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**Testing for Market Efficiency in Nairobi Stock Exchange:  
A Serial Correlation Analysis**

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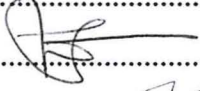
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## **ABSTRACT**

The study examined the weak-form informational efficiency in the Nairobi Securities Exchange (NSE), using a sample of data of both the NSE 20 and All Share Indices, in the period between January 1999 and January 2013. The study adopted a serial auto-correlation and regression method of analysis to examine the informational efficiency. The variables used in the study were market return proxies. The Serial Correlation test revealed that the NSE exhibited informational inefficiency, and that returns did not follow a random walk.

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## **1.1 Introduction**

### **1.1.1 Background on Seminal Work**

The concept of efficiency is central to finance and had been anticipated at the beginning of the twentieth century in the dissertation submitted by (Bachelier, Louis, 1900). In his opening paragraph, Bachelier recognizes that “past, present and even discounted future events are reflected in market price, but often show no apparent relation to price changes”. This recognition of the informational efficiency of the market leads Bachelier to continue, in his opening paragraphs, that “if the market, in effect, does not predict its fluctuations, it does assess them as being more or less likely, and this likelihood can be evaluated mathematically”. This gave rise to a brilliant analysis.

Regulation of any financial market is dependent on informational efficiency. In advanced studies, researchers such as (Bernard V. and J. Thomas , 1989) and (Bernard V. and J. Thomas, 1990) have tried to measure efficiency by creating a ‘laboratory’ market that is efficient and have used the laboratory to measure the level of efficiency in markets. The concept of market efficiency, however, was first introduced by (Fama E. , 1970) who proposed a weak form, semi-strong and strong form of efficiency.

Under weak form efficiency, the current price reflects the information contained in all past prices, suggesting that charts and technical analyses that use past prices alone would not be useful in finding undervalued stocks.

Under semi-strong form efficiency, the current price reflects the information contained not only in past prices but all public information (including financial statements and news reports) and no approach that was predicated on using and massaging this information would be useful in finding undervalued stocks. Strong form efficiency, the current price reflects all information, public as well as private, and no investors will be able to consistently find undervalued stocks.

This study attempted to ascertain the weak-form market efficiency of the Nairobi Stock Exchange. The premise is that for the stock market to be deemed weak-form efficient, the stock price changes have to be unpredictable, in line with the EMH, therefore making it impossible for

investors to consistently make abnormal profits (Fama 1976). A serial autocorrelation analysis was performed to test for efficiency.

## **1.1.2 An Elaboration of Key Concepts**

### **1.1.2.1 Asset market efficiency**

An efficient market is one that fully and correctly reflects all relevant information in determining asset prices. Under the EMH framework, relevant information is that which is fundamental but does not disclose what is fundamental and what is not. This aspect of ambiguity makes EMH controversial but it is misleading to conclude that the hypothesis is wrong rather EMH is just but incomplete. Some law literature has referred to relevant information as price-sensitive information.

The implication is that a model is always required to provide a benchmark criterion for efficiency. The model is only as good as the argument in its favour. The joint hypothesis problem by Eugene Fama stipulates that market efficiency is not testable by itself. It must be tested jointly with some model of efficiency where any inference about market efficiency is conditional on an assumed model and what determines the model is prior idea of what constitutes efficiency. However, tests of efficiency are not useless rather, the conclusions on efficiency must be based on the model that provides the criteria of efficiency and hence disputes would always arise upon a conclusion.

The aggressive pursuit of abnormal profits in the market is an approach to market information efficiency where, if decision rules or investment strategies can be constructed in such a way to yield abnormally high returns than those of the market, the market is considered inefficient.

Investors have benefited immensely due to the occurrence of unexpected phenomena known as anomalies. An anomaly is something that goes against a conventional wisdom where a conventional wisdom in this case is that asset returns should follow a certain pattern. Asset market anomalies are typically supposed to represent asset market inefficiencies. Popular asset market anomalies include, calendar effects (such as January effect, Monday Blues), weather and stock markets, sports results and stock price declines, eclipse and stock market performance, small firm / size effects, and high earning / price ratio effects, among many others. Anomalies have certain characteristics. It's absolutely important to ascertain whether the anomaly is

genuine. A one-off fluke is something that has occurred is unlikely to be repeated. There should also be a model that explains that particular phenomena and the phenomena should be easily understandable. The issue then becomes whether the most generally acceptable model of the anomaly is interpreted as representing efficiency. Secondly, the anomaly ought to be substantive. Curiosity could just be a trivial discrepancy due to measurement error. Inefficient markets would justify curiosity.

#### **1.1.2.2      Patterns of information**

- Weak form efficiency- prices reflect all public price information therefore one cannot use price fluctuations or trends to predict future prices.
- Semi strong efficiency- prices reflect all publicly available information
- Strong form efficiency- prices reflect both public and private information. Here, it becomes almost impossible to profitably implement strategies on private information such as insider trading.

Grossmann-Stieglitz paradox stipulates that because information is costly, prices cannot perfectly reflect all the information available since if it did, those who spent resources to obtain it would receive no compensation. Therefore, the strong form efficiency is a rare occurrence only likely to be observed when all information is observable.

Empirical tests on market informational efficiency have been focused on the weak form efficiency which includes the filter tests, run tests and correlation tests. Despite the fact that the most popular tests have been based on testing the semi strong market efficiency using event studies, the paper focuses on weak form efficiency because the studies on testing semi-strong EMH in developing countries' markets are few, and it is widely accepted that the semi-strong hypothesis encompasses the weak-form hypothesis, which means if one market is tested in semi-strong efficiency then it should be in weak form efficiency simultaneously, and we also can say if weak form hypothesis is rejected in one market, the semi-form hypothesis should be rejected simultaneously for the same market as well. Therefore, the market has to be weak-form efficient to qualify for a test on semi-strong form of efficiency (Gupta and Yang 2011).

### **1.1.3 Emerging Trends of NSE market participants**

For a very long time, market participants have reaped profits and losses in equal measure. Some have attributed their misfortunes in the financial markets to sheer bad luck, while others are sure footed that they had their numbers right and claim to have taken calculated risk that ultimately bore fruit. More puzzling, have they been able to replicate this success over time? Is there actually a way to accurately and correctly predict price changes and, in turn, predict returns on them? Delusions of grandeur do exist; time to find out empirically.

Determining predictability of stock prices is based on a joint hypothesis, namely, a hypothesis that asset prices follow a random walk, and that the model is such that prices correctly incorporate all relevant available information so that deviations from the expected/ normal returns are unpredictable (random) or so small that efforts to exploit them are unlikely to survive transactional costs.

There is a common agreement in financial economics that asset prices are barely predictable, case in point Eugene Fama - in his acclaimed research papers of 1971 and more recently 1991, through the revered Efficient Market Hypothesis - defends such wisdom through the martingale theorem and subsequently the random walk theorem.

Many an investor have shared the belief that they could, without a doubt, predict market price changes of assets, based on the information that they have, which could have been accumulated through experience, number crunching or mere speculation. Such investors will exploit their knowledge to obtain the best returns from their portfolio of assets through activities such as buying low and selling high. The ability to predict with a high degree of certainty that one asset will increase more in value than another, would reflect rather a basic malfunctioning of the market. However, with the presence of high returns comes the cost of high risk hence, predictability need not necessarily be a sign of market malfunctioning hence, predictability is of secondary importance. Rather of primary importance is risk as evidenced by traditional asset pricing models where predictability of returns is driven by risk factors such as beta coefficient, factor loadings and the market risk premium.

Fama's EMH assertion on unpredictability firmly states that price movements are unpredictable. This claim is based on the martingale and random walk theory.

## **1.2 Problem Statement**

Many individuals trading on stock market like to think of themselves as investors. They believe that the best strategy for yielding profits is to search for undervalued stocks. When their approach is successful, they are pleased of themselves as they have successfully “beat” the market. The reality is that most of them owe the profits to the pure luck and they are even not aware of it. Burton Malkiel theorized once that “a blindfolded monkey throwing darts at a newspaper’s financial page could select a portfolio that would do just as well as one carefully selected by experts”. From that perspective, hypothetically, there is no difference on which stocks the individual should choose, as it is the market who determine the returns. Hence any investor should be familiar of how market tends to react.

Eugene Fama in 1970’s introduced the concept of efficient markets which separates them into two groups: efficient and inefficient. Since then there has been an on-going debate as to how efficient markets really are. In other words, how quickly and completely information of various types is reflected in stock prices. An analysis into the serial correlation of the stock market indices should shed more light on the informational efficiency of the Nairobi Stock Exchange.

## **1.3 Research Objectives and Hypothesis**

### **1.3.1 Research Objectives**

The objective of this study is as follows:

- To test for market efficiency in the stock market
- To find out whether stock prices follow a random walk

### **1.3.2 Research Hypothesis**

The following are the preliminary research hypotheses:

$H_{01}$ : The stock market indices exhibit market efficiency.

$H_{02}$ : The stock market indices do not exhibit market efficiency.

## **1.4 Significance of the Study**

The Efficient Market Hypothesis matters in financial world because it provides the basis for investment valuation. If markets are indeed efficient, the market price would be the best way to value an investment. On the flipside, inefficiency would lead to often deviations of values and in the process securities might be over- or undervalued, hence the proper valuation of investment might be difficult. Important to note, once the market is defined as efficient, it does not necessarily mean that it is efficient at every point in time. Besides, the hypothesis does not even require for efficiency to market's price being equal true value all the time. What matters is that any errors in the market's price are unbiased, i.e. under- or overvalued stocks appear because of randomly occurred deviations. These deviations are the results of information being introduced to the market, and if the news is random, the investor cannot predict the next price movement.

## 2.0 Literature Review

Market efficiency is a topic that evokes a lot of controversy because most people hold different opinions on what market efficiency really is. We, however, will consider informational efficiency where investors with superior information are expected to dominate the market. According to (Fama, 1970) markets are extremely effective in reflecting information about individual stocks and the stock market as a whole. The implication of this is that when new information arises the news spreads very quickly and is incorporated into security prices; hence leading to the widely used definition of efficient markets.

A market is said to be efficient when fully reflects all the information available in the market. However over time it has been close to impossible to conclusively define “fully reflect”. This has led to many arguing that efficient markets are hypothetical and could never exist implying that the Efficient Market Hypothesis (EMH) is unrealistic (Sewell, 2011). Anomalies such as short term momentum including under reaction to new information studied by Lo and Mackinlay in 1999 and long term reversals by Debono and Thaler in 1995 have been used to dispute efficient market hypothesis with behavioural finance being advocated for as a stronger tool as compared to EMH (Malkiel, 2003). Strictly speaking the EMH is false but in spirit it is profoundly true and sciences seek at establishing the best hypothesis and until a flawed hypothesis is replaced by better hypothesis criticism is of limited value (Sewell, 2011).

Research into market efficiency at the beginning of the 20<sup>th</sup> century delved deeper into the mathematics of and statistics of Brownian motion with contributions from both Louis Bachelier in “*The Game of chance and hazard*” and further by Albert Einstein in 1905. The first ten years of the 20<sup>th</sup> century produced the framework of the efficient market hypothesis by providing the tools and intuition behind the theory. John Maynard Keynes was the next to allude to the efficiency of markets he argued that investors on financial markets are rewarded not for knowing better than the financial market what the market has in store but rather for risk bearing which is a consequence of EMH. (Keynes, 1936).

When (Kendall, 1953) examined 22 UK stock and commodity price series, he concluded that “*in series of prices which are observed at fairly close intervals the random changes from one term to*

*the next are so large as to swamp any systematic effect which may be present. The data behave almost like wandering series.*” The near-zero serial correlation of price changes was an observation that appeared inconsistent with the views of economists.

The landmark of efficient market hypothesis was the conclusion by (Fama E. , 1970) that stock prices follow a random walk, after an empirical analysis of stock market prices. These empirical observations are what came to be labelled the “random walk model” or even the “random walk theory”. The idea that asset prices may follow a random walk pattern was introduced by Louis Bachelier in 1900 (Gupta and Basu 2007). The random walk hypothesis is used to explain the successive price changes which are independent of each other.

Hence, price changes are unpredictable because information is random. What this means is that all investors in the market should enjoy the similar return. (Bailey, R. E, 2005). Assuming that stock prices change based on information, prices hence change on the receipt of new information. The arrival of information tends random and unpredictable manner which means that stock prices should therefore not exhibit any patterns but should move in a random unpredictable fashion. For this scenario to hold efficient markets are necessary. (Eric S. Maskin and JJ Laffont, 1990)

However, (Samuelson, 1973) proposed the first formal economic argument for efficient markets. He argued that properly anticipated prices fluctuate randomly. As opposed to (Fama E. , 1970), he delved deeper into the random walk theorem emphasizing that stock prices follow a martingale.

When carrying out empirical tests of market efficiency, defining relevant information and the term ‘fully reflect’ proves to be difficult. (Bailey, 2005) argues that market efficiency per se is not testable, and that it must be tested jointly with some model of equilibrium in an asset pricing model. To make the model testable, Fama argued that market efficiency only made sense in the realms of a specific model of market equilibrium. One possibility was to use the Sharpe-Linter model borrowing from the Capital Asset Pricing Model (CAPM). This model specifies the nature of market equilibrium together with how prices fully reflect available information.

In most efficient market hypothesis information is known to adequately move prices move with regard to a given information set (Jensen, 1978). However propositions have arisen purporting

that information does not adequately explain market movement (Cutler, 1989). The question however is not whether information moves markets but rather can it be identified and its one determined (is it positive or negative) in this case there is a very close link between price movements and information.

History shows that there have been very few studies conducted that test for market efficiency in emerging markets. In his analysis of the Indian stock market, Poshakwale (1996) observed weak form inefficiency, while using data from 1987 to 1994. Still in India, but a decade later, Gupta and Basu (2007) generated mixed evidence for weak form efficiency in their model, having used data for the period 1997 to 2006 this time round. Back home in Kenya, weak form inefficiency was observed in the Nairobi Stock Exchange in the paper written by Dickinson and Muragu (1994). A similar result was observed by Ho and Cheung (1994) for Asian markets.

Contrary to the aforementioned, the Kuala Lumpur market demonstrated a high degree of efficiency, according to Barnes (1996). Though technically not an emerging market, Groenewold and Kang (1993) identified the Australian market as being semi-strong efficient. More recently, a selected group of Asian markets were tested for efficiency, with varying results, in Kim and Shamsuddin (2008). Weak form efficiency was observed in the Japan and Taiwan Stock markets, whereas there have been no traces of market efficiency in the Indonesian, Malaysian and Philippine markets. The paper also asserts that the Thai and Singaporean markets efficient after the Asian crisis. Several other studies have been done to test for market efficiency but have not received as much citations as the above. They include: a study on Korea by Ryoo and Smith (2002), that notably uses a variance ratio test and finds the market to follow a random walk process if the price limits are relaxed during the period March 1988 to Dec 1988; a study on China by Mahmood et al (2011) that shows that the Chinese stock market is weak form efficient; another study on China by Liu (2010) employs unit root test, autocorrelation function, BDSL, Engle-LM and AR (p)-EGARCH and AR (p)-TARCH to test the market efficiency of Chinese stock market over 2001 to 2008, however, it concludes that Chinese stock markets are not weak-form efficient. There were also studies done on Hong Kong (Jarrett (2008); Cheung and Coutts (2001)), Slovenia (Dezlan (2000)), Spain (Regulez and Zarraga (2002)), Czech Republic (Hajek (2002)), Turkey (Buguk and Brorsen (2003)), Africa (Smith et al. (2002); Appiah-kusi and Menyah (2003)) and the Middle East (Abraham et al. (2002), where variance ratio test and the

runs test was used to test for random walk for the period 1992 to 1998 and found that these markets are not efficient).

### 3.0 Methodology

There are several ways of performing an efficiency test on stocks in a financial market. The method used in this study to test for the weak-form efficiency, based on the efficient market hypothesis, was to find out whether the historical sequence of prices of a given stock are either independent of one another or are related to one another. In this study, a test of a weak-form of the efficient market hypothesis of the Nairobi Securities Exchange was performed using the serial correlation analysis.

According to finance models such as Capital Asset Pricing Model and random walk theory, returns of an asset are not predictable and should not have autocorrelations. If the returns are non-random, it means that returns are predictable and an individual investor could benefit from collecting information (Malkiel, 1973).

### 3.1 Theoretical Methodology

#### 3.1.1 Martingale Theory (why asset prices are unpredictable)

A martingale is a stochastic variable  $X_t$  which has the property that given the information set  $\Omega_t$  there is no way an investor can use  $\Omega_t$  to profit beyond the level which is consistent with the risk inherent in the security. This implies that asset prices evolve according to a stochastic process:

$$E(p_{t+1}|\Omega_t) = p_t$$

The information set  $\Omega_t$  contains all past prices of the asset and other additional information such as price of other assets, companies' earnings data etc. Ideally  $\Omega_t$  contains anything known as at time  $t$ . Given the martingale theory, all information available as at time  $t$  is encompassed in  $p_t$  alone as a result actions of investors; the information that influences their decisions is somehow reflected in  $p_t$ .

Likening investment to a gamble, the ownership of assets is viewed as a participation in a fair game where gains or losses are equal to zero. Therefore, asset returns from investment are equally zero under the martingale theorem,

$$E(p_{t+1} - p_t | \Omega_t) = 0$$

However, investments are expected to yield non zero returns, therefore:

$$E(p_{t+1}|\Omega_t) = (1+\mu)$$

Given that  $r_{t+1} = \mu + \varepsilon_{t+1}$ , the expected return representation will be given by,

$$E(r_{t+1}) = E(\mu) + E(\varepsilon_{t+1}|\Omega_t) = \mu$$

The force of the martingale hypothesis is the assumption that  $\mu$  is a constant, in particular that does not vary with any element of  $\Omega_t$ . Applying the law of iterated expectations,

$$E(r_{t+1}|\Omega_t) = E(p_{t+1} - p_t|\Omega_t) = \mu = E(E(r_{t+1}|\Omega_t)) = E(r_{t+1}) = \mu$$

The expected rate of return conditional on information available at date  $t$  equals the unconditional expectation of the rate of return. Thus, the information available at date  $t$  is of no value in predicting future returns.

### 3.1.2 Martingales and random walks

Martingale is a general form of random walk which is not testable since the martingale hypothesis is just a theory which does not have to be true. For testability purposes, restrictions are imposed on the underlying distribution of asset returns where the random error terms,

$$\varepsilon_{t+k} \text{ for all } k \geq 0$$

, are assumed to be independent over time, independent and identically distributed. However, random walk does not provide justification why additional restrictions should hold.

As stated before, EMH claims that stock prices and returns follow a random walk, where price changes are independent of each other. This is achieved due to the fact that investors react instantaneously to any informational advantages they have, thereby eliminating arbitrage opportunities. Thus, prices always fully reflect the information available and no profit can be made from information based trading (Lo and McKinley, 1999). This leads to a random walk where the more efficient the market, the more random the sequence of price changes, hence the dawn of unpredictable asset prices.

### 3.1.3 Empirical evidence for random walk for asset prices

Under the random walk framework, asset returns are uncorrelated across time periods; therefore empirical tests on random walk are based upon testing the hypothesis of non-correlation. This is written as

$$\text{Cov}(r_t, r_{t+1} \dots r_{t+k}) = 0.$$

In general, there have been mixed results. Evidence of non-zero autocovariances between returns has been documented where predictability has been found to increase with time horizons. For instance, (McKinley and Lo 1999) empirical tests results reveal that short term stock prices have a positive correlation, while in the long run there is a negative correlation observed, and stock return depicted a mean reversion tendency. Fama (1970) conclusion on time horizon predictability was that, short term predictability was limited where daily, weekly and monthly returns are somewhat predictable but with little magnitude such that transaction costs could eventually wipe out any gains from predictability. Shiller (1981) asserts that stock prices are excessively volatile in the short run and at a horizon of few years; the overall market is quite predictable.

However, empirical tests have often been faced with limitations such as data mining which finds patterns that vanish out of sample, and the use of small sample sizes which are susceptible to unreliable statistical tests.

## 3.2 Empirical Methodology

### 3.2.1 Unit Root Test

Since the nature of the data is time series, it is imperative to check for serial correlation in the error term, before carrying out serial correlation analysis. To examine the stationarity properties of the time series of the NSE 20 and All Share Indices, the Augmented Dickey-Fuller (ADF) test was instituted.

The general structure of the ADF test equation is given as:

$$\Delta r_t = \alpha_0 + \beta_1 t + \rho r_{t-1} + \sum \sigma_k \Delta r_{t-k} + \varepsilon_t \dots \dots \dots (1)$$

Where:  $\Delta$  is the first difference operator,  $\Delta r_t = r_t - r_{t-1}$ ,  $\sigma_k$  are coefficients,  $\beta_1$  is the coefficient of the time trend for  $r_t$ ,  $\rho$  is the coefficient of the lagged 1st difference  $r_{t-1}$  and  $\varepsilon_t$  is a white noise error term.

If the series is not stationary and only becomes stationary after differencing it once, it is said to contain a unit root.

### 3.2.2 Serial correlation analysis

This statistical technique was adopted in this study to examine the weak-form hypothesis. The random walk model was used as the model of investigation, which is mathematically written as:

$$r_t = r_{t-1} + \varepsilon_t \dots \dots \dots (2)$$

Where  $r_t$  is the return at time  $t$ ;  
 $r_{t-1}$  is the return in the immediate preceding period; and  
 $\varepsilon_t$  is the random error term

The returns were calculated by the following formulae  $r_t = p_t - p_{t-1}$  and the random error term is a white noise variable assumed to be random from previous price changes.

The reason for selecting serial correlation is that the coefficient of the random walk model measures the degree of dependence between itself ( $\varepsilon_t$ ) and its value of  $n$ th period earlier ( $\varepsilon_{t-n}$ ). This is formally defined as:

$$r_t = \frac{\text{covariance}(\varepsilon_t, \varepsilon_{t-n})}{\text{variance}(\varepsilon_t)} \dots \dots \dots (3)$$

Drawing from the serial correlation analysis, if it is found that the calculated serial correlation coefficient is not statistically different from zero, it follows that the conclusion that the random walk model is valid. This means that the previous stock price movement cannot be used to predict future behavior of stock price movement. This conclusion is an extrapolation of the weak-form efficiency market hypothesis.

The general structure of serial correlation test carried is given below:

$$\Delta\varepsilon_t = \varepsilon_{t-1} + y_1\Delta\varepsilon_{t-1} + y_2\Delta\varepsilon_{t-2} + y_3\Delta\varepsilon_{t-3} + \dots + y_n\Delta\varepsilon_{t-n}$$

Where  $\varepsilon_t$  is the residual from the regression;  $\gamma_n$  are coefficients of the lagged residuals, while  $\Delta\varepsilon_t = \varepsilon_t - \varepsilon_{t-1}$ . If autocorrelation is present, this implies that investors in the NSE are not rational. Ljung-Box Q statistics were used to test for autocorrelations; which follows the chi-square distribution.

### **3.3 Nature of the Data**

For empirical data, the values of NSE 20 share Index and All Share Index between January 1999 and January 2013 were used to calculate the overall return of the Nairobi Securities Exchange. These two indices were where the  $r_t$  for the random walk model was computed from. The indices are the most widely used to evaluate an investors' return. The analysis was carried out on Eviews 5.

## 4.0 Empirical Results

### 4.1 Unit Root Test Results

The result of the unit root test is presented in the tables below.

**Table 4.1 (a)**

Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(ALLRT)				
Method: Least Squares				
Included Observations: 924 after adjustments				
Null Hypothesis: ALLRT has a unit root				
Exogenous: Constant				
Lag Length: 0				
Variable	Coefficient	Standard Error	t-Statistic	Probability
ALLRT(-1)	-0.655962	0.030967	-21.18230	0.0000
C	0.000321	0.000200	1.608765	0.1080
R-squared	0.327346	Mean dependent var	1.54E-05	
Adjusted R-squared	0.326616	S.D. dependent var	0.007382	
S.E. OF regression	0.006058	Akaike info criterion	-7.372830	
Sum squared resid	0.033833	Schwarz criterion	-7.362378	
Log likelihood	3408.248	F-statistic	448.6899	
Durbin-Watson Stat	2.021470	Prob(F-statistic)	0.000000	

**Table 4.1 (b)**

Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(NSE20)				
Method: Least Squares				
Included Observations: 924 after adjustments				
Null Hypothesis: NSE20 has a unit root				
Exogenous: Constant				
Lag Length: 1				
Variable	Coefficient	Standard Error	t-Statistic	Probability
NSE20(-1)	-0.579983	0.037238	-15.57483	0.0000
D(NSE20(-1))	-0.105684	0.032725	-3.229501	0.0013
C	0.000230	0.000191	1.207591	0.2275
R-squared	0.332797	Mean dependent var	1.60E-05	
Adjusted R-squared	0.331346	S.D. dependent var	0.007069	
S.E. OF regression	0.005780	Akaike info criterion	-7.465411	
Sum squared resid	0.030741	Schwarz criterion	-7.449720	
Log likelihood	3448.287	F-statistic	229.4451	
Durbin-Watson Stat	2.009121	Prob(F-statistic)	0.000000	

As observed from the ADF test shown in tables 4.1 for both the All Share Index and NSE 20 share Index, the time series was non stationary. To achieve stationarity, the returns series was differenced once. The results show that the series was non-stationary in levels and stationary in first difference form. Therefore, the NSE 20 and All Share indices' returns are integrated of order one, I (1). This leads to a preliminary conclusion that the Nairobi Securities Exchange is not efficient at level but becomes stationary after first difference. Hence, the null hypothesis on stationarity was rejected in the series.

## 4.2 Serial Correlation Test

Table 4.2 (a)

SERIES: ALLRT				
Included Observations: 925				
Lag	Autocorrelation	Partial Correlation	Q-Stat	Probability
1	0.341	0.341	107.81	0.000
2	0.148	0.036	128.20	0.000
3	0.124	0.071	142.43	0.000
4	0.056	-0.012	145.35	0.000
5	0.036	0.010	146.54	0.000
6	-0.007	-0.034	146.59	0.000
7	0.038	0.052	147.90	0.000
8	0.044	0.020	149.71	0.000
9	-0.007	-0.033	149.76	0.000
10	0.008	0.010	149.81	0.000
11	0.000	-0.008	149.81	0.000
12	0.040	0.049	151.34	0.000

**Table 4.2 (b)**

SERIES: NSE20				
Included Observations: 925				
Lag	Autocorrelation	Partial Correlation	Q-Stat	Probability
1	0.352	0.352	115.12	0.000
2	0.216	0.105	158.61	0.000
3	0.131	0.030	174.55	0.000
4	0.037	-0.040	175.85	0.000
5	0.007	-0.014	175.90	0.000
6	-0.008	-0.008	175.95	0.000
7	0.014	0.028	176.15	0.000
8	-0.017	-0.028	176.42	0.000
9	0.043	0.060	178.15	0.000
10	0.023	-0.005	178.65	0.000
11	0.011	-0.007	178.77	0.000
12	0.025	0.014	179.33	0.000

It can be observed from tables 4.2 (a) and (b) that the coefficients of the lag variables were positive and highly significant. The fact that the serial correlation coefficients are positive indicates that successive daily price changes tend to have the same sign, meaning that a positive (negative) stock price at time  $t$  is likely to be followed by a positive (negative) change in stock price at time  $t+1$ .

This leads to the conclusion that stock prices in the NSE can be explained by previous stock prices and that the NSE is therefore information inefficient. This implies that previous stock returns can effectively predict current stock prices. The results from serial correlation analysis contradicts evidence from literature that the stock market is informational efficient and that stock prices exhibit randomness.

## **5.0 Conclusion**

The study focused on the NSE 20 and NSE All Share Indices in the Nairobi Stock Exchange. The main issue investigated was whether the behaviours of the price series in the market were consistent with the weak-form of the EMH. Results from the individual serial correlation coefficients indicated that they were statistically different from zero.

The efficient market hypothesis is founded on the premise that stock prices fully reflect all available information in the market. Although empirical evidence from developed and emerging stock market support the efficient market hypothesis, this empirical analysis of the Nairobi Securities Exchange revealed that it exhibits informational inefficient. This means that a financial analyst trading in this stock market cannot solely rely on previous stock prices to predict the pattern of future price changes and future stock return.

### **5.1 Recommendations**

The policy makers must seek to enhance informational efficiency of the NSE by ensuring strong and adequate supervision by the regulatory authorities. In addition, the above conclusion, the findings of this study opens up other avenues of research, for instance to identify the phenomena of inefficiency in the Nigerian stock market. An extension of study into this area would go a long way in improving the policy implications and the rigor of the study findings.

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