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TEST OF RANDOM WALK ON SELECTED STOCK MARKETS IN AFRICA

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ABSTRACT

This study investigated the efficiency market theory in four (4) selected African stock markets (Nigeria, South Africa, Kenya and Morocco) proxied by their All-share indices from the perspective of random walk hypothesis using the variance ratio tests. Daily market returns data from 01/02/2012 to 26/03/2020 obtained from the individual national stock markets via their official websites was employed. The findings of the study evince that over the study period, the daily returns movement on Nigeria stock exchange All-share index is affected by historical price information; hence, Nigeria stock market follows the random walk pattern whereas the daily returns movement on South Africa FTSE-JSE stock exchange index, Kenya (Nairobi) stock exchange index and Morocco (Casablanca) stock exchange index are not affected by historical price information; hence, South Africa, Kenya and Morocco stock markets do not follow the random walk pattern. We therefore conclude that African stock markets are largely inefficient; hence, they are characterized by market anomalies and momentum effects implying that financial resources are not efficiently and effectively mobilized. Also, there is lack of evidence of weak form efficiency in African markets which also implies the existence of arbitrage opportunities which would lead to abnormal returns or profits if well exploited. From the findings of this study, we recommend amongst others that there is need for investors and traders in the African stock markets to exploit the existing arbitrage opportunities that are created by market anomalies in order to possibly beat the stock markets and earn abnormal returns. This can be achieved by using market trading strategies that are consistent with technical analysis such as day-of-the week momentum strategy.

KEYWORDS

Random walk hypothesis, efficient market theory, all-share index, market returns,buy and hold' strategy, stock exchange, investors' behaviours

1.0 Introduction

The random walk hypothesis is a financial theory which assumes that stock market prices move randomly (in a completely unpredictable way) and are not influenced by its own historical movement, thus cannot be reliably predicted. The theory also assumes that the movement in the price of one security is independent of the movement in the price of another security. If stock markets are indeed random, then markets are efficient, reflecting all available information.This directly implies that it is impossible to predict future price movements and/or consistently outperform the market in the long run basis using either technical or fundamental analysis. An investor should only be able to beat the overall market average by luck or chance. Random walk theory has been a subject of debate amongst market practitioners and financial economists, whereas some agree with the theory, others have challenged the theory pointing out instances where stock prices did not move randomly. According to the critics of the theory, the market can be outperformed through careful analysis (fundamental or technical) and devoting a significant amount of time, effort and understanding in research to enable identification of trends and patterns amongst the chaotic market movements irrespective of random market behaviour.Random walk hypothesis is consistent with the efficient market hypothesis (EMH) as both theories agree that it is impossible to beat the performance of the stock market and attempting to do so would incur huge amounts of additional risk.The difference between the two theories lie in the fact that for EMH, prices reflect all the relevant information regarding a financial asset whereas for random walk, prices literally take a 'random walk' and can even be influenced by 'irrelevant' information. Owing to the fact that longer-term positions will have the most chance of success according to the theory, subscribers to the hypothesis recommend a ‘buy and hold’ strategy.

In financial economics, the efficient market hypothesis (EMH) as developed by Fama (1970) states that the market cannot be beaten because current assets prices fully reflect all important available information, hence, stocks trade at the fairest value, making it impossible for investors to either purchase undervalued stocks or sell stocks at inflated prices.There are three variants of the EMH; the “weak”, “semi-strong”, and “strong” form. The weak form claims that stock prices already reflect all available public information of past prices and that no form of technical analysis can aid investors in making trading decisions, in other words, trends do not matter. The semi-strong form of the EMH claims that current prices reflect all publicly available information and that prices instantly change to reflect new public information, hence, it is impossible forinvestors to utilize either technical or fundamental analysis to gain higher returns in the market. However, information not available to the public can aid investors to boost their returns to a performance level higher than that of the general market. The strong form of the EMH further claims that current stock prices fully and immediately reflect all available public and private information, hence, it is difficult for an investor toachieve superior returns (returns on investments that exceed normal market returns), irrespective of information retrieved or research conducted.

The efficiency of the stock market in the economic growth and development of a country cannot be overemphasized as it provides a tool for mobilizing national savings, financing new investment projects and channelling financial and investment resources into productive ventures, in addition to providing opportunities for investors to diversify their investment portfolios. Stock market efficiency is of utmost importance to all the various economic agents particularly the market practitioners and policy makers.According to Fama (1970), an ideal market is a market where stock prices provide accurate signals for resource allocation. African financial markets has a weak status in the market efficiency hypothesis, hence, accommodates fewer international investors (Amadou, 2021). Several studies relating to market efficiency with respect to African stock markets have been conducted by

several scholars (Ntim, Opong, Danbolt &Dewofor, 2009; Appiah-Kusi &Menyah, 2003; Magnusson &Wydick, 2002; Bundoo, 2000; Smith et al., 2002; Dickinson &Muragu, 1994; Olowe, 1999) etc.) to determine the status of the market and reached the same conclusion that the African stock market is inefficient or efficient in the weak form. This characterization is partly due to their developmental stage and partly due to its low speed of processing trading information, which has resulted in asset mispricing and resource misallocation. Also, the existence of manipulation in the market, insider trading and slow pace of provision of security and market information to the market, and the dependence of security prices determination on security and market information on prior periods resulted in the description of the Nigerian stock market and its African counterparts as inefficient in the weak form (Adelegan, 2003).African markets are frequently hard to penetrate, located in war-torn regions or countries subject to sanctions, hence, have a long time history of neglect by international investors (Simons & Laryea, 2005).

The issue of whether stock prices are predictable has continued to dominate economics and finance literature, despite being an agelong debate. The efficient market theory (Bachelier, 1900;Fama, 1970)implies that the predictability of stock market is not possible since stock prices are fairly determined, move at random, and already reflect all known information in the market including previous price information.According to Fama (1970), market efficiency can exist at three levels (strong form, semi strong form and weak form) depending on the extent and speed of information flow in the market. The strong form efficiency implies that stock prices reflect all known and available information including insider information, while the semi-strong form efficiency imply that stock prices reflect all publicly available information. The weak form efficiency implies that stock prices reflect only information about previous market prices. While both the strong form and semi strong form efficiency have been related to developed stock markets, it is believed that African markets and other developing stock markets are either efficient in the weak form or not efficient at all levels.

With the recent adoption of AfCTA(African Continental Free Trade Area) by all African countries, it has become important to examine the extent of stock market efficiency in African stock markets. This would provide an insight, not only on whether relying on historical price information can help individual investors toidentify which stocks are underpriced or overpriced forpossibility of earning abnormal profits both within and across African markets, but also would help policy makers and regional actors to identify the level of efficiency of the individual African markets so as to design appropriate policy response that would guarantee smooth transition from isolated to a more integrated markets.

Fortunately, there are several studies on the predictability of the stock market in the context of Africa. However, previous studies have reported conflicting evidence regarding the impact of previous price market information on the current and future market trend. While some studies have reported evidence that are consistent with market efficiency, others announced that African markets are inefficient due to market anomalies and momentum effects. This study therefore contributes to the on-going debate by investigating the link between previous stock returns and both current and future market returns in African stock marketsusing both the variance ratio test and Threshold Generalized Autoregressive Conditional Heteroscedastic(TGARCH) framework withGeneralized Error Distribution (GED) distribution, which allows for asymmetric volatility effects, a common feature of stock returns. More so, the study seeks toexamine the weak form efficiency and random walk hypothesis of African stock markets (Nigeria, South Africa, Kenya and Morocco) using the daily returns on national stock market indices from 01/02/2012 to 26/03/2020.

This study is significant as it deviates from previous studies in two ways. First, the use of TGARCH model to test the random walk model in African stock markets is novel as none of the previous studies (to our knowledge) incorporated the asymmetric effect in their stock returns predictability model. Secondly, the estimation of TGARCH model assuming GED errors while testing the random walk hypothesis in African stock markets is also novel in literature.

2.1. Conceptual Framework

2.1.1 Concept of Stock Market

Although common, the term stock market is somehow abstract for the mechanism that enables the trading of company stocks. It is also used to describe the totality of all stocks, especially within a country, for example in the phrase "the stock market was up today", or in the term "stock market bubble". Stock market is different from a stock exchange, which is an entity (a corporation or mutual organization) in the business of bringing buyers and sellers of stock together.

2.1.2 Stock Market Participants and Trading

Many years ago, worldwide, buyers and sellers were individual investors such as wealthy businessmen, with long family histories (and emotional ties) to particular corporations (think Ford). Over time, markets have become more institutionalized with buyers and sellers largely institutions e.g. pension funds, insurance companies, mutual funds, hedge funds, investor groups and banks. The rise of institutional investor has brought with it some improvements in stock market operations, but not necessarily in the interest of the small investors or even of the naïve institutions, of which there are many. Now, participants in the stock market range from small individual stock investors to large hedge fund traders, who can be based anywhere. Their orders usually end up with a professional at a stock exchange, who executes the order. Most stocks are traded on exchanges e.g. NYSE, which are places where buyers and sellers meet and decide on a price. Some exchanges are physical locations where transactions are carried out on a trading floor, by a method known as open outcry. The other type of exchange is a virtual kind e.g. NASDAQ, composed of a network of computers where trades are made electronically via traders at computer terminals. Actual trades are based on an auction market paradigm where a potential buyer bids a specific price for a stock and a potential seller asks a specific price for a stock. When the bid and ask prices match, a sale takes place on a first come first serve basis if there are multiple bidders and askers at a given price. The purpose of a stock exchange is to facilitate the exchange of securities between buyers and sellers, thus providing a marketplace (virtual or real). Really, a stock exchange is nothing more than a super-sophisticated farmers' market providing a meeting place for buyers and sellers.

2.1.3 Importance of Stock Markets

Just as it is important that networks of transportation, electricity and telecommunications function properly, so is it essential that payments can be transacted, capital can be saved and channelled to the most profitable investment projects and that both households and firms get help in handling financial uncertainty and risk as well as possibilities of spreading consumption over time. Financial markets constitute an important part of the total infrastructure for every society that has passed the stage of largely domestic economies. Stock market which is part of the financial markets, perform the following functions in an economy:

1. **Raising Capital for Businesses:** The stock exchange provides companies with the facility to raise capital for expansion through selling shares to the investing public.

2. **Mobilizing Savings for Investment:** When people draw their savings and invest in shares, it leads to a more rational allocation of resources because funds, which could have been consumed or kept in idle deposits with banks, are mobilized and redirected to promote business activity with the benefits for several economic sectors such as agriculture, commerce and industry, resulting in a stronger economic growth and higher productivity levels.
3. **Facilitate Company Growth:** Companies view acquisitions as opportunity to expand product lines, increase distribution channels, hedge against volatility, increase its market share or acquire other necessary business assets. A takeover bid or merger agreement through the stock market is the simplest and most common way to company growing by acquisition or fusion.
4. **Redistribution of Wealth:** By giving a wide spectrum of people a chance to buy shares and therefore become part owners (shareholders) of profitable enterprises, the stock market helps to reduce large income inequalities. Both casual and professional stock investors through stock price rise and dividends get a chance to share in the profits of promising business that were set up by other people.
5. **Corporate Governance:** By having a wide and varied scope of owners, companies generally tend to improve on their management standards and efficiency in order to satisfy the demands of these shareholders and the more stringent rules for public corporations by public stock exchange and the government. Consequently, it is believed that public companies (companies that are owned by shareholders who are members of the general public and trade shares on public exchanges) tend to have better management records than privatively held companies (those companies where shares are not publicly traded, often owned by the company founders and/or their families and heirs or otherwise by a small group of investors). However, some well-documented cases are known where it is alleged that there has been considerable slippage in corporate governance on the part of some public companies (e.g. famous Enron Corporation, MCI WorldCom, Pets.com, Webvan or Parmalat).
6. **Creates Investment Opportunities for Small Investors:** As opposed to other businesses that require huge capital outlay, investing in shares is open to both the large and small stock investors because a person buys the number of shares they can afford. Therefore the stock exchange provides an extra source of income for small savers.
7. **Government Raise Capital for Development Projects:** The Government and even local municipalities may decide to borrow money in order to finance huge infrastructure projects such as sewerage and water treatment works or housing estates by selling another category of securities known as bonds. These bonds can be raised through the stock exchange whereby members of the public can buy them. When the government or municipal council gets this alternative source of funds, it no longer has the need to overtax the people in order to finance these development projects.
8. **Barometer of the Economy:** At the stock exchange, share prices rise and fall depending, largely on the market. Share prices tend to rise or remain stable when companies or the economy in general show signs of stability. Therefore, the movement of share prices can be an indicator of the general trend in the economy.

2.1.4 Morocco's Stock Market

Morocco's stock exchange in Casablanca is the third oldest in Africa being established in 1929. There is only one index and this is known as the 'the index de la Bourse des Valeurs de Casablanca'. It currently has fourteen members with below fifty listed securities. In 1993, the stock exchange saw a major reformation that has led to the installation of a modern electronic trading system with the future

hope of implementing a central scrip depository. There are no restrictions when it comes to foreign investment or foreign ownership of companies on the stock exchange. However local and foreign investors receive a 10% tax implication on dividends but no capital gains tax. Casablanca and the Tunis stock markets are covered by a quarterly report that includes individual indexes for each market on the Arab stock exchange which was established by the Arab Monetary fund based in Abu Dhabi.There are about 66 listed companies in Morocco's stock market across several sectors like Insurance, Construction & Building Materials, Oil & Gas, Real estate participation and promotion, Real estate investment, Banks, Distributors, Food producers & Processors, Transport, Engineering & Equipment Industrial Goods, Holding Companies, Investment Companies & Other Finance, Materials, Software & Computer Services, Telecommunications, Utility, mining, Forestry & Paper, chemicals, Electrical & Electronic Equipment, Pharmaceutical Industry, beverages, Leisures and Hotels, Transportation Services, electricity, transport, Holding Companies (**Source:**http://www.casablancabourse.com/bourseweb/en/ListedCompany.aspx?IdLink=245&Cat=7). The Moroccan Capital Market Authority (AMMC) regulates the Morocco's stock exchange in Casablanca.

2.1.5 Kenya Stock Market

The Nairobi Stock Exchange (NSE) was established in 1954 and became officially recognized as an overseas stock exchange by the London Stock Exchange. The NSE continued to grow and eventually became a major financial stock exchange institution. Currently, it continues to avail new products such as ETFs (Exchange Traded Funds), Carbon Credits, Financial and Commodity Derivatives as well as Mobile based products for example M-Akiba. The products traded at NSE are shares/equities and bonds/debt instruments. The NSE is located in the central business district of Nairobi, on the first floor of the Nation Centre building. In fact, the NSE has now adapted the automated trading system and currently trades over a 100 million shares per month. Trading takes place only five days a week Monday to Friday and between 10 am and noon.The official website of NSE offers investors a chance to monitor their movement of stocks and trading action. There are about 66 listed companies in Kenyan stock marketacross several sectors like finance, industrial, basic materials, consumer goods and services, utility, telecom, oil and gas(Source: https://www.african-markets.com/en/stock-markets/nse/listed-companies).The Capital Markets Authority of Kenya, also known as Capital Markets Authority (CMA) in short, is an independent government financial regulatory agency responsible for supervising, licensing and monitoring the activities of market intermediaries, including the stock exchange, and the central depository and settlement system and all the other persons licensed under the Capital Markets Act of Kenya.

2.1.6 South African Stock Market

The Johannesburg Stock Exchange ("JSE") located at 1 Exchange Square, 2 Gwen Lane, Sandton, Johannesburg, South Africa. The JSE offers secure, efficient primary and secondary capital markets across a diverse range of securities, supported by their post-trade and regulatory services.The JSE is currently ranked the 19th largest stock exchange in the world by market capitalisation and the largest exchange in the African continent.

The JSE was formed in 1887 during the first South African gold rush. Following the first legislation covering financial markets in 1947, the JSE joined the World Federation of Exchanges in 1963 and upgraded to an electronic trading system in the early 1990s. The bourse demutualised and listed on its own exchange in 2005.In 2003, it launched an alternative exchange, AltX, for small and mid-sized listings, followed by the Yield X for interest rate and currency instruments. The JSE then acquired the South African Futures Exchange (SAFEX) in 2001 and the Bond Exchange of South Africa (BESA)

in 2009. Today we offer five financial markets namely Equities and Bonds as well as Financial, Commodity and Interest Rate Derivatives.

There are about 400 listed companies in South African stock market across several sectors like financial services, banking, Real Estate Investment Trusts, Chemicals, Real Estate Investment & Services, Software & Computer Services, Pharmaceuticals & Biotechnology, Support Services, Health Care Equipment & Services, General Retailers, Industrial Metals & Mining, Media, Construction & Materials, Food Producers, Aerospace &Defense, Technology Hardware & Equipment, Electronic & Electrical Equipment, Mining, Support Services, Beverages, General Industrials, Pharmaceuticals & Biotechnology, Personal Goods, Industrial Engineering, Industrial Metals & Mining, Health Care Equipment & Services, Tobacco, Oil Equipment, Services & Distribution, Software & Computer Services, Electronic & Electrical Equipment, Industrial Transportation, Technology Hardware & Equipment, General Retailers, Media, Travel & Leisure, Food & Drug Retailers, Life Insurance, Food Producers, Fixed Line Telecommunications, Nonlife Insurance, Oil & Gas Producers, Industrial Transportation, Forestry & Paper, General Industrials, Fixed Line Telecommunications, Automobiles & Parts, Electricity. Automobiles & Parts, Household Goods & Home Construction, Mobile Telecommunications
(Source: https://www.african-markets.com/en/stock-markets/jse/listed-companies**).**

The Financial Services Board (FSB) was the government of South Africa's financial regulatory agency responsible for the non-banking financial services industry in South Africa from 1990 to 2018. It was an independent body which had a mandate to supervise and regulate the non-bank financial services industry in the public interest. This included the regulation of the biggest stock exchange in Africa the Johannesburg Stock Exchange. From 1 April 2018 the FSB was split into prudential and market conduct regulators.

2.1.7 The Nigerian Stock Market

The Nigerian Stock Exchange (NSE) was established in1961 as the Lagos Stock exchange but its name was later changed to the Nigerian Stock Exchange in 1977. The stock exchange council was inaugurated on September 15, 1960 and operations began officially on August 25, 1961 with 19 securities listed for trading. As at November 2019, the equity market has a total of 161 listed companies with 8domestic companies on the premium board, 144 companies on the mainboard, and 9 companies on the alternative securities Market (ASeM) board. When it comes to the fixed income market, the NSE has 84 FGN bonds, 21 state bonds and 27 corporate bonds, 1 supranational bond and 5 memorandum listings. Operations of the NSE were initially conducted inside the Central Bank building with the exchange having four firms as market dealers namely, Inlaks, John Holt, C.T. Bowring and the Investment Company of Nigeria (ICON). In 1977, it became known as the Nigerian Stock Exchange and by that time, the Nigerian Stock Exchange had branches established in some major Nigerian commercial cities. There are about 161 listed companies in Nigerian stock market across various sectors like financials, consumer goods and services, health care, industrial, oil & gas, basic materials, technology, telecom,
(Source: https://www.african-markets.com/en/stock-markets/ngse/listed-companies).
The Nigerian stock exchange is currently regulated by the Security and Exchange Commission, which is a commission guided by mandate to deter and detect unfair manipulations and trading practices in Nigeria.

2.2 Theoretical Framework

2.2.1 Random Walk Hypothesis

Many theorists examine the behavior of stock prices, and the random walk hypothesis attempts to explain why stocks move the way they do. The random walk hypothesis states that stock market prices change in a random manner, and therefore, you can't predict what price movements will occur in advance. The theory argues that each change is independent of previous changes, and so the trends that many investors see in stock charts aren't meaningful. Made popular by Professor Burton Malkiel of Princeton in his 1973 book, A Random Walk Down Wall Street, the random walk hypothesis has implications for both short-term traders and long-term investors.

Random walk theory suggests that changes in stock prices have the same distribution and are independent of each other. Therefore, it assumes the past movement or trend of a stock price or market cannot be used to predict its future movement. In short, random walk theory proclaims that stocks take a random and unpredictable path that makes all methods of predicting stock prices futile in the long run.Random walk theory believes it's impossible to outperform the market without assuming additional risk. It considers technical analysis undependable because chartists only buy or sell a security after an established trend has developed. Likewise, the theory finds fundamental analysis undependable due to the often-poor quality of information collected and its ability to be misinterpreted. Critics of the theory contend that stocks do maintain price trends over time – in other words, that it is possible to outperform the market by carefully selecting entry and exit points for equity investments.The name of the random walk hypothesis refers to the broader concept of the random walk, which is a mathematical construct that describes a succession of random events. In finance, the hypothesis assumes that financial markets stock price changes are the random events.

The random walk hypothesis is closely related to the efficient market hypothesis, which also points to the futility of trying to make predictions about stock price movements. The efficient market hypothesis says that stock prices incorporate all available information that's relevant to the underlying company's financial prospects, and so any movement in the stock price that doesn't result from new information is essentially random. Moreover, if you believe that new information affecting a stock is as likely to be positive as it is negative, then the flow of that information is also a random event. That further supports the random walk hypothesis and its explanation of stock price movements.

2.2.2 Efficient Market Hypothesis

Our theoretical model assumes that stock prices/returns are generated by a random walk process, and hence are not predictable. This theoretical model is consistent with the weak-form efficiency of Fama (1970). Hence, the main theory guiding of this study is the efficient market theory originally due to Bachelier (1900) and later by Fama (1970). Fama (1970) made the argument that in a market with well informed and intelligent investors, securities prices will reflect all available information and will be well priced. Therefore, if a market is efficient, no information or analyst can outperform the market. Proponents of the Efficient Market Hypothesis argue that security prices are random and thus there is a zero chance for profitable speculation in the market. The Efficient Market Hypothesis is an assumption that share prices follow a random walk and subsequent prices of shares are independent of previous prices (Rapuluchukwu, 2010). This means that no individual can make excessive profit from trading in securities since share prices are well priced and not predictable (Mishra, 2009).

Samuels and Wilkes (1981) defined an efficient market as a market where prices of securities always reflect fully all publicly available information of the securities. Reilly (1989) sees security prices in an efficient market as one which adjusts rapidly to new and available information and current stock

prices therefore fully reflect all available information including the risk involved. Therefore, an efficient market is such which information are available to the public and also cheap to investors such that share prices are fair. A fair share price is a price that reflects all relevant, available and detectable information in the market. An efficient stock market emerges from the availability of numerous competitive and rational profit maximizing investors.Fama (1970) propounded three forms of efficient market hypothesis based on the type of information in the security prices, namely, weak form, semi-strong from and strong form. “

Assumptions of Fama (1970) based on the weak form efficiency are:

1. Excess return cannot be earned using investment strategies based on historical share prices.
2. Technical analysis technique (study of past stock prices to predict future prices) will not be able to consistently produce excess return though some form of fundamental analysis technique (study of economy, industry and company related factors) will still provide excess returns.
3. Share prices, exhibits no serial dependence, therefore, there is no pattern to asset prices. This implies that future price movement are determined entirely by unexpected information and therefore are random.

The assumptions based on the semi-strong efficiency are:

1. That share prices adjust to publicly available new information very rapidly and in an unbiased fashion such that no excess return can be earned by trading on that information.
2. That neither fundamental nor technical analysis technique will be able to reliably produce excess returns.
3. That to test for semi-strong efficiency, the adjustments to the previous unknown muse must be of a reasonable size and must be instantaneous. To do this, consist upward and downward adjustments after the initial change must be looked for. So, if there are any such adjustments, it suggests that investors have interpreted the information in a bias fashion and hence, in an inefficient manner.

The assumptions of the strong efficiency are:

1. Share prices reflect all information both public and private such that no one can earn excess return.
2. That if there are legal barriers, to private information becoming public as with insider trading laws, strong efficiency is impossible except in the case where the laws are universally ignored.
3. That for the test of the strong form efficiency; a market needs to exist where investors cannot constantly earn excess return over a long period of time.

Malkiel (2003) further restated that no matter the kind of analysis whether technical of fundamental, no analyst can make abnormal return, therefore, market prices will show best estimate of risk and expected returns of all assets based on the information available in the market at that particular time. Gupta and Basu (2007) stated that, Information that are imbedded in the current stock prices are information particular to the entity offering the share and the general market information. All these information follow a random path in their occurrence and the share prices reflect them, thus no investor can accurately predict its occurrence. An interesting future of the random walk hypothesis is the persistence of random walk shock (Mayowa & Richard, 2012). Random walk hypothesis purport that current prices of stock reflect fully all the information contained in the historical sequence of

price. Consequently, predicting future stock prices based on historical prices sequences do not yield excess return to investors. If random walk hypothesis is correct, it implies that it is the direct disapproval of the technical analysis. If there is no value in monitoring and studying past price and price changes, then there is on value for technical analysis (Fisher & Jordan, 2005).

The implications of the Efficient Market Hypothesis are achromatic. Most participants of the market who buy and sell securities are under an assumption that the securities they are buying are worth then the purchase price of the security while the securities they are selling are worth less than price they are being bought. If markets are efficient, anytime securities are sold or bought to outperform the market, the participants will be engaging in a game of chance not skill.

2.3 Empirical Review

The study by Amadou (2021) examined eight (8) African financial markets and tested them under the weak form efficient market hypothesis (EMH). These markets include Johannesburg Stock Exchange (JSE), Uganda Stock Exchange, Kenya Stock Exchange, Lusaka Stock Exchange, Mauritius Stock Exchange, BourseRegionale de Valeurs Mobiles, Botswana Stock Exchange and Nigeria Stock Exchange. The selected markets trade securities from at least 10 firms. Monthly data were collected from January 1998 to January 2018 except for Nigeria which dates from 2010. This weak form was divided into three (3) groups based on the random walk concept (RW3, RW2 and RW1). A market conforming to RW3 is characterized by a random walk and is therefore efficient in weak form. For RW2, it is not possible to predict future volatility by referring top past volatility whereas under RW1, it is neither possible, examining past price information to predict future price movements nor future volatility. Results of the study evinced that Cote d'Ivoire, Nigeria, Uganda and South African markets are characterized by random walk of RW3 whereas the markets in Lusaka, Kenya and Mauritius failed the criteria of random walk of RW3.The test was further carried out with the markets to evaluate if they are efficient in RW2. All the markets successfully passed the random walk test RW2. Finally, only South Africa (Johannesburg Stock Exchange) and Uganda met the criteria of random walk RW1 whereas Cote d'Ivoire and Nigeria did not.

Cavin and Philip (2020) tested the weak form of efficient market hypothesis (EMH) for Nairobi stock exchange (NSE) using daily as well as weekly index data from NSE 20 share index over the three months period. Secondary data was obtained from Nairobi Stock Exchange market website. The results of the study showed that the daily returns as regards skewness and kurtosis were be non-normal. More so, fractional integration using ARFIMA was employed to test long term memory. Furthermore, the traditional unit root test was incorporated to compare both results to ascertain whether NSE stock market is definitely weak form efficient. The NSE-20 share Index stocks were used to make an Exchange Traded Fund that is priced and forecasted. Ultimately, the forecasted values of ETF are done on the trend lines similar to the NSE-20 share Index trends, which helps investors to make informed financial decisions when buying any securities traded in NSE market.

Rui and Hortense (2020) tested the weak form of efficient market hypothesis in some African stock markets (Botswana, Egypt, Kenya, Morocco, Nigeria and South Africa) for the period September 2, 2019 to September 2, 2020. The study actually set out to investigate whether the COVID-19 global pandemic has decreased the efficiency, in its weak form, in these African stock markets. The results of the study evinced that the random walk hypothesis is not supported by the financial markets analyzed during the period of global pandemic. This led to the conclusion that that the indices of African markets do not follow the random walk hypothesis during COVID 19. The results suggest that the ratios of variances are lower than the unit implying that that the yields are autocorrelated in time and, there is reversal to the mean, and no differences were identified between the stock markets

analyzed. This study has revealed that the high sensitivity of prices to the arrival of new information will be attributed to the climate of pessimism and uncertainty experienced by investors during the period.

David, Natalya and Andrew (2020) examined the weak-form efficiency market hypothesis (EMH) for 8 African Frontier markets (South Africa, Botswana, Mauritius, Kenya, Nigeria, Tunisia, Egypt and Morocco) which collectively account for over 95 percent of total market activity in the content using two sets of time series data (daily and weekly)over the period 2003-2017, with the exception of the data for the Nairobi Stock Exchange whose data only starts from 2006. The study employed a nonlinear unit root test (i.e. ADF, PP and KPSS tests) augmented witha FFF on each of the series, which is considered robust enough to both nonlinearities and smooth structural breaks. The empirical findings of the study using KSS tests augmented with a FFF evinced that of all the countries studied, only the stock exchanges in Kenya and Botswana that provided evidence of weak-form EMH and attributable to lack of participation in market activity in these exchanges.More so, the study showed that irrespective of whether daily or weekly series are employed, most African frontier markets are weak form inefficient, excluding the Kenyan stock market and to a very much lesser degree the Botswana and South African stock series.

Cherono (2020) used firm-level data to examine the extent to which the market responds to investor behaviour in terms of herding, loss aversion, mental accounting and overconfidence. A sample of 48 listed companies was considered and the panel data regression framework was employed. The study found a significant market response to investor behavioural biases, which suggests evidence of market inefficiency.

Falloul (2020) considered the weak form efficiency theory in the Moroccan stock market using daily data from 01/01/2002 to 28/09/2018. The results obtained from fitting an ARFIMA model to market returns on Casablanca stock exchange All-share index indicates that Moroccan stock market is characterized by chaotic dynamic and long memory effects, invalidating the random walk hypothesis. This implies that the Moroccan market is largely inefficient.

Lekhal and El Oubani (2020) employed both linear and nonlinear tests to evaluate the evolution emerging stock market efficiency from the perspective of the Adaptive Market Hypothesis (AMH), focusing on the Moroccan stock market. They argued that AMH implies the existence of profit opportunity arising from time to time depending on the extent to which the market is efficient as well as market conditions. They used the daily market returns series for Moroccan stock exchange All-share index from 02/01/1992 to 10/09/2019. The results from different testing procedures, which validates the AMH, show that while the degree of market efficiency is time varying, the presence of momentum effects depends on both the degree of market efficiency and certain market conditions. This implies that the Moroccan stock market is inefficient, hence investors can exploit the market efficiency and certain market conditions using the momentum trading strategy.

Osabuohien-Irabor (2020) examined whether African stock market indices follow a random walk process or are mean reverting in the presence of multiple structural shocks. The stock markets considered are those of Botswana, Cote D'Ivoire, Nigeria, Egypt, South Africa, Kenya, Mauritius, Morocco Namibia, Senegal, Tanzania, Tunisia, Uganda and Zambia. They used weekly data from for the period May 31, 2009 to April 19, 2020. The results obtained from unit root tests with structural breaks show that most of the sampled African markets follow the random walk process; hence, they are efficient in the weak form. The two exemptions are Botswana and Senegal whose stock indices exhibit mean reversion behaviour.

Ogbonna and Ejem (2020) revisited the weak-form efficiency hypothesis in Nigeria using different parametric statistical testing frameworks: namely, ADF test, serial correlation test, Granger causality and ARCH/GARCH frameworks. They applied these tests on two sets of market price data: (1) daily All-share index from 02/01/2014 to 20/05/2019 and (2) yearly All-share index from 1985 to 2018. They found no evidence of weak-form market efficiency which implies that Nigerian stock market is inefficient.

Ejem, Ogbonna and Okpara (2020) employed three econometric frameworks (Unit root test, GARCH model and Autocorrelation test) to reconsider the debate on which information efficiency level describes the Nigerian stock market. They used both daily (from 02/01/2014 to 20/05/2019) and yearly (1985 to 2018) market (All-share index) data. They found that there is significant relationship between stock market data and their previous values, hence they conclude that Nigerian stock market is not efficient even in the weak form.

Andabai(2019) employed the Augmented Dickey Fuller (ADF) test to examine the extent to which Nigerian stock market returns can be predicted based on historical returns information using market-level data from 1990 to 2007. The results indicate no evidence of weak-form efficiency as previous market returns can satisfactorily predict current and future market returns. Hence, they concluded that the Nigerian stock market is not efficient, implying that profit opportunity can be explored using the technical analysts' price prediction strategy.

Gbalam and Nelson (2019) tested the weak form efficiency of the Nigeria stock exchange market. Nigerian stock exchange all share historical daily, weekly and monthly returns were employed for the analysis. The data was analysed using unit root tests of stationarity and random walk, Jarque-Bera for normality and graph presentation. The results revealed that, the Nigerian stock exchange all share historical daily, weekly and monthly returns exhibited significant random walk. The study concludes that the Nigerian stock exchange market is efficient in the weak form.

Tiwari, Aye and Gupta (2019) employed the MF-DFA (Multifractal Detrended Fluctuation Analysis) framework to test the multifractality and efficiency of both developed and emerging stock markets in including South Africa. The other emerging market included their sample is India while eight developed stock markets are considered which are Canada, USA, France, Germany Switzerland, Italy UK and Japan. They used monthly market data covering nearly a century to test both the long run and the short run dimensions of market efficiency. They find, among other things, evidence of stock market efficiency in the long run than the short run.

Focusing on the BRICS countries, Kiran, Mallikarjuna and Rao (2019) employed both parametric and non-parametric testing frameworks to examine the extent of market efficiency in emerging markets using daily market returns data from 01/01/2000 to 31/03/2018. They divided their sample into three periods: namely, pre-crisis, crisis and post crisis periods. The results based on serial correlation test, runs test and Ljung box test show that all the BRICS (Brazil, Russia, India, China and South Africa) markets are efficient at the weak form in the crisis period. However, when the Hurst exponent test is applied, the results show that only the Russian stock market is efficient for the entire sample period.

Mangeni and Mike (2018) considered the weak form efficiency in the Kenyan stock market by testing whether the Nairobi stock exchange exhibits the random walk features. In particular, the study tested for the existence of the market anomalies such as day of the week effect and month of the year effect on stock market returns using daily data from 2001 to 2015. The results obtained from the t-test and

ANOVA indicate the presence of seasonal anomalies in the Kenyan stock market, implying that the market is not efficient in the weak form.

The study by Emmanuel, Paul, Mensah and Ohene-Asare (2018) re-examined the weak form efficiency of five African stock markets (South Africa, Nigeria, Egypt, Ghana and Mauritius) over the period 2000-2013. The weekly returns of S&P/IFC return indices for the selected African countries were obtained from DataStream and analysed using various tests to ascertain the impact of non-linearity effect and thin trading which are prevalent in African markets on market efficiency. The study adopted the newly developed Non-Linear Fourier unit root test to test the Random Walk Hypothesis (RWH) for the five markets, and an augment regression model. The findings of the study show thatusing Non-Linear Fourier unit root test, the stock markets in South Africa, Nigeria and Egypt follow the RWH and weak-form efficient whilst Ghana and Mauritius are weak-form inefficient. More so, evaluating the non-linear models without adjusting for thin trading effect shows that South Africa and Ghana markets are weak-form efficient while Nigeria, Egypt and Mauritius are not. However, after accounting for thin trading effect, the results showed that South Africa and Egypt markets follow the RWH. From the findings, the authors concluded that market efficiency results depend on the methodology used.

Graham and Gillian(2006) tested random walk hypothesis for four stock index futures and a sample of 36 single stock futures traded on the JSE Securities Exchange, South Africa, using joint variance ratio tests based on *(i)* ranks and signs and *(ii)* wild bootstrapping. The results of the study show that there is a high degree of weak-form efficiency as all four stock index futures and twenty-five out of the sample of 36 single stock futures follow a random walk.

3.0 Methodology

This study focused on testing the well-established weak form efficient market and random walk theories in selected stock markets in Africa using quantitative aggregate market-level data. This requires the application of scientific methods to study investors' behaviours regarding asset allocation, risk pricing and valuation in selected stock markets in Africa. Thus, our epistemological position is positivism while our research approach is deductive, which allows us to formulate several hypotheses relating to stock market efficiency, which must be subjected to empirical evaluations based on economic and finance theories (Bryman, 2012). This study is a market-level research focusing on African stock markets; hence, its population comprises all aggregated stock markets in Africa.There are31 stock markets (29 national stock exchanges and 2 regional stock exchanges) in Africa (Source: https://en.wikipedia.org/wiki/List_of_African_stock_exchanges).

Although, our study population is countable and small, there is need to obtain a valid sample, since daily price data observations are not available or accessible for several stock markets. Accordingly, we selected four stock markets: namely Nigeria stock exchange (Nigeria), Johannesburg stock exchange (South Africa), Nairobi stock exchange (Kenya) and Casablanca stock exchange (Morocco). These stock markets represent the four regional blocks (East, West, North and South) and are selected judgmentally based on data availability. The secondary data for the study consists of daily returns on the selected stock market indices for the period from 01/02/2012 to 26/03/2020 and obtained from two reputable sources; namely; www.investing.com and individual national stock markets via their official websites but were randomly verified based on data published on the individual stock markets.

3.1 Model Specification

The test of random walk hypothesis is usually based on current and previous stock prices and returns. Here, we used daily continuously compounded market returns data which are derived from daily stock prices as follows:

$$R_t = Ln\left(\frac{P_t}{P_{t-1}}\right) * 100 (3.1)$$

Where:

R_t = Daily market returns at time *t*

Ln = Natural logarithm

P_t = Daily stock market prices at time *t*

P_{t-1} = Daily stock market prices at time *t* – 1

3.2 Method of Data Analysis

In this study, the conventional summary statistics such as mean, standard deviation, maximum, minimum, skewness and kurtosis are used for descriptive analysis, while the variance ratio test and GARCH (Generalized Autoregressive Conditional Heteroskedasticity) frameworks are employed for empirical analysis. Based on the random walk model, which posits that stock prices do not respond to information about previous prices, we specify our basic econometric model as follows:

$$P_t = \alpha + P_{t-i} + \epsilon_t (3.2)$$

$$R_t = \alpha + \epsilon_t (3.3)$$

$$R_t = P_t - P_{t-1} (3.4)$$

Where:

P_t = daily stock prices at time *t*

P_{t-i} = lagged stock prices
ϵ_t = error term.
R_t = Stock returns at time *t*

α = drift parameter

To test the weak form efficiency, we focus on testing the two main assumptions of random walk as follows:

$$E(\epsilon_t) = 0 \text{ and } E(\epsilon_t, \epsilon_{t-i}) = 0$$

These assumptions imply that error term is expected to have a zero mean value and is uncorrelated with its previous values.

A. Variance Ratio Tests

Lo and MacKinlay (1988) proposes a method of testing (3.3) that compares the variances of differences of R_t calculated over different time periods under the assumption that ϵ_t are uncorrelated: $E(\epsilon_t, \epsilon_{t-i}) = 0$. Accordingly, the variance of the q-period difference is equated to the variance of the one-period difference. This can be expressed as follows:

$$\hat{u} = \frac{1}{T}\sum_{t-1}^{T}(R_t - R_{t-1}) \quad (3.5)$$

$$\hat{\sigma}^2(q) = \frac{1}{Tq}\sum_{t-1}^{T}(R_t - R_{t-q} - q\hat{u})^2 (3.6)$$

where (3.5) is the equation for the mean of the difference and (3.6) is the equation for the scaled variance of q-th difference. The variance ratio can be written as follows:

$$VR(q) = \frac{\hat{\sigma}^2(q)}{\hat{\sigma}^2(1)} (3.7)$$

Lo and MacKinlay (1988) compute the variance ratio test statistic(z) as follows:

$z(q) = VR(q) - 1$(3.8)

However, according to EViews (2015), since the variance ratio restriction is maintained for every difference$q$> 1, there is motivation to evaluate the VR statistic at several values of$q$. Chow and Denning (1993) developed a test statistic (a conservative approach), the Max |z| statistic, that controls the size of the joint test. The resulting statistic examines the maximum absolute value (MAD) of several variance ratio statistics (EViews, 2015). This study employed the Chow and Denning's (1993) approach to variance ratio test.

B. TGARCH Model

The Threshold GARCH (TGARCH) model can be traced to the work ofZakoian (1994). The TGARCH model incorporates asymmetric parameter such that bad news would have a higher impact on volatility than good news of equal magnitude. The mean and variance equations of the simple TGARCH model can be specified as follows:

$R_t = \gamma + \theta \mathrm{R}_{\mathrm{t-1}} + \lambda.\sigma_t + \epsilon_{\mathrm{t}}$(3.9)

${\sigma_t}^2 = \psi + \alpha_1 {\epsilon^2}_{t-1} + \beta_2.d_{t-1}{\epsilon^2}_{t-1} + \beta_1 {\sigma^2}_{t-1}$(3.10)

Where:

R_t = Stock market returns at time *t*; γ = intercept term; θ = coefficient on lagged market returns (If this coefficient is significant, then stock market returns are predictable); λ = coefficient capturing the effect of conditional variance on returns; ϵ_t = error term; ${\sigma_t}^2$ = conditional variance at time *t*; ψ = long run average value of conditional variance; α_1 = ARCH parameter capturing volatility information in the previous value; β_1 = GARCH parameter capturing fitted conditional variance in the previous period ; β_2 = Asymmetric parameter capturing the asymmetric effect on current volatility.

Further, d_{t-1} is a dummy variable which is equal to 1 if $\epsilon_{t-1} < 0$, otherwise, it is equal to zero. Zakoian (1994) assigned bad news higher weight than good news of equal size so that the effect of good news or $\epsilon_{t-1} > 0$ is α_1 while the effect of bad news or $\epsilon_{t-1} < 0$ is represented by $\alpha_1 + \beta_2$.

The random walk hypothesis implies that current market returns are correlated with previous market returns. However, the findings reported by most previous studiessuggest that South African stock market is efficient in the weak form while the stock markets of Nigeria, Kenya and Morocco are

largely inefficient. Accordingly, our apriori expectations are as follows: For South Africa, we expect that $\theta \neq 0$; whereas for Nigeria, Kenya and Morocco, we expect that $\theta = 0$

4.1 Data Analysis

4.1.1 Descriptive Statistics

Table 4.1 presents the descriptive summaries for daily market prices for the four selected African indices. The descriptive statistics for daily price data and daily market returns are shown in Tables 4.1 and 4.2 respectively. The graphs of daily market prices are presented in Figures 4.1 – 4.4, while daily market returns are plotted in Figures 4.5 – 4.8.

Table 4.1: Descriptive Statistics for Daily Price Data

COUNTRY	OBS.	MEAN	MAX	MIN	SD	SK	KT	JB
NIG_ASI	2019	31685.30	45092.83	20123.51	5968.10	0.19	2.05	88.69 (0.0000)
SA_JSE	2127	3058.09	3931.29	2035.47	463.97	-0.74	2.43	223.66 (0.0000)
KYA_ASI	2024	141.53	196.57	68.68	27.02	-0.96	3.48	327.84 (0.0000)
MOR_ASI	2023	10511.83	13284.94	8356.40	1276.98	0.36	1.90	145.08 (0.0000)

Table 4.2: Descriptive Statistics for Daily Market Returns Data

COUNTRY	OBS.	MEAN	MAX	MIN	SD	SK	KT	JB
RTN_NIG	2019	0.002	7.98	-5.03	1.01	0.20	8.12	2214.43 (0.0000)
RTN_SA	2127	0.013	6.94	-9.47	1.14	-0.82	12.09	7562.57 (0.0000)
RTN_KYA	2024	0.029	32.01	-33.72	1.42	-1.08	309.09	7901434 (0.00000)
RTN_MOR	2023	-0.007	5.31	-9.23	0.68	-1.63	32.42	73860.33 (0.0000)

From Table 4.1, although, the mean values are not comparable (since different indices have different base values), it appears that African markets have been highly volatile over time, given the large standard deviation (SD) associated with each of the four market index series as well as the large difference between their minimum and maximum values. However, while both NIG_ASI (SK = 0.19) and MOR_ASI (SK = 0.36) have a positively skewed distribution, both SA_JSE (SK = -0.96) and KYA_ASI (SK = -0.74) have a negatively skewed distribution. Also, with the exemption of Kenyan Market Index (KT = 3.48), all the market indices have a kurtosis coefficient that is higher than 3, indicating that they have a platykurtic, or flatter than normal, distribution. This is an indication that none of the price series has a normal distribution. A normally distributed data is expected to have a skewness value of 0 and a kurtosis value of 3. Also, for all markets, the Jarque-Bera (JB) statistic is large with the zero associated p-value, hence confirming confirms that our data are not normally distributed. However, this is not a serious issue given that non-normal distribution is an important feature of stock prices and returns data.

From Table 4.2, we can see that the mean return of 0.002 indicates thatan investor in Nigeria who tracked the NSE all-share index on daily basis from 01/02/2012 to 26/03/2020 earned an average of approximately 0.002% on continuously compounded basis. This is higher than the negative mean return of -0.007% earned by an investor tracking the Morocco (Casablanca) all-share index, but lower than themean market return of 0.013% and 0.027% in the case of South Africa (FTSE-JSE) and Kenya (Nairobi) indices respectively over the same period. Further, although, the market volatility, measured in terms of standard deviation of returns, is generally low, it seems that the Nairobi stock index (SD = 1.42) is the most volatile, while the Casablanca stock index (SD = 0.68) is the least volatile. Also, the skewness coefficient shows that daily Nigerian stock index returns (SK = 0.20) may have a positively skewed distribution, while the returns distribution is negatively skewed in the case of South Africa, Kenya and Morocco. These results suggest that daily African market returns, like the daily price series, are not normally distributed. Again, this is not a series issue since normal distribution is not a feature of stock prices and returns.

Figure 4.1: Daily Price Movement for Nigerian Stock Market All-share-index (ASI) (01/02/2012 – 26/03/2020)

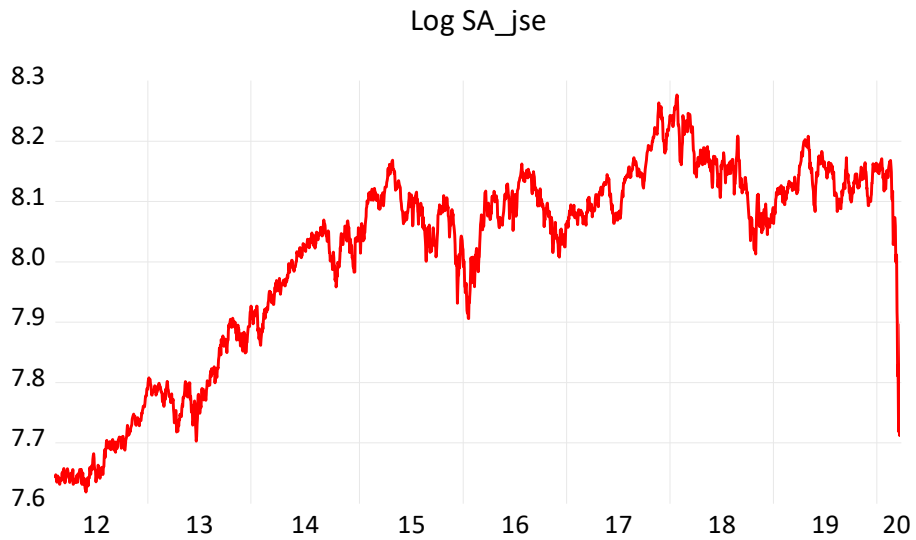

Figure 4.2: Daily Price Movement for South African FTSE-JSE index (ASI) (01/02/2012 – 26/03/2020)

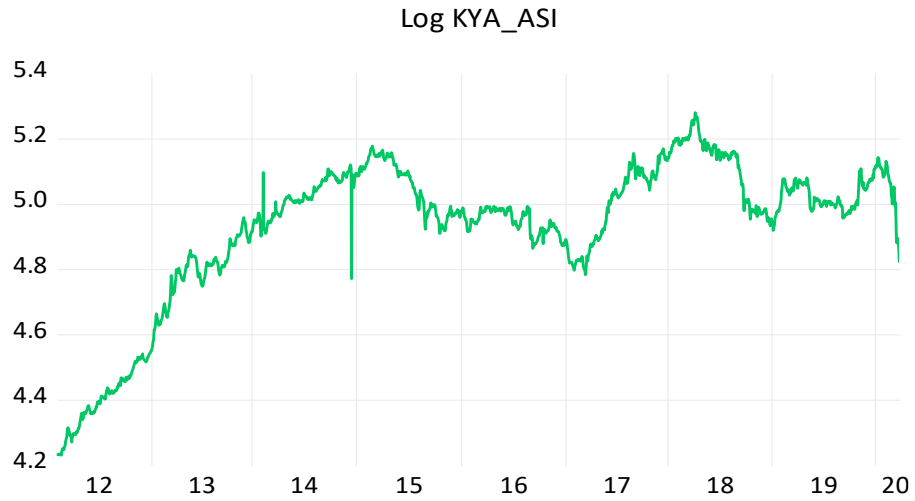

Figure 4.3: Daily Price Movement for Kenyan Nairobi Stock Market All-share-index (NASI) (01/02/2012 – 26/03/2020)

Figure 4.4: Daily Price Movement for Morocco Stock Market All-share-index (NASI) (01/02/2012 – 26/03/2020)

From the time series plots in Figures 4.1 – 4.4, we can observe that for all African markets, daily market indexappears to move unpredictably over the sample period. The plots also show that these price series have some outlying points, especially for South Africa, Kenya and Morocco.Hence, there is need to consider the hypothesis that daily market prices for these African stock markets cannot be predicted based on its past behaviour.

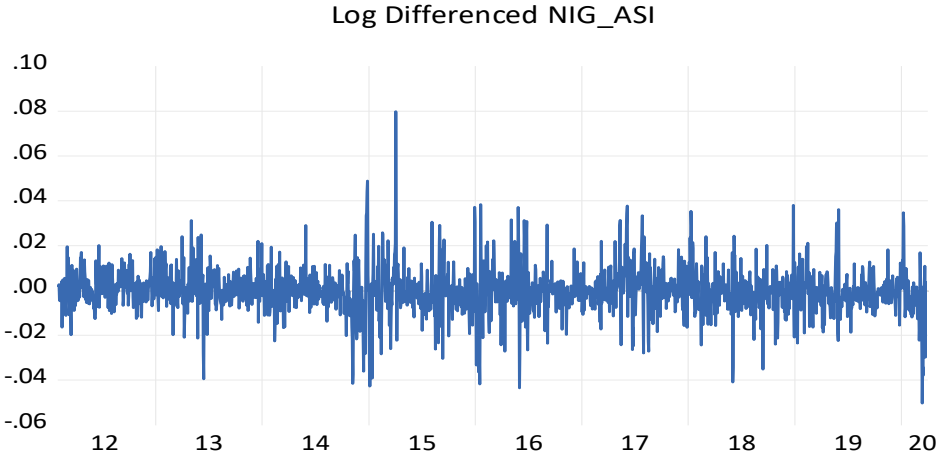

Figure 4.5: Daily Market Returns for Nigerian Stock Market All-share-index (ASI) (01/02/2012 – 26/03/2020)

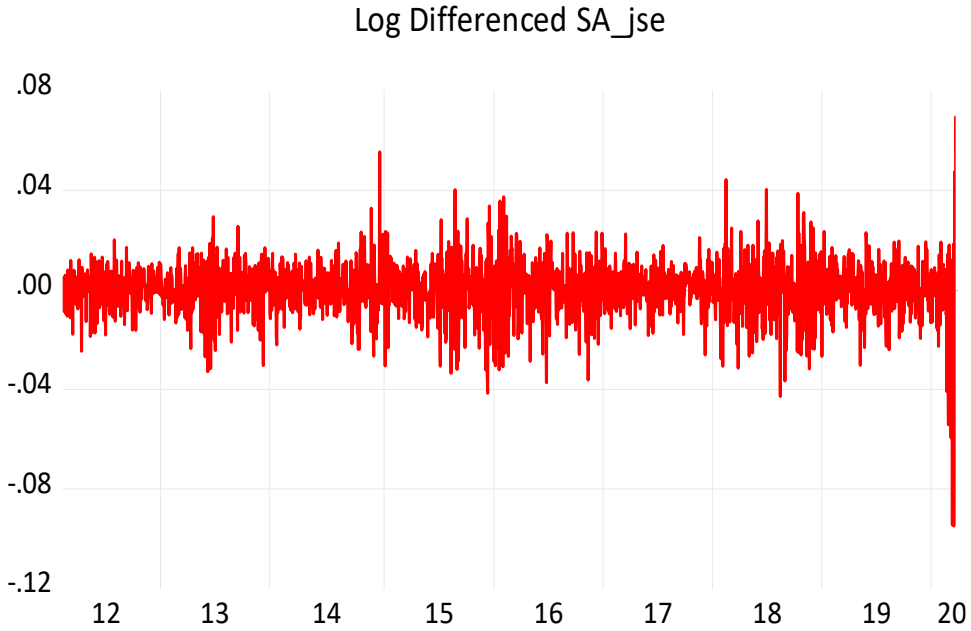

Figure 4.6: Daily Market Returns for South African FTSE-JSE index (ASI) (01/02/2012 – 26/03/2020).

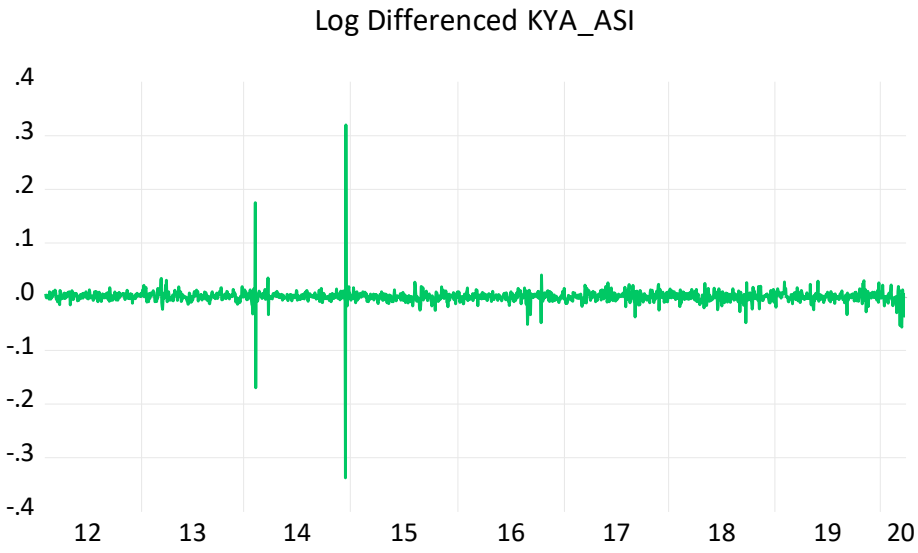

Figure 4.7: Daily Market Returns for Kenyan Nairobi Stock Market All-share-index (NASI) (01/02/2012 – 26/03/2020)

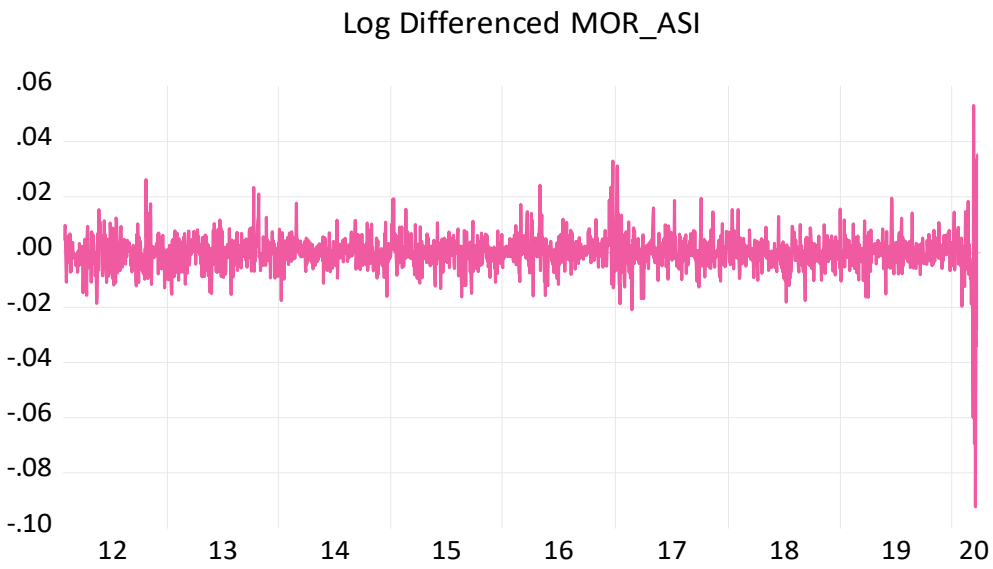

Figure 4.8: Daily Market Returns for Morocco Stock Market All-share-index (NASI) (01/02/2012 – 26/03/2020)

From the time series plots in Figures 4.5 – 4.8, we can observe that for all African markets, daily market returns moved in a stationary way but with significant outliers, which may have significant impact on their statistical distributions. Hence, there is motivation to formally test the hypothesis that daily market prices for these African stock markets does not exhibit a random walk characteristics.

4.1.2 Stationarity Tests

Table 4.3 presents the results of the ADF (Augmented Dickey Fuller) tests for daily market indices and their returns for the selected African stock markets. We include a constant term in the ADF test equation, which allows us to estimate the drift parameter. The optimum lag order for plausible specification of the ADF test equation is selected based on Schwarz information criterion (SIC), while E-Views allows a maximum lag of 25 for all series.

Table 4.3: ADF tests for Log Price Series and Returns; p-values in parenthesis.

Country	Series	Level Data	First Difference Data	Remark
Nigeria	NIG-ASI	-1.8046* (0.3786)	-32.1831 (0.0000)	I(1)
	RTN-NIG	-32.1944 (0.0000)	–	I(0)
South Africa	SA-JSE	-2.3226** (0.1649)	-46.0355 (0.0001)	I(1)
	RTN_SA	-46.0445 (0.0001)	–	I(0)
Kenya	KYA-ASI	-1.9139** (0.6467)	-57.5646 (0.0000)	I(1)
	RTN-KYA	-57.4178 (0.0001)	–	I(0)
Morocco	MOR_ASI	-1.5010 (0.5331)	-38.4052 (0.0000)	I(1)
	RTN_MOR	-38.4097 (0.0000)		I(0)

Source: E-Views Output based on research data

*** drift parameter is significant at 10% level.**

**** drift parameter is significant at 10% level.**

From Table 4.3, the p-value values associated with the level price data are 0.3786, 0.1649, 0.6467 and 0.5331, which is higher than the conventional significance levels, an indication that none of the index series is stationary. Hence, the null hypothesis of unit root at level data is not rejected for all the selected African markets. On the contrary, the p-values of 0.0000, 0.0001, 0.0000 and 0.0000 indicates that the ADF test statistic is highly significant for all first difference data, hence, strongly rejecting the unit root assumption. This implies that the stock indices data are all generated by a first level integrated process, a typical feature of a random walk process. However, as indicated by the asterisks (*), while the drift parameter is significant at 10% level for NSE_ASI, and at 5% level for both SA_JSE and KYA_ASI, it is not significant for MOR_ASI (no asterisk mark).This therefore suggests that market index series may be defined by a random walk with drift process for Nigeria, South Africa and Kenya, while it can be characterized by a pure random walk for Morocco.

For stock market returns, we can see that all the p-values are almost zero, hence the test statistic is highly significant and strongly reject the unit root hypothesis. Therefore, consistent with the graphical movements in Figures 4.5 – 4.8, there is evidence that market returns are generated by a stationary process for all selected African markets.

4.1.3 Variance Ratio Tests

Table 4.4 shows the results of the variance ratio test for the four selected African markets, with intervals whose variances are compared with the one-period innovations being 5, 10, 20 and 30. The test is performed under the assumptions homoskedasticity or constant variance.

Table 4.4: Variance Ratio Tests; p-values in parenthesis

VR Ratio	Nigeria (Period 5)	South Africa (Period 30)	Kenya (Period 5)	Morocco (Period 5)
Panel A: Joint Tests				
Max |z|	13.0179 (0.0000)	2.6637 (0.0306)	7.5113 (0.0000)	6.8007 (0.0000)
Wald(Chi-Square)	185.519 (0.0000)	11.2395 (0.0240)	62.237 (0.0000)	48.784 (0.0000)
Panel B: Individual Tests (Period)				
5	1.6348 (0.0000)	0.0475 (0.9794)	0.6341 (0.0000)	1.3313 (0.0000)
10	1.7898 (0.0000)	0.0732 (0.4263)	0.5962 (0.0000)	1.3979 (0.0000)
20	1.7813 (0.0000)	0.1077 (0.0488)	0.5563 (0.0007)	1.4031 (0.0003)
30	1.8883 (0.0000)	0.1337 (0.0077)	0.5340 (0.0001)	1.3632 (0.0081)

Source: E-Views Output

From Panel A of Table 4.4, we can see that the Chow-Denning maximum Max |z| statisticassuming homoskedasticity has a probability that is lower than 5% for all markets, hence indicating that the variance ratio joint tests are all statistically significant. However, while the significance of the Max |z| statistic occurs at period 5 for Nigeria, Kenya and Morocco, it occurs at period 30 for South Africa. The Wald test statistic also has a zero p-value in all cases; hence it is highly statistically significant.

These resultsclearly show that the null hypothesis that daily market data are generated by random walk process is not supported by the data for the selected African markets. For the individual tests, the variance ratio statistic under homoskedasticity assumption is significant mostly at less than 1% level for all markets and all test intervals, except for South Africa at period 10. Hence, our results that reject random walk assumption for the selected African market returns data are robust.

4.1.4 Estimation and Analysis of TGARCH (1, 1, 1) Model

Table 4.5 shows the results of ARCH Effects test for the four selected African markets, which is usually the starting point of estimation under GARCH framework. Table 4.6 presents the estimation results for TGARCH (1, 1, 1) model for the four selected African stock markets predictability. The mean equation incorporates two factors: (1) one-period market returns so that the random walk hypothesis can be examined, and (2) conditional standard deviation so that the risk-return relationship can be estimated. The ARCH effect is tested by examining the residuals of this regression whether they show evidence of heteroskedasticity due to volatility clustering or ARCH effects. A significant test indicates that ARCH effect is present in the residuals and GARCH model can be estimated for the series. The estimation is based on the assumption that the statistical distribution of the conditional errors is equivalent to GED (Generalized Error Distribution).

Table 4.5: ARCH Effect Test Results

Series	LM statistic	p-value
RTN_NIG	171.159	0.0000
RTN_SA	908.269	0.0000
RTN_KYA	396.613	0.0000
RTN_MOR	966.018	0.0000

Source: E-Views Output

From Table 4.5, we can see that the LM statistic is associated with a zero p-value for all stock markets, indicating that the ARCH effect test is highly significant in all cases. This leads us to reject the null hypothesis of no ARCH effect and conclude that volatility clustering is present in African stock markets. Therefore, we can fit our TGARCH model to the daily market returns data to capture most of its time-varying features.

Table 4.6: TGARCH Estimation Results; ( ) contains p-values

Coefficients	Nigeria	South Africa	Kenya	Morocco
Panel A: Mean Equation				
$\lambda(\sigma)$	0.1226 (0.0899)	0.1668 (0.0348)	-0.1195 (0.0534)	-0.0765 (0.4447)
$\gamma(Intercept)$	-0.1267 (0.0295)	-0.1264 (0.0801)	0.1122 (0.0144)	0.0426 (0.4178)
$\theta(R_{t-1})$	0.1837 (0.0000)	-0.0081 (0.7088)	0.2958 (0.0000)	0.0356 (0.1372)
Panel B: Variance Equation				
ψ Constant	0.1175 (0.0000)	0.0267 (0.0001)	0.2103 (0.0000)	0.0495 (0.0000)
$\alpha_1(ARCH\text{effect})$	0.2723 (0.0000)	-0.0122 (0.1684)	0.3145 (0.0006)	0.1628 (0.0000)
β_2 (Asymmetric effect)	-0.0448 (0.4109)	0.1263 (0.0000)	0.1121 (0.3333)	0.04180 (0.3024)
β_1(GARCH effect)	0.6339 (0.0000)	0.9205 (0.0000)	0.4060 (0.0000)	0.6744 (0.0000)

$\alpha_1 + \beta_1$(Persistence)	0.9062	0.9083	0.7205	0.8372
Panel C: Diagnostics				
$r(GED)$	1.1487 (0.0000)	1.4485 (0.0000)	0.8773 (0.0000)	1.2820 (0.0000)
$LogL$	-2484.1	-2938.4	-2155.9	-1611.3
AIC	2.4699	2.7718	2.1393	1.6017
SIC	2.4921	2.7931	2.1615	1.6239
$ARCH\ LM$(30)	34.175 (0.2739)	72.997 (0.1210)	0.1163* (0.9999)	23.442 (0.7066)

Source: E-Views Output

***indicates lag order = 60**

From Panel C of Table 4.6, we can see that the GED parameter is less than 2 and is highly significant for all markets, hence corroborating our initial assumption that conditional errors have fat-tailed distribution. The ARCH LM is not significant for all markets, indicating that ARCH effect is no longer present in the fitted TGARCH models, a result that shows that our model is correctly specified.

From Panel A of Table 4.6, we can see that the coefficient on conditional standard deviation, σ is significant at different levels for Nigeria, South Africa and Kenya, but not significant for Morocco. This implies that conditional volatility in most of African markets is contemporaneously related to daily stock returns. However, the effect of volatility varies across markets, being positive for Nigeria ($\sigma = 0.1226, p$-value = 0.0899) and South Africa ($\sigma = 0.1668, p$-value = 0.0348)and negative for both Kenya ($\sigma = -0.1195, p$-value = 0.0534)and Morocco($\sigma = -0.0765, p$-value = 0.4447). Further, the results for the mean equation shows that one-period lagged daily return is highly significant for both Nigeria ($\theta = 0.1837, p$-value = 0.0000) and Kenya ($\theta = 0.2958, p$-value = 0.0000), indicating evidence against random walk theory. This result is consistent with the results of the variance ratio test in Table 4.4,hence, for both markets, information about previous daily market returns has a highly predictive power for current and future daily market returns. This implies that our results for Nigerian stock market and Kenyan stock market are robust to different methodology. On the contrary, however, the one-period lagged daily market return is not significant for both South Africa ($\theta = -0.0081, p$-value = 0.7088) and Morocco($\theta = 0.0356, p$-value = 0.1372), hence there is no evidence suggesting that both stock returns can be predicted in both stock markets. Therefore, our results for both South Africa and Morocco are not robust as they are sensitive to methodological differences.

From Panel B of Table 4.6, we can see that the ARCH parameter, α_1 is significant for most of the stock markets, except South Africa, indicating that information about volatility in the past period significantly affects the current conditional variance in most African markets. This can also be interpreted as suggesting evidence of stock returns predictability which is consistent with our earlier results. The GARCH parameter, $\beta_1$is however, highly significant for all markets, indicating the presence of GARCH effect in African markets. This implies that conditional variance depends on its previous value which also supports the view that previous market information (volatility) can be used to predict current market trend. The persistence parameter, $\alpha_1 + \beta_1$, is less than one for all stock markets, an indication that volatility shocks are mean reverting.

In terms of asymmetric volatility effect, we can see that the asymmetric coefficient is significant only for South African (β_2 = 0.1263, p-value = 0.0000) market. The coefficient of 0.1263 indicates the presence of leverage effect in that market. This shows that in the South African stock market, bad news has a much higher effect on volatility than good news of similar size. However, the lack of significance of the asymmetric coefficient for Nigeria, Kenya and South Africa shows that

asymmetric effect is not present in those markets. The implication is that the estimated TGARCH model for the three markets is not significantly different from the standard GARCH model as both good news and bad news affect volatility in symmetrically.

4.2 Hypotheses Testing

The hypotheses are stated in null form and implies that Nigerian All-share index return series, South African FTSE-JSE index return series, Nairobi All-share index return series, Casablanca All-share index return series are generated by a random walk process, hence, Nigerian stock market, South African stock market, Nairobi stock market, Morocco stock market is efficient in the weak form.

To test these assumptions, we employ the variance ratio test statistic (Max |z|) in Panel A of Table 4.4 corresponding to Nigeria, South Africa, Kenya and Morocco. While the above hypotheses would be tested based on the p-values associated with the Max |z| statistic in Panel A of Table 4.4, the chosen level of significance for decision making is 5% or 0.05. Therefore, a p-value of less than 0.05 would imply that the test is significant.

Decision Rule: Reject H0 is the p-value associated with the Max |z| statistic corresponding to a particular country is less than 0.05. Otherwise, H0 would be a valid statement and would not be rejected.

Test of Hypothesis 1

$H0_1$: Daily returns movement on the Nigerian All-share index is not affected by historical price information.

From Panel A of Table 4.4, we can see that the Max |z| corresponding to Nigeria is 0.0000, which is much lower than 0.05, indicating that the variance ratio test is highly statistically significant. Therefore, there is sufficient statistical evidence to reject $H0_1$ leading us to conclude that the daily returns on the Nigerian stock market All-share index are not generated by a random walk process. In other words, the Nigerian stock market is not efficient in the weak form.

Test of Hypothesis 2

$H0_2$: Daily returns movement on South African FTSE-JSE index is not affected by historical price information.

From Panel A of Table 4.4, we can see that the Max |z| corresponding to South Africa is 0.0306, which is much lower than 0.05, indicating that the variance ratio test is statistically significant at 5% level. Therefore, there is sufficient statistical evidence to reject $H0_2$ leading us to conclude that the daily returns on the FTSE-JSE index are not generated by a random walk process. In other words, the South African stock market is not efficient in the weak form.

Test of Hypothesis 3

$H0_3$: Daily returns movement on Nairobi (Kenya) stock exchange All-share index is not affected by historical price information.

From Panel A of Table 4.4, we can see that the Max |z| corresponding to Kenya is 0.0000, which is much lower than 0.05, indicating that the variance ratio test is highly statistically significant. Therefore, there is sufficient statistical evidence to reject $H0_3$ leading us to conclude that the daily returns on the Nairobi All-share index are not generated by a random walk process. In other words, the Kenya stock market is not efficient in the weak form.

Test of Hypothesis 4

$H0_4$: Daily returns movement on Casablanca (Morocco) stock exchange All-share index is not affected by historical price information.

From Panel A of Table 4.4, we can see that the Max |z| corresponding to Morocco is 0.0000, which is much lower than 0.05, indicating that the variance ratio test is highly statistically significant. Therefore, there is sufficient statistical evidence to reject $H0_4$ leading us to conclude that the daily returns on the Casablanca All-share index are not generated by a random walk process. In other words, the Morocco stock market is not efficient in the weak form.

4.3 Discussion of Findings

Random Walk Theory and Nigeria Stock Market

Our first hypothesisstates that Nigerian stock market does not respond to previous price information. This hypothesis focuses on addressing the issue of whether the Nigerian stock market returns are generated by a random walk process. Theoretically, if a stock marketfollows a random walk pattern, it means that the market is efficient in the weak form and stock prices in that market cannot be predicted based on historical information (Fama, 1970). However, most of the findings of recent empirical studies in the Nigerian stock market suggest that the Nigerian stock market does not follow a random walk, implying that the market is not efficient in the weak form. Therefore, we expected, apriori, that Nigerian stock market returns would respond to previous price information so that the above hypothesis would be rejected.

Consistent with our expectation, our results show that the Nigerian stock market does not follow a random walk, hence it is not efficient in the weak form. This evidence is provided in Table 4.4, which shows that the variance ratio test statistic is highly significant for Nigeria (Max|z| = 13.0179, p-value = 0.0000), hence rejecting the null hypothesis that Nigerian stock market returns are generated by a random walk process. Thisimplies that in the Nigeria stock market, current and future market trend can be predicted based on previous market data, hence arbitrage opportunity exists which can lead to abnormal returns if well exploited.This finding also implies that in the Nigerian stock market, daily market returns contain anomalies such as day-of-the-week effects, which investors can exploit to earn excess returns over what the market can offer.

This result contradicts the efficient market theory but supports the main assumption of technical analysisthat future stock prices are correlated with current and previous prices, hence stock markets are predictable. This finding also underscores theinefficiency of the Nigerian stock market found in recent studies such as Gimba (2012), Andabai (2019), Ogbonna and Ejem (2020) and Ejem, Ogbonna and Okpara (2020). The findings in these studies suggest that Nigerian stock market is inefficient at the weak form level. On the contrary, our evidence disagrees with Olowe (1999) who found that Nigeria stock market is efficient in the weak form. This contradiction can be explained by the differences in sample, data and statistical techniques used for empirical analysis. For example, while this study used daily market data and is based on variance ratio test, Olowe (1999) used firm-level data at monthly frequency and its empirical analysis is based on autocorrelation tests.

Random Walk Theory and South African Stock Market

Our second hypothesis states that South African stock market does not respond to previous price information. This hypothesis focuses on addressing the issue of whether the South African stock market returns are generated by a random walk process. In theory, the random walk theory implies the market is efficient in the weak form andboth current and future stock market trend cannot be tracked

or predicted based on historical market data (Fama, 1970). However, most of the findings of recent empirical studiesprovide mixed evidence on the level of informational efficiency (i.e., weak form efficiency vs inefficiency) in the South African stock market. Therefore, based on theory, we expected, apriori, that the South African stock market is efficient in the weak form so that the above hypothesis would not be rejected.

Contrary to our expectation, our results show that the South African stock market does not follow a random walk, hence it is not efficient in the weak form. This evidence is provided in Table 4.4, which shows that the variance ratio test statistic is significant at 5% level for South Africa (Max |z| = 2.6637, p-value = 0.0306), hence rejecting the null hypothesis that South African stock market returns are generated by a random walk process. Like the case of Nigeria, this finding implies that in the Johannesburg stock market, current and future market trend can be predicted based on previous market data, hence arbitrage opportunity exists which can give investors abnormal returns if well exploited. This finding also implies that in South African stock market, daily market returns contain anomalies such as day-of-the-week effects, which investors can exploit to earn excess returns over what the stock market can offer.

Again, this result contradicts the efficient market theory but supports the main assumption of technical analysis that future stock prices are correlated with current and previous prices, hence stock markets are predictable This finding therefore supports the findings of Nwosu, Orji and Anagwu (2013), Grater and Struweg (2015), Tiwari, Aye and Gupta (2019), and Vitali and Mollah (2010). These studies all found that South African stock market is not efficient in the weak form. On the contrary, this result disagrees with Simons and Laryea (2005), Fusthane and Kapingura (2017), and Kiran, Mallikarjuna and Rao (2019). They all found evidence that is consistent with weak-form efficiency in the South African stock market.

Random Walk Theory and KenyanStock Market

Our third hypothesis states that Kenyan stock market does not respond to previous price information. This hypothesis focuses on addressing the issue of whether the Kenyan stock market returns are generated by a random walk process. In theory, the random walk theory implies the market is efficient in the weak form and both current and future stock market trend cannot be tracked or predicted based on historical market data (Fama, 1970). However, most of the findings of recent empirical studies found that the Kenyan stock market is not efficient in the weak form. Therefore, we expected, apriori, that the Kenyan stock market is not efficient in the weak form so that the above hypothesis would be rejected.

Consistent with our expectation, our results show that the Kenyan stock market does not follow a random walk, hence it is not efficient in the weak form. This evidence is provided in Table 4.4, which shows that the variance ratio test statistic is significant at 1% level for Kenya (Max |z| = 7.5113, p-value = 0.0000), hence rejecting the null hypothesis that Kenyan stock market returns are generated by a random walk process. Like the case of Nigeria and South Africa, this finding implies that in the Nairobi stock market, current and future market trend can be predicted based on previous market data, hence arbitrage opportunity exists which can give investors abnormal returns if well exploited. This finding also implies that in Nairobi stock market, daily market returns contain anomalies such as day-of-the-week effects, which investors can exploit to earn excess returns over what the stock market can offer.

Again, this result contradicts the efficient market theory but supports the main assumption of technical analysis that future stock prices are correlated with current and previous prices, hence stock markets

are predictable. This finding therefore corroborates most of the previous studies including Onyuma (2009), Balparda, Caporale and Gil-Alana (2015), Kamau (2017), and Cherono (2020). These studies all found that Nairobi stock market is largely inefficient. On the contrary, this result disagrees with Bulla (2015) who found that information about previous price trend cannot be used to predict both current and future price movement.

Random Walk Theory and Moroccan Stock Market

Our third hypothesis states that Moroccan stock market does not respond to previous price information. This hypothesis focuses on addressing the issue of whether the Moroccan stock market returns are generated by a random walk process. In theory, the random walk theory implies the market is efficient in the weak form and both current and future stock market trend cannot be tracked or predicted based on historical market data (Fama, 1970). However, almost all the findings reported by recent empirical studies indicate that the Moroccan stock market is not efficient in the weak form. Therefore, we expected, apriori, that the Moroccan stock market is not efficient in the weak form so that the above hypothesis would be rejected.

Consistent with our expectation, our results show that the Moroccan stock market does not follow a random walk, hence it is not efficient in the weak form. This evidence is provided in Table 4.4, which shows that the variance ratio test statistic is significant at 1% level for Morocco (Max |z| = 6.8007, p-value = 0.0000), hence rejecting the null hypothesis that Moroccan stock market returns are generated by a random walk process. Like the case of Nigeria, South Africa and Kenya, this finding implies that in the Casablanca stock market, current and future market trend can be predicted based on previous market data, hence arbitrage opportunity exists which can give investors abnormal returns if well exploited. This finding also implies that in Nairobi stock market, daily market returns contain anomalies such as day-of-the-week effects, which investors can exploit to earn excess returns over what the stock market can offer.

Again, this result contradicts the efficient market theory but supports the main assumption of technical analysis that future stock prices are correlated with current and previous prices, hence stock markets are predictable This finding therefore corroborates most of the previous studies including Gyamfi, Kyei and Gill (2016), Falloul (2020), Lekhal and El Oubani (2020) and Osabuohien-Irabor (2020). These studies all found that Casablanca stock market is largely inefficient and characterized by market anomalies such as momentum effects.

5. 0 Summary, Conclusions and Recommendations

This studyexamined the efficiency market theory in four (4) selected African stock markets (Nigeria, South Africa, Kenya and Morocco) proxied by their All-share indices from the perspective of random walk hypothesis using the variance ratio tests. The main variable of this study is daily continuously compounded market returns. In terms of specific research design, we found from the literature review that previous studies on stock market efficiency and random walk theory were largely predictive and explanatory in nature and focused on analyzing the dynamic relationship between the current stock market price and its previous values. Accordingly, to empirically examine the random walk hypothesis in the context of selected stock markets in Africa, this study employed an explanatory or causal design based on historical time series data.

The main findings of the study are as follows:

1. Over the period (01/02/2012 - 26/03/2020), daily returns on the selected African stock market indices (Nigeria, South Africa, Kenya and Morocco) have been generally low ranging from -0.007% to 0.029%, with average return on Casablanca stock market All-share index being the

lowest, and average return on Nairobi stock market All-share index being the highest. The daily market returns on Nigeria stock exchange All-share index averaged at 0.002%, while daily returns on FTSE-JSE index averaged at 0.013%.

2. Daily returns movement on Nigeria stock exchange All-share index is affected by historical price information;hence Nigeria stock market follows the random walk pattern.
3. Daily returns movement on South Africa FTSE-JSE stock exchange index, Kenya (Nairobi) stock exchange index and Morocco (Casablanca) stock exchange index are not affected by the historical price information; hence, the stock markets in South Africa, Kenya, Morocco do not follow the random walk pattern.
4. Volatility shocks are generally mean reverting in African stock markets.

Theoretically, efficient and effective mobilization and allocation of financial resources require that stock markets are efficient at least in the weak form. However, the degree of efficiency of African markets is still an unresolved issue as previous studies have reported mixed empirical evidence. This study employed the variance ratio tests to provide dependable evidence on the level of efficiency of African markets using daily market returns data from 01/02/2012 to 26/03/2020 for four African markets.

The main conclusions are as follows:

i. African stock markets are largely inefficient; hence, they are characterized by market anomalies and momentum effects. This implies that financial resources are not efficiently and effectively mobilized which can be explained by factors such as unprofessional practices of stockbrokers, high transaction costs and behavioural biases of investors.
ii. There is lack of evidence of weak form efficiency in African markets which also implies the existence of arbitrage opportunities which would lead to abnormal returns or profits if well exploited. However, this may threaten the on-going efforts by African leaders to fully integrate the regional stock markets into one large market through AfCFTA (African Continental Free Trade Area) adoption and implementation.

From the findings of this study, we recommend the following;

1. First, for a stock market to effectively perform its core function of resource mobilization, it must be efficient at least in the weak form. Therefore, African governments and regulatory bodies can improve the informational and pricing efficiency of their respective stock markets by taking specific actions that are aimed at minimizing the delays in information flow and other information related encumbrances that significantly affect daily transactions in the market. This can be achieved through increasing investment in information and communication technologies, facilitating training and research for stockbrokers and market makers, and reducing transaction costs as well as institutional barriers in their respective stock markets.
2. Regulators should also focus on reducing unprofessional practices of stockbrokers in their respective stock markets which can lead to behavioural biases among investors. This can be achieved through information and knowledge sharing as well as strict enforcement of market rules and standards.
3. There is need for investors and traders in African stock markets to exploit the existing arbitrage opportunities that are created by market anomalies in order to possibly beat the stock markets and earn abnormal returns. This can be achieved by using market trading strategies that are consistent with technical analysis such as day-of-the week momentum strategy.

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