

Weak Form Efficiency of the Nigerian Stock Market: An Empirical Analysis (1984 – 2009)

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ABSTRACT: This paper examines the weak-form efficient markets hypothesis for the Nigerian stock market by testing for random walks in the monthly index returns over the period 1984-2009. The results of the non-parametric runs test show that index returns on the Nigerian Stock Exchange (NSE) display a predictable component, thus suggesting that traders can earn superior returns by employing trading rules. The statistically significant deviations from randomness are also suggestive of sub-optimal allocation of investment capital within the economy. The findings, in general, contradict the weak-form of the efficient markets hypothesis. Finally, a range of policy strategies for improving the allocative capacity and quality of the information environment of the NSE are discussed.

Keywords: Random walk hypothesis; Market efficiency; Runs test; Stock returns; Nigeria

JEL Classification: G10; G14

1. Introduction

A major focus of empirical finance literature has centered on the performance of financial markets and their ability to efficiently allocate investment capital within an economy. For many growth strategists, access to investment capital, mainly through well functioning financial markets, is crucial for economic development (Obstfeld, 1994). Consequently, recent years have seen an increasing prominence of stock markets in the developing regions of the World, including Africa. The expansion in stock market activity across the African continent is widely seen as a positive development in view of the potentially significant role financial markets play in the economic growth process.

However, the ability of a stock market to contribute to the financial development and growth of an economy depends on its informational, operational and allocational efficiency (Lagoarde-Segot and Lucey, 2008). According to the random walk version of the efficient markets hypothesis (EMH), a market is ‘efficient’ if stock prices reflect all currently available information such that future prices cannot be predicted on the basis of this information (Fama, 1965). Hence, tests of the randomness of stock prices are commonly used to determine whether a market is (weak-form) efficient or not. If stock prices exhibit random walk, then the market is ‘efficient’ in the sense that investors cannot use today’s stock price information to predict tomorrow’s price. On the other hand, presence of serial correlations or predictable components in stock prices suggest that past trends in price movements can be used to predict future prices.

Early research into the random walk and efficient markets hypothesis (EMH) has shown that developed markets, particularly the US and UK, are ‘efficient’ in the sense that security prices are random and reflect all historical information (e.g. Kendall, 1953; Fama, 1965). More recent studies (e.g. Ojah and Karemera, 1999; Fifield *et al.*, 2002; and Worthington and Higgs, 2004) have focused on mature emerging markets domiciled in Europe, Latin America and Asia, and the evidence indicates that these markets are weak-form efficient.

The literature relating to emerging markets in the Africa region is notably scant despite the remarkably superior returns and significant diversification benefits that many of the region’s equity markets offer. For example in 2004, returns on African stock markets (ASMs) outperformed both the Morgan Stanley Capital International (MSCI) global index and S&P 500 index by 14 percent and 18 percent respectively¹. Similarly, recent research (e.g. Senbet and Otchere, 2010) shows that the recent

¹ See Databank, (2004), *Africa stock markets: 2003 Review & Outlook*. Group Research

global financial crisis which wiped equity markets across the globe only marginally affected African equity markets (excluding South Africa, Egypt and Nigeria).

Against this backdrop, the nature of the price discovery process in Africa's capital markets is of significant interest to investors, policy makers, regulators and researchers alike. For investors, the presence of exploitable patterns in these markets presents opportunities for profit-making. Similarly, inefficiencies in the price formation process of financial assets are a matter of concern to regulators and policy makers because it implies less-than-optimal allocation of investment capital in the economy. Researchers on the other hand are interested in determining the extent to which the theory of efficient markets is upheld or contradicted by empirical findings from these markets. As earlier mentioned, the literature on market efficiency in Africa's emerging markets is scant and the existing evidence controversial. As a result very little is known about the price discovery process in these markets. The aim of this paper therefore is to expand the scope of the empirical literature of the EMH by employing a range of tests to investigate the weak-form efficiency for the Nigerian stock market.

Most of the previous studies on weak-form efficiency of the Nigerian stock market (e.g. Samuels and Yacout, 1981; Ayadi, 1984; and Olowe, 1999) relied on samples from individual stock prices and the studies were conducted in the period preceding the introduction of major reforms to the Nigeria Stock Exchange (NSE). This study marks a departure from previous studies and contributes to the literature in a number of important ways: First, by using the NSE All share (monthly) index prices, we are able to analyze a broad-based return series representative of the whole market. Second, by investigating the statistical properties of the NSE All share index, we are able to establish the extent to which the market as a whole exhibits the stylized facts for financial time series. From a policy perspective, this paper marks an important contribution by discussing useful strategies for improving the efficiency of the NSE. On the whole, this paper expands the scope of the empirical literature of the EMH for the Nigerian stock market in particular and African markets in general and, by so doing, contribute to our understanding of current research into Africa's equity markets.

Our results show evidence of significant deviations from randomness for the NSE All share price index. This implies that index price changes are non-random and predictable, suggesting that traders can earn superior returns over the buy-and- hold strategy by using trading rules. This observation contradicts the random walk hypothesis and the weak form EMH that security prices are unpredictable and reflect all historical information.

The rest of the paper is organized as follows: The next section reviews major theoretical debates and empirical findings of studies of the weak form EMH previously undertaken in Nigeria. Section 3 describes the data set and discusses some of the useful tests of the random walk hypothesis employed in this study. Results and findings are reported in section 4 while section 5 concludes.

2. Theoretical Framework and Review of Relevant Literature

2.1 The Efficient Markets Hypothesis (EMH)

According to Jensen (1978), a market is 'efficient' with respect to information set Θ_t if it is not possible to generate excess returns on the basis of the information set Θ_t . This implies that excess returns cannot be generated by trading on the basis of the available information set because prices adjust instantaneously and in an unbiased manner to new information, leaving no room for investors to make excess returns. This further means that all information available about a stock's expected future cash flows is incorporated into the price of the stock.

The three variants to the EMH are: (i) *the weak form efficiency* in which all historical price information constitute the information set which is reflected in stock prices; (ii) *the semi strong form efficiency* in which all publicly available information (e.g. dividend, earnings and merger announcements) constitutes the information set which is reflected in stock prices, and; (iii) *the strong form efficiency* where all available information, including private or insider information, make up the information set which is reflected in stock prices.

2.2 The Random Walk Model

The random walk model maintains that the price change at time t should be independent of the sequence of price changes in previous time periods. And this is in consonance with the postulations of the weak-form version of the EMH that technical analysis, based on historical price information, is worthless since current prices always adjust to all historical information. Like the EMH, the Random Walk Model also is in three variants.

Random walk 1 (*RW1*) implies that successive price increments are *independently and identically distributed (IID)*, and represents the strictest version of the random walk model. Thus the stock price at time t is computed as:

$$P_t = \mu + P_{t-1} + e_t \quad e_t \sim \text{IID}(0, \sigma^2) \quad (1)$$

where P_t represents stock price at time t ; μ , the expected price change or drift, and; *IID* $(0, \sigma^2)$, denotes that the successive price changes, e_t s, are independently and identically distributed with a zero mean and a constant variance.

Considering that financial time series, over long periods, display time-varying volatility and deviations from normality (Lo, 1997), the random walk 2 model (*RW2*) allows for unconditional heteroskedasticity in the successive price changes, such that:

$$P_t = \mu + P_{t-1} + e_t \quad e_t \sim \text{INID}(0, \sigma^2) \quad (2)$$

where *INID* denotes that the successive price changes are *independently but not identically distributed* with a zero mean and a constant variance. Nevertheless, the major definitional property implied by the *RW1* remains unchanged; that is “any arbitrary transformation of future price increments [cannot be forecast] using arbitrary transformation of past price increments” (Campbell *et al.*, 1997:33).

On the other hand, the weakest version of the random walk model, random walk 3 (*RW3*), relaxes the assumption of independence to accommodate dependent but uncorrelated increments. A case in which *RW3* will hold but not *RW1* and *RW2* is any process where $\text{Cov}(e_t, e_{t+k}) = 0$ for all k , but where $\text{Cov}(e_t, e_{t+k}) \neq 0$ for some k , in both cases $k \neq 0$. While the increments are uncorrelated, they are not independent owing to the fact that the squared increments are correlated (Campbell *et al.*, 1997). The current study focuses on *RW3*.

2.3 Review of Relevant Literature

Previous investigations on the weak-form efficiency of the Nigerian stock market have employed different methodologies and data of varying duration and frequency. Also, the existing literature consists of individual studies on the Nigerian stock market and multi-country studies in which the NSE is covered.

A number of these studies report evidence of randomness in equity prices. For example, Samuels and Yacout (1981) apply autocorrelation tests on weekly price series of 21 stocks listed on the NSE over the period 1978 to 1979. They fail to find evidence of dependence and conclude the Nigerian stock market is weak-form efficient. Ayadi (1984) uses a number of non-parametric tests, including the runs test, in his investigation. Employing weekly prices of 30 stocks between 1977 and 1980, Ayadi reports evidence that prices on the Nigerian stock market follow a random walk. Similarly, Olowe (1999) tests for serial correlations using monthly data for a sample of 59 stocks listed on the NSE. He concludes the Nigerian stock market is weak-form efficient. In a separate study, Jefferis and Smith (2005) test for efficiency across time in 11 African markets (Nigeria inclusive). Employing time-varying GARCH models on equity price data spanning the period 1990 to 2001, Jefferis and Smith report that Egypt, Morocco and Nigeria only became weak-form efficient towards the end of the study period i.e. 2001. Okpara (2010), in a recent study, applied the runs test and autocorrelation on NSE index prices and concludes the Nigerian stock market follows a random walk, and therefore is weak-form efficient.

In contrast, evidence against stock price randomness on the NSE has also been reported in previous studies. For example, Magnusson and Wydick (2002) use partial autocorrelation test for a number of African markets including Nigeria. They find evidence of significant correlations in stock returns for Nigeria, Ghana and Zimbabwe, thus suggesting that these markets are not weak-form efficient. In another multi-country, Smith (2008), using variance ratio tests, concludes none of the 11 markets in his study, which includes Nigeria, is weak-form efficient.

What emerges from a review of previous studies on the weak-form EMH for Nigeria (and Africa in general) is the mixed and often conflicting findings of the study. This current study attempts to shed more light on the efficiency debate by investigating additional evidence on the predictability of stock returns and its implications on the efficiency of the price formation process with respect to the Nigerian stock market.

2.4 Stock Market Development in Nigeria

The Nigerian capital market was established in 1960 as the Lagos stock exchange. The exchange was renamed Nigeria Stock Exchange (NSE) in December 1977. Trading commenced at the exchange in 1961 with about nineteen (19) securities. By the end of 1971, there were 34 securities

quoted on the NSE. Since then, there have been significant changes to the NSE in terms of structure and operations. These changes have resulted in a significant growth in the number of listed firms and trading activity. The major stock market index – the Nigerian All Share Index - was introduced in 1984 and its composition is restricted to ordinary shares only. In February 2009 the NSE introduced five (5) additional indices. These are: NSE 30 index, NSE Banking 10 index, NSE Insurance 10 index, NSE Food/Beverage 10 index and NSE Oil/Gas 5 index.

As at April 2009, there were 13 branches of the NSE and trading takes place 5 days a week, Monday through Friday. The trading settlement cycle is currently T+3, which is the international standard. Additionally, the Exchange boasts of a central depository - the Central Securities and Clearing Systems (CSCS) - which electronically handles clearing, settlement and delivery of transactions on the Exchange. Currently, no restrictions exist for participation or ownership by foreign investors. In 2009, the NSE received a big boost towards its drive at internationalization when Bloomberg announced that real-time stock market data from Nigeria can be accessed from its database by the global investment community. As at 2010, market capitalization to GDP ratio stood at 26.27% while the total number of listed securities stood at 215. The Nigerian stock market is currently the most liquid stock market in West Africa and the third largest stock market in Africa, after South Africa and Egypt (Allen *et al.*, 2011).

3. Data and Methodology

3.1 Description of Data and Hypothesis

This study used the monthly all share index data for the Nigerian stock exchange (NSE). The All share index includes all listings on the exchange. Given that using daily or weekly prices in a return series comprising of infrequently traded stocks may lead to significant biases in the results (Lo and MacKinlay, 1988), we use monthly price series because of the potential for thin trading in Nigerian equities (Olowe, 1999). Additionally, we use index prices, rather than individual stock prices, to provide market-wide evidence. The index used is in local currency and the data consists of 305 observations spanning the period February 1984 to June 2009.

The monthly index returns derived from the index levels were transformed into continuously computed returns as:

$$R_{mt} = \ln(P_t - P_{t-1}) \quad (3)$$

where R_{mt} represents monthly market return for period t , P_t and P_{t-1} denote market prices for period t and period $t-1$ respectively and \ln denotes natural logarithm.

Tests of statistically significant dependence or correlation in stock price changes, as defined by the random walk model, are traditionally used to test for weak-form efficiency in a market (Mabhunu, 2004). Therefore, to investigate the weak-form efficiency of the NSE, we test, in the main, the following hypotheses:

H_0 : prices on the Nigerian stock exchange follow a random walk

H_1 : prices on the Nigerian stock exchange do not follow a random walk

3.2 Methodology

3.2.1 Kolmogrov-Smirnov (K-S) goodness of fit test

The normality of return distribution is one of the basic assumptions of the weak-form EMH (Simons and Laryea, 2005). Therefore, we use the K-S goodness of fit test to test the null hypothesis that the observed cumulative distribution function (CDF) of the returns is identical to a normal distribution. If the Z-statistic is greater or equal to the p value, we accept the null hypothesis of normality in the return distribution.

3.2.2 Runs test

To test for randomness or serial independence in stock price changes, we use the runs test. Being a non-parametric test, the runs test is robust to non-normal return distributions. A run occurs when there is no difference between the sign of two changes (Okpara, 2010). The objective is to compare the actual number of runs with the expected number of runs. If the actual number of runs is significantly different from the expected number of runs, the null hypothesis of randomness in successive price changes is rejected

We estimate the expected number of runs as:

$$m = \frac{2n_1 n_2 + 1}{n} \quad (4)$$

where m represents the expected number of runs, n_1 , n_2 , denote the number of positive observations and number of negative observations respectively, and n represents the total number of observations.

The variance of m is given by:

$$\sigma^2 m = \frac{2n_1 n_2 (2n_1 n_2 - n)}{(n)^2 (n - 1)} \quad (5)$$

For a larger sample size ($N > 30$), the distribution of m is approximately normal and the standard normal Z -statistic is estimated as:

$$Z = \frac{r - m}{\sigma^2 m} \quad (6)$$

where r represents the actual number of runs.

To accept the null hypothesis of randomness, the Z statistic must fall within the critical value ± 1.96 , at the 5% significance level, or ± 2.576 at 1% significance level.

4. Results

4.1 Normality Tests

A normal distribution is symmetric around the mean, while a skewed distribution is not (Brooks, 2008). Also, a normal distribution is defined to have a coefficient of kurtosis of 3. Large kurtosis (>3) is indicative of a leptokurtic (peaked) distribution while small kurtosis (<3) is indicative of a platykurtic (flat) distribution.

The statistical properties of the data presented in Table 1 show that the mean return is 0.01812 while the standard deviation is 0.06583. We also see that the distribution is negatively skewed and non-symmetric with a (negative) coefficient of skewness of -0.42, indicating that there are more negative extreme values than positive extreme values in the sample period. The quartile - quartile ($Q - Q$) plot of the stock price return, as shown in figure 1, confirms that the return distribution is non-normal and negatively skewed, with a long left tail. We see also that the distribution of the returns has a kurtosis coefficient of 10.25 which is larger than 3. The leptokurtic nature of the price series is indicative of a peaked distribution. According to Brooks (2008), a leptokurtic distribution is more likely to characterize financial time series.

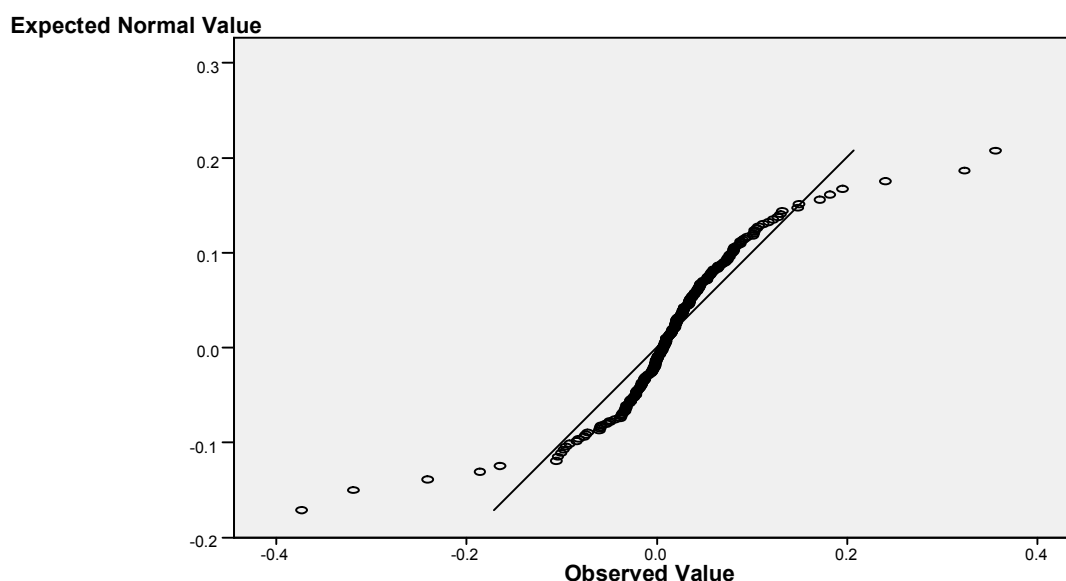
Table 1. Statistical properties of stock returns

N	Mean	St. Dev	Minimum	Maximum	Skewness	Kurtosis
304	0.01812	0.06583	-0.037331	0.35627	-0.42	10.25

The results of the Kolmogrov-Smirnov goodness of fit test are presented in Table 2. The null hypothesis that the return series come from a normal distribution is rejected since the probability of the computed Z -statistic is less than the p value, 0.05.

Table 2. Results of One-Sample Kolmogrov-Smirnov Goodness of Fit Test

No. of observations	Mean	Std. Dev.	Most extreme absolute diff.	Positive	Negative	Kolmogrov-Smirnov Z	Asymp. Sig. (2-tailed)
304	0.0182042	0.0659170	0.122	0.111	-0.122	2.127	0.000

Figure 1. Q-Q plot of stock returns

In sum, the preliminary statistical results clearly indicate that the assumption of normality cannot be maintained for the monthly index returns. The index returns are negatively skewed and the evidence of peakedness is inconsistent with a normal distribution. To this end, we employ the non-parametric runs test which is robust to deviations from normality in a return distribution.

4.2 Runs Tests

The results of the runs test reported in Table 3 indicate that the null hypothesis of independence and randomness in stock price changes is rejected since the calculated Z-statistic of -5.047 lies outside the critical values of ± 1.96 and ± 2.576 at the 5% and 1% significance levels respectively. A significant negative Z value means the actual number of runs is lower than the expected number. A negative Z value also indicates the presence of positive serial correlations with respect to the return series. As mentioned in the methodology section, a significant Z-statistic is indicative of non-randomness and serial dependence in a return series. Therefore the random walk and weak-form efficiency hypothesis is rejected for the Nigerian stock market.

Table 3. Results of runs test

Total cases	Mean	Cases<mean	Cases>mean	Actual runs	Expected runs	Z-statistic	Asymp. Sig. (2-tailed)
304	0.0182	156	148	109	153.37	-5.047	0.000

Although the results from this study contradict few previous studies on the NSE which have employed the runs test (e.g. Olowe, 1999 and Okpara, 2010), they are consistent with most others (e.g. Appiah-Kusi and Menyah, 2003; Simons and Laryea, 2005; Smith, 2008; Emenike, 2008 and Mollah and Vitali, 2011). Given that African stock markets, including the NSE, are bedeviled by problems of illiquidity, thin trading, lack of market transparency and poor regulatory standards (Mlambo and Biekpe, 2005), the results reported in this study are not inconsistent with expectations.

4.3 Implications of findings

The pattern of dependence in stock price changes suggests that past data on prices may be used to predict future prices, and this violates the weak-form of the EMH. The discovery of significant positive correlations in stock price changes also suggests that stock prices only partially reflect the fair value of stocks, leading to mispricing of risk and misallocation of investment capital. This further implies that investment resources are not channeled to their most productive uses, thereby hampering growth and development of the domestic economy.

Additionally, evidence of non-randomness of index returns on the NSE could be a reflection of “no change” in prices, or “zero returns”, which in turn is a result of the prevalence of infrequently traded stocks on the NSE All share index. The results reported in this study could also be attributed to the peculiar nature of the information environment characterized by poor dissemination of information relating to price movements on the exchange. According to Hirota and Sunder (2002), scant information relating to securities in markets may lead to speculative and or herding mentality amongst investors, ultimately resulting in large and correlated price movements.

To this end, policy makers and the regulatory authorities need to intensify efforts to vigorously pursue extensive reforms to improve the quality of the information environment. One useful strategy to achieve this would be to encourage more institutional investors to participate on the NSE. The argument is that the superior capacity of institutional investors to conduct extensive security analyses would help improve the informational efficiency of the price formation process in the market. Indeed, Mishra (2011) explains that (in the long run) as the number of sophisticated traders increase, the market becomes more informationally ‘complete’, thereby becoming more efficient. Furthermore, the regulatory authorities need to ensure that the effectiveness of support institutions are in line with international best practices since it is easier to attract investors into markets that have strong, transparent and effective institutions.

5. Conclusion

This paper examined the weak form efficiency of the Nigerian stock exchange (NSE) using the non-parametric runs test over the period 1984 to 2009. Specifically, the paper tested the random walk hypothesis for the Nigerian All share monthly index returns. Significant deviations from independence were observed in the return series. On the whole, the results from this study suggest that stock price changes on the NSE are not random and that exploitable patterns exist, making it possible for arbitrage portfolios to be constructed based on trading rules. This observation contradicts the weak form of the EMH.

The results, going forward, are subject to several caveats. First, the use of the market index returns instead of individual stock returns exposes our analyses to the potential biases associated with infrequently traded stocks. However, the monthly price data used here would have minimized this potential bias. Secondly, the use of the runs test assumes the return generating process of securities on the NSE is linear. Therefore a re-examination of the weak form EMH using robust non-linear models is required. Third, the mere presence of significant serial correlations in price changes may not necessarily violate the ‘no arbitrage condition’ of the EMH if the use of trading rules does not yield superior returns over the buy-and-hold strategy after accounting for transaction costs (Alagidede, 2008). Therefore, establishing the profitability of trading rules on the NSE, after accounting for trading costs, opens up a potentially interesting area for future research. Finally, as this study is limited in scope to a single emerging African stock market, future work might be required to ascertain the extent to which the findings from this study are generalisable to other emerging stock markets domiciled in the Africa region.

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