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Author(s): Ikechukwu Kelikume

Source: *The Journal of Developing Areas*, 2016, Vol. 50, No. 5, Special Issue on the Kuala Lumpur Conference, November 23-24, 2015 (2016), pp. 185-197

Published by: College of Business, Tennessee State University

Stable URL: https://www.jstor.org/stable/10.2307/26415577

**The Journal of Developing Areas**
Special Issue on Kuala Lumpur Conference Held in November 2015
Volume 50 No. 5 2016

# NEW EVIDENCE FROM THE EFFICIENT MARKET HYPOTHESIS FOR THE NIGERIAN STOCK INDEX USING THE WAVELET UNIT ROOT TEST APPROACH

***Ikechukwu Kelikume****
Pan-Atlantic University, Nigeria

## ABSTRACT

The efficient market hypothesis (EMH) assumes the absence of asymmetric information in trading activities in a typical stock market. The EMH has been tested extensively in the developed market economy with mixed results, but very little contribution has been made on the subject matter in developing market economy because of the presence of asymmetric information, institutional constraints and poor data collection method. Validating the hypotheses for the African economy has remained of great interest to researchers and investors given the repeated emphasis on the African economy as the next frontier of economic growth. Issues surrounding the EMH in developing economy rest on the possibility of exploiting the stock market to make quick returns. The validity of this statement remains to be tested empirically for the developing market economy. This paper investigates the EMH for a major developing African economy-Nigeria being the most populous country in Africa and the second financial hob in Africa, next only to South Africa. The study seeks to test the efficiency of the Nigerian stock market, using a wavelet unit root test with different lags and other traditional random walk testing procedure. The use of the wavelet unit root test entails the decomposition of the variance of the time series stochastic process into the variance in its high and low-frequency series. The study made use of monthly average stock price index of the Nigeria Stock Market over the sample period 1985 to 2015 to carry out the test. The result obtained from the wavelet-based unit root tests showed clear and conclusive evidence that the Nigerian Stock Market follows the random walk behavior during the period of the study and that the Nigerian Stock Market is efficient. In other words, stock prices fully reflect all the available information existing in the market and investors, armed with the trading rules, cannot exploit the market to earn extraordinary returns. This has vital implications for speculators, investors and rent-seekers hoping to capitalize on the unstructured nature of a typical developing market economy to make quick wins. Since the Nigerian Stock Market is efficient, investors should desist from futile attempts to forecast long-run share prices with the hope of making a quick, sustained win in the market.

**JEL Classifications**: G10, C22, G14, G12, G17
**Keywords**: efficient market hypothesis, random walk hypothesis, wavelet unit root test
**Corresponding Author's Email Address**: ikelikume@lbs.edu.ng

## INTRODUCTION

The stock market in Nigeria has witnessed significant volatility since the 2007-2008 global financial crisis that had its root in the U.S Subprime mortgage crisis. The trend analysis in the Appendix (Figure 1) shows that the stock market has responded significantly to changes in the international oil price and exchange rate movement between 2010 and 2015. Between January 2010 and December 2013, the Stock market in Nigeria experienced significant growth as indicated by the market capitalization of listed equities which rose from N5.411 trillion in January 2010 to N13.226 trillion in December 2013 (CBN Statistical Bulletin). However, stock market capitalization of listed equities saw a sharp drop from N13.005 trillion in January 2014 to N11.477 trillion in December 2014. The sharp drop in market capitalization in 2014 can be traced to the declining international crude oil price and the series of devaluation that have taken place in Nigeria since the beginning of the third quarter of 2014 (see Chart in Appendix 1).

The declining trend in market capitalization has produced many losers and very few gainers with many companies listed on the Nigerian Stock Exchange experiencing wide swing in their share prices. The current trend in the stock market points directly to the predictability of the movement of share prices and ability of players in the market to "beat the stock market."[1] The debate on the (EMH) which is still ongoing between financial market players and core finance academics is whether the stock market reflects all information made available to market participants at any given time thereby making it impossible for any one player in the market to beat the market through the attainment of greater profitability.

The efficient market hypothesis (EMH) has played a central role in stock market research. A series of studies allows us to have a robust technical knowledge on key issues on EMH. For the most acceptable framework and econometric modeling technique (see, for example, Fama, 1970, 1991; Fama and French, 1988; Lo and MacKinlay, 1988), though a growing body of literature has been giving arguments in contradiction to the EMH theory (i.e. Schleifer, 2000, Barber and Odean, 2000; Lo, 2005). The theory is closely related to the idea of a "random walk," which is characteristics of a price series where all successive price changes are random deviations from past prices. The idea behind the random walk is that if the information flow is unrestricted and information is instantaneously reflected in stock prices, then today's price change will reflect only today's news and will not be determined by the price changes yesterday.

The major goal of the present paper is to advance knowledge on the particularities of the EMH in Nigeria by testing the efficiency of the stock markets. Most empirical studies on EMH have focused on the weak form[2] (which is the lowest level of EMH) because if the evidence does not support the weak-form of market efficiency, examining the EMH at the stricter levels of semi-strong and strong form becomes

[1] The term "beat the market," refers to the ability of investors to produce a better return than the market average which is usually benchmarked with S and P 500 or the Dow Jones industrial Average Index

[2] The weak form of efficient market hypothesis describes a market in which historical price data are efficiently digested and, therefore, are useless for predicting subsequent stock price changes (see Hagin. 1979).

unnecessary. Therefore, we contribute to the literature by re-investigating the EMH, using daily Nigerian stock market data.

Though various studies have addressed issues in this domain in the recent past, we extend the existing studies using a larger sample and newer methodology; we study daily data for the Nigerian stock market over the period 1885–2015. The large sample affords us the availability of a greater variety of information. This should reflect the dramatic transformations that have taken place in Nigeria's securities sector in the past decade. Methodologically, this study investigates the efficient market hypothesis in Nigeria using the wavelet unit root tests, introduced by Fan and Gençay (2010).

The remainder of the study is organized as follows. Section 2 summarizes the important literature on the efficient market hypothesis. Section 3 describes the methodology as well as the data on the Nigeria stock markets. Section 4 reports the empirical results. The conclusion is drawn in Section 5.

## LITERATURE REVIEW

The study of the efficient market hypothesis has yielded a vast body of literature, being a subject of main debate of traditional finance from the 1970s. In his E*fficient Capital Markets*, Fama (1970), defined a stock market as efficient if the price of securities fully reflects all available and relevant information. In the words of Dima and Milo (2009, p. 402): "The efficient market hypothesis … states that asset prices are rationally connected to economic realities and always incorporate all the information available to the market. In this way, securities markets are seen as efficient in reflecting information about individual stocks or about the stock market as a whole."

In such a situation, the market participants cannot achieve unusual returns, different from what is obtainable if holding a randomly selected portfolio of individual stocks with comparable risks. The main attractiveness of the Efficient Market Hypothesis relies on the fact that it is built upon economic theory, specifically "random walk". That is, the efficient market hypothesis is related to "the random walk", where price series have subsequent price changes which are random departures from previous prices.

Eugene Fama's (1970) seminal article, "Efficient Capital Markets" gave birth to the efficient market hypothesis as the idea that "securities markets were extremely efficient in reflecting information about individual stocks and about the stock market as a whole" (Malkiel, 2003, p. 59). Today, as researchers have been discussing EMH for the past decades, the literature on the theme is now vast (see Fama, 1970; 1991; Fama and French, 1988, Lo and MacKinlay, 1988; Fawson, Glover, Fang and Chang, 1996; Kadapakkam, 1999; Karemera, Ojah and Cole, 1999; Schleifer, 2000, Barber and Odean, 2000; Lo, 2005, Alam, Tanweer and Groenewold, Sam and Wu, 2003; Wheeler, Bill, Tadeusz and Steve, 2002; Charles and Darne, 2009; Udoka, 2012; Gimba, 2012). In fact, this decade started with one overview of literature on the Efficient Market Hypothesis by Sewell (2011), which mainly focused on the history.

Economic theory suggests that a stock market is efficient if stock prices fully reflect all available and relevant information at any time. For that reason, according to Charles and Darne (2009, pp. 117-126), "given only past price and return data, the current price is the best predictor of the future price, and the price change or return is expected to be zero. The essence of the weak-form efficient market hypothesis [EMH], which implies a random walk".

More advanced econometric techniques have been applied to Efficient Market Hypothesis studies in the late 1990s and early 2000s compared to the studies between the 1970s and 1980s, contributing to improvements in the understanding of efficient markets. Some of the most advanced techniques have been applied to improve, among others, the estimates of the random walk. An exhaustive review of the literature shows that the most commonly tested form of EMH in the empirical literature is this random-walk implication.

Some of the several statistical techniques commonly used to test weak form efficiency are runs test, unit root test, serial correlation tests, and spectral analysis.

The runs test and unit root test are very common in studies from emerging stock markets. For example, Karemera *et al.* (1999), Wheeler *et al.* (2002), and Abraham *et al.* (2002) used the runs test; Groenwold *et al.* (2003), and Seddighi and Nian (2004) used the unit root test; Fawson *et al.* (1996), Moorkerjee and Yu (1999), and Abeysekera (2001) used both. Furthermore, Dickinson and Muragu (1994), Fawson *et al.* (1996), Moorkerjee and Yu (1999), Abeysekera (2001), and Groenwold *et al.* (2003) used a combination of correlation coefficient test and Q-test 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), Smith et al (2002) and Lima and Tabak (2004) used variance ratio tests. In addition, Ayadi (1983) used non-parametric tests; Sharma and Kennedy (1977) and Fawson *et al*., (1996) used spectral analysis; Buguk and Brorsen (2003) used fractional integration test; Seddighi and Nian (2004) used ARCH test.

The empirical literature shows that these empirical studies used different data. While studies such as Abeysekera (2001), Abraham et al. (2002), Lima and Tabak (2004) and Mikailu and Sanda (2007) used stock price indices, Dickinson and Muragu (1994), Olowe (1999) and Wheeler *et al*. (2002) used individual stock prices while Seddighi and Nian (2004) used both. Another issue is the frequency of time series. Mookerjee and Yu (1999), Cheung and Coutts (2001), Groenewold *et al.*, (2003), Lima and Tabak (2004) and Seddighi and Nian (2004) used daily data; Samuels and Jacout (1981), Dickinson and Muragu (1994), Dockery and Vergari (1997), Abraham *et al*., (2002) and Bashir (2010) used weekly data, Sharma and Kennedy (1977), Barnes (1986), Fawson *et al*., (1996), Olowe (1999), Karemera *et al.*, (1999), Alam *et al.*, (1999) and Udoka (2012) used monthly; Chang and Ting (2000) used yearly.

These differences in methodologies used to test the EMH in emerging markets have produced mixed and conflicting results. As a result, while some authors have evidence in support, others have evidence to oppose the EMH. For the Warsaw Stock Exchange, for instance, Wheeler *et al.* (2002) finds no evidence to support the weak form efficient hypothesis. For the stock markets in Chile, Mexico, Argentina and Brazil, Urrutia's (1995) study provides mixed evidence on the weak form efficiency. 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. Bombay and Dhaka Stock Exchanges, Sharma and Kennedy (1977) and Alam *et al.* (1999) show that the stock price changes support the random walk hypothesis. For stock markets in Sri Lanka, Kuwait, Saudi Arabia and Bahrain, Abeysekera (2001) and Abraham's (2002) studies rejected the hypothesis of weak form efficiency.

Information efficiency and operational efficiency (Baumol, 1965; Fama, 1970; Weston and Copeland, 1986) are the two major areas of stock market efficiency.

Research finds that a stock market may not be simultaneously operationally efficient and informationally efficient (Udoka, 2012).

Studies such as Baumol (1965) and Fama (1970) have shown that a stock market is operationally efficient based on its transaction costs, availability of price information, price continuity and timeliness. Information efficiency of the stock market, on the other hand, suggests that the market adjusts quickly to new information in accordance with financial valuation theory (Udoka, 2012). In other words, the market can capture correctly the impact of any new information on the stock price, in such a way that it will be unnecessary for any investor to carry out independent valuation. This is the idea behind the Efficient Market Hypothesis.

Moreover, today, one of the most remarkable features of international financial development is the increasing prominence of stock markets in emerging markets. Yet, these stock markets must be efficient in order to play their roles in the allocation and pricing of capital, and the pricing of risk. Malkiel (2003, p. 60) defines efficient financial markets as "markets which do not allow investors to earn above-average returns without accepting above-average risks". Yet, the current context of institutional rigidities in the emerging markets raises efficiency concerns and necessitates an in-depth analysis of the EMH in emerging markets. According to Smith, Jefferis and Ryoo (2002, p. 475):

*"While the more-established emerging markets have been the topic of extensive analysis of market efficiency, the same cannot be said for African markets, largely because many of them are new and very small, and there has often been a problem obtaining data series of sufficient frequency and duration".*

There have been many empirical studies on the weak form of EMH in emerging stock markets, especially Nigeria (Smith et al 2002; Gimba, 2010; Mikailu and Sanda, 2007), but no none has ever used the wavelet unit root test applied in the present study. As a matter of fact, only recently has Tiwari and Kyophilavong (2014) adopted the wavelet unit root test approach for the investigation of the random walk hypothesis for BRICS stock indices. Thus, the main difference between those studies and this one is the econometric method. It is obvious from surveying the literature on this topic that much has been learned about Efficient Market Hypothesis. For the Nigerian stock exchange, Olowe (1999), Bashir (2009), Mikailu and Sanda (2007) and Udoka (2012) found that evidence to support efficient in the weak form while Sanda (2009) found otherwise. Therefore, much work remains. Quite interesting is Smith et al (2002) which rejected the random walk hypothesis for Nigeria in a study on African stock markets.

Yet they posed a question: where the random walk hypothesis is presently rejected, do those markets approach a random walk as they become more liquid and more institutionally mature? Since Smith et al. (2002) study, the Nigerian Stock Exchange has grown rapidly, operating in a continuously changing regulatory environment. The stock market is now one of the biggest in Africa. The speculation is that the securities market has the potentials to rank among the largest in the world in the coming decades. Therefore, a step further is necessary in the study of EMH in Nigeria. In the next section, the model that we use and the econometric method are described in more details.

**METHODOLOGY**

The unit root tests literature have developed one framework after another, with different assumptions and incorporating different levels of less nonlinearity, less volatility and structural breaks. While the previous unit root tests in the literature are on the basis of a time domain analysis, the present study uses a different test in the framework of wavelet analysis. The usage of the wavelets eases the decomposition of the stochastic processes into its wavelet components, with each related to a specific frequency band. According to Tiwari and Kyophilavong (2014, p. 39) "the wavelet power spectrum measures the contribution of the variance at a particular frequency band in comparison to the overall variance of the process". In order to develop the wavelet-based unit root tests, Fan and Gençay (2010) decomposed the variance of the underlying processes into the variance in its high and low frequency components by means of discrete wavelet transformation (DWT) process. Specifically, to develop the wavelet-based unit root tests, Fan and Gençay (2010) defined $\{X\}^{T}_{t=1}$ as a univariate time series which can be represented as

$$x_t = \beta x_{t-1} + \varphi_t \tag{1}$$

$\varphi_t$ is a weakly stationary zero mean error with a strictly positive long-run variance which can be represented as;

$$\theta^2 = \delta_0 + 2\sum_{j=1}^{\infty} \delta_j \tag{2}$$

$$\delta_j = E(\varphi_t \varphi_{t-j}) \tag{3}$$

The test is only applicable to the linear trend and non-zero mean cases.
Assuming that the process $\{x_t\}$ can be defined as:

$$x_t = \xi + \gamma t + x_t^s \tag{4}$$

Where, $x_t^s$ is produced from equation (1).

If the null hypothesis $H_0$: $\beta = 1$, then $\{ x_t^s \}$ is a unit root process. On the other hand, if $H_0$: $\beta < 1$, then $\{ x_t^s \}$ is a zero mean stationary process.

If $\gamma = 0$, then the demeaned series is $(x_t - \bar{x})$.

Where, $\bar{x} = \frac{1}{T}\sum_{t}^{T} x_t$ , (5)

defines the sample mean of $\{ x_t \}$.

If $\gamma \neq 0$, then the detrended series is $(\bar{x}_t - \hat{x})$.

Where, $\overline{x_t} = \sum_{j=1}^{T} (\Delta x_j - \Delta \bar{x})$ (6)

defines the sample mean of { $x_t$ }.
$\bar{\bar{x}}$ is the sample mean of $\overline{x_t}$.

Where, $\Delta x_t = x_t - x_{t-1}$ (7)

And $\Delta \bar{x}_t$ is the mean of $\Delta x_t$.

Subject to the unit scale discrete wavelet transformation (DWT), Fan and Gençay (2010) established two test statistics, for the aforementioned demeaned and the detrended series. The test statistics for the demeaned series is defined as:

$$\overline{S}_{T,1}^{LM} = \frac{\sum_{t=1}^{T/2} (B_{t,1}^{M})^2}{\sum_{t=1}^{T} (x_t - \bar{x})^2} \quad (8)$$

Where $B^{M}_{t,1}$ denotes the scaling coefficient of the demeaned series.
The test statistics for the detrended series is defined as:

$$\overline{S}_{T,1}^{LM} = \frac{\sum_{t=1}^{T/2} (B_{t,1}^{d})^2}{\sum_{t=1}^{T} (\bar{x}_t - \bar{\bar{x}})^2} \quad (9)$$

Where $B^{d}_{t,1}$ denotes the scaling coefficients of the detrended series. These two can be used to test the null hypothesis, $H_0$: $\beta = 1$ against the alternative hypothesis, $H_1$: $\beta < 1$in model (1). We use the monthly average stock index of the Nigerian Stock Exchange for the period of January 1985 to June 2015. The data is collected from the Central Bank of Nigeria (CBN) Statistical Bulletin.

**EMPIRICAL RESULTS**

The outcomes of the wavelet-based unit root tests of the test statistics for Equations. (8) and (9) are as shown in Table 1.

**TABLE 1: WAVELET UNIT ROOT TESTS**

| Stock Indices | Test Statistics | |
|---|---|---|
| | $\overline{S}_{T,1}^{LM}$ | $\overline{S}_{T,1}^{Ld}$ |
| Lag 5 | -97.2* | -412.2* |
| Lag 10 | -96.2* | -408.2* |
| Lag 15 | -96.1* | -407.5* |
| Lag 20 | -95.2* | -403.4* |
| Lag 25 | -95.8* | -402.7* |
| Lag 30 | -94.9* | -402.3* |

*Notes: * Denotes significance at the 1% level.*

The test statistic based on Eq. (3) clearly rejects the null hypothesis. The test statistic based on Eq. (4) affords sufficient evidence to reject the null hypothesis despite the different lag lengths. The use of six different lags: 5, 10, 15, 20 (the optimal choice), 25 and 30 ensures the robustness of our results. In the final analysis, we compare our wavelet results with a battery of traditional unit root tests such as Augmented Dickey-Füller (ADF), Phillips and Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS). The ADF, PP, ADF-GLS, and KPSS reveal the fact that the series are non-stationary in levels, irrespective of the level of confidence (i.e. 1 %, 5 % or 10 %). On the contrary, the same tests in first-order differences confirmed that the series evolution is I(1) process as shown in Table 2.

**TABLE 2: TRADITIONAL UNIT ROOT TESTS**

| | Constant | Constant and Trend |
|---|---|---|
| ADF | -6.501754* (9) | -7.430542* (9) |
| DF-GLS | -0.849515* (9) | -4.488887* (9) |
| PP | -6.288269* (3) | -7.267419* (3) |
| KPSS | 0.195439* (3) | 0.085535* (3) |

*Notes: * Denotes significance at the 1% level. "(k)" denotes the lag length. Selection of lag length in ADF*

DF-GLS test is based on the SIC, NP test is based on the Spectral GLS-detrended AR based on the SIC and the PP test is based on the Newey–West with a Bartlett kernel.

Evidence from this study has therefore shown that the prices of stocks on the Nigerian Stock Exchange are random. According to Nwosa and Oseni (2012; p. 42):

*"The efficient market hypothesis is based on the proposition that stock price fully reflect all available information in the market and investors cannot use available information or any trading rules to earn extraordinary returns or use available information to exploit the market."*

While contrary evidence of the Nigerian stock market has been reported in Olowe (1999), Vitali and Mollah (2010) and Nwosa and Oseni (2012), similar evidence

was found by Ajao and Osayuwu (2012). Although some empirical evidence from Nigeria and other emerging stock markets negates the efficient market hypothesis, however our empirical evidence shows that the Nigerian stock market is informational efficient. That is to say, stock prices actually possess all available information in the market and hence financial analysts cannot earn abnormal returns from stocks, using previous stock prices to foresee the pattern of future stock returns. Evidence from this study has therefore shown that the prices of stocks on the Nigerian Stock Exchange are random.

## CONCLUSIONS

This paper investigates the efficient market hypothesis in Nigeria, testing for the efficiency of the Nigerian stock market, using the Fan and Gençay's (2010) wavelet unit root test approach with different lag lengths. Further, we used a battery of traditional unit root tests to ensure the robustness of our results. The wavelet-based unit root tests show clear and conclusive evidence that the Nigerian Stock Market follows the random walk behavior during the studied period. That is, the market is efficient. In other words, the stock prices fully reflect all available information in the Nigerian Stock Market and investors, armed with the available information or the trading rules, cannot exploit the market to earn extraordinary returns.

Although some empirical evidence from Nigeria and other emerging stock markets negates the efficient market hypothesis, however our empirical evidence shows that the Nigerian stock market is informational efficient. That is to say, stock prices actually possess all available information in the market and hence financial analysts cannot earn abnormal returns from stocks, using previous stock prices to foresee the pattern of future stock returns. Evidence from this study has therefore shown that the prices of stocks on the Nigerian Stock Exchange are random.

This has vital consequences on the fortunes of equity investors. Since the Nigerian Stock Market is efficient, investors should desist from futile attempts to forecast share prices. Policy makers can come to the aid of potential investors, to enlighten them of the opportunities available in the market in order to stimulate their interest and thus deepen the breadth of the capital market.

As well, to augment the informational efficiency of the Nigerian stock market, durable and adequate supervision by the regulatory authorities is necessary. Coupled with appropriate policies, this would preclude any stock price bubble while ensuring that information about stock prices is a true reflection of share values.

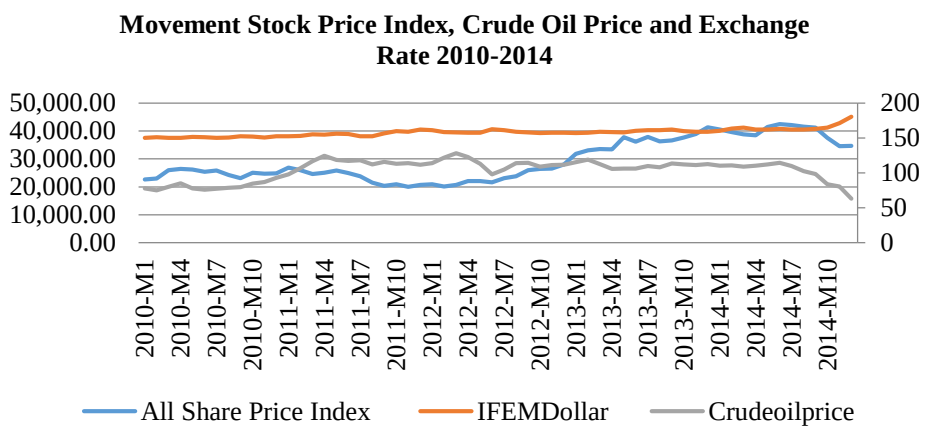
## ENDNOTES

[1]The term "beat the market," refers to the ability of investors to produce a better return than the market average which is usually benchmarked with S&P 500 or the Dow Jones industrial Average Index.

[2]The weak form of efficient market hypothesis describes a market in which historical price data are efficiently digested and, therefore, are useless for predicting subsequent stock price changes (see Hagin. 1979).

## APPENDIX

### FIGURE 1 TREND IN STOCK PRICE INDEX, CRUDE OIL PRICE AND EXCHANGE RATE IN NIGERIA 2010-2014




Note IFEM Dollar implies interbank foreign exchange market while Crude oil price is Price of Nigeria Burning Light Crude oil.

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