A TEST OF WEAK FORM EFFICIENCY FOR THE BOTSWANA STOCK EXCHANGE (2004-2008)

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Abstract
Aim: This study aims to evaluate the presence of weak form efficiency in the Botswana Stock Exchange (BSE) using a number of methods that specifically assess the Random Walk Model.
Study Design: Multi-model econometric study.
Place and Duration of Study: Botswana, Gaborone, between December 2011 and January 2012.
Methodology: The study uses a number of tests to examine the randomness of the BSE stock prices. The testing methods used are the Augmented Dickey Fuller tests, autocorrelation test, Kolmogorov-Smirnov Test, Runs Test and the Phillips Perron unit root test. The methodology was adopted because it mixed both parametric and nonparametric tests. All the tests are investigated on weekly and monthly All Company Index (ACI) data for the period 2004 to 2008.
Results: All the tests show that the BSE is inefficient at the weak-form and that there is need for a number of adjustments to improve its efficiency.
Conclusion: The random Walk hypothesis is rejected implying that experienced investment analysts have an advantage of outperforming the market and hence make higher than expected profits through the use of historical data.
Keywords: Botswana stock exchange; random walk; weak form efficiency; parametric tests; nonparametric tests.

1. INTRODUCTION

In Botswana, the Botswana Stock Exchange (BSE) was established in 1989, solidified by the Botswana Stock Exchange Act of 1994. Currently the BSE has 35 market listings (23 Domestic and 12 Foreign) and 3 stock indices: the Domestic Company Index (DCI), the Foreign Company Index (FCI) and the All Company Index (ACI) which is a weighted average of the DCI and FCI. The DCI and the FCI are the principal stock indices of the BSE. Each is calculated from the weighted averages of the values of their category of stock. A third index value, the ACI, is derived from a weighted average of the two indices. On the BSE, a company that is designated as a "foreign company" is a company that is "dual-listed", meaning that it is also listed on another stock exchange. Equities, BDC bond and Investec Floating Rate Notes are traded on the market. Given more than a decade of stock trading, there are probable implications for the efficiency and dynamics of stock prices and trading. Stock market efficiency is an important concept for understanding the working of capital markets. This study will make use of ACIw and ACIm, that is, the All Company weekly Index and the All Company monthly Index, respectively.

This study differs from previous similar studies due to the fact that it only focused on the BSE, it assesses the efficiency of BSE after a considerable number of years in operation (the maturity argument), it uses a mixture of proven econometric methods among other things. Focusing on BSE has been encouraged by the fact that the majority of studies of African Stock Markets have been more on the Johannesburg Stock exchange (JSE).

Market efficiency studies on the JSE have found it to be weak form efficient with a few contrary results. The maturity argument as we term it asserts that the more years a stock market has been running the more it becomes efficient. There are few studies that have specifically focused on the BSE and its market efficiency. Most of these though have found the BSE to be weak-form inefficient for the respective periods being investigated. It is noteworthy to mention that the periods of investigation mainly focused on the initial trading data of the BSE that is from its inception to the latest 2002 (Appiah-Kusi and Menyah, 2003). In addition, the period under investigation has seen changes in government exchange rate policy and internal public debt policy, the government's drive has been more on the opening-up of the economy and hence this might lead to increased efficiency in the stock market. For example, since 2005, the Botswana economy has been implementing the crawling band exchange rate mechanism that is aimed at maintaining international competitiveness of domestic producers. The exchange rate is adjusted in a crawling peg arrangement rather than in discrete steps, and the spread between the buy and sell rates of ± 0.125, to encourage further development of the interbank market for foreign exchange. More so, the BSE has seen an increase in many new listed counters since its establishment and many changes in regulations that govern its operations. We note that in some cases, the predictability of stock returns can be affected by time-varying risk premiums therefore analysing subperiods therefore enables an assessment of the degree to which market efficiency changes over time. All the aforesaid factors have led to the need to evaluate the market efficiency of the BSE during the period 2004 to 2008 using weekly and monthly data.

Various theoretical propositions and empirical models have been extensively developed with highly restrictive assumptions to determine and predict the stock prices across economies. The Random Walk model is one of the tests used to determine whether stock prices follow a random walk (Fama, 1965). If they follow a random walk, past stock prices cannot be used to predict future prices. The conclusion will be that the market is efficient. If the stock prices do have memory, past prices can be used to predict future prices, then trend analysis can be used to make abnormal profits. The market will be said to be not efficient. There are three types of market efficiency, the weak form, semi-strong and the strong market efficiency, (Fama, 1970). The weak form asserts that all past market prices and data are fully reflected in securities prices. In other words, technical analysis, to try and take advantage of the market is of no use. Security prices exhibit no serial dependencies, meaning that there are no "patterns" to asset prices. This implies that future price movements are determined entirely by information not contained in the price series. Hence, prices follow a random walk. A weakly efficient market is essentially a refutation of technical analysis which asserts that market prices do not follow a random process, data has memory: expected price changes are not independent of past price changes nor are distributions of rates of returns independent from past distributions. The semi-strong form asserts that all publicly available information is fully reflected in securities prices. It is implied that share prices adjust to publicly available new information very rapidly and in an unbiased fashion, such that no excess returns can be earned by trading on that information. This is a refutation of the fundamental analysis. The strong form asserts that all information is fully reflected in securities prices. In other words, even insider information is of no use because the market is unbeatable. A key testable implication of all three forms of the EMH is that investors in trading on the

provided stock prices information set should not be able to realise excess returns above the normal rate. To prove that securities markets are efficient in weak form, one needs to show that successive price changes are independent (Cootner, 1962). A number of studies have established that, the sample serial correlation coefficients computed for successive price changes were extremely close to zero, implying that successive changes in prices are independent, (Kendall, 1953).There have been a number of studies that focused on stock market efficiency though a plethora of them have been done in developed nations than in developing nations.

The variance-ratio test was used to examine random walks in Taiwan's stock prices, (Chang and Ting, 2000). The empirical results showed that with weekly value-weighted market index, the null hypothesis of random walk is rejected. The study also finds that the random walk hypothesis cannot be rejected with monthly, quarterly and yearly value-weighted market indexes. Chan and Lai (1993) use 14 major stock markets in evaluating market efficiency over a period spanning between 1988 to 1990. Their study uses unit root and cointegration tests to examine the relationships among the stock markets in Hong Kong, South Korea, Singapore, Taiwan, Japan, and the United States. All the stock prices were analyzed both individually and collectively to test for international market efficiency. Unit roots in stock prices were found. Pairwise and higher-order cointegration tests indicate that there is no evidence of cointegration among the stock prices. The findings suggest that the stock prices in major Asian markets and the United States are weak-form efficient individually and collectively in the long run, (Chan et al., 1992).

Evidence on the efficiency of stock markets in developing countries was extended by Dickinson and Muragu (1994), using data from the Nairobi Stock Exchange (NSE). Evidence is provided that small markets such as the NSE may provide empirical results consistent with weak-form efficiency. This evidence holds for the NSE irrespective of whether bid-, ask-, or market-price series are used in conducting the study. Mollah (2007) in his study of the BSE uses the triangulation econometric approach to assess the predictability of daily return series of BSE and to test the null hypothesis of random walk model. The empirical results reject the null hypothesis of random walk model for the daily return series of BSE for the period of 1989 to 2005 and evidenced serial autocorrelation of return series, which clearly indicate predictability and volatility of security prices of Botswana market. The study did not take into

account though the maturity argument and the general liberal policy changes in Botswana. Notwithstanding it uses the domestic company index while our study uses the all company index which gives a more summative analysis of the BSE. The use of more recent data would take into account or evaluate the effectiveness of any changes in the market on the market efficiency of BSE though prior studies imply it being weak-form inefficient. Inherently, the predictability of stock returns is susceptible to time-varying risk premiums and the need for analysing subperiods or additive research cannot be underplayed. This enables an assessment of the degree to which market efficiency changes over time.

Studies were done in some other emerging stock markets. Evidence from Bangladesh, the study seeks evidence on whether the return series on Bangladesh's Dhaka Stock Exchange (DSE) is independent and follows the random walk model (Mobarek et al., 2008). The study focuses on assessing if the DSE deviates from idealised efficiency. The sample primarily includes all the listed companies on the DSE daily price index over the period 1988 to 2000. The results of both non-parametric (Kolmogrov—Smirnov: normality test

and run test) and parametric test (Auto-correlation test, Auto-regressive model, ARIMA model) provide evidence that the security returns do not follow the random walk model and the significant auto-correlation coefficient at different lags reject the null hypothesis of weak-form efficiency. Most of the early studies supported the random-walk behavior of stock prices, (Lo and MacKinlay, 1997). Some including most recent studies on the stock markets reject the random walk behavior of stock prices, (Gallagher and Taylor, 2002).

2. METHODOLOGY

The study made use of the ACI, which is the weighted average of the two indices namely DCI and the FCI. The data was collected from the BSE in the form of daily reports for the sample period January 2004 to December 2008. Monthly and weekly data ware extracted and made use of in the study. These were the last calculated indices for the month and for the week for the sampling intervals monthly and weekly respectively. The ACI was used so as to include all the counters at the BSE since both domestic and foreign counters were actively traded over the sample period. The study uses both parametric and nonparametric testing techniques assuming the Random Walk Model to examine evidence for weak form efficiency. The methods employed are the Augmented Dickey-Fuller (DF) test, the runs test, serial correlation tests, the Phillips-Perron test and the Kolmogorov – Smirnov Test so as to have an elevated level of comparison of results.

2.1 Augmented Dicky-Fuller (DF) Unit Root Test

In this study, the Augmented Dickey-Fuller tests are conducted so as to investigate whether the variables have a unit root or not. We test for unit roots by applying the following equation, which represents the Augmented Dickey-Fuller specification:

$$\Delta Y_t = \theta + \theta_1 T + \eta Y_{t-1} + \lambda_i \sum_{i=1}^{m} \Delta Y_{t-i} + \nu_t$$

Where Y_t represents the variable under consideration at time t, that is, ACIw and ACIm, represents the first difference operator, and T stands for the time trend. The null hypothesis in this instance is that $\eta = 0$ (i.e. a unit root exists) at the 5% level otherwise rejection of this hypothesis means that the time series does not contain a unit root and is stationary. The null hypothesis of a unit root is rejected against the one-sided alternative if the t-statistic is less than (lies to the left of) the critical value.

$$H_0: \quad \rho = 1 \quad \text{or} \quad \eta = 0$$
$$H_1: \quad \rho \neq 1 \quad \text{or} \quad \eta \neq 0$$

Failing to reject the null hypothesis means that the stock prices follow a random walk and shocks to the system will be explosive. This confirms that the future stock prices cannot be predicted from past stock prices, which would imply that the BSE is weakly efficient. Alternatively, rejecting the null hypothesis would imply that stock prices do not follow a random walk and economic agents can predict future prices from past prices. The conclusion will be that the market is not weak form efficient.

2.2 The Phillip-Perron (PP) Test

The Phillip-Perron test for unit root corrects for any autocorrelation and heteroskedasticity in the errors nonparametrically by modifying the Dickey Fuller test statistics for a detailed

discussion of the underlying equations (Phillips and Perron, 1988).

2.3 The Runs Test

It is a non-parametric test which means that it does not require a specific form of a probability distribution and the test statistic uses the run counts of both the positive and the negative runs. If there is random walk, the actual number of runs and the expected numberof runs will be the same (Geary, 1970).

2.4 Kolmogorov–Smirnov Test

The Kolmogorov–Smirnov test (K–S test) is a nonparametric test that can be used to compare a sample with a reference probability distribution (one-sample K–S test), or to compare two samples (two-sample K–S test). The Kolmogorov–Smirnov statistic measures the discrepancy between the empirical distribution function of the sample and the cumulativedistribution function of the reference distribution, or between the empirical distribution functions of two samples. The null distribution of this statistic is calculated under the null hypothesis that the samples are drawn from the same distribution (in the two-sample case)or that the sample is drawn from the reference distribution (in the one-sample case). In each case, the distributions considered under the null hypothesis are continuous distributions but are otherwise unrestricted. It can be used after modification as a goodness of fit test. In this study, the K-S test is used to test for normality and to give us the appropriate type of test to be used in assessing the Random Walk model. If it is not normal, parametric tests would be the best measure for independence.

2.5 Serial Correlation Tests

These test that the correlation coefficients of ACI to ACI returns at all lags are zero against the alternative hypothesis that they are not. If the alternative hypothesis is accepted then that means there is autocorrelation and the stock market is not weak-form efficient.

3. RESULTS AND DISCUSSION

The study makes use of a number of tests to test the weak-form market efficiency of the BSE for the period 2004 to 2008. The results of all these tests are illustrated and discussed herein. Tables 1 and 2 below show the results of the Augmented Dickey – Fuller tests and the Phillips-Perron test in both levels and in differences, for both the monthly data and the weekly data, with drift and trend, drift no trend and no drift no trend respectively.

Table 1. ADF and PP Test Results in levels

| | Augmented Dickey Fuller (ADF) Test | | | | Phillips-Perron (PP) Test | | | |
| | ACIw | | ACIm | | ACIw | | ACIm | |
	T-Stat	5% Critical Values	T-Stat	5% Critical Values	T-Stat	5% Critical Values	T-Stat	5% Critical Values
With drift and trend	-1.381	-3.990	-0.340	-3.491	-0.466	-3.43	-0.640	-3.491
With drift, no trend	-1.289	-1.651	-1.392	-1.672	-1.351	-2.880	-1.433	-2.923
No drift,no trend	0.128	-1.950	-0.188	-1.950	-0.047	-1.950	-0.227	-1.950

Table 2. ADF and PP Test Results in differences

	Augmented Dickey Fuller (ADF) Test				Phillips-Perron (PP) Test			
	ACIw		ACIm		ACIw		ACIm	
	T-Stat	5% Critical Values	T-Stat	5% Critical Values	T-Stat	5% Critical Values	T-Stat	5% Critical Values
With drift and trend	-11.74	-3.43	-7.36	-3.492	-11.70	-3.43	-7.371	-3.492
With drift, no trend	-11.64	-1.651	-7.24	-1.672	-11.00	-2.880	-7.245	-2.924
No drift, no trend	-11.64	-1.950	-7.288	-1.950	-11.62	-1.950	-7.298	-1.950

The results of ADF and PP show that the BSE ACI is not stationary at levels and stationaryfor the first difference, hence confirms that the BSE is not weak-form efficient. Table 3 gives the result of the Runs test. The Runs test clearly shows that the BSE is weakform-efficient.

Table 3. Runs Test

	Test Value	P-value	Total Cases
ACIw	-0.1591	0.000	260
ACIM	-0.0729	0.000	60

The returns were tested for normality using the Kolmogorov-Smirnov test and all the indexesrejected the normality assumption at the 5% level of significance which means the BSE is not weak form efficient.

Serial Correlation test results are shown in Figure 1 and 2 below and confirm that the BSE is not weak-form efficient. Even higher lags confirm the presence of weak-form inefficiency.
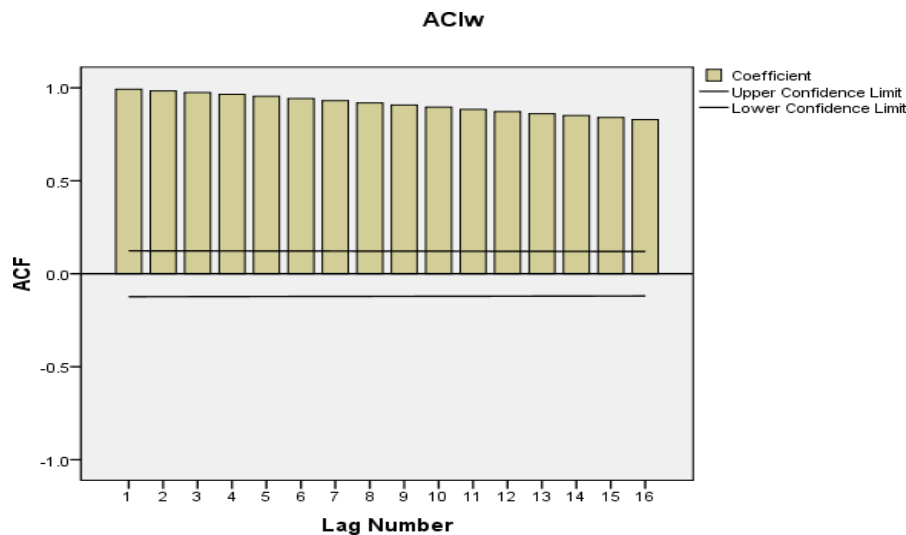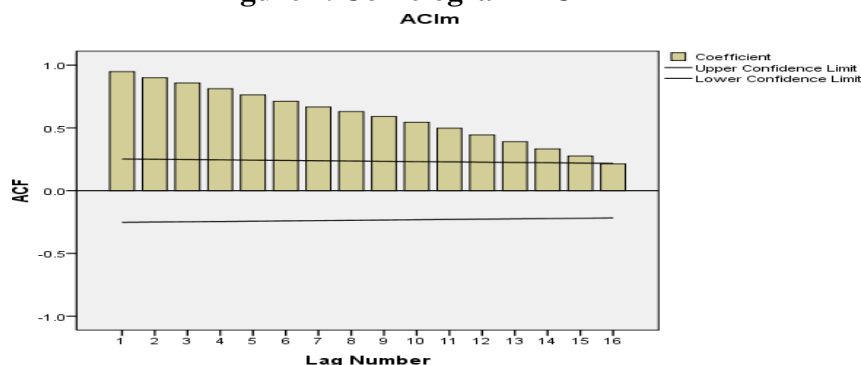

Figure 1. Correlogram ACIw

Figure 2. Correlogram ACIm

Using weekly data, the results as shown in tables1, 2 and 3 rejected the null hypothesis of weak form efficiency just like the monthly data. The autocorrelation tests reject the null hypothesis of no autocorrelation and give significant evidence at the 5% level of significance that there is autocorrelation. Furthermore, the significance of autocorrelation coefficients reveals that the null hypothesis of weak-form market efficiency is rejected. Despite our study focusing on the recent years of the BSE our findings are consistent with Mollah (2007) who also found out that the BSE is not weak-form efficient. However, there is need to periodical investigation of the weak-form efficiency of all fully developed stock exchanges so as to evaluate how they are faring.

4. CONCLUSION

The random walk hypothesis was rejected using both weekly and monthly data of the BSE from the period 2004 to 2008. This means that the BSE is not weak form efficient. Expected price changes are not independent of past price changes nor are distributions of rates of returns independent from past distributions. Experienced investment analysts and skillful market players have an advantage of outperforming the market, and hence make abnormal profits. Investment strategies based on technical analysis or chartism, which rely on use of past stock prices will yield positive returns. Based on the conclusions of the study, a number of recommendations can be put forward. There is need for the BSE to have coordinated information dissemination. The present system by which the BSE announces information during trading does not seem adequate. The BSE must, apart from trading floor announcement, find a wider information network to disseminate stock market information. It should work in conjunction with the brokerage houses, the print media, the audio and visual media for faster dissemination of stock market information such as earnings information and dividend information for investors (news release). Furthermore, improvements to the utilisation of the electronic Trading System because current trading occurs by the open out-cry system while clearing occurs transaction by transaction. An electronic trading system will enable investors to act more quickly on any relevant information, thereby making the BSE efficient or improving the same. Not to metion the need to reduce the time taken to transact shares: The authorities should endeavor to reduce the settlement period. Settlement is due five days after the transaction is completed (T+5) for both local and overseas clients. This delay in trading means that share prices take longer to adjust to their fundamental values. Also, there is need to re-drafting the BSE Act to bring it in line with regional and international standards: it is important to have a good and up-to-date legal environment to harness investor confidence with respect to the

integrity of the trading and settlement process of the market. More so, the initiation of policy incentives for research in investment analysis through maybe the government investment code which might provide substantial incentives for research by investment companies. Investment analysis is highly technical and is in need of considerable expenditure. Further research should be made with the use of a lag length necessary to remove autocorrelation from residuals, a limitation of the present study when use of the weekly data was made for the five models, but not the case with monthly data. Other methods for testing market efficiency can also be used like the variance-ratio test etc.

References

1. Appiah-Kusi, J., Menyah, K. (2003). Return predicability in African Stock Markets. Review of Financial Economics, 12, 247 – 270.

2. Chan, K.C., Gup, B.E., Pan, M. (1992). An Empirical analysis of stock prices in major Asian markets and the United States. The Journal Review, 27(2), 288 – 307.

3. Chan, K. C., Lai, P. (1993). Unit root and cointegration tests of world stock prices, in Stanley Stansell ed. International Financial Market.

4. Chang, K.P., Ting, K.S. (2000). A variance ratio test of the random walk hypothesis for Taiwan's stock market. Applied Financial Economics, 10(5), 525.

5. Cootner, P.H. (1962). Stock Prices, Random vs. Systematic Changes. Industrial Management Review, 3, 24-45.

6. Dickinson, J.P., Muragu, K. (1994). Market efficiency in developing countries: A case studyof Nairobi Stock Exchange. Journal of Business Finance and Accounting, 21(1), 133 – 150.

7. Fama, E.F. (1965). The Behaviour of Stock Market Prices. The Journal of Business, 38, 34- 105.

8. Fama, E. (1970). Efficient capital markets: A review of markets and empirical work. Journalof Finance, 25, 383–423.

9. Gallagher, l., Taylor, M. (2002). Permanent and temporary components of stock prices: evidence from assessing macroeconomic shocks. Southern Economic J, 69, 345-362.

10. Geary, R.C. (1970). Relative efficiency of count of sign changes for assessing residual autoregression in least squares regression. Biometrika, 57, 123-127.

11. Gujarati, N.D. (1995). Basic Econometrics, third ed. McGraw-Hill, New York.

12. Jefferis, K.R. (1995). The development of stock markets in sub-Saharan Africa. SouthAfrican Journal of Economics, Economics Society of South Africa, 63(3), 192-201.

13. Karemera, D., Ojah, K., Cole, J.A. (1999). Random walks and market efficiency tests: Evidence from emerging equity markets. Review of Finance and Accounting, 13(2), 171-188.

14. Kendall, M.G. (1953). The analysis of economic time series. Journal of the Royal Statistical Society, 96, 11-25.

15. Lo, A.W., MacKinlay, A.C. (1997). Stock market prices do not follow random walks: market efficiency. Stock Market Behaviour in Theory and Practice, 1, 363 – 389.

16. Mobarek, A., Mollah, A.S., Bhuyan, R., (2008). Market Efficiency in Emerging Stock Market: Evidence from Bangladesh. Journal of Emerging Market Finance, 7(1), 17-41.

17. Mollah, A.S. (2007). Testing weak-form market efficiency in emerging market: evidence fromBotswana Stock Exchange. International Journal of Theoretical and Applied Finance, 10, 1007 -1094.

18. Phillips, P.C.B., Perron, P. (1988). Testing for a unit root in time series regression. Biometrika, 75(2), 335-346.