# Testing the Weak-Form Efficiency Market Hypothesis on the Ghana Stock Exchange: A Sectoral Analysis*

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## Abstract

Testing the efficiency of the financial market is of much importance to investors who wish to hold diversifiable assets. This paper analysed the weak form market efficiency hypothesis for five sectors of the Ghana stock exchange using monthly returns of their respective stock market capitalisation as the information generating event. The paper investigated the weak form market efficiency in the framework of random walk hypothesis for the sectors of Ghana stock exchange by using the Run and the Lo-MacKinlay Variance Ratio tests. The results revealed that the sectors - consumer staples, financials and pharmaceuticals do not follow random walk and thus imply these sectors are not weak form efficient. The results also revealed contradictory results on the mining and the petroleum sectors, hence the issue of whether or not the random walk hypothesis holds for the two sectors is inconclusive.

**Keywords**: Weak-Form, Sectoral, Efficiency Market Hypothesis, Ghana Stock Exchange

## 1 Introduction

Over the past few years, several empirical works have payed attention to investigating the efficiency of the stock market. The interest in researching in this area is motivated by various reasons. One of such is that in inefficient market the risk-weighted returnis anticipated to be higher (Degutis and Novickytė, 2014). Notwithstanding, it is challenging to drawing definite conclusion with regards to whether the stock market is weak form efficient or not. Although the idea is sound, evidence on weak form efficiency is ambiguous and highly debatable precisely in developing countries like Ghana.

Testing for the weak-form Efficient Market Hypothesis is concerned with the power to predict historical prices or returns. Therefore, to test the weak-form market efficiency, there is the need to examine whether the changes of stock returns follow random walk behaviour (Al Ashikh, 2012). There are several studies devoted to examining the validity of the weak-form efficient market hypothesis in both developed and emerging markets. The Efficient Market Hypothesis (EMH) theory makes use of the idea that future prices cannot be predicted based on the current information set. It asserts that investors react instantaneously to any available information they have and thereby eliminate profit opportunities (Dupernex, 2007). Thus, prices always fully reflect all available information and no profit can be made from informationally based trading. According to Fama *et al*. (1969), efficient-market hypothesis is usually stated in three forms namely; strong-form, semi-strong form and the weak-form. But for the purposes of this study we stick to the weak-form efficiency which states that future prices cannot be foretold by examining past prices (Manasseh *et al*., 2016).

Right from earlier foundations laid by Fama (1970); Lucas (1978); and LeRoy and Porter (1981) on the efficient market hypothesis, other researchers have conducted several studies to test the random walk theory of the financial market. Kristoufek and Vosvrda (2012) assessed the market efficiency on 41 different stock indices of the Japan financial market. The study established that the NIKKEI of Japan is strong form efficient. The study further indicated that usually Asian markets are not efficient due to their topographical segmentation.

Aumeboonsuke (2012) examined the weak form efficient market hypothesis using equity indices from Malaysia, Indonesia, Philippines, Thailand, Singapore and Vietnam from 1991 to 2012. The search used correlation and run tests reveal to verify the random walk hypothesis. Both the correlation and the run tests showed that all the above equity markets are not efficient in the weak form. Also, Spulbar and Birau (2018) conducted a comparative study on Romania, India, Poland and Hungary stock markets to verify the weak form efficiency market hypothesis. The study employed data spanning from January 2000 to July 2018 for the test. Findings indicated that all markets are not weak form efficient.

Manasseh *et al*. (2016) tested whether the Nigerian Stock Exchange (NSE) is efficient in the semi-strong form using bonus issues as the information

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generating event. Using daily data, a total of 121 bonus issues were collected and examined for the period 2002-2006. The stocks which were tested were classified according to the size of their bonus issues and also according to the price of the stock to know the impact of information on the price of the different stocks. Using the event study methodology, the vector auto regression model was used with resulting finding indicating that information release impacted significantly only in the year 2002. Also, Bulla (2015) tested the efficiency market hypothesis on the Nairobi Securities Exchange for the period 2000 - 2009. Both serial correlation and run tests for random walk established that the Nairobi security prices conform to random walk hypothesis. The results therefore indicated that historical price contained no useful information to beat the Nairobi Securities market to generate excess profit in the period reviewed.

In Ghana some few studies have been done to investigate whether the Ghana Stock Exchange (GSE) is efficient in the conventional forms. Such studies include that of Frimpong (2008) who assessed whether the GSE is weak form efficient and found that the GSE is inefficient. Ayentimi *et al*. (2013) used weekly closing stock prices on the GSE from January, 2007 to June, 2012 to also verify whether the weak form efficiency market hypothesis holds on the GSE. Finding from the study was that the Ghana stock exchange is not weak form efficient.

All the reviewed literatures have provided immense contribution in understanding the capital market and its prediction. However, all these studies used the all-share index which aggregates all the markets as one. Even though the approach is allowed, it is problematic, the reason being that the approach does not give investors the opportunity to understand the characteristic behavior of individual sectors of the market which they may want to invest.

Again, there were many research works devoted to the issue of efficient market hypothesis on numerous money markets, it is not proven with certainty that the efficient market hypothesis hold (Tokić *et al*., 2018). Some of the existing literature have concluded that developing markets are inefficient while developed markets are mostly efficient (Song and Jin (1995); Tokić *et al*. (2018)).

In that regard, the objective this paper seeks to verify the weak form market efficiency of GSE by taking into consideration five main sectors and modern approaches.

# 2 Resources and Methods Used

## 2.1 Data and Data Source

The study makes use of monthly time series data spanning from January 2010 to December 2016 for five sectors of the Ghana Stock Exchange; consumer staples, financials, pharmaceuticals, mining as well as petroleum. Data on Stock Market Capitalisation (SMC) with respect to the overall market (ASMC), Consumer staples (CSMC), Financials (FMC), Pharmaceuticals (HCMC), Mining (MMC) and the Petroleum (PMC) sectors were obtained from the Ghana Stock Exchange. SMC is the measure of the total value of a companies' outstanding shares. It is computed by multiplying the market price of the underlying stock by the number of shares outstanding.

## 2.2 Estimation Strategy

Testing for the weak-form Efficient Market Hypothesis (EMH) is concerned with the power to predict historical prices or returns. Therefore, to test the weak-form of EMH we need to examine whether the changes of security prices feature random walk behaviour (Al Ashikh, 2012). The EMH asserts that investors react instantaneously to any available information they have hence eliminating any arbitrage opportunities (Dupernex, 2007). Thus, prices always fully reflect all available information and no profit can be made from informationally based trading. Several statistical models have been developed in testing for the Efficient Market Hypothesis and the most famous and widely used models in the checklist are the Runs and the Durbin-Watson tests.

### 2.2.1 Unit Root

Mishkin (1982) had noted that economic series such as stock market capitalisation, inflation and interest rate, among others, tend to possess unit root. The presence of unit root in the underlying series points to the fact that there is non-stationarity in that series. If the variables in a series are non-stationary, using standard econometric techniques can mislead results, so standard economic theory requires the variables to be stationary.

In order to ensure that spurious results were not obtained, unit root tests were conducted using the KPSS test proposed by Kwiatkowski *et al*. (1992) and PP test proposed by Phillips and Perron (1988) to check for the stationarity or otherwise of the variables.

The null hypothesis for the KPSS test is that, the series is stationary and the alternative is that the series is $I(0)$ while the for the PP test is the

reverse. The KPSS test is based on the following statistic:

$$\eta = \frac{\sum_{i=1}^{T} s_t^2}{T^2\sigma^2} \quad (1)$$

And that for the PP test is based on

$$y_t = \pi y_{t-1} + (constant, time\ trend) \quad (2)$$

*2.2.2 Random Walk Hypothesis*

The rule for trading used in this study is constructed based on the fact that historical prices can help determine future market prices. As a result, the stock market returns can be represented mathematically as equation (3).

$$R_t = \ln\left(\frac{p_t}{p_{t-1}}\right) \quad (3)$$

where

$R_t$ represents the current period return, $P_t$ is the current market price and $P_{t-1}$ is the previous market price. The objective of the paper is to examine whether $R_t$ follows a random walk by testing the weak-form market efficiency. Hence, the hypothesis to be tested is:

$H_o$ : Ghana stock market returns follow random walk (weak-form efficient)

$H_1$ : Ghana stock market returns does not follow random walk (not weak-form efficient)

The underlying principle of the weak-form efficient market is to test the randomness of the stock market returns. To test whether the sectors (consumer staples, financials, pharmaceuticals, mining and petroleum) of the Ghana stock market is weak form efficient, two different tests were carried out. These tests are non-parametric, Run test and Durbin Watson test. The null hypothesis for the Run test is that the series is random and that for the Durbin Watson test is that the residuals are efficient. The reason for choosing these tests is due to their reputation and extensive use in literature on market efficiency.

*Run Test*

Run test is one of the most standard nonparametric tests used to examine randomness of a time series (Al Ashikh, 2012). The run is an order of days in which a series changes in the same direction. For instance, a series may have positive or negative runs depending on its direction of movement. Since the test is a nonparametric test it does not require the assumption of the normally of the distribution (Campbell *et al*., 1997). When using the run test, the number of sequences of consecutive positive and negative series called the runs are compared with its sampling distribution under the random walk hypothesis (Campbell *et al*. 1997). To complete a run test, it suffices to compare the actual number of runs with the expected number of runs (Bulla, 2015) by using the standard normal Z-statistic given by Equation (4)

$$Z = R - \frac{X}{\sigma} \quad (4)$$

where

$$X = 2n_1n_2 + \frac{1}{(n_1 + n_2)}$$

$$\sigma = \sqrt{2n_1n_2\left(\frac{2n/(n^2-n)}{n^2(n-1)}\right)};$$

$R = n_1 + n_2$ and $n_1; n_2$ are the positive and negative runs respectively.

*Lo-MacKinlay Variance Ratio Test*

Lo and MacKinlay (1988) originally introduced the variance ratio test. According to Lo and MacKinlay (1988); and Liu and He (1999), the variance ratio test has proven to be a powerful and consistent test for testing the randomness of a series as compared to other tests. The underlying assumption of the variance ratio test is that if a time series moves in a random manner, then the variance of its $(X_t - X_b)$ difference would be $b$ times the variance of its first difference $(X_t - X_{t-1})$ (Gimba, 2012). Hence the random walk hypothesis can be verified by comparing $1/n$ multiplied by the variance of $(X_t - X_{t-b})$to that of $(X_t - X_{t-1})$ (Chen, 2008).

If we assume $\psi_t$ to be the stock market returns at time $t$ and $lnR_t$ be equal to the random walk of the series $X_t$, then the variance ratio of the series defined by $VR(n)$ is defined by:

$$VR(n) = \frac{\sigma^2(b)}{\sigma^2(1)} \quad (5)$$

where $\sigma^2(b)$ represent $1/n\,[var(X_t - X_{t-b})]$ and $\sigma^2(1)$ represents the variance of $(X_t - X_{t-1})$.
Thus, the statistics for $\sigma^2(1)$ and $\sigma^2(b)$ are:

$$\sigma^2(1) = \frac{1}{nb-1}\sum_{t=1}^{nb}(X_t - X_{t-1} - \hat{\mu})^2 \quad (6)$$

where

$$\hat{\mu} = \frac{1}{nb}(X_{nb} - X) \quad (7)$$

and

$$\sigma^2(b) = \frac{1}{m}\sum_{t=b}^{nb}(X_t - X_{t-b} - b\hat{\mu})^2 \quad (8)$$

where

$$m = b(nb - b + 1)\left[1 - \frac{b}{nb}\right] \quad (9)$$

If the data consist of $nb+1$ observations, then $X_0$ is the initial observation and $X_{nb}$ is the last observation. When the p-value is for the statistic is less that the conventional 5% significant level, it implies that the hypothesis that the stock market returns follow a random walk is rejected. Again, if the z-statistic falls outside the critical region of [-1.96, 1.96], it further confirms that the market returns does not follow a random walk.

## 3 Results and Discussion

### 3.1 Unit Root Results

Results of the unit root tests are presented in Table 2. Both tests indicated that the variables were not stationary at their levels at 5% significance.

However, the variables became stationary after first difference. Hence, the variables are integrated of order one, $I(1)$

### 3.2 Results of the Run Test

The run test results for the overall market and the five individual sectors are reported in Table 3. As observed from the table, the z-statistics of the test is -6.978 for the overall market, -7.858, -6.563, -7.652, -6.403 and -6.403 for the consumer staples, financials, pharmaceuticals, mining and petroleum sectors respectively. The negative and significant z-values for the stock market capitalisation indicate that the actual number of runs is less than the expected number of runs which depict that the series is serial independence. As a result, the null hypothesis that the series follows a random walk was rejected for the entire market and the various sectors of the Ghana stock Exchange. These results are in support of earlies works by Gimba (2009); Nwidobie (2014) for the Nigerian Stock Exchange, Spulbar and Birau (2018) for the Hungary stock markets, Stănculescu and Mitrică (2012) for the Romanian capital market, Kristoufek and Vosvrda (2012) for Japan financial market, Thomas and Kumar (2010); Nadig and Shivaraj (2013); Patel *et al*. (2012) for India stock exchange, Frimpong (2008); Ayentimi *et al*. (2013) for the Ghana stock exchange respectively.

**Table 1 Descriptive Statistics of the Data**

| | Mean | Min | Max | Std. Dev. | Obs |
|---|---|---|---|---|---|
| **ASMC** | 25554.040 | 16363.870 | 34444.510 | 5469.658 | 84 |
| **CSMC** | 1959.417 | 714.931 | 3623.897 | 829.124 | 84 |
| **FMC** | 8252.198 | 3769.163 | 15846.430 | 3763.624 | 84 |
| **HCMC** | 38.951 | 26.696 | 49.092 | 4.959 | 84 |
| **MMC** | 14679.380 | 11544.130 | 15590.680 | 996.087 | 84 |
| **PMC** | 624.093 | 201.373 | 1083.345 | 292.857 | 84 |

**Table 2 Results of Unit Root Test**

| Variables | Levels | | First Difference | |
|---|---|---|---|---|
| | ADF | PP | ADF | PP |
| **ASMC** | -1.751 | -1.722 | -6.485*** | -6.485*** |
| **CSMC** | -1.537 | -1.504 | -5.198*** | -5.280*** |
| **FMC** | -1.334 | -1.249 | -6.473*** | -6.473*** |
| **HCMC** | -2.618* | -2.620* | -11.354*** | -11.328*** |
| **MMC** | -3.380** | -3.380** | -8.489*** | -8.489*** |
| **PMC** | -1.862 | -1.848 | -8.383*** | -8.353*** |

The null hypothesis for both PP and ADF tests: the series contains a unit root
***, **, * denotes rejection of the null hypothesis of unit root at the 1%, 5% and 10%

**Table 3 Run Test Result**

| | Run Test Results | | | | | |
|---|---|---|---|---|---|---|
| **Sectors** | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** | **Model 6** |
| **Test Value** | 16400 | 800 | 3866 | 32 | 11545 | 202 |
| **No of Runs** | 4 | 2 | 4 | 4 | 2 | 2 |
| **Z-Score** | -6.978 | -7.858 | -6.563 | -7.652 | -6.403 | -6.403 |
| **P-Value** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Null Hypothesis: The Series Follows a Random Walk
*** (Significance At 1%)

### 3.3 Results of the Lo-MacKinlay Variance Ratio Estimate

Table 3 contains the results of the variance ratio test for the overall market and the five individual sectors of the Ghana stock exchange. The variance ratio values were 1.331, 1.537, 2.020, 2.424, 2.986 respectively for the standard lag levels of 2,4,8,10 and 16. The estimates were significant at 5% level. Results indicates that the Ghana stock exchange in general does follow a random walk. This implies that speculator and financial analysts can take advantage of the market to make benefit as a result of their access to information. Again, with respect to the individual sectors, the consumer staples sector, the financial sector and the pharmaceutical sector have shown up to disobey the weak form efficiency market hypothesis as indicated by the test statistic. At the conventional lag levels of 2, 4, 8, 10 and 16 respectively, the test statistic values were 1.437, 2.059, 3.424, 4.105 and 4.438 for the consumer staples, 1.348, 1.607, 2.029, 2.351 and 3.016 for the financials, 0.750, 0.760. 0.845, 0.875 and 0.612 for the pharmaceuticals. All these values were 5% significant for at least lag 2. Hence, the indication is that the stock market returns of these sectors do not follow random walk behaviour as such the possible movement of the market returns can be predicted with time.

**Table 3 Lo-MacKinlay Variance Ratio Estimates**

| | **Number of Months (b) in Holding Period** | | | | |
|---|---|---|---|---|---|
| **Lags (B)** | **B = 2** | **B = 4** | **B = 8** | **B = 10** | **B = 16** |
| | | | **Model 1** | | |
| **Vr(B)** | 1.331 | 1.537 | 2.020 | 2.424 | 2.986 |
| **Z(B)** | 2.835 | 2.753 | 3.646 | 4.481 | 4.841 |
| **P-Value** | 0.005 | 0.006 | 0.000 | 0.000 | 0.000 |
| **Std Error** | [0.117] | [0.195] | [0.410] | [0.318] | [0.410] |
| | | | **Model 2** | | |
| **Vr(B)** | 1.437 | 2.059 | 3.424 | 4.105 | 5.538 |
| **Z(B)** | 2.832 | 4.045 | 6.608 | 7.738 | 9.353 |
| **P-Value** | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Std Error** | [0.154] | [0.262] | [0.367] | [0.401] | [0.485] |
| | | | **Model 3** | | |
| **Vr(B)** | 1.348 | 1.607 | 2.029 | 2.351 | 3.016 |
| **Z(B)** | 2.305 | 2.423 | 3.037 | 3.652 | 4.472 |
| **P-Value** | 0.021 | 0.015 | 0.002 | 0.000 | 0.000 |
| **Std Error** | [0.151] | [0.251] | [0.339] | [0.451] | [0.451] |
| | | | **Model 4** | | |
| **Vr(B)** | 0.750 | 0.760 | 0.845 | 0.875 | 0.612 |
| **Z(B)** | -3.224 | -1.634 | -0.627 | -0.416 | -0.879 |
| **P-Value** | 0.001 | 0.102 | 0.531 | 0.677 | 0.379 |
| **Std Error** | [0.078] | [0.147] | [0.248] | [0.301] | [0.441] |
| | | | **Model 5** | | |
| **Vr(B)** | 1.080 | 0.872 | 0.879 | 0.829 | 0.636 |
| **Z(B)** | 1.432 | -1.230 | -0.668 | -0.684 | -0.926 |
| **P-Value** | 0.152 | 0.219 | 0.504 | 0.494 | 0.355 |
| **Std Error** | [0.056] | [0.104] | [0.181] | [0.250] | [0.393] |
| | | | **Model 6** | | |
| **Vr(b)** | 1.089 | 1.173 | 1.213 | 1.236 | 1.347 |
| **Z(b)** | 0.575 | 0.633 | 0.534 | 0.534 | 0.645 |
| **P-Value** | 0.565 | 0.527 | 0.593 | 0.594 | 0.519 |
| **Std Error** | [0.155] | [0.273] | [0.399] | [0.442] | [0.538] |

Vr(B) Represent the Variance Ratios at the Standard Lag Levels, Z(b) Represent the Z-Statistic and the Standard Errors Are Reported in [].

The coefficients for the mining and the petroleum sector equations at the standard lag levels were, 1.080, 0.872, 0.879, 0.829, 0.636 and 1.089, 1.173, 1.213, 1.236, 1347 respectively. None of these estimated was significant at the selected 5% percent level of significance. This therefore implies that the null hypothesis that the market returns of the two sectors follow a random walk behaviour cannot be rejected. Hence, this means that it is impossible to predict the movement of the stock returns for the mining and petroleum sectors. As a result, both sectors are therefore termed as weak form efficient sectors. In view of that active investors and arbitrageurs who always want to beat the market are not compensated.

## 4 Conclusions

The objective of the study was to test the weak form market efficiency on the main sectors of the Ghana stock exchange. The various sectors which were considered are the Consumer Staples, Financials, Pharmaceuticals, Mining and Petroleum sectors. Two tests namely; run test and Lo-MacKinlay variance ratio test were used for the study. The run test showed that the Ghana stock market returns does not follow random walk movement for the overall market and for all the selected sectors. This therefore means that equity prices can be predetermined by analysing the values of the securities' fundamentals, dividend value per share over the years, growth rate of dividends and stock capitalization. Thus, the test provides an information that active investors, speculators and a privileged few who may have information about the market would enjoy abnormal or excess profit from the Ghana stock market. The Lo-MacKinlay variance ratio test also confirmed that the market in general and three out of the five sectors namely; the consumer staple, financials and the pharmaceuticals are not weak form efficient. Conversely, the results further indicated that the mining and petroleum sectors are weak form efficient which contradicts the results of the run test. Hence based on the results from both run and variance ratio tests for the consumer staple, financials and the pharmaceuticals sectors, the conclusion is that these sectors are not weak for efficient, hence their movement can be predicted. However, since the two tests have contradictory results on the mining and the petroleum sectors, the existence of whether or not the random walk hypothesis hold on the sectors is inconclusive.

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