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# Testing the Weak-form Efficiency Market Hypothesis: Evidence from Nigerian Stock Market

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# Testing the Weak-form Efficiency Market Hypothesis: Evidence from Nigerian Stock Market

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*In recent years, the Nigerian Stock Exchange (NSE) has witnessed an unprecedented growth in market capitalization, membership, value and volume traded. By December 2007, the All Share Index has grown massively over 57,990.2 from 1113.4 in January 1993. This rising interest in investment opportunities in the NSE raises questions about its efficiency. This paper tests the Weak-form Efficient Market Hypothesis of the NSE by hypothesizing Normal distribution and Random walk of the return series. Daily and weekly All Share Index and five most traded and oldest bank stocks of the NSE are examined from January 2007 to December 2009 for the daily data and from June 2005 to December, 2009 for the weekly data. The empirical findings derived from the autocorrelation tests for the observed returns conclusively reject the null hypothesis of the existence of a random walk for the market index and four out of the five selected individual stocks. In general, it can be concluded that the NSE stock market is inefficient in the weak form. Given the empirical evidence that the stock market is weak-form inefficient, it is believed that anomalies in stock returns could be existent in the market and reduction of transaction cost so as to improve market activities and minimizing institutional restrictions on trading of securities in the bourse were therefore recommended.*

**JEL Classification:** G1, C1.

**Keywords:** Weak-form Efficiency; Random-walk; Autoregression; Nigerian Stock Exchange; Runs and Variance Ratio tests

## 1.0 Introduction

During the past decades, the efficient market hypothesis (EMH) has been at the heart of the debate in the financial literature because of its important implications. Fama (1970) defined a market as being efficient if prices fully reflect all available information, and suggested three models for testing market efficiency: the Fair Game model, the Submartingale model, and the Random Walk model. Also, according to Fama (1970), EMH can be categorised into three levels based on the definition of the available information set, namely weak form, semi-strong form, and the strong form. Following the work of Fama, the EMH has been widely investigated in both developed and emerging markets. Especially, in emerging

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stock markets, most empirical studies have focused on the weak form, the lowest level of EMH because if the evidence fails to support the weak-form of market efficiency, it is not necessary to examine the EMH at the stricter levels of semi-strong and strong form (Wong and Kwong, 1984). Although many empirical studies have been devoted to testing for the weak form of EMH in emerging stock markets such as the Nigerian stock market (Mikailu and Sanda, 2007), but no published research exists for the Nigerian stock market index and the five most traded and the oldest stocks in recent years on the NSM. This paper aims to seek evidence of the weak form market efficiency in the Nigerian stock market. In order to achieve the objective, a set of complementary tests, namely autocorrelation tests, runs and variance ratio tests are employed in this paper. The data used for these tests primarily comprise daily and weekly observed returns of the market index and five individual stocks listed on the market. Then, the data are adjusted for thin (infrequent) trading that is a prominent characteristic of the Nigerian stock market and that could seriously bias the results of the empirical studies on market efficiency.

The rest of this paper is organized as follows, literature review in section two, section three compresses of materials and methods while section four is the result and discussion. The final section is section five, conclusion and recommendations.

## 2.0 Literature Review and Theoretical Framework

The EMH, which plays an important role in the financial economics literature, relies on the efficient exploitation of information by economic actors. Generally, an asset market is referred to be efficient if the asset price in question must fully reflect all available information. If this is true, it should not be possible for market participants to earn abnormal profits. Based on the definitional statement of an efficient market above, Fama (1970) suggested three models for testing stock market: the Expected Return or Fair Game model, the Submartingale model, and the Random Walk model.

### 2.1 The Fair Game Model

In general, the fair game model states that a stochastic process $X_t$ with the condition on information set $I_t$, is a fair game if it has the following property:

$$\varepsilon(x_{t+1}|I_t) = 0 \qquad (2.1)$$

In the case of stock markets, Fama (1970) introduced a model of the EMH that is derived from the Fair Game property for expected returns and expressed it in the following equations:

$$x_{j,t+1} = p_{j,t+1} - \varepsilon\left(p_{j,t+1}\middle|I_t\right), \qquad (2.2)$$

with

$$\varepsilon(X_{t+1}|I_t) = \varepsilon\left[p_{j,t+1} - \left(p_{j,t+1}\middle|I_t\right)\right] \qquad (2.3)$$

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 $\varepsilon\left(p_{j,t+1}\middle|I_t\right)$ is the expected price of security $j$ that was projected at time $t$, conditional on the information set $I_t$ or equivalently

$$z_{j.t+1} = r_{j,t+1} - \varepsilon\left(r_{j,t+1}\middle|I_t\right) \qquad (2.4)$$

with

$$\varepsilon\left(r_{j,t+1}\middle|I_t\right)\right] = \varepsilon\left[r_{j,t+1} - \left(r_{j,t+1}\middle|I_t\right)\right] \qquad (2.5)$$

where $z_{j.t+1}$ is the unexpected (excess) return for a security $j$ at time $t+1$, $r_{j,t+1}$ is the observed (actual) return for a security $j$ at time $t+1$, and $\varepsilon\left(P_{j,t+1}\middle|I_t\right)$ is the equilibrium expected return at time $t+1$ (projected at time t) on the basis of the information set $I_t$.

This model implies that the excess market value of security $j$ at time $t+1$ ($p_{j,t+1}$ ) is the difference between actual price and expected price on the basis of the information set It. Similarly, the unexpected (excess) return for a security $j$ at time $t+1$ ($z_{j.t+1}$ z) is measured by the difference between the actual and expected return in that period conditioned on the set of available information at time $t, I_t$.

According to the Fair Game model, the excess market value and excess return are zero. In other word, Equations (2.3) and (2.5) indicate that the excess market value sequence $\{x_{j,t+1}\}$ and $\{z_{j.t+1}\}$ respectively are fair games with respect to the information sequence $\{I_t\}$.

## 2.2 The Submartingale Model

The Submartingale model is the Fair Game model with a small adjustment in expected return. In this model, the expected return is considered to be positive instead of zero as in the Fair Game model. The adjustment implies that prices of securities are expected to increase over time. In other word, the returns on investments are projected to be positive due to the risk inherent of capital investment. The Submartingale model can be mathematically written as follows:

$$E\left(\frac{r_{i-1}}{I_t}\right) \geq P_{j,t} \qquad (2.6)$$

$$E\left(\frac{r_{i-1}}{I_t}\right) = \frac{E\left(\frac{r_{i-1}}{I_t}\right)}{P_{j,t}} \geq 0 \qquad (2.7)$$

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

## 2.3 The Random Walk Model

According to Fama (1970) an efficient market is a market in which prices reflect all available information. In the stock market, the intrinsic value of a share is equivalently measured by the future discounted value of cash flows that will accrue to investors. If the stock market is efficient, share prices must reflect all available information which is relevant for the evaluation of a company's future performance, and therefore the market price of share must be equal to its intrinsic value. Any new information, which is expected to change a company's future profitability, must be immediately reflected in the share price because any delay in the diffusion of information to price would result in irrationality, as some subsets of available information could be exploited to forecast future profitability. Thus, in an efficient market, price changes must be a response only to new information. Since information arrives randomly, share prices must also fluctuate unpredictably. The Random Walk model can be stated in the following equation:

$$P_{t+1} = P_t + e_{t+1} \qquad (2.8)$$

where:

$P_{t+1}$ : Price of share at time $t+1$; $P_t$ : price of share at time $t$;

$e_{t+1}$: random error with zero mean and finite variance.

Equation (2.8) indicates that the price of a share at time $t+1$ is equal to the price of a share at time $t$ plus given value that depends on the new information (unpredictable) arriving between time $t$ and $t+1$. In other word, the change of price, $e_{t+1} = P_{t+1} - P_t$ is independent of past price changes.

Fama (1970) argued that the random walk model is an extension of the expected return or fair game model. Specifically, the fair game model just indicates that the conditions of market equilibrium can be stated in terms of expected returns while the random walk model gives the details of the stochastic process generating returns. Therefore, he concluded that empirical tests of the random walk model are more powerful in support of the EMH than tests of the fair game model.

The EMH can be more specifically defined with respect to the available information set ($I_t$) to market participants. Fama (1970) classified the information set into three subsets and suggested three forms (levels) of EMH, depending on the definition of the relevant information subsets, namely the weak, semi-strong, and strong form. This section highlights these forms with their practical implications.

## 2.4 The weak form of EMH

The weak form of EMH is the lowest form of efficiency that defines a market as being efficient if current prices fully reflect all information contained in past prices. This form implies that past prices cannot be used as a predictive tool for future stock price movements. Therefore, it is not possible for a trader to make abnormal returns by using only the past history of prices.

## 2.5 Semi-strong form of EMH

The semi-strong form of the EMH states that current market prices reflect all publicly available information, such as information on money supply, exchange rate, interest rates, announcement of dividends, annual earnings, stock splits, etc. If by increasing the information set to include private information, it is not possible for a market participant to earn abnormal profits, then the market is referred as strong form of EMH. In other words, under the strong form of EMH market prices of securities reflect all relevant information, including both public and private information. The strong form of EMH implies that private information (inside information) is hard to obtain for making abnormal returns because if a market participant wants to have it, he/she has to compete with many active investors in the market. It is important to note that an assumption for the strong form is that inside information cost is always zero. However, this assumption hardly exists in reality, so the strong form of EMH is not very likely to hold.

The empirical literatures on the weak form efficiency in emerging stock markets by authors show conflicting result, some authors support while many others oppose the efficient market hypothesis. The weak form of EMH implies that current market prices of stocks are independent on their past prices. In other words, a market is efficient in the weak form if stock prices follow a random walk process. Therefore, tests of weak form efficiency are naturally based on an examination of the interrelationship between current and past stock prices (Fawson *et al.*, 1996). Practically, several statistical techniques, such as runs test, unit root test, serial correlation tests, and spectral analysis, have been commonly used for testing weak form efficiency. Most studies on the weak form of EMH in emerging stock markets have used the runs test and/or unit root test as a principle method for detecting a random walk, a necessary condition for market efficiency in the weak form. Specifically, the runs test is adopted by Sharma and Kennedy (1997), Barnes (1986), Dickinson and Muragu (1994), , Karemera *et al.* (1999), Wheeler *et al.* (2002), Abraham *et al.* (2002), and the unit root test was employed by Groenwold *et al.* (2003), and Seddighi and Nian (2004) while Fawson *et al.* (1996), Moorkerjee and Yu (1999), and Abeysekera (2001) conducted both techniques in their study. A further test for market efficiency in the weak form that has been applied by a number of researchers is the serial correlation test, including the correlation coefficient test, Q-test, and variance ratio tests. Indeed, a combination of correlation coefficient test (testing for significance of individual serial correlation coefficient) and Q-test (testing for significance of a set of coefficients) is adopted by Dickinson and Muragu (1994), Fawson *et al.* (1996), Moorkerjee and Yu (1999), Abeysekera (2001), and Groenwold *et al.* (2003) while , Dockery and Vergari (1997), ), Karemera *et al.* (1999), Alam *et al.* (1999), Chang and Ting (2000), Cheung and Coutts (2001), Abraham *et al.* (2002), and Lima and Tabak (2004) apply variance ratio tests as the main methodology to determine the weak form of market efficiency in their study. Finally, a few researchers use some other techniques, such as spectral analysis (Sharma and Kennedy, 1977; Fawson *et al*., 1996), GPH (Geweke and Porter-Hudak) fractional integration test (Buguk and Brorsen, 2003), and autoregressive conditional heteroscedasticity (ARCH) test (Seddighi and Nian, 2004) in order to find evidence for market efficiency.

Data obtained for testing weak form of EMH in emerging stock markets include stock price indices and/or individual stock prices series. Specifically, stock price indices are used in studies of Sharma and Kennedy (1997), , Fawson *et al.* (1996), Dockery and Vergari (1997) Abeysekera (2001), Abraham et al. (2002), Lima and Tabak (2004) also Mikailu and Sanda (2007), while individual stock prices are employed by Dickinson and Muragu (1994), Olowe (1999), Wheeler *et al*. (2002). Especially, Barnes (1986), Seddighi and Nian (2004) employed both kinds of data for their tests in order to detect the weak form of market efficiency. Another aspect of data used for testing weak form efficiency hypothesis in emerging stock markets is frequency of time series. Based on this respect, the data consist of daily (Mookerjee and Yu, 1999; Cheung and Coutts, 2001; Groenewold *et al.,* 2003, Lima and Tabak, 2004 and Seddighi and Nian, 2004), weekly (Dickinson and Muragu, 1994; Dockery and Vergari, 1997; Abraham *et al*., 2002; and ), monthly (Sharma and Kennedy, 1977; Barnes, 1986; Fawson *et al*., 1996; Olowe, 1999; Karemera *et al.*, 1999; and Alam *et al.*, 1999) and even yearly time series (Chang and Ting, 2000). Empirical findings derived from the studies in emerging stock markets have been mixed. Indeed, some studies provide empirical results to reject the null hypothesis of weak form market efficient while the others show evidence to support the weak form of EMH. Regarding emerging European stock markets, for instance, the empirical evidence obtained from Wheeler *et al.* (2002) fails to support the weak form efficient hypothesis for the Warsaw Stock Exchange (Poland). On the other hand, Dockery and Vergari (1997) document that the Budapest Stock Exchange is efficient in the weak form. In addition, Karemera *et al.* (1999) shows empirical evidence to support the null hypothesis of weak form market efficiency for the stock market in Turkey. Surprisingly, in the perspective of Africa, Dickinson and Muragu (1994), Olowe (1999) and Mikailu & Sanda (2007) find that the Nairobi and Nigerian stock exchanges respectively are efficient in the weak form. Turning to stock markets in the Latin American region, Urrutia (1995) provides mixed evidence on the weak form efficiency for the stock markets in Argentina, Brazil, Chile, and Mexico. Specifically, results of the variance ratio test reject the random walk hypothesis for all markets while findings from the run tests indicate that these markets are weak form efficient. Consistent with the results reported by Urrutia (1995), Grieb and Reyes (1999) show empirical findings, which are obtained from the variance ratio tests, to reject the hypothesis of random walk for all stock market indexes and most individuals stock in Brazil and Mexico. Moreover, Karemera *et al.* (1999) find that stock return series in Brazil, Chile, and Mexico do not follow the random walk, based on the results of single variance ratio tests, but Argentina does. However, when the multiple variance ratio test is applied, the market index returns in Brazil is observed to follow the random walk process (the others are not changed).

In the Southern part of Asia, Sharma and Kennedy (1977) and Alam *et al.* (1999) report that the random walk hypothesis cannot be rejected for stock price changes on the Bombay (India) and Dhaka Stock Exchange (Bangladesh) respectively. However, Abeysekera (2001) and Abraham (2002) show evidence to reject the hypothesis of weak form efficiency for stock markets in Sri Lanka, Kuwait, Saudi Arabia and Bahrain, while Sanda (2009) used stock prices of 24 companies show evidence to reject the hypothesis of weak form efficiency in the case of Nigerian stock market. However, some recent studies on the EMH on the Nigerian Stock Market shows that the hypothesis of the market efficiency not rejected; study by Bashir (2009) using weekly returns for the 69 most actively traded shares over the period 1995-2005. His paper tests the weak-form of the EMH using a battery of tests including tests of autocorrelations and technical trading strategies. Overall, the analysis indicates that the Nigerian market may be weak-form efficient for ordinary investors who operate in a costly trading. According to Godwin (2010), the weak form hypothesis has been pointed out as dealing with whether or not security prices fully reflect historical price or return information. To carry out this investigation with the Nigerian stock market data, he employed the run test and the correlogram/partial autocorrelation function as alternate forms of the research instrument. His results of the three alternate tests revealed that the Nigerian stock market is efficient in the weak form and therefore follows a random walk process. He concluded that the opportunity of making excess returns in the market is ruled out. However, there are many conflicting studies on the issue of EMH on the Nigerian Stock Market. Our own shall take a position whether or not to reject EMH or not to reject, best on the data and the period of study.

## 3.0 Materials and Methods

The data used in this study primarily consist of daily and weekly price series of the market index (NSINDEX) and the five oldest stocks listed on the Nigerian stock exchange. Specifically, the market index, namely NSINDEX, is a composite that is calculated from prices of all stocks traded on the STC while individual stocks selected for this study are FIRSTB, UBA, UNIONB, CADBURY and NESTLE. All data are obtained over the period from January, 2005 (the first trading session in the year) to Dec., 2009 from the NSE, Kaduna branch. Then, a natural logarithmic transformation is performed for the primary data. To generate a time series of continuously compounded returns, daily returns are computed as follows:

$$r_t = \log(p_t) - \log(p_{t-1}) = \log(p_t/p_{t-1}) \quad (3.1)$$

where $p_t$ and $p_{t-1}$ are the stock prices at time *t* and *t-1*.

Similarly, the weekly returns are calculated as the natural logarithm of the index and the stock prices from Wednesday's closing price minus the natural logarithm of the previous Wednesday's close. If the following Wednesday's price is not available, then Thursday's price (or Tuesday's if Thursday's is not available) is used. If both Tuesday's and Thursday's prices are not available, the return for that week is reported as missing. The choice of Wednesday aims to avoid the effects of weekend trading and to minimize the number of holidays (Huber, 1997).

**3.1 Autocorrelation tests**

The first approach to detecting the random walk of the stock returns summarized here is the autocorrelation test. Autocorrelation (serial correlation coefficient) measures the relationship between the stock return at current period and its value in the previous period. It is given as follows:

$$\rho_k = \frac{\sum_{t-1}^{N-K}(r_t-\bar{r})(r_{t+k} \quad -\bar{r})}{\sum_{t=1}^{N}(r_t-\bar{r})^2} \quad (3.2)$$

where $\rho_k$ is the serial correlation coefficient of stock returns of lag $k$; $N$ is the number of observations; $r_t$ is the stock return over period $t$; $r_{t+k}$ is the stock return over period $t+k$; $r$ is the sample mean of stock returns; and *k* is the lag of the period. The test aims to determine whether the serial correlation coefficients are significantly different from zero. Statistically, the hypothesis of weak-form efficiency should be rejected if stock returns (price changes) are serially correlated $\rho_k$ is significantly different from zero). To test the joint hypothesis that all autocorrelations are simultaneously equal to zero, the Ljung–Box portmanteau statistic (*Q*) is used. The Ljung–Box *Q*statistics are given by:

$$Q_{LB} = N(N+2)\sum_{j=1}^{k}\frac{{\rho_j}^2}{N-j} \quad (3.3)$$

$\rho_j$ is the j$^{th}$ autocorrelation and *N* is the number of observations. Under the null hypothesis of zero autocorrelation at the first $k$ autocorrelations ($\rho_1 = \rho_2 =$

$\rho_3 = \ldots = \rho_k = 0$), the Q-statistic is distributed as chi-squared with degrees of freedom equal to the number of autocorrelations ($k$).

**3.2 Runs test**

The runs test is a non-parametric test that is designed to examine whether or not an observed sequence is random. The test is based on the premise that if a series of data is random, the observed number of runs in the series should be close to the expected number of the runs. A run can be defined as a sequence of consecutive price changes with the same sign. Therefore, price changes of stocks can be categorized into three kinds of run: upward run (prices go up), downward run (prices go down) and flat run (prices do not change). Under the null hypothesis of independence in share price changes (share returns), the total expected number of runs (m) can be estimated as:

$$M = \frac{\{N(N+1) - \sum_{i=1}^{3} n_i^2}{N} \qquad (3.4)$$

where $N$ is the total number of observations (price changes or returns) and $n_i$ is the number of price changes (returns) in each category (N = $\sum_{i=1}^{3} n_i$).

For a large number of observations ($N > 30$), the sampling distribution of $m$ is approximately normal and the standard error of $m$ ($\sigma_m$) is given by:

$$\sigma_m = \left\{\frac{\sum_{i=1}^{3} n_i^2 \left[\sum_{i=1}^{3} n_i^2 + N(N+1)\right] - 2N \sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)}\right\}^{1/2} \qquad (3.5)$$

The standard normal Z-statistics that can be used to test whether the actual number of runs is consistent with the hypothesis of independences is given by:

$$Z = (R \pm 0.5 - m)/\sigma_m \qquad (3.6)$$

where $R$ is the actual number of runs, $m$ is the expected number of runs, and 0.5 is the continuity adjustment (Wallis and Roberts, 1956) in which the sign of the continuity adjustment is negative (- 0.5) if $R \geq m$ , and positive otherwise. Since there is evidence of dependence among share returns when R is too small or too large, the test is a two-tailed one.

### 3.3 Variance ratio test

The variance ratio test, proposed by Lo and MacKinlay (1988), is demonstrated to be more reliable and as powerful as or more powerful than the unit root test (Lo and MacKinlay, 1988; Liu and He, 1991). The test is based on the assumption that the variance of increments in the random walk series is linear in the sample interval. Specifically, if a series follows a random walk process, the variance of its q-differences would be q times the variance of its first differences.

$$Var(p_t - p_{t-q}) = qVar(p_t - p_{t-1}) \quad (3.7)$$

where $q$ is any positive integer. The variance ratio, $VR(q)$, is then determined as follows:

$$VR(q) = \frac{\frac{1}{q}\mathrm{Var}(p_t - p_{t-q})}{\mathrm{Var}(p_t - p_{t-1})} = \frac{\sigma^2(q)}{\sigma^2(1)} \quad (3.8)$$

For a sample size of $n_{q+1}$ observations $(p_0, p_1, \dots, p_{nq})$, the formulas for computing $\sigma^2$ ( *q)* and $\sigma^2$ (1) are given in the following equations:

$$\sigma^2\,(\mathrm{q}) = \frac{\sum_{i=q}^{nq}(p_t - p_{t-q} - q\hat{u})^2}{h} \quad (3.9)$$

where

$$h = q(nq + 1 - q)\left(1 - \frac{q}{nq}\right) \quad (3.10)$$

and

$$\hat{u} = \frac{1}{nq}\sum_{t=1}^{nq} p_t - p_{t-1}) = \frac{1}{nq}(p_{nq} - p_0) \quad (3.11)$$

$$\sigma^2\,(1) = \frac{\sum_{t=1}^{nq}(p_t - p_{t-1} - \hat{u})^2}{(nq-1)} \quad (3.12)$$

Under the assumption of homoscedasticity and heteroscedasticity increments, two standard normal test-statistics, $Z(q)$ and $Z^*(q)$ respectively, developed by Lo and MacKinlay (1988), are calculated by Equations (3.13) and (3.14):

$$\mathrm{Z(q)} = \frac{VR(q) - 1}{[\emptyset\,(q)]^{1/2}} \sim N(0,1) \quad (3.13)$$

$$Z^*(q) = \frac{VR(q) - 1}{[\emptyset^*(q)]^{1/2}} \sim N(0,1) \quad (3.14)$$

where $\emptyset\,(q)$ is the asymptotic variance of the variance ratio under the assumption of homoscedasticity, and $\emptyset^*\,(q)$ is the asymptotic variance of the variance ratio under the assumption of heteroscedasticity:

$$\emptyset(q) = \frac{2(2q-1)(q-1)}{3q(nq)} \tag{3.15}$$

$$\emptyset^*(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q}\right]^2 \delta(j) \tag{3.16}$$

Where $\delta(j)$ is the heteroscedasticity – consistent estimator and computed as follows:

$$\delta(j) = \frac{\sum_{j+1}^{nq}(p_t - p_{t-1} - \hat{u})^2\,(p_{t-1} - p_{t-j-1} - \hat{u})^2}{[\sum_{t=1}^{nq}(p_t - p_{t-1} - \hat{u})^2\,]^2} \tag{3.17}$$

## 4.0 Results and Discussion

### 4.1 Autocorrelation tests

To test the weak form of EMH for the Nigerian stock market, first the autocorrelation tests with 12 lags are performed for daily weekly returns of the NSINDEX and five individual stocks. The results of these tests are as summarized in Table1.

### 4.2 Results for daily returns

The result shows that the autocorrelation tests for daily observed and corrected returns for thin (infrequent) trading respectively. When the observed returns are used, it is found that the null hypothesis of random walk is rejected for all studied series (except UNIONB). Specifically, for the NSINDEX, it is evident that autocorrelation coefficients are significantly different from zero with a positive sign for 1st, 4th, 5th, 6th and 7th lag. It is worth to note here that the positive sign of the autocorrelation coefficients indicates that consecutive daily returns tend to have the same sign, so that a positive (negative) return in the current day tends to be followed by an increase (decrease) of return in the next several days. Especially, the results of the Liung-Box Q-test reveal that the autocorrelation coefficients of all 12 lags are jointly significant at 1% level. Regarding the individual stocks returns, it is observed that serial correlation coefficients are significant at $1^{st}$ , $4^{th}$ , $5^{th}$ , $6^{th}$ and $7^{th}$ lag for FIRSTB; at $1^{st}$ , $2^{nd}$, $3^{rd}$ and $6^{th}$ for CADBURY; at $1^{st}$ , $7^{th}$ and $10^{th}$ lag for UBA and at $1^{st}$ and $3^{rd}$ lag for NESTLE. Importantly, the results of Q-test fail to support the joint null hypothesis that all autocorrelation coefficients of 12 lags are equal to zero for all individual stocks return series in question.

The empirical results for the corrected returns, again reject the random walk hypothesis for the Index and all selected individual stocks (except UNIONB). However, the rejection of the null hypothesis is less pronounced for FIRSTB and NESTLE when observed returns are corrected for thin 28. They are significantly different from zero trading. Specifically, the joint hypothesis that all autocorrelation coefficients are simultaneously equal to zero is only rejected for some lags, not all 12 lags as in the case of observed returns presented above.

**Table 1:** Descriptive statistics for the NSINDEX and the individual stocks returns

| | NSINDEX | FIRSTB | UBA | UNIONB | CADBURY | NESTLE |
|---|---|---|---|---|---|---|
| *Daily returns* | | | | | | |
| Observations | 802 | 802 | 802 | 802 | 802 | 802 |
| Mean | 0.0001 | -6.35E-05 | 0.0002 | -0.0003 | -6.28E-05 | 9.38E-05 |
| Median | -0.0003 | 0.0000 | 0.0000 | 0.0000 | 0.00000 | 0.0000 |
| Maximum | 0.0204 | 0.1811 | 0.1798 | 0.2168 | 0.2942 | 0.1447 |
| Minimum | -0.0206 | -0.1811 | -0.1798 | -0.2117 | -0.2942 | -0.1567 |
| Std. Dev. | 0.0046 | 0.0138 | 0.0152 | 0.0196 | 0.0182 | 0.0110 |
| Skewness | 0.9 | -2.8 | -2.0 | -1.3 | -1.1 | -0.8 |
| Kurtosis | 7.9 | 121.5 | 106.2 | 83.5 | 204.3 | 100.3 |
| Jarque-Bera | 800.7[a] | 415,586.2[a] | 314,917.0[a] | 191,786.2[a] | 1,196,997.0[a] | 279,808.7[a] |
| *Weekly returns* | | | | | | |
| Observations | 300 | 285 | 285 | 255 | 250 | 245 |
| Mean | 0.0016 | 0.0007 | 0.0014 | 0.0007 | 0.0016 | 0.0013 |
| Median | 0.0003 | 0.0000 | 0.0011 | 0.0011 | 0.0000 | 0.0000 |
| Maximum | 0.0840 | 0.0834 | 0.0853 | 0.1718 | 0.2850 | 0.1567 |
| Minimum | -0.0894 | -0.1774 | -0.1768 | -0.2553 | -0.3010 | -0.1467 |
| Std. Dev. | 0.0189 | 0.0259 | 0.0240 | 0.0365 | 0.0376 | 0.0283 |
| Skewness | -0.4 | -1.5 | -2.0 | -3.1 | -0.97 | -0.1 |
| Kurtosis | 8.0 | 13.6 | 17.8 | 26.4 | 36.97 | 11.0 |
| Jarque-Bera | 239.9[a] | 1,129.9[a] | 2,201.8[a] | 5485.9[a] | 10,808.3[a] | 543.5[a] |

*a : Indicates that the null hypothesis of normality is rejected at the 1% significant lev*

### 4.3 Results for weekly returns

Similar to the results for the daily observed returns, it is found that autocorrelation coefficients of the weekly observed index returns are significant with a positive sign at 1$^{st}$ , 2$^{nd}$ , 3$^{rd}$ , 4$^{th}$ , and 5$^{th}$ lags. Additionally, based on the Q-statistics, the null hypothesis of no autocorrelation on the index returns for all lags selected is strongly rejected at the one percent significant level.

Furthermore, results of the autocorrelation tests on weekly observed returns for the individual stocks show significant autocorrelation coefficients at the first lags for each individual stock returns series. Specifically, significant autocorrelation coefficients are found at $1^{st}$ , $2^{nd}$ , and $4^{th}$ lag for FIRSTB; at $1^{st}$ , $2^{nd}$ , $4^{th}$ , and $5^{th}$ lag for UBA; at $1^{st}$ and $2^{nd}$ lag for UNIONB; at $1^{st}$ , $2^{nd}$ , $3^{rd}$ , $4^{th}$ , $5^{th}$ and $7^{th}$ lag for CADBURY; and at $1^{st}$ , $2^{nd}$ , $3^{rd}$ , and $5^{th}$ lag for NESTLE. Once again, the Q-statistics fail to support the joint null hypothesis that all autocorrelation coefficients from lag 1 to 12 are equal to zero for all individual stocks observed return series.

Further, the results of the autocorrelation tests for the corrected returns indicate that the random walk hypothesis is also rejected for the market index and all selected individual stocks, except FIRSTB. However, the extent of rejection is less pronounced for these series, especially for the market index, UBA and UNIONB, as the returns are adjusted for thin trading. On the basis of the empirical results obtained from autocorrelation tests for the observed returns, it can be concluded that the null hypothesis of random walk is rejected for the market index and all selected individual stocks (except UNIONB). When the corrected returns for thin trading are used, the random walk hypothesis is also rejected for the market index and four out of five selected individual stocks although the extent of rejection is less pronounced.

### 4.4 Run tests

To detect for the weak form efficiency of the Nigerian stock market, the nonparametric runs test is also used in this study. The runs test is considered more appropriate than the parametric autocorrelation test since all observed series do not follow the normal distribution, (sess the Jarque-Bera test in appendix). Specifically, the results of the runs test for daily observed returns, the results indicate that the actual runs of all series are significantly smaller than their corresponding expected runs at 1% level, so that the null hypothesis of independence among stock returns is rejected for these series. Moreover, the results of runs test based on the corrected returns also support the null hypothesis of random walk for NSINDEX, FIRSTB, UBA and CADBURY. However, these results fail to reject the null hypothesis for UNION and NESTLE. For the weekly observed returns, the results indicate that the null hypothesis of independence among stock returns is rejected for the market index and all selected individual stocks, except UNIONB.

However, when the corrected returns are used, the results of the runs test reveal that the null hypothesis cannot be rejected for UNIONB, but it is rejected for FIRSTB and NESTLE. For the remaining series, the rejection of the null hypothesis is unchanged, but the extent is less pronounced as compared with the results for the weekly observed data.

In summary, the runs test provides evidence to reject the null hypothesis of random walk for both daily and weekly observed returns of the market index and all selected individual stocks (except weekly returns for UNIONB). However, when the corrected returns are used, the empirical results obtained from the test fail to reject the null hypothesis for UNIONB and NESTLE with the daily data and for FIRSTB and NESTLE with the weekly one.

### 4.5 Variance ratio tests

This study employs variance ratio tests for both null hypotheses, namely the homoscedastic and heteroscedastic increments random walk. In addition, the variance ratio is calculated for intervals (q) of 2, 4, 8, 16 and 32 observations. The results of the variance ratio tests are reported in Table

### 4.6 Results for daily returns

Empirical evidence obtained from the variance ratio tests for daily observed returns indicates that the random walk hypothesis under the assumption of homoscedasticity is rejected for all series. In the case of NSINDEX, for instance, the Z-statistics suggest that the variance ratios are significantly different from one for all values of q at the one percent level. Therefore, the null hypothesis of random walk is strongly rejected for the market index series. Similarly, the empirical findings reveal that the null hypothesis of random walk for all selected individual stocks cannot be accepted for all levels of q at the one percent level of significance. Moreover, the rejections of the random walk hypothesis under both homoscedasticity and heteroscedasticity assumptions for all series do not change even when the daily corrected returns for thin trading are used. Indeed, all the test-statistics of Z(q) and Z*(q) are still larger than the critical statistic at one percent level of significance.

### 4.7 Results for weekly returns

Results of the variance ratio tests on the weekly observed return data confirms again that the null hypothesis of random walks under the assumption of homoscedasticity is strongly rejected for all series at all cases of q. Indeed, all Z-statistics are greater than the conventional critical value (1.96 for the five percent level). In addition, the heteroscedasticity-consistent variance ratio test provides consistent evidence that the null hypothesis of random walk cannot be accepted for all weekly observed return series. Specifically, a comparison the Z*-statistic to the conventional critical value reveals that the random walk hypothesis is rejected at q = 2, 4, 8, and 16 for CADBUTY and FIRSTB, and at q = 2, 4, and 8 for NSINDEX and NESTLE. Moreover, the evidence against the null hypothesis under the assumption of heteroscedasticity in the case of UNIONB is weak because only two rejections (q=2 and q=4) are reported. Further, when the corrected returns are employed, similar results are obtained from the tests. Specifically, the null hypothesis of random walks under the assumption of homoscedasticity is strongly rejected for all series at all cases of q while the null under the assumption heteroscedasticity cannot be accepted for all series at some cases of q. The rejection of the null hypothesis is less pronounced for NSINDEX, FIRSTB, CADBURY and NESTLE, but more pronounced for UBA and UNIONB as compared with the results for the weekly observed returns.

On the basis of empirical evidence provided above, it can be concluded that the null hypothesis of random walk is rejected for the market index and all selected individual stocks. Moreover, thin trading is unlikely to affect the market efficiency.

## 5.0 Conclusion and Recommendations

This paper first provides an overview of the theoretical literature on the EMH. Specifically, three theoretical models suggested by Fama (1970), namely the Fair Game model, the Sub-martingale model, and the Random Walk model, are briefly summarised. The theoretical models of efficient market consistently imply that the future price of stock is unpredictable with respect to the current information, so market participants cannot earn abnormal profits. Additionally, this paper also highlights three different levels of EMH, weak form, semi-strong form, and the strong form. Following the theoretical literature, empirical studies on the weak form of EMH in emerging stock markets have been extensively conducted, especially in recent years. The empirical evidence obtained from these studies is mixed. Indeed, while some studies show empirical results that reject the null hypothesis of weak form market efficiency, the others report evidence to support the weak form of EMH. In general, emerging stock markets are unlikely to be efficient in weak form possibly due to their inherent characteristics, such as low liquidity, thin and infrequent trading, and lack of experienced market participants.

On the basis of the theoretical and empirical literature that is reviewed in this paper, the weak form of market efficiency for the market index and five selected individual stocks is tested by using both daily and weekly return data for the period from January 2007 to December, 2009 and from July, 2005 to December 2009. In addition, to deal with the problem of thin (infrequent) trading, which would seriously bias the results of the empirical study on market efficiency, the observed returns are corrected by using the methodology proposed by Miller *et al*. (1994). Moreover, in order to test the weak form of EMH for the Nigerian stock market, three different techniques are employed, namely autocorrelation, runs, and variance ratio tests. The results obtained from the autocorrelation indicate that the null hypothesis of random walk is conclusively rejected for the market index and four out of five selected individual stocks, even in the case where the returns are corrected for thin trading. In addition, the runs test shows evidence to reject the null hypothesis of a random walk for both daily and weekly observed returns of the market index and all selected individual stocks (except weekly returns for UNIONB). However, when the corrected returns are used, the empirical results given by the tests fail to reject the null hypothesis for the daily returns of UNIONB and NESTLE and weekly returns for FIRSTB and NESTLE. Moreover, the results of the Lo and MacKinley's variance ratio test under both homoscedastic and heteroscedasticity assumptions for both observed and corrected returns fail to support the random walk hypothesis for the market index and all selected individual stocks. In general, it can be concluded that the Nigerian stock market is inefficient in the weak form. A question arises here is whether investors can make abnormal profits by establishing a trading strategy on the basis of past information. Motivated by this interesting question, further studies on the issue of market efficiency are conducted.

The policy implications of this analysis are that the NSE, as an emerging market, must be closely monitored to achieve an optimal maturity level. Greed and bad choices should not take the place of risk management capacity and market discipline. Investors must be aware that, in inefficient stock markets, heavy gains are just as likely as heavy losses. Furthermore, the Securities and Exchange Commission should take a leading role in regulating abnormal financial activities. In the meantime, an inefficient market could suffer over inflated stock prices, speculation, and insider trading, all potentially intensified by herding behaviour. Several policy challenges need to be confronted to enhance the efficiency of the NSE, including (and not limited to):

- Increase market activities through reduction in transaction cost and increase in membership of the NSE.

- The NSE and SEC also need to strengthen their regulatory capacities to enhance market discipline and investor confidence. This will involve training personnel to enforce financial regulations, perform market surveillance, analytical and investigative assignments.
- Establishing a stock exchange news service, which will be responsible for early, equal and wide dissemination of price sensitive news such as financial results and other information that are material to investors' decision. This will ensure that participants and investors have equal access to high quality and reliable information.
- Minimize institutional restrictions on trading of securities in the bourse. This will make all other markets to flow as a deregulated market.

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