0$ in (1), or by testing for a unit root in (2). An *F*-test could be used for the former if R_t satisfied stationarity, i.e. it didn't have a unit root. An alternative to this test used by many investigators of the EMH is the Box-Pierce test. Let correlation between R_t and R_{t-h} be ρ_h. Under the weak EMH, $\rho_h = 0$ for all h. In this case, the statistic $Q = T \sum_{j=1}^{h} \hat{\rho}_j^2$ where T is the number of observations, is asymptotically distributed as chi-square with h degrees of freedom.[2]

The presence of unit roots is usually tested by an augmented Dickey-Fuller (ADF) or a Phillips-Perron (PP) test, but a more commonly used test in financial economics is the variance ratio (VR) test developed by Lo and MacKinlay (1988). This test is based on the fact that the variance of the q^{th} difference of a random walk increases linearly with q. Let $\Delta \ln P_t = \ln P_t - \ln P_{t-1}$ be the first difference, and $\Delta_q \ln P_t = \ln P_t - \ln P_{t-q}$ be the q^{th} difference. The variance ratio, $\text{var}(\Delta_q \ln P_t)/q\ \text{var}(\Delta \ln P_t)$, will equal one for a random walk process. Using this ratio, Lo and MacKinlay define another measure:

$$M(q) = [\text{var}(\Delta_q \ln P_t)/q\text{var}(\Delta \ln p_t)] - 1 \approx \sum_{j=1}^{q-1} \frac{2(q-j)}{q} \hat{\rho}_j \qquad (3)$$

2 In the case of a small sample, it is typical to use an adjusted form of this statistic known as the Ljung-Box *Q* statistic with the same asymptotic distribution.

where $\hat{\rho}_j$ is the sample autocorrelation coefficient of order j of the $\Delta \ln P$ series. A significant departure of $M(q)$ from zero would indicate absence of a random walk (i.e. the presence of weak-form inefficiency).

Given a total of T observations, a test statistic using (3) is given by:

$$z(q) = \frac{\left(\sqrt{T-1}\right)M(q)}{\sqrt{\theta(q)}} \tag{4}$$

where: $\theta(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q}\right]^2 \hat{\delta}_j$, $\hat{\delta}_j = \frac{(T-1)\sum_{k=j+2}^{T} (\Delta \ln P_k - \hat{\beta}_0)^2 (\Delta \ln P_{k-j} - \hat{\beta}_0)^2}{\left[\sum_{k=2}^{T} (\Delta \ln P_k - \hat{\beta}_0)^2\right]^2}$,

and $\hat{\beta}_0$ is the sample mean of the first differences. Under the null hypothesis of a random walk, statistic (4) is asymptotically standard normal for any q, and is robust to both heteroscedasticity and non-normality. VR tests are typically carried out using this statistic.

The hypothesis of random walk cannot be rejected by the VR test if it is not rejected for all the selected values of q. For a test at the 5% level, if we compared each $|z(q)|$ with 1.96, the overall significance of the test would not be 5% as multiple variance ratios are involved in this comparison. Chow and Denning (1993) proposed a multiple variance ratio test by which the random walk hypothesis can be rejected at 5% significance only if $\underset{q}{\text{Max}} |z(q)| > \text{SMM}(0.05, k, v)|$, the latter being the critical value with a 5% upper tail area of the Studentised Maximum Modulus (SMM) distribution with the number of q values selected given by k, and the degrees of freedom by $v = T - k$.[3]

Lo and MacKinlay (1989, p. 210–11) pointed out that a heteroscedasticity-robust Box-Pierce test could also be constructed using $\hat{\delta}_j$. In this case, the test statistic $Q = \Sigma_{j=1}^{h} \hat{\rho}_j^2 / \hat{\delta}_j$,

3 SMM critical values for $v = \infty$ can be read off the standard normal z table. For example, the 5% SMM critical value is the z value leaving an upper tail area of $0.5[1 - (1 - 0.05)^{1/k}]$. Miller (1981, p. 239) provides 5% SMM critical values for $v \leq 120$.

which has an asymptotic chi-square distribution with h degrees of freedom, could be used in the case of large samples.

3. DATA

Unlike other Asian countries, the size of the DSE, in terms of market capitalization and number of listed securities, is relatively small, but the turnover ratio is comparatively large. The position of Bangladesh in terms of these measures, compared to other emerging markets in Asia in 1999, is shown in Table 1.

The DSE has been growing rapidly since 1999. As of October 2002, there were 258 securities listed on the stock exchange consisting of 239 stocks, ten mutual funds and nine debentures. Total market capitalization of all listed securities was approximately US$ 1.2 billion.

After the stock market crash in 1996, the policy makers took various steps to reorganize the capital market and to regain the confidence of investors. The market is now comparatively more transparent due to self-regulation by the Exchange and the close monitoring by the Securities and Exchange Commission (SEC). The Dhaka Stock Exchange is now being considered as one of the frontier emerging markets of South Asia.

This study uses daily, weekly and monthly market prices and returns of the Dhaka Stock Exchange during the years 1990 to 2001. Starting from January 1990, the daily market price data cover the period up to 23 November, 2001, while the weekly

Table 1

Comparative Statistics: Emerging Stock Markets, 1999

Country	*No. of Listed Companies*	*Market Capitalization (US$ Million)*	*Turnover (US$ Million)*	*Turnover Ratio (%)*
Bangladesh	211	865	789	83.0
Sri Lanka	239	1,584	209	12.7
Philippines	226	48,105	19,673	47.2
Thailand	392	58,365	41,604	89.2
Indonesia	277	64,087	19,903	39.8
Malaysia	757	145,445	48,512	30.9
India	5,863	184,605	122,247	84.4

Source: *Emerging Stock Markets Fact Book 2000* (IFC, Washington).

and monthly price data cover the period up to 21 November, 2001 and 31 October, 2001 respectively. The price indices for the period 1992 to 2001 were collected from *Data Stream Advanced Version 3.5* developed by Data Stream International Limited. Data for the period 1990 to 1991 were taken from the daily price quotations (after adjustment for bonus and rights issues) of the Dhaka Stock Exchange.

4. RESULTS

(i) Unit Root Tests

The daily, weekly and monthly price index series were first tested for the presence of unit root in the log of the index using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. In both tests, a linear trend term was included. Presence of a unit root couldn't be rejected by either test at the 5% level of significance, the ADF *t*-test statistics (all smaller than the PP statistics) being −1.85, −1.50 and −1.74 respectively for the daily, weekly and monthly index series compared to the critical value −3.41. The presence of a unit root supports the weak efficient market hypothesis in the absence of autocorrelation in errors. Since the presence of a unit root is a necessary, but not a sufficient condition for a random walk process, we now proceed to a more definitive test of return predictability.

(ii) Variance Ratio Tests

Results of the variance ratio tests are shown in Table 2. Variance ratios were calculated for lags up to 128 for the daily index, up to 64 for the weekly index, and up to 32 for the monthly index. The variance ratios are reported in the main rows of the table, with heteroscedasticity-robust test statistics given in parentheses immediately below each estimated variance ratio.

Under the null hypothesis that the variance ratios equal one, the test statistics have a standard normal distribution. Test of any single variance ratio at the 5% level of significance can be carried out by comparing the test statistic with critical value ±1.96, but the appropriate critical values for a multiple variance

Table 2

Variance Ratio Tests of DSE All-Share Price Indices

	Sample Size	*At Lag 2*	*At Lag 4*	*At Lag 8*	*At Lag 16*	*At Lag 32*	*At Lag 64*	*At Lag 128*
Daily	3,105	1.068*	1.052	1.093	1.236	1.466	1.739	1.924
Index		(2.884)	(0.425)	(0.489)	(0.961)	(1.397)	(1.722)	(1.718)
Weekly	618	0.991	1.050	1.257	1.488	1.547	1.475	
Index		(−0.085)	(0.230)	(0.765)	(1.099)	(0.976)	(0.686)	
Monthly	142	1.208	1.323	1.279	1.192	1.083		
Index		(1.382)	(1.124)	(0.632)	(0.323)	(0.113)		

Note:
* Indicates significantly different from one at the 5% level.

ratio test are ±2.69 for seven variance ratios (the daily index), ±2.64 for six variance ratios (the weekly index) and ±2.57 for five variance ratios (the monthly index) from the table of critical values in Miller (1981, p. 239).

Thus, the results in Table 3 show that the null hypothesis of random walk (i.e. weak-form efficiency) cannot be rejected at the 5% significance level for the weekly and monthly indices, all the test statistics being inside the respective critical ranges. For daily data, the test statistic is outside the critical range for only the smallest (lag 2) of the seven lags. This is clearly a result of error autocorrelation at a lag of a day or two since we found previously that the daily index also had a unit root. In the presence of transaction costs, any error predictability over just a day or two is highly unlikely to offer profit opportunities to investors. Given this evidence, it appears that the Dhaka stock market is weak-form efficient.

(iii) Robustness to Structural Changes and Test Methods

Since the Securities and Exchange Commission (SEC) took steps to make the capital market more transparent soon after the stock market crash of 1996, it is important to check if the above finding is robust to structural changes that may have occurred since the market crash of 1996. The stock market boom started in July 1996, and the crash in mid-November continued until March 1997. We tested for market efficiency both before and after this unusual period by applying the VR

Table 3

Box-Pierce Tests of DSE All-Share Daily Price Index for Post-Crash Data

	Sample Size	*At Lag 2*	*At Lag 4*	*At Lag 8*	*At Lag 16*	*At Lag 32*	*At Lag 64*	*At Lag 128*
Test not robust to heteroscedasticity	1,197	4.932 (0.026)	13.783 (0.003)	40.961 (≈0)	62.830 (≈0)	84.112 (≈0)	109.495 (≈0)	182.254 (≈0)
Test robust to heteroscedasticity	1,197	0.001 (0.976)	0.003 (≈1)	0.010 (≈1)	0.020 (≈1)	0.037 (≈1)	0.055 (≈1)	0.113 (≈1)

Note:
Numbers within parentheses are the *p*-values.

test separately for the period before July 1996 and for the period after March 1997. The hypothesis of market efficiency could not be rejected at the 5% significance level for either of the data regimes in the case of monthly data. For weekly data, and for daily data, however, market efficiency was rejected for the pre-boom period, but not for the post-crash.

From these results, it appears that the steps taken by the SEC to promote transparency and efficiency made a difference. In order to encourage trading of shares with strong fundamentals, the SEC can now suspend trading of Z category shares (i.e. those with weak fundamentals). A Circuit Breaker System (CBS) was introduced within three months of the stock market bubble of 1996 to deter speculation in abnormal price changes. Under this system, share prices on a day are subjected to specified upward and downward limits around the previous day's closing price. In the case of new issues, free trading is permitted for the first five consecutive market days to allow the business fundamentals to be reflected, with the CBS limits becoming applicable after this time. In the case of listed securities not traded for 30 consecutive market days, and for those involving the announcement of any price-sensitive information like dividends, bonus and rights issues, free trading may be allowed for three consecutive market days after which the CBS limits apply.

Our results indicate that the finding of weak-form efficiency of the Dhaka market by Alam et al. (1999) using pre-boom data results from the use of monthly data. This conclusion is reversed by the use of daily or weekly data during that time, indicating short-term predictability of share prices. Mobarek and Keasey (2002) also found predictability of share prices using daily data for the period January 1988 – December 1997. Their sample overlaps to some extent with our daily or weekly post-crash sample for which we find that the Dhaka market is weak-form efficient.

Since Mobarek and Keasey (2002) relied on the Ljung-Box Q test, the large sample version of which – the Box-Pierce Q – was shown to be a less powerful test of autocorrelations in the presence of heteroscedastic errors (Lo and MacKinlay, 1989), we check the robustness of our result for post-crash daily data by using a Box-Pierce test of autocorrelations with and without heteroscedasticity adjustment. The results displayed in Table 3

indicate that the null hypothesis of zero autocorrelations (i.e. weak-form efficiency) could be rejected at any of the lags if the Box-Pierce tests were not adjusted for heteroscedasticity, but with an adjustment for this problem, our finding of market efficiency for post-crash data is shown to be robust to a different test method as well.

Although a heteroscedasticity-robust Box-Pierce test was suggested by Lo and MacKinlay (1989) in the context of their Monte Carlo experiments, our study appears to be the first to apply this test to stock market data. Results based on autocorrelation tests not corrected for heteroscedasticity typically result in rejection of the hypothesis of weak-form market efficiency, e.g. Claessens et al. (1995), Poshakwale (1996) and Groenewold (1997). Given our results for the Dhaka market, we suspect that previous results based solely on autocorrelation tests not adjusted for heteroscedasticity may be reversed by the use of a heteroscedasticity-robust test.

5. CONCLUSIONS

The conflicting evidence on weak-form efficiency of the Dhaka Stock Market reported by the two studies on this market to date appears to stem from the use of data at different frequencies (monthly versus daily or weekly), structural changes from the pre-boom to the post-crash period, and from the use of tests with and without heteroscedasticity adjustment. By using heteroscedasticity-robust tests, we find evidence in favour of short-term predictability of share prices in the Dhaka stock market prior to the 1996 boom, but not during the post-crash period investigated. The finding of weak-form efficiency during the latter period may be explained by the steps taken by the Securities and Exchange Commission to promote transparency and efficiency in the stock market after the crash of 1996.

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