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Stock Market Efficiency of Ghana Stock Exchange: An Objective Analysis

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There has been profuse development in the stock markets all over the world in the past decades. The 21st century has seen intriguing changes in the stock markets in both developed and emerging economies. This paper examines the weak-form efficiency of listed firms on the Ghana Stock Exchange (GSE) by applying the Random Walk Hypothesis using weekly closing stock prices on the GSE from January, 2007 to June, 2012. The GSE financial market returns series exhibit volatility clustering that shows an indication of inefficiency on the GSE. The results of both the descriptive statistics of the weekly market returns and the normality tests show that returns from GSE did not follow the normal distribution. The study recommends that transaction cost should be reduced to improve the market activities of the GSE. Also, efforts should be intensified to get as many firms as possible to be listed on the stock market to enhance competition among stocks.

Keywords: Ghana stock exchange, efficient market hypothesis, weak-form efficiency, random walk model

JEL: G14, G18

Efficient Market Hypothesis (EMH) assumes that security markets are efficient in reflecting information concerning individual stocks and the stock market in general. Market efficiency concept is important to an investor who wishes to invest in the stock market. An investor with a diversified portfolio of individual securities with comparable risk achieve greater returns to one who rely only on the spread of information about stock prices without technical and fundamental analysis about the information (Malkiel, 2003). An efficient market has little or no friction in the trading process. Information on prices and volumes of past transactions is widely available and price sensitive information is both timely and accurate; thus information dissemination is fast, timely, spread easily and is reflected in the various assets on the Stock Market. Liquidity is such that it enables market participants to buy or sell quickly at a price close to the last traded price. Also, there is price continuity, such that prices do not change much from one transaction to another unless significant new information becomes available (Fama, 1970).

According to Malkiel (2003), a market can become efficient if investors see the market as in-efficient and try to outperform it. On the contrary, investment strategies intended to take

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advantage of inefficiencies are actually the tool that keeps a market efficient. He also argued that when money is put into the stock market, it is done with the aim of generating a return on the capital invested. Many investors try not only to make a profitable return, but also to outperform or beat the market (arbitrage operations). The stock market subject to variations in pricing the same as the commodity market and its success depends on the successful prediction of future prices and only possible, if information is available in the market. However, market efficiency been led by the efficient market hypothesis (EMH) developed by Fama (1970), suggested that at any given time prices fully reflect all available information about an individual stock and the market in general. He classified market efficiency into three forms namely, weak-form, semi strong form and strong form.

Fama (1970) further noted that if the market is efficient in the weak-form, prices reflect all past security market information; hence information on past prices and trading volumes cannot be used for profit. A semi strong form efficient market is a market in which prices fully reflect all publicly available information. This form is concerned with both the speed and accuracy of the market' s reaction to information as it becomes available. For the strong form efficiency, Fama explained that prices are expected to reflect both public and private information, which seems to be more concerned with the disclosure efficiency of the information market than the pricing efficiency of the securities market. Base on the EMH model, an individual investor do not have an advantage in predicting a return on a stock price due to the fact that no individual has access to information not already available to everyone else.

The Ghana Stock Market been the primary stock exchange in Ghana was incorporated in July 1989 and started its trading in 1990 with twelve listed companies and government. Securities on the GSE include equities, corporate and government bonds. Currently there are thirty six (36) listed companies on the GSE, one with preferred stock i.e. Standard Chartered Bank and two corporate bonds. The market capitalization for the first two years of its commencement was GH¢ 4.2 billion in 1992 and GH¢47.35 billion in 2011. The GSE All share index and the Databank Stock Index are the primary indices for the stock exchange. In addition to these indices, Strategic African Securities Limited has also published SAS Index, SAS manufacturing Index and SAS financial Index for the exchange. There are several key sectors of the economy listed on the Stock exchange. These include oil, banking, manufacturing firms, mining and brewing in the Ghana Stock Exchange annual report. Due to the GSE' s vibrant role in raising domestic and international capital for economic development, recent reforms have focused on enhancing institutional development (Frimpong, 2008).

Globally, stock markets play significant role for investors, companies and serve as a tool for accelerated growth (Watson, 2009). The equity market provides investors and entrepreneurs with an exit strategy. This is important especially to venture capital investments as it gives potential investors an opportunity to recoup their investments through an initial public offering. The market also serves as capital inflows for both direct and portfolio investments (Watson, 2009). Investors have shown great interest in portfolio investment because of its developed nature over the years and the ability to diversify investments. Again, the market provides liquidity for international and domestic investors so as to transfer their short-term securities to the long term capital market (Fama, 1970).

Unfortunately, majority of studies conducted on market efficiency had focused on developed countries capital markets and just a few have been conducted in developing countries and emerging economies. The subject of capital markets in developing countries needs a lot of research attention. As a results, this study attempts to fill the gap in literature in the developing world especially Ghana' s Stock Market. Available literature on stock market efficiency reflects the studies done on less developed countries were mainly focused on how such developing countries can work toward reforms; deepen their financial markets through the expansion of capital markets in order to improve their ability to mobilize resources and efficiently allocating them?. The problem of the Ghana Stock Market been efficient has generally been missing or not much work had been done in previous studies. In response to this gap, this paper seeks to examine the weak-form efficient market of the Ghana Stock Exchange (GSE) an emerging market by applying the Random walk model.

LITERATURE REVIEW

The Weak-form Efficiency

Fama (1970) argued that this is the lowest level efficiency and concluded that prices of financial assets fully reflect all available information contained in past prices, volume traded and short interest. This form of efficiency implies that historical prices and volume traded cannot be used to predict future price movements. Investigating the presence of any statistically significant dependence (autocorrelation or price runs), or any recognizable trend in share prices changes, is traditionally used to directly test weak-form efficiency. Weak-form tests are abundant in terms of both frequency and research target, and the results mainly support weak-form efficiency. In some cases, statistically significant dependence in return series has been found, but Fama (1970: 414) maintains that some of the dependence is consistent with the fair game model and the rest does not appear to be sufficient to declare market inefficient. In any case, most of the profit opportunities presented by the trends tend to fall away when transaction costs are taken into account. Consequently, there are empirical evidences in support of the weak-form of the efficient market hypothesis. Stock price movement does not give investors any information that permits them to beat and simple buy and hold investment strategy.

Models of Weak-form Efficiency

The EMH states that prices fully reflect all the available information. To determine this, the process of price formation has to be identified in a model form, in order to define more precisely the empirical implication it fully reflects. Fama (1970), suggested three models for testing weak-form efficiency, these are the expected return or fair game model, the submartingale model, and the random walk model.

The Expected Return or Fair Game Model

The Fair Game Model states that a stochastic process Xt conditioned on information set Θ t is a fair game if it has the following property:

$X_{j,t+1} = P_{j,t+1} - \varepsilon(P_{j,t+1} / \Theta_t)$ …………(i)

With $E(X_{j,t+1} / \Theta_t) = \{\varepsilon P_{j,t+1} - (P_{j,t+1} / \Theta_t)\} = 0$ ……………………(ii)

Where: $X_{j,t+1}$ is the excess market value of security j at time $t + 1$, $p_{j,t+1}$ is the observed (actual) price of security j at time $t + 1$, and $\varepsilon(p_{j,t+1} / \Theta_t)$ is the expected price of security j that was projected at time t, conditional on the information set Θ_t or equivalently.

$Z_{j,t+1} = r_{j,t+1} - \varepsilon(r_{j,t+1} / \Theta_t)$ ………(iii)

With $\varepsilon(Z_{j,t+1} / \Theta_t) = \varepsilon(r_{j,t+1} - (r_{j,t+1} / \Theta_t)\} = 0$……………………(iv)

Where: $Z_{j,t+1} / \Theta_t$ is the unexpected (excess) return for security j at time $t+1$, r_{jt+1} is the observed or actual return for security j at time $t+1$, and $\varepsilon(r_{j,t+1} / \Theta_t)$ is the equilibrium expected return at time $t+1$ on the basis of the information set Θ_t. This model implies that the excess market value of security j at time $t+1$ ($X_{j,t+1}$) is the difference between actual price and expected price on the basis of the information set Θ_t. Similarly, the excess return for security j at time $t + 1$ ($Z_{j,t+1}$) is measured by the difference between the actual and expected return in that period conditioned on the set of available information at time t according to the fair game model, the excess market value and the excess return are zero (Fama, 1970).

The Submartingale Model

The Submartingale Model is the fair game with small modification from the expected return model. With this model, the expected return is considered to be positive instead of zero as in the fair game model. The modification implies that prices of securities are expected to increase overtime. Specifically, the returns on investments are estimated to be positive due to the risk characterize in capital investment. The Submartingale model can be estimated as:

$\varepsilon(P_{j,t+1} / \Theta_t) \geq P_{j\,t}$ or equivalently $\varepsilon(r_{j,t+1} / \Theta_t) \geq 0$ ……………………(v)

This model states that the expected return sequence ($r_{j,t+1}$) follows a submartingale with respect to the information set Θ_t, which is to say that the expected return for the next period, as projected on the basis of the information set Θ_t, is equal to or greater than zero (Fama, 1970). The important empirical implication of the submartingale model is that no trading rule based on the information set Θ_t can have greater expected returns than a strategy of always buying and holding the security during the future period in question.

The Random Walk Model

The financial asset's price series is said to follow a random walk if the successive price changes are independent and identically distributed (Fama, 1970). Nevertheless, in practice a stock price is said to follow a random walk if successive residual increments are independent and identically distributed (*i.i.d*). This implies that future price changes cannot be estimated from historical price changes. Financial assets price series is said to follow a random walk if:

$P_t = P_{t-1} + \alpha + \varepsilon_t,\ \varepsilon_t \sim i.i.d\,(n)\,(0, \sigma^2)$ …… (vi)

Where:

P_t = Securities price under consideration

α = Drift parameter (i.e. the expected price change)

ε_t = Random error term (residual)

i.i.d (n) (0, σ^2) = Independent and identically distributed as a normal distribution with zero mean and variance.

The main principle of the random walk model is that the price changes during period *t* are independent of the sequence of price changes during previous period. Fama (1970) explained that the random walk model is an extension of the fair game model. Specifically, the fair game model just indicate that the conditions of market equilibrium can be stated in terms of expected returns while the random walk gives details of the stochastic process generating returns. Therefore, he concluded that empirical tests of the random walk model are more powerful in support of EMH than test of the fair game model.

Efficient Market Hypothesis: Empirical Literature

Generally, EMH is used to explain whether stock prices reflect all available pertinent information. From past literature, it can be seen that several studies have been conducted to test the three forms of efficient market hypothesis on various stock markets across the world. The main implication of weak-form efficiency is the Random Walk Hypothesis (RWH) for an efficient market, which denotes successive price changes are random and serially independent. A joint research by Lo and MacKinlay (1988) on the New York Stock Exchange (NYSE), using a Variance Ratio test, found that in market returns, on a weekly basis, did not follow a random walk over the period 1962-1985. They had an opposite results by using a base observation period of four weeks.

Empirical studies on stock price responses towards dividends and earnings announcements were also found in many developed markets. Watts (1978) used a sample of the US stocks and found a statistically significant return in the quarter of the announcement on earnings, proposing a clear signal that quarterly earnings reports contain new information. However, he also found a statistically significant return in the subsequent quarter and came to the conclusion that the existence of those abnormal returns is evidence that the market is inefficient. Aharony and Swary (1980) considered whether quarterly dividend changes provide information outside that already provided by quarterly earning numbers. Their data consisted of all dividends and earnings announcements projected within the same quarter that are at least eleven trading days apart from the NYSE over the period 1963-76. They concluded that both quarterly earnings announcement and dividends change announcements have important effects on the stock prices. Importantly, they found no evidence of market inefficiency when the two types of announcement effects are separated. Concentrating on European equity markets, Worthington and Higgs (2004) found that the existence of random walk in the daily returns was rejected for all markets, except Germany, Ireland, the Netherlands, Portugal and the UK, while the more rigorous Multiple Variance Ratio (MVR) process rejected the existence of random walk in most European equity markets.

Over the years, there have been mixed evidence on the RWM for studied conducted in Central and Eastern Europe equity markets. According to Nivet (1997) the performance of the Polish stock market from 1991-1994, using both daily and weekly returns showed that RWM does not hold for that stock market. Chun (2000) found evidence that both the Czech and Polish stock prices did not follow a random walk during the sample period considered that is 1992-1997. Gilmore and McManus (2003), focusing on several Central European equity markets (the Czech Republic, Hungary and Poland) and using different methodologies, found proof these markets are weak-form efficient and Buguk and Brorsen (2003) tested the RWM for the Turkish stock market using its composite, industrial, and financial weekly closing prices.

Using the Augmented Dickey-Fuller (ADF) unit root tests, Univariate Variance Ratio (UVR) tests, and fractional integration test, empirical results indicated the three series followed the random walk hypothesis. Abraham *et al.* (2002) tested the random walk behaviour and efficiency of the Gulf stock market. Weekly index values for the three major Gulf stock markets of Kuwait, Saudi Arabia and Bahrain from October 1992 to December 1998 were used for the study. They examined the hypotheses for ADF area by three methods: variance ratio, test runs test and estimation of the true index-correction for infrequent trading. The results show that they cannot reject the RWM for the Saudi and Bahrain markets. The Kuwait market, however, failed to follow a random walk even after the correction. However, Moustafa (2004) studied the weak-form efficiency of the United Arab Emirates stock market. Daily prices of the 43 stocks from October 2001 to September 2003 were used and the two methods of runs test and autocorrelation. The results indicated that returns of all the 43 sample stocks do not follow the normal distribution, and support, the weak-form EMH for UAE stock market.

Osamah and Ding (2007) studied a new Variance Ratio Test of random walk in emerging markets using a nonparametric Variance Ratio (VR) test, they returned to empirical validity of the random walk hypothesis in eight emerging markets in the Middle East and North Africa (MENA). The correction of measurement biases caused by thin and infrequent trading predominately in emerging and small stock markets, the study did not reject the random walk hypothesis for the MENA markets. They concluded that a nonparametric Variance Ratio test is appropriate for the emerging stock markets, and argued that the findings can validate previously opposed results in relation to efficiency of the MENA markets.

The study of Sergeant (1995) and Bourne (1998) are comparable. The former used monthly data for the Trinidad and Tobago Stock Exchange (TTSE) from November, 1981 to December, 1989 and the latter covered the period November, 1981 to December, 1984. Both researchers tested the random walk hypothesis using simple Ordinary Least Squares (OLS), standard significance tests and runs tests. Singh (1995) studied the weak-form of the efficiency hypothesis for the TTSE and indicated it to be weakly inefficient over both the short and long-term horizons. Singh (1995) used monthly data and examined the correlations of returns (lags 1- 5), the Ljung- Box statistic and the runs tests. For a subset of the data, he used the variance ratio tests but failed to enlist the asymptotic distribution associated with this test. Alternatively, he used the actual value of the statistic, which he compared to unity, in order to draw his conclusions. According to Watson (2009), testing for the existence of weak-form efficiency will probably result in different conclusions depending on the method employed, as with his study where three different approaches were used with different results in some cases. His study opted for the preferred use of Wright' s rank and sign statistics and used the latter. Using the sign test, the study concluded that all the markets, in all their aspects, are inefficient and this is also the most intuitive conclusion given by (Fama, 1970) as pre-requisites to an efficient market.

Watson (2009) said Stock Exchanges are expected to play a major role in the economic growth process in emerging economies like those of the CARICOM region. Until now, there is strong indication that they function inefficiently and may lead to resource misallocation. Since, it is more likely that the effectiveness of the exchange in promoting growth and development will improve with greater efficiency, still there is more work to be done. Watson (2009) also outlined legal, institutional, political, regulatory and managerial problems that need to be addressed. Steps should be taken to advance these processes as the existence of one or the other is likely to result in more active trading on the exchanges.

Research done in the Asian market for eight emerging equity market by Hoque *et al.* (2007) found that stock markets follow a random walk in Indonesia, Malaysia, the Philippines, Singapore and Thailand, but not in the Taiwanese and Korean stock markets. They used weekly data from 1990 to 2004 and carried out the variance ratio, Chow-Denning multiple variance ratio and Wright' s sign tests to re-examine the random walk hypothesis in these markets. Many studies have endeavored to address the market efficiency of Taiwan markets and have come up with mixed results. However, Kawakatsu and Morey (1999) found that financial market liberalization improves market efficiency.

The first form of the efficiency concept was to last for 25 years. Within this period came some remarkable development in the financial markets, and subsequently the creation of more sophisticated instruments using all the available probability techniques. Until the stock market crash in 1987, consolidated by expansions in the investment management and derivatives industry, the concept of Gaussian efficiency of the markets was not challenged. In spite of the larger number of measurement inconsistencies, which put into question the probability premises of efficiency. The professional practices applied a financial theory whose fundamental hypotheses rendered useless any attempt at prediction, and a set of empirical rules which were meant to detect trends in price movements. That the separation of the populations concerned partly explains this contradiction does not resolve the internal problem of the fusion of financial theory itself, thrown into this contradiction by Bachelier' s hypothesis of random walk (Walter, 2003).

The crash of the stock market precipitated the intellectual movement to review the fundamental hypotheses at work in market efficiency. In financial theory, the efficient market was a good idea but later it crashed. The theory initiated a revolution, but failed to explain why investors panicked during the late 1980s. In practice, several bankruptcies resulting from risk management and hedging techniques based on a Gaussian conception of stock market fluctuations brought a new surge in research into finance, in order to better understand the nature of randomness at work in market fluctuations. According to Walter (2003) this movement was reinforced by a growing concern on the part of supervising authorities and international groups, which wished, after these accidents, to establish prudential rules of operation, by imposing minimum levels of solvency ratios on the financial institutions active in these markets. He further argued that as these ratios calculate the capital equivalent corresponding to confidence intervals on the probability densities of market returns, it became important to better quantify these risks. All these led to the questioning of the validity of the efficiency concept. It was from now on acknowledged and well recognized that the financial markets did not possess the basic statistical behaviour assumed by Gaussian density (Walter, 2003 c.f. Green and Figlewski, 1999).

Many successive derivatives models have generalized the returns process but continue to assume that the stochastic component remains locally Gaussian. However, empirical studies almost consistently find that actual returns are too fat-tailed to be log-normal. The standard valuation models are based on assumptions about the returns process that are not empirically supported for actual financial markets. Also, if any efficiency existed, it is not Gaussian efficiency. It is still too early today to determine by which route financial theory will rethink the efficiency concept because several competitive currents of thought coexist (Walter, 2003). However, one can speculate that this pattern of crisis will probably lead to better unify the theory, in the sense of understanding between probability models and professional practices of technical analysts. For that reason, the investment management industry will be able to quantify risk even with the bottom up form of the investment processes. Therefore, probability theory has become an indispensable component of the derivatives business and investment management industry today.

Generally, the literature offers a wealth of evidence for both supporting and contradicting efficient market theory. But, most of the research agrees that the market is at least weak-form efficient with respect to past information especially in developed economies which are generally weak-form efficient. That means the successive returns are independent and follows random walk. On the other hand, the research findings on the market of developing and less developed countries are divisive. Because of this mixed results that emerging market equities require clarification and the need for additional information on equity prices.

On the basis of the literature review, we proposed the following hypotheses and tested the two hypotheses to determine the weak-form efficiency of the GSE using the financial stocks across time. The first hypothesis involves determining whether the financial stocks returns follow a normal distribution or not. The null and alternative hypotheses are:

H_{0a}: The financial stocks returns in GSE are normally distributed under study.

H_{1a}: The financial stocks returns in GSE are not normally distributed under study.

The second hypothesis involves determining whether the stock returns are random across time. The null and alternative hypotheses are:

H_{0b}: The financial stocks returns in GSE are random across time.

H_{1b}: The financial stocks returns in GSE are not random across time.

Though the hypotheses of normality and randomness are complementary, we use them together in order to make our analyses robust.

METHODOLOGY

Model Specification

Various statistical tests for random walks (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 Fama (1965), and the more popular variance ratio test by Lo and MacKinlay (1988). The serial correlation test of returns has also been used extensively by Kendall (1953) and Fama (1965). These conventional tests of random walks are based on the test of independently and identically distributed (*i.i.d*) assumptions which state that each random variable has the same probability distribution as the others and all are mutually independent. In this study, we use the basic Random Walk (RW) model. Fama (1970) argued that the main principle of the random walk model is that the price changes during period *t* are independent of the sequence of price changes during previous period. Also the random walk model gives details of the stochastic process generating returns. Therefore, empirical tests of the random walk model are more powerful in support of EMH than test of the fair game model.

The study starts by modeling the process of price formation using the Random Walk model so that empirical test of the weak-form efficiency of the GSE can be done. A share price is said to follow random walk if the successive residual increments are independent and identically distributed (Fama, 1970). The random walk (RW) with a drift model for testing the EMH is given in equation (i) as;

$$P_t = P_{t-1} + \alpha + \varepsilon t \ , \ \varepsilon t \sim i.i.d\ (n)\ (0, \sigma 2) \quad \text{.................................} \ (i)$$

Where:

P_t = the price index observed at time *t*

α = Drift parameter (i.e. the expected price change)

εt = Random error term (residual)

$i.i.d\ (n)\ (0, \sigma 2)$ = Independent and identically distributed as a normal distribution with zero mean and variance. The model indicates that the price of a share at a time (weekly) *t* is equal to the price of the share at time (weekly) *t-1* plus given value that depends on new (unpredictable) information arriving between time *t-1* and *t*.

Sources of Data

The data primarily consist of weekly closing share prices of the financial stocks in the GSE. The share prices are the volume weighted average price of each equity for every given trading day. The use of weekly prices for this study is in line with Barnes (1986) and other studies on weak-form efficiency on emerging stock markets around the world. The weekly observation is also preferred to daily observation because daily data may suffer from problems associated with thin trading. The period under consideration for the data begins from January 2007 and ends June 2012 because of the easily availability of data for the study excluding non-trading days and public holidays. This yields a total of 2921 time series observations.

Data Analysis technique

This study sets out to specifically determine the weak-form efficiency of the GSE. Time series and regression analysis are used to test whether period-to-period price changes of the financial stocks follow a random walk to determine if the prices or returns are predictable from the past prices or returns and the extent of dependency, thus testing if the GSE is efficient in the weak-form. As such it investigates the returns from specific shares over time. The techniques of the data analysis involve normality test and non-parametric test. The Random Walk hypothesis suggests that in an efficient market, sequential outstanding increments follow the normal distribution (Fama, 1965). It is therefore necessary to investigate the extent to which the return series on GSE approximates a normal distribution.

Description of Research Variables

This study uses weekly market returns as individual time series variables. Market returns are computed from the weekly stock prices as:

$R_{mt} = (P_t - P_{t-1}) / P_{t-1}$ ……………………… (ii)

Where:

R_{mt} = Weekly market returns for the individual financial stock for period *t*

P_t = Weekly stock price for time *t*

P_{t-1} = Weekly stock price for time *t-1*

The study calculates market returns from the weekly prices without adjustment of dividend, bonus and right issues. This is because Lakonishok and Smidt (1988) and Fama and French (1993) confirmed that their results remain unchanged whether they adjusted their data for dividend or not. The weekly returns are calculated as the stock prices from Friday' s closing price minus the previous Friday' s closing price. If the following Friday price is not available, then the Thursday price (or Wednesday if Thursday is not available) is used. The choice of Friday prices aims to minimize the number of holidays in the week.

Normality Test

Normality tests will be performed using skewness, kurtosis and the Jarque-Bera (JB) test. Skewness is a measure of asymmetry of the distribution of a series around its means. The skewness of a symmetric distribution, such as the normal distribution, is zero (0). Positive skewness means that the distribution has a long right tail and negative skewness implies that the distribution has a long left tail Fama (1965). Kurtosis measures the peaked or flatness of the distribution of a return series. The Kurtosis of a normal distribution is 3. If the kurtosis exceeds 3, the distribution is peaked (Leptokurtic) relative to the normal; if the Kurtosis is less than 3, the distribution is flat (Platykurtic) relative to normal. He further noted that the JB test is a statistic for testing whether or not a series is normally distributed. It measures the difference of the skewness and kurtosis of a series with those from a normal distribution (Fama, 1965).

JB test is projected as: JB = n [S2 /6 + (K−3)2 /24] ……………………………………… (iii)

Where: n = sample size

S = skewness coefficient, and

K = kurtosis coefficient

For a normally distributed series, S=0 and K=3. Therefore, the JB test of normality is a joint hypothesis test that S and K are 0 and 3 respectively. Under the null hypothesis of normality in distribution, the JB test statistic is equal to 0. Positive or negative JB value indicates evidence against normality in series (Fama, 1965).

Non- Parametric Tests

The study uses two different non-parametric tests, Kolmogorov-Smirnov test and run test. The Kolmogorov Smirnov Goodness of fit test examines if the distribution is normal and the (run test) is to prove if the daily return or weekly return series follows random walk model. The non-parametric test Kolmogorov-Smirnov (K-S) goodness of fit test compares the observed cumulative distributional function of the returns with a normal distribution to determine if they are identical. The null hypothesis of normality in return distribution will be accepted if K-S statistic is greater than or equal to the p-value (Mobarek and Keasey, 2000; Rahman and Hossain, 2006).

The runs test is also a non-parametric test designed to examine whether or not an observed sequence is random. The runs test is preferred to prove the random-walk model because the test ignores the properties of distribution. It has widely been used by former researchers of weak-form efficiency in emerging markets (Barnes, 1986; Dickinson and Muragu, 1994; Claessens *et al.*, 1995; Mobarek and Keasey, 2000; Rahman and Hossain, 2006). This test is based on the principle that if a series of data is random, the observed number of runs in the series should be close to expected number of runs. If there are too many runs, it would mean that the residuals change signs frequently, thus indicating negative serial correlation. Similarly, if there are too few runs, they may suggest positive autocorrelation (Gujarati, 2003). Positive autocorrelation infers predictability of returns in the short horizon, while negative autocorrelation reflects predictability in the long horizon (Fama and French, 1988). Many runs or few runs indicate evidence against the hypothesis of Random walk (Spiegel and Stephens, 1999). Under the null hypothesis of independence in share returns, the expected number of runs is estimated as:

$$M = \frac{2N1N2}{N} + 1 \quad \text{(iv)}$$

Where:

N = Total number of observation (N1+N2)

N1 = Number of + symbols (i.e. + residuals)

N2 = Number of – symbols (i.e. – residuals)

M = Expected number of runs. For a large number of observations (N > 30), the sampling distribution of M is approximately normal and the variance is given by:

$$\sigma 2\, m = 2N1N2\,(2N1N2 - N) \quad \text{(v)}$$

$$(N)\, 2\, (N - 1)$$

The standard normal z statistics which will be used to test whether the actual number of runs is consistent with the hypothesis of independence is given by:

$$z = R - M \quad \text{(vi)}$$

$$\sigma 2\, m$$

Where, R = the actual number of runs. We will accept the null hypothesis of randomness at 5 percent significance level if $-1.96 \leq z \leq 1.96$, and reject it otherwise.

RESULTS

Test of Normality for the GSE

A summary of descriptive statistics of the financial stock returns is presented in Table 1 (see Appendix-I). The high standard deviation with respect to the mean is an indication of the high volatility in the market returns and the risky nature of the market. Generally, values for skewness (zero) and kurtosis (3) indicate that the observed distribution is perfectly normally distributed .The returns also show evidence of negative skewness in its distribution for seven of the financial stocks except GCB, SCB SIC and UTB which showed positive skewness. The negative skewness indicating the greater probability of large decreases in market portfolio falls other than returns and the positive skewness shows large increases in market portfolio for returns than falls. This means that the financial stocks return of negative skewness implies that the distribution has a long left tail. Kurtosis generally is either much higher or lower indicating extreme leptokurtic or extreme platykurtic (Parkinson, 1987). The kurtosis values falls under the extreme leptokurtic distribution. Generally, values for skewness zero and kurtosis value 3 indicate that the observed distribution is perfectly normally distributed. Lastly, the calculated Jarque-Bera statistic is also used to test the null hypotheses that the financial return is normally distributed. Under the null hypothesis of normality in distribution, the JB is equal to 0. Positive or negative JB value indicates evidence against normality in series. The positive JB values of the stocks from Table 1 (see Appendix-I) indicate evidence against normality in the return distribution. So, skewness and leptokurtic frequency distribution of the financial stocks returns series on the GSE indicates that the distribution is not normal. Hence, the non-normal frequency distributions of the stock return series deviate from the prior condition of random walk model.

Non-Parametric Tests

The study uses two different non-parametric tests; one (Kolmogorov-Smirnov Goodness of fit test) is to examine if the distribution is normal and another (runs test) is to prove if the weekly return series follows random walk model. The results show that K-S test is 0.0000 probability for the *z-scores* for all the financial stocks, clearly indicating that the frequency distribution of the weekly prices of the financial stocks in the GSE do not fit by normal distribution. Hence, the stocks returns reject the null hypothesis of normality since their *p*-values are less than 0.05. The results are shown in Table 2 (see Appendix-II). These results are in consonance with Mlambo *et al*. (2003) conclusion that emerging market returns are not normally distributed. They then suggested that when there is a strong deviation from normality, correlation analysis should be done using non-parametric testing methods, such as the runs test, since they do not assume a specific distribution.

The second hypothesis postulates that stock returns on the GSE are random using the financial stocks under study. The results of the runs test for weekly observed returns indicate (Table 3, see Appendix-III) that the actual number of runs for some of the financial stocks return series are significantly smaller than the corresponding expected runs at 5 percent significance level of about 70 percent, 59 percent, 69 percent, 71 percent, 84 percent, 84 percent, 43 percent, 85 percent for CAL , EBG, EGL, GCB, HFC, SCB, SG SSB, SIC respectively of the expected runs and 98 percent,100 percent and 92 percent for ETI, TBL and UTB respectively of the expected runs. The *z*-statistic of the weekly market returns of the financial stocks is greater than ±1.96 and negative, which confirms that the observed number of runs is fewer than the expected number of runs under the null hypothesis of independence. Moreover, the results of run test for the financial weekly share returns show that among the 11 companies, 8 companies *z*-value are negative and greater than ±1.96, which is consistent with previous findings that the return series are not following random walk model. The significant two-tailed with negative *z*-values greater than ±1.96 suggest non-randomness because of too few observed numbers of runs than expected.

In addition to above evidence, the positive and negative mean values of the stocks contradicts the random walk model which postulates zero mean. In a weak-form efficient stock market, the positive returns cancel out the negative returns so that their average effect on investment is zero. The positive mean value indicate evidence against the null hypothesis of independence in financial stocks of GSE return series. In addition, the asymptotic significance (2-tailed), which is the *p*-value corresponding to the *z*-values of the financial stocks; show a probability of 0.000 of *z* for eight of the stocks excluding three from the weekly returns data. Under the null hypothesis of random walk in return series, asymptotic significance corresponding to the *z*-value should be greater than or equal to 5 percent significance level. Therefore, we can accept the alternative hypothesis that the return series do not follow random walk for eight financial stocks. In summary, the results of the runs test on the GSE indicate that the weekly financial stock returns are not random as the *z*-statistic does not fall between ±1.96 of the distribution.

The study also uses regression technique in time series analysis to examine if there is non-zero significant relationship existing between the contemporary financial stocks market return series and the first lag values of itself. From Table 4 (see Appendix-IV), the coefficients of some financial stocks, EBG, GCB, HFC, SG SSB and SIC are significantly different from zero indicating the predictability of share return from the past information. The regression coefficients at first lags are significant at 5 percent showing that the series are not independent and the market is not weak-form efficient. Also the *p*-values of CAL, EGL, ETI, SCB,TBL and UTB financial stocks excluding EBG,GCB, HFC,SG SSB and SIC are greater than 5 percent significant level. This shows the relationship of dependency between the R_{mt-1} and the dependent variable R_{mt} for the stocks with *p*-value greater than 5 percent significant level. Thus the series are not independent and the market is not weak-form efficient.

DISCUSSION

The study mainly focused on the evidence of weak-form efficiency by hypothesizing normality of the GSE weekly return series and random walk assumptions. The weekly return series show evidence of negative skewness in its distribution for seven of the financial stocks except GCB, SCB, SIC and UTB which show positive skewness. The negative skewness indicated the greater probability of large decreases in return series falls other than returns and the positive skewness shows a large increase in return series for returns than falls. This means that the financial stocks return of negative skewness implies the distribution has a long left tail. The kurtosis values fall under the extreme leptokurtic distribution as well.

The calculated Jarque-Bera statistic was also used to test the null hypotheses that the financial returns are normally distributed. Under the null hypothesis of normality in distribution, the JB is equal to zero. Positive or negative JB value indicates evidence against normality in series. The positive JB values of the stocks from Table 1 (see Appendix-I) indicate evidence against normality in the return distribution. The skewness and leptokurtic frequency distribution of the financial stocks returns on the GSE indicated that the distribution is not normal. As a result, the null hypothesis of normality in return series was rejected and alternative hypothesis remained in effect.

K-S test show a 0.00 probability for the *z-scores* for all the financial stocks indicating that the frequency distribution of the weekly prices of the financial stocks in the GSE do not fit the normal distribution. Therefore, the stocks returns reject the null hypothesis of normality since their *p*- values less than 0.05. The runs test results reject the randomness of the return series of the GSE and the alternative hypothesis of non-randomness series is accepted. The auto regression coefficients of some of the financial stocks EBG, GCB, HFC, and SG SSB and SIC were significantly different from zero. This implied the predictability of the share returns from past information can be determined. The regression coefficients at the first lags with a significant level of 5 percent showed that the return series are not independent and the market is not weak-form efficient. Moreover, the *p*-values of CAL, EGL, ETI, SCB, TBL and UTB financial stocks were greater than 5 percent significant level. This shows the significant dependency between R_{mt-1} and the dependent variable R_{mt} for the stocks. It can therefore be concluded that the series are not independent and the Ghana stock market is not weak-form efficient. This finding is in line with Singh (1995) who studied the weak-form efficiency hypothesis for the TTSE and concluded that it was weakly inefficient over both the short and long-term horizons.

CONCLUSION

The financial stock returns exhibited volatility clustering, which is an indication of inefficiency in the GSE. The weak-form efficient market (random walk) hypothesis was rejected for the GSE, meaning that the market is inefficient. Normality of the return series and random walk assumptions were tested. The results indicated that the financial stock return series do not follow normal distribution. The normality was tested using skewness, kurtosis and Jarque-Bera from the descriptive statistics of the market returns. Kolmogorov-Smirnov (K-S) goodness of fit test was also used to compare the observed cumulative distributional function of the returns with a normal distribution to determine if they are identical. The null hypothesis of normality in return distribution was rejected since the *p*-values less than 0.05. As a result, the null hypothesis of normality in return series was rejected and alternative hypothesis remained in effect. The runs test results reject the randomness of the return series for the period under studied and the alternative hypothesis of non-randomness in periodic return series is accepted. Overall result from the empirical analysis suggested that the Ghana stock exchange is not efficient in the weak-form. The rejection of weak-form efficiency is not only consistent with some previous studies by Osei (1998), Appiah-Kusi and Menya (2003), Frimpong and Oteng-Abayie (2008) but also theoretically not surprising. Illiquidity and scantiness of instruments traded dominate the GSE specifically with the financial stocks under the study. Because there are so few liquid financial instruments, supply and demand of these instruments control prices and investment decisions than the actual performance of the various companies.

A few studies have raised concerns about the efficiency of the Ghana Stock Exchange (GSE). Osei (2002) tested the response to annual earnings announcements of the GSE. The study established that the market was inconsistent with the EMH. The conclusion was that, the GSE was inefficient with respect to annual earnings information released by the companies listed on the exchange. Frimpong (2007) also examined the weak-form EMH in the case of the GSE. He concluded that the GSE is weakly inefficient. According to Frimpong (2008) the Ghana Stock Exchange is weakly inefficient as his results from the random walk and GARCH models unanimously rejected the presence of random walk in the DSI daily market returns. Furthermore, his 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. Hence the absence of random walk concludes that the distortions in asset pricing and risk indicate a mark of market inefficiency. This implies a sizeable amount of stock prices on the GSE are either undervalued or overvalued as the market is generally inefficient. From the EMH, it will therefore not be a waste of time for interested experts to analyze the stocks. Hardworking analyst can constantly outperform the market averages.

RECOMMENDATIONS

On the basis of our study we recommend firstly, investors must be aware that in inefficient stock markets, heavy gains are just as likely as heavy losses. There is the need of the GSE to be reformed to improve the efficiency of the market and secure the flow of information to market participants. Secondly, the size of market capitalization, the small number of listed companies, and the lack of significant market makers are essential factors causing the market not to be efficient. Therefore, individual investors should concentrate on stocks with greater market capitalization and trading activity. Furthermore, there should be the reduction of transaction cost so as to improve market activities and hence liquidity. The Securities and Exchange Commission (SEC) and GSE should embark on public education about stock market investments to boost the growth of the various listed companies and encourage new listings. Efforts should also be made to get many companies listed on the stock market to enhance competition. The GSE and SEC also need to strengthen their regulatory capacities to enhance investor confidence. This will involve training personnel to enforce financial regulations and perform market surveillance. Great care should be taken in all policy decisions that do not directly target the stock exchange as these may have their indirect effects on the GSE.

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Appendix-I

Variable	Stock	N	Min.	Max.	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
The Mkt. Return	CAL	280	-0.2500	0.2273	0.001663	0.0547206	-0.103	5.060	49.9852
	EBG	280	-0.2413	0.1588	0.003395	0.338468	-0.569	13.774	1369.2760
	EGL	280	-0.7363	0.4173	-0.000922	0.0645943	-0.4.245	66.702	48183.372
	ETI	280	-0.7996	0.4000	-0.004920	0.0814539	-0.3.815	38.830	15656.418
	GCB	279	-0.2347	0.2222	0.005362	0.0505179	0.064	4.971	45.345818
	HFC	279	0.2258	0.1538	-0.000142	0.0316609	-0.619	15.732	1902.4255
	SCB	279	-0.1840	0.2079	0.004489	0.03177950	0.776	20.107	3383.4596
	SG SSB	279	-0.5044	0.4500	0.000076	0.0590924	-0.461	32.088	9845.599
	SIC	225	-0.1489	0.3043	0.001668	0.0504172	1.456	7.956	309.7948
	TBL	279	-0.6992	0.00	-0.002506	0.0418629	-16.703	279	893519.51
	UTB	181	-0.1613	0.300	0.001351	0.0566004	1.528	7.127	198.8305

Table 1. Descriptive Statistics of weekly market return on financial stocks

Appendix-II

Variables	CAL	EBG	EGL	ETI	GCB	HFC	SCB	SG SSB	SIC	TBL	UTB
N	280	280	280	280	279	279	279	279	225	279	181
Most Extreme Absolute	.242	.217	.263	.331	.231	.387	.360	.256	.264	.520	.277
Difference positive	.197	.200	.245	.276	.231	.387	.301	.235	.264	.476	.277
Negative	-.242	-.217	-.263	-.331	-.209	-.380	-.360	-.256	-.189	-.520	-.214
Kolmogrov-Smirnov *z*	4.042	3.638	4.398	5.542	3.852	6.466	6.006	4.272	3.965	8.690	3.733
Asymp. Sig (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Table 2. One Sample Kolmogorov- Smirnov Test

Appendix-III

	CAL	EBG	EGL	ETI	GCB	HFC	SCB	SG SSB	SIC	TBL	UTB
Test Value	.001663	.003395	-.000922	-.004920	.005362	-.000142	.004489	.000076	.001668	-.002506	.001351
Cases <Test Value	189	193	68	52	200	34	219	188	169	1	139
Cases>= Test Value	91	87	212	228	79	245	60	91	56	278	42
Total Cases	280	280	280	280	279	279	279	279	225	279	181
Number of Runs	87	71	72	85	81	51	80	53	72	3	61
z	-5.031	-6.984	-5.212	-.136	-4.918	-2.735	-2.704	-9.643	-2.349	0.85	-.945
Expecte d Run	124	121	104	86	114	61	95	124	85	3	66
Asymp. Sig. (2-Tailed)	.000	.000	.000	.892	.000	.006	.007	.000	.019	.932	.345

Table 3. Run Test

Appendix-IV

Variable	Stock	Coefficient	Std. Err.	*t*-statistic	*p* -value	R^2	Adjusted R^2	D-W Statistics
R_{mt-1}	CAL	0.052	0.06	0.868	0.386	0.003	0.000	1.992
	EBG	0.282	0.058	4.896	0.000	0.080	0.076	2.105
	EGL	0.031	0.060	0.514	0.608	0.001	-0.003	1.996
	ETI	0.070	0.060	1.160	0.247	0.005	0.001	2.005
	GCB	0.264	0.058	4.553	0.000	0.070	0.066	2.026
	HFC	-0.182	0.059	-3.070	0.002	0.033	0.030	2.021
	SCB	0.058	0.060	0.969	0.334	0.003	0.000	2.009
	SG SSB	0.126	0.060	2.112	0.036	0.016	0.012	1.988
	SIC	0.164	0.066	2.474	0.014	0.027	0.022	2.004
	TBL	-0.004	0.060	-0.060	0.952	0.000	0.0000	2.000
	UTB	0.061	0.075	0.822	0.412	0.004	-0.002	2.005

Table 4. Results of Regression Analysis (weekly market return)