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Frimpong, Joseph Magnus and Oteng-Abayie, Eric Fosu

Kwame Nkrumah University Of Science Technology, Ghana

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Frimpong Joseph Magnus, Kwame Nkrumah University Of Science & Technology, Ghana
Oteng-Abayie Eric Fosu, Garden City University College, Ghana

ABSTRACT

This paper examines the weak-form efficient market hypothesis (EMH) in the case of the Ghana Stock Exchange (GSE) an emerging market. Daily returns from the Databank Stock Index (DSI) over a 5-year period 1999-2004 were used for the exercise. Random walk (RW) and GARCH(1,1) models are used as the basis for our analysis. The GSE DSI returns series exhibit volatility clustering, an indication of inefficiency on the GSE. The weak-form efficient market (random walk) hypothesis was rejected for the GSE, meaning that the market is inefficient. The inefficient market has important implications for investors, both domestic and international. Knowledge of profitable arbitrage opportunities due to market predictability serves to attract investors to diversify from more efficient markets to invest on the GSE bourse to increase their returns.

INTRODUCTION

Since the 1983 to 1988 financial crisis in Ghana, the financial sector has undergone a lot of reforms aimed at liberalising and opening up access to long-term capital for investments. A comprehensive Financial Sector Adjustment Programme (FINSAP) was launched in 1988. Among the major objectives of FINSAP was the restructuring of the financial sector and the creation of new institutions to revitalize the financial sector. Ghana's capital market, Ghana Stock Exchange, was established in 1989 under the FINSAP. The Ghana Stock Exchange (hereafter, GSE) began full operations in November 1990 with 12 listed companies and one Government bond. Market capitalization within the first two years of operation increased from GH¢3 billion in 1991 to GH¢4.3 billion in 1992 while the listed companies increased to 15. The number of listed companies increased to 19 in 1995 and as at June 2007 stood at 34 (SAS, 2007). The main indices are the GSE All Share Index and the Databank Stock Index (DSI). Strategic African Securities Limited has also published three new indices comprising the SAS Index (SASI), SAS Manufacturing Index (SAS-MI), and the SAS Financial Index (SAS-FI).

In spite of the macroeconomic challenges facing the country, the performance of the GSE has been impressive in recent times. The GSE, with a U.S. dollar return of 144%, outperformed 61 markets around the world surveyed by Databank Financial Services Limited (retrieved from www.ghanaweb.com, Business News, 29 June 2004) to be adjudged the world's best performing stock market in 2003. The GSE has also provided a good platform for corporations to raise long-term capital to the tune of about $125.8 million from 1991 to 1998. For the whole of 2005, the GSE All Share remained disappointingly low. The GSE has however been on the path of recovery slowly since the beginning of 2006, after the bearish market in 2005 (SAS Investment Report, 2007). By mid 2007, the market capitalisation had increased by about 2%.

Due to the GSE's vibrant role in raising domestic and international capital for economic development recent reforms has focused on enhancing institutional development. These include efficient and wider dissemination of information through the operation of an electronic trading system. The GSE has currently adopted a new electronic trading system, permitting a high degree of price transparency and real-time price quotations on Reuters. Work on enhancing the automation of the trading platform started January 2008. When completed, brokers will be able trade via computers either on the floor of the Exchange or from their offices. The new Rule Book was adopted and implemented in February 2007, under which commissions have been partially liberalised to encourage investors shop for available best rates. Total commissions and levies now range from 1.5% to 2.5% of the value of a transaction, out of which 0.75% is non-negotiable fees payable to regulators. Also under the new rules, the Third Official List has been abolished and companies planning to list on the GSE will need to have a minimum of GH¢1 million post-offer capitalisation to be admitted to the First Official List and GH¢0.5 million to be on the Second Official List. New listing fees also apply. Also following the redenomination of the cedi, the GSE with market players and other stakeholders have issued new guidelines for trading and settlement of securities. Post-redenomination prices on the Exchange are currently quoted in the new currency up to four decimal places. Moreover, with the passing of the Central Securities Depository (CSD) Bill into law, all equities were expected to migrate to the CSD by the end of 2007. This saw to the gradual phasing out of Share Certificates and enabled settlement of transactions electronically. These institutional developments are expected to have important implications for efficiency of the market.

The young GSE market has not been deeply researched in terms of its degree of efficiency in the academic field. Efficiency has deep implications for asset pricing, risk and returns on the Exchange. Theoretically we expect a young emerging capital market such as the GSE to be weakly efficient at best. However the degree of efficiency of the GSE needs to be investigated using more robust approaches or methods. The objective of this paper is to determine the degree of efficiency of the GSE in the face of on going developments.

The rest of this paper is organized as follows. Section 2 provides a brief literature on random walks and efficient market hypothesis. Section 3 deals with the analytical models. Section 4 describes the data and presents the summary statistics. The results and discussions are presented in section 5 and section 6 concludes the paper.

RANDOM WALKS AND EFFICIENT MARKET HYPOTHESIS

A fundamental question concerning capital markets is their efficiency. Allocational, operational, and informational efficiencies are the types of market efficiency described in the financial markets literature. However, it has been noted that capital markets with higher informational efficiency are more likely to retain higher operational and allocational efficiencies (Müslümov *et al,* 2004). A market is efficient with respect to a set of information if it is impossible to make economic profits by trading on the basis of this information set (Ross, 1987). Consequently no arbitrage opportunities, after costs, and after risk premium can be tapped using ex ante information as all the available information has been discounted in current prices.

According to Samuelson (1965) and Fama (1970), under the 'efficient market hypothesis' (EMH), stock market prices must always show a full reflection of all available and relevant information and should follow a random walk process. Successive stock price changes (returns) are therefore independently and identically distributed (*iid*). Based on the information set, Fama (1970) categorizes the three types of efficient markets as weak-form, semi-strong-form, and strong-form efficient if the set of information includes past prices and returns only, all public information, and any information public as well as private, respectively. The implication here is that all markets can be weak-form but the reverse cannot be the case.

Furthermore, stock market returns unlike other economic time-series, typically exhibit a set of peculiar characteristics such as clusters or pools of volatility and stability (i.e. large changes in these returns series tend to be followed by large changes and small changes by small changes) Mandelbrot (1963) and Fama (1965), and leptokurtosis, (i.e. the distribution of returns tends to be fat-tailed) Fama (1965).

3. ANALYTICAL METHODS

Many statistical tests for random walks (or EMH) have been used in the literature. The earlier tests have included the sequence and reversal test used by Cowles and Jones (1973); the runs test used by David and

Barton (1962), Fama (1965), Aldous (1989); and the more popular variance ratio test by Lo and MacKinlay (1988). The serial correlation test of returns has also been used extensively (See Kendell (1953), Moore (1962), Godfrey *et* al (1964), and Fama (1965). These conventional tests of random walks are based on the test of *iid* assumptions.

In this study, we use the basic Random Walk (RW) model and a GARCH (1,1) model. The basic RW model is used directly to test for the random walk hypothesis (RWH). The GARCH (1,1) model is also used to capture the main characteristics of financial time series such as stationarity, fat-tails, and volatility clustering. The GARCH model will further be used to find the presence of nonlinear autoregressive conditional heteroscedasticity (ARCH) effects which contradicts the random walk concept.

In addition, we use nonlinear serial independence tests to confirm the random walk hypothesis by employing five sets of nonlinearity tests used by Patterson and Ashley (2000). According to Patterson and Ashley (2000), a standalone statistical test for nonlinearity can only detect or (fail to detect) nonlinearity. Therefore the application of a battery of nonlinearity tests can provide valuable information about any nonlinear structure in the data generating process on a given time series. Identification of any nonlinear structure in the time series is used as a basis to either accept or reject the RWH.

The five tests include the McLeod and Li (1983) for ARCH effects; the Engle (1982) LM test for ARCH effects; the BDS test proposed by Brock, Dechert, and Scheinkman (1996); the Tsay (1986) test for quadratic serial dependence; and the Hinich and Patterson (1995) bicovariance test. All the tests are based on the same hypothesis that once any linear serial dependence is removed from the data through a pre-whitening of the model, any remaining serial dependence must be due to a nonlinear data generating process (Patterson and Ashley, 2000). See Patterson and Ashley (2000) for more details about each test.

The Basic Random Walk Model

The logarithmic random walk (RW) with a drift model for testing the EMH is given in equation (1 and 2) as:

$$\ln p_t = \ln p_t + \mu + \varepsilon_t \qquad (1)$$

or

$$r_t = \Delta \ln p_t = \mu + \varepsilon_t \qquad (2)$$

where p_t is the logarithm of the price index observed at time *t*, μ is an arbitrary drift parameter, r_t is the change in the index and ε_t is a random disturbance term satisfying $E(\varepsilon_t) = 0$, σ_ε^2 is constant and $E(\varepsilon_t \varepsilon_{t-s}) = 0$, where $s \neq 0$, for all *t*. Under the random walk hypothesis, a market is (weak-form) efficient if the most recent price contains all available information and therefore the best predictor of future prices is the most current price. In the strictest version of the efficient market hypothesis, ε_t is not only random and stationary, but exhibits no autocorrelation, since the disturbance term cannot possess any systematic forecast errors.

The GARCH (1,1) Model

Engle (1982) and Bollerslev (1986) independently introduced the autoregressive conditional heteroscedasticity (ARCH) and the generalized ARCH (GARCH) models, which specifically allows for a time variant conditional variance and nonlinearities in the generating mechanism. The basic GARCH (1,1) derived below is estimated in this study. According to Brook and Burke (2003), the lag order (1,1) model is sufficient to capture all of the volatility clustering that is present from the data. The GARCH (1, 1) model by Bollerslev (1986) is based on the assumption that forecasts of time varying variance depend on the lagged variance of the asset. An unexpected increase or decrease in returns at time *t* will generate an increase in the expected variability in the next period. The basic model GARCH (1,1) can be expressed as:

$$r_t = \mu + \phi r_{t-1} + \varepsilon_t$$
$$\varepsilon_t / \Phi_{t-1} \sim N(0, h_t) \qquad (3)$$
$$h_t = \kappa + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1}$$

where $\kappa \succ 0,\ \alpha \succeq 0,\ \beta \succeq 0$. The GARCH (1, 1) is weakly stationary if $\alpha + \beta \prec 1$, μ is the mean, ε_{t-1}^2 is the news about volatility from the previous period (the ARCH term), and h_{t-1} the conditional variance is the last period forecast variance (the GARCH term) and must be nonnegative. If $\phi = 0$ and ε_t is *i.i.d*, we accept weak form EMH otherwise we reject the hypothesis. Also if the value of ($\alpha+\beta$) is very close to one, it shows high persistence in volatility clustering and implies inefficiency on the market.

Nonlinear Serial Independence Tests for Random Walks

The battery of tests are only implemented in this study to test linearity assumption and not for model selection. To implement these tests we first estimate the data generating processes considered: the RW model (equation 2) and the GARCH (1,1) model (equation 3). The ordinary regression residuals of the RW model and the standardized residuals generated from the GARCH model are then used for nonlinear serial independence tests. Since these tests are only asymptotically justified, we compute the significance levels based on asymptotic theory and then bootstrap the significance levels for each test using 1000 bootstrap replications under the null hypothesis of serial independence. See Patterson and Ashley (2000) for more details. The summary of the test results are presented in table 3.

DATA DESCRIPTION

The nonlinear tests described above are applied to the logarithmic returns for the closing prices of the Ghana Stock Exchange Databank Stock Index (DSI) over the sample of 1,508 observations running from 15th June 1994 to 28th April 2004 excluding non-trading days and public holidays. The DSI data were obtained from the Databank Research and Information Limited (DRIL), Ghana. The DSI was the first major share index on the GSE and its computation began in November 1990. The index is composed of all the listed equities on the market.

RESULTS AND DISCUSSION

Descriptive Statistics for the DSI Returns

Table 1 presents a summary of descriptive statistics of the DSI returns. Sample mean, standard deviation, skewness and kurtosis, and the Jacque-Bera statistic and *p*-value have been reported. The mean continuously compounded daily returns for the DSI range from -0.0921 to 0.1212. As is expected for a time series of returns, the mean is close to zero. The high standard deviation with respect to the mean is an indication the high volatility in the market returns and the risky nature of the market. A visual analysis of the volatility of returns can be gained from the DSI and returns (R_t) plots in Figure 1.

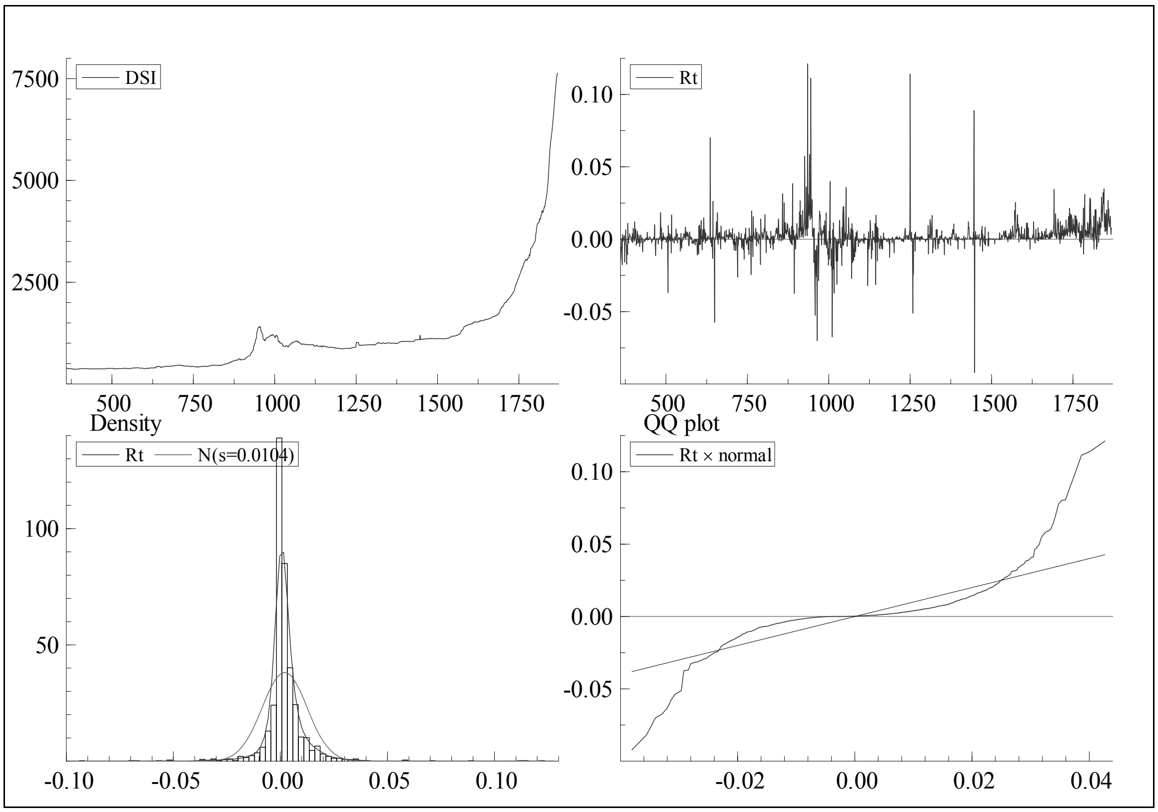
Table 1: Descriptive Statistics of DSI Returns Series

Mean	0.000663	*Skewness*	2.217609
Maximum	0.121210	*Kurtosis*	44.86563
Minimum	-0.092106	*Jarque-Bera*	111439.8
Std. Dev.	0.010434	*Probability*	0.000

Observations: 1,508

The returns also shows evidence of significant positive skewness in its distribution, indicating the greater probability of large increases in market portfolio returns than falls. This means that the DSI returns is asymmetric. DSI's returns are leptokurtic or fat-tailed. The kurtosis or degree of excess, in the DSI returns is very large greater than the normal value of 3. Lastly, the calculated Jarque-Bera statistic and corresponding *p*-value in Table 1 are used to test the null hypotheses that the DSI returns is normally distributed. The *p*-value is smaller than the 1% level of significance suggesting the null hypothesis can be rejected. The DSI returns are thus not well approximated by the normal distribution. From figure 1, the index looks like a random walk. The density graph and QQ-plot against the normal distribution shows that the returns distribution also exhibits fat tails confirming the statistics in table1.

Figure 1: DSI Returns and Tail Distribution



Random Walk and GARCH (1,1) Models Estimation

The RW and GARCH(1,1) models were estimated for the DSI returns series using the robust method of Bolleslev-Wooldridge's quasi-maximum likelihood estimator (QMLE) assuming the Gaussian standard normal distribution. The results including their statistical checks are presented in Table 2.

The conditional mean (μ) parameter is significantly different from zero in both models. The AR1 parameter (ϕ) in the mean equation for the GARCH model is also significant. These results primarily reject the random walk hypothesis. In the variance equation the value of ($\alpha+\beta$) equals 0.92188, which is very close to 1, suggests a high persistence of volatility clusters on the market. This is an indication of inefficiency.

Table 2: Random Walk and GARCH (1,1) Model Estimation		
Models	**RW**	**GARCH (1,1)**
Mean Equation		
μ	0.002 (7.33)***	0.0006 (2.95)***
ϕ	-	0.1645 (2.92)***
Variance equation		
κ	-	1.01E-05 (1.31)
α	-	0.1421 (3.40)***
β	-	0.7798 (10.34)***
γ	-	-
Adjusted R^2	0.000000	
S.E. of regression	0.010433	
Schwarz criterion	-6.283463	-6.6397
Note: z-statistics (t-stat for RW) in brackets. ***denotes 1% significance.		

Results for Test of Nonlinear Serial Independence

The results from the battery of nonlinear serial independence tests are presented in table 3. Both the asymptotic theory and bootstrapped significance levels for all tests are reported. Note that all figures quoted in table 3 are based on 1508 samples. The 1% significance level for each test was obtained using 1000 bootstrap replications. The parameters m, ℓ, p, k, and, m have been defined in section 2.3, where each test was briefly discussed. BDS test results were calculated for each ε equal to 0.5, 1, and 2 standard deviations (fraction of pairs) respectively; for brevity and without much loss of information, results are quoted only for $\varepsilon = 2$. Only bootstrap significance levels are reported.

From table 3, all the tests conducted show that the null hypothesis of serial independence for the RW model is significant at 1% level. This implies that the residuals (ε) of the RW model are not *iid* and accordingly suggests some hidden nonlinear structure drives the DSI returns series. This is consistent with the results reported in table 2 for the RW model which rejects the random walk hypothesis.

Table 3: Diagnostic Tests for Nonlinear Serial Independence					
	McLeod-Li Test	**Bicovariance Test**	**Engle test**	**Tsay test**	**BDS test**
Asymptotic theory (*p*-values)					
	m=24	$\ell = 18$	*p =5*	*k=5*	*m=2*
RW	0.000	0.000	0.000	0.000	0.000
GARCH(1,1)	0.038	0.695	0.098	0.836	0.000
Bootstrap (*p*-values)					
	m=24	$\ell = 18$	*p =5*	*k=5*	*m=2*
RW	0.006	0.001	0.001	0.002	0.000
GARCH(1,1)	0.047	0.654	0.108	0.819	0.000

The results is however inconclusive in rejecting the null hypothesis of serial independence in the standardized residuals of the GARCH(1,1) model. Only the *p*-values for the McLeod-Li and BDS tests are less than the 5% significant level for both asymptotic and bootstrap significance test. Based on the strength of these two tests, we could conclude that there is evidence of significant non-linearity in the DSI returns data and therefore they do not follow a random walk.

6. CONCLUSION

One of the main research branches in financial economics relates to the area of market efficiency. This paper investigated the issue of weak-form efficiency on the Ghana Stock Exchange. Two main analytical models: the RW and GARCH(1,1) models have been employed to test for significant random walks (*iid* residuals) in daily market returns. A battery of five complementary statistical tests was also applied to the residuals of the estimated models to verify for serial independence.

Our findings in this study indicate that the Ghana Stock Exchange is weakly inefficient. The results from the RW and GARCH models unanimously reject the presence of random walks in the DSI daily market returns. Furthermore, the tests for nonlinearity proved on the strength of the McLeod-Li and BDS test that the residuals of the market returns do not follow a random walk generating process. The absence of random walks infers distortions in asset pricing and risk, a mark of market inefficiency.

The implication here is that one should expect a sizeable amount of stock prices on the GSE to be either undervalued or overvalued. It is therefore not a waste of time for interested experts to analyze GSE stocks by looking for those that are undervalued. There is a chance for a hardworking analyst to consistently outperform the market averages. People such as corporate officers who have inside information can do better than the market averages, and individuals and organizations that are especially good at digging out information on small, new companies are likely to consistently do so well.

The GSE's bullish runs in recent years could be one of the explanations to this finding. For instance reports registered in the Strategic African Securities Ltd (SAS) Investment Research document (SAS Investment Research, January 2008) indicated that the market capitalization of GSE crossed the GH¢12 billion mark in 2007. Actually in that year the size of the equities component of the Ghana capital market increased by 21.40%, resulting in a total market capitalization of GH¢12,362.11 million. The Ghana Stock Exchange (G5E) All Share Index closed at a record high of 6599.81 points, the highest since November 12, 1990, as a result of the strong Ghanaian economy and a solid performance of the financial firms. Activity in financial equities is dominating market activity in recent times and is dominated by Non-Resident foreigners. Overseas investors have continued to actively purchase Ghanaian stocks. In 2007 the total value traded by Non Resident Foreigners (NRF) was GH¢422.85 million which represented about 80% of total volume traded. The trend totally confirms our finding of a weakly inefficient market which implies market predictability that provides profitable arbitrage opportunities. Investors (especially foreign ones) are therefore attracted to diversify or totally shift from investing in other financial instruments or markets to invest on the GSE bourse in order to increase their returns.

However, one major concern about the GSE is that even though it has been in existence for nearly two decades the total number of enlisted companies to date suggests a paltry average of two enlistments per year. This means that most firms still prefer to use the traditional financial institutions especially the banks as an alternative for financing rather than the stock market. The implication is that Ghanaian firms are rather interested in higher productivity which is more short term than higher capital accumulation which is otherwise needed for long run economic growth. Left on their own Ghanaians themselves are not making any momentous efforts to exploit the rife opportunities on the young GSE to enrich themselves. A possible reason is that the degree of ignorance, conservatism and/or indifference on corporate financial matters is so high as to defy the usefulness of theoretical postulations such as the implications of the findings of this paper.

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