LONG MEMORY BEHAVIOUR AND PREDICTABILITY OF STOCK RETURNS.A CASE OF GHANA STOCK EXCHANGE.

BY

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DECLARATION

I hereby declare that this thesis submitted is my own work towards the Master of Science(Accounting) and that, to the best of my knowledge, it contains no material previously published by another person or material which has been accepted for the award of any other degree in any university except where due acknowledgement has been made in the text.

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ABSTRACT

This research work explores the long memory behaviour on Ghana stock Exchange (GSE). It further seeks to examine long memory in both equity returns and volatility using the weak-form version of the efficient market hypothesis (EMH) as a criterion. The estimates are based on daily closing prices of seven (7) stocks listed on the GSE. The data were changed into compounded returns by taking the first difference of the natural logarithm of the daily closing prices. The study employs unit root, variance ratio, ARFIMA and FIGARCH models to estimate the long memory parameter in order to unearth the weak-form inefficiency ascertained by other researchers. The results showed that these stocks display a predictable component in returns. In general, these findings contradict the precepts of the EMH and a variety of remedial policies are suggested. The evidence which recommends the null hypothesis of the price series as random walk processes is strongly rejected for all the stocks, at any of the intervals of *k* at the 1% significant level. The results of the ARFIMA-FIGARCH model suggest that stock returns in GSE are characterised by stochastic processes which have a potentially predictable component, this in turn implies a departure from the EMH suggesting that relevant market information was only partially reflected in stock price changes. This pattern of time dependence in stock returns may allow for past information to be used to improve the predictability of future returns. To improve the efficiency of the market, there must be approval of electronic trading platform, which takes into account the selection of a fundamental store framework that, can enhance the accuracy to speed the flow of information in order ensure a safe flow of information to market applicants and enhance the efficiency of the market.

DEDICATION

I dedicate this thesis to my late grandmother Afia Maanu and the entire Nkrumah Ababio family for their contribution either financially or morally to my education. God richly bless you all.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Financial markets efficiency has remained a significant assumption for most financial modelling techniques. According to Fama (1970), Efficient Market Hypothesis (EMH) is the ability of a market to incorporate freely and fairly relevant information in the price generation process. The weak form of the proposition which claims that, markets must follow an unpredictable or random walk trend has attracted a considerable amount of empirical research in the past few decades. Due to the unrelenting attempt by analysts and researchers alike to investigate this hypothesis, a lot of controversy has been generated and leaves the matter far from settled.

Long memory processes can be outlined as physical sciences in the form of assessment of data. Hurst (1951) introduced formal models with long memory, which relate to investigating the nonperiodic (flooding) cycles by hydrological studies which relates normal flow of the Nile River. Long memory process is concerned with clarification in the past that is extremely linked with explanation in the future. In other words, long range dependence can be expressed as long memory, thus the present value depends on previous value.

Global market efficiency has been directly affected in stock market returns by the presence (or absence) of stochastic long memory and can pose a severe challenge to the proponents of random walk behaviour of the stock returns. These behaviours have imperative repercussion for asset pricing models and fund managers, financial and economic development, investors and trading approaches, capital markets and market

efficiency as a whole. In the light of the interest generated by these parties (market Players) for instance, trading strategies vary when proceeds are branded by a positive autocorrelation above negative autocorrelation and short horizon and above the long horizon. The absence or presence of knowledge in long memory properties of stock prices enables investors to make informed decision about their investment portfolios. This also goes a long way in making the stock market more efficient since all information about the market is open to all investors. An investor, in the above instance, will spend more in stocks with a risk aversion relatively better than unity or if returns will be successively independent in any long investment horizon.

Similarly, Long memory process in the volatility of prices is considered to be a stylized fact in finance. It is well known that asset returns contain insignificant serial correlation, in agreement with the efficient markets hypothesis although its volatilities exhibit significant autocorrelation. Presently, there is considerable evidence from other world markets in support of the stock prices stochastic volatility in long memory and these are well documented in several studies (Andersen & Bollerslev, 1997, 1998; Breidt, Crato, & Lima, 1998; Ding, Granger & Engle, 1993). According to Harvey (1993), he acknowledged the long memory volatility of stock prices. His findings initiated research into possible explanations and development of different models for volatility, like Fractionally Integrated Generalized Autoregressive Conditional Heteroskedasticity (FIGARCH) which serves as the current technique for measuring stock prices volatility due to the deficiencies of rescaled range model.

Mandelbrot (1971) "first studied the financial market on impact of long memory and he examined whether security returns exhibit long memory subsequently, probability that any current information from the market can never be arbitraged away, which

presuppose arbitrage cannot imitated in security returns with martingale technique". Additionally, the arbitrage pricing theory on the standard tests was analysed and long memory showed in asset prices led to the dismissed of capital asset pricing model" Lo (1991).

In July 1989, the Ghana Stock Exchange (GSE) was incorporated and started trading officially in 1990, serving as the principal stock exchange of Ghana. There are forthone listed companies currently trading on the stock exchange (GSE, 2016). The stock exchange has all type of securities listed provided it meets the following criterion: profitability spread of shares/bond, years of existence, capital adequacy and management efficiency. Although there has not been a major issue with the stock market, GSE has had its fair share of some ups and downs, and has received varying shocks. With the increasing of companies listed on the Ghana Stock Exchange, the need for consistent verification on their informational significant is of important interest to regulators and investors.

Ghana as a developing economy has not taken full advantage of its stock market as one of the engines for economic growth based on the number of listed companies, underutilized economic opportunities, and information on the market. The research work seeks to test the efficiency of the GSE to see how quickly information today affects the returns on stock.

1.2 Statement of the problem

Since November 1990 the Ghana Stock Exchange (GSE) has been in active business. The weak form efficiency in returns of listed stocks has been examined by Osei

(1998) and Dewotor and Gborglah (2004) by utilizing weekly closing prices on the GSE from January, 2007 to June, 2012. They used Kolmogorov-Smirnov test to establish if periodically price altering follows a random walk and to decide whether price series can be predicted. Their findings specified that evidence of volatility can be demonstrated in prices series gathering on the GSE as a sign of inefficiencies. The efficiency of the Ghana Stock Market is being explored by Mensah, Owusu-Antwi and Bokpin (2016) on the outcome of day of the week utilizing the All-share daily index data on GSE from November, 1990 to August, 2012. They used numerous models namely; dummy variable regression, generalized autoregressive conditional heteroskedastic, one-sample t-test and autoregressive models. Their results indicated that, stock prices are not wholly random on the GSE and this does not hold for efficient market hypothesis. Moreover, Ayentim et al (2013) explored the efficiency of listed companies in terms of the weak-form on the (GSE) by employing weekly returns on the GSE from January, 2007 to June, 2012. They used KolmogorovSmirnov model to verify whether periodical returns adjustments go after a random walk, in addition to also establish the predictable in terms of price series. Their findings specified that the price series confirmed volatility evidence, which showed a signal on the GSE as inefficiencies.

Importantly, the strength of serial correlation test which has been queried elsewhere (Hsieh, 1991), by using parametric variance-ratios test is a remarkable trait, giving significant worries as to how these findings will hold an empirically established methodology similar to Lo and MacKinlay (1988, 1989). Wright (2000) using a nonparametric variance-ratios model provided a convincing foundation to study the market in terms of weak form efficiency. Mensah et al 2014 analyse both the pre and post automation periods from 2006 – 2011, and concluded that, the GSE on the

automation has not established the needed impact to enhance the efficiency of the exchange. This research is to study how efficient the "Ghana Stock Exchange" is, considering its post automation of the exchange from 2010 – 2014 and compare it to the previous study to assess the extent of market efficiency. There is therefore the need to obtain empirical evidence by conducting an investigation into the efficiency of stock market in Ghana to identify an important gap in the various time series techniques used in the market.

This research is based on the fact that none of the existing studies have applied ARFIMA and FIGARCH models in their research to explore the efficiency of GSE. But, with the exception of Tweneboah et al, (2015), where they utilize ARFIMA and FIGARCH to scrutinized the Long Memory Behaviour of Real Interest Rates in Ghana. Basically, this research is to explore the "Ghana Stock Exchange" efficiency, with focus on post automation of the market from 2010 – 2014 after Mensah et al (2014).

Therefore, this study is designed to scrutinize the impact of long memory behaivour and predictability of stock price, taken into consideration financial firms (Banks) on the GSE within the period of 2010 to 2014 and to bridge the gap that no research has tried to employ unit root, variance ratio, ARFIMA, and FIGARCH techniques to examine the long memory parameter to unearth the weak-form inefficiency ascertained by other researchers.

1.3 Objectives of the study

The general aim of the research is to scrutinize long memory behaviour and predictability with respect to returns on stock. The specific objectives to be achieved are:

1. To explore the long memory behaviour of stock returns on the GSE.
2. To examine whether returns on the GSE market is predictable.
3. To investigate whether there is evidence consistent with the weak form market efficiency on GSE.

1.4 Research question

Grounded on the above objectives, the study seeks to present responses to the below questions:

1. Is there proof of long memory behaviour of stock prices on the GSE?
2. Is the GSE market predictable?
3. Does GSE market exhibit proof of weak form market efficiency?

1.5 Scope of the study

The research is to find the long memory features whether presence or absence in the Ghana Stock Exchange‟s stock prices for a four year period. Thus, taking into consideration the post automation of the exchange from 2010 – 2014 and compare it to the previous study to measure the extent of efficiency of the market. This study focuses on all the financial institution on the GSE which are (Standard Chartered Bank Ghana, HFC Bank, UT Bank, Societe Generale, Ecobank Ghana, Cal Bank Ghana and Ghana Commercial Bank). The theoretical concept will base on the efficient market hypothesis, long memory behaviour and random walk of stock returns. This study will

employ unit root, variance ratio, ARFIMA, and FIGARCH models to estimate the long memory parameter.

1.6 Significance of the study

This research will ensure a decisive assessment of the degree of weak form efficiency of both the individual listed stocks and market index. This will be significant because investors and traders in general could best appreciate the way shocks influence volatility and the function that structural adjustment could involve in this development. Certainly, Poterba and summers (1986) prove the level as to how stock price volatility is determined and how it influences equity returns during risk premium base on time. The study on the behaviour of stock return would have a serious implication for economic policy making, market efficiency and risk modelling.

The research will add a new trend of information to the stock prices of the GSE in terms of absence or presence of long memory with key interest in the market player‟s ability to efficiently diversify their portfolio due to accurate and precise market information. The market information will go to the extent of assisting them to easily identify arbitrage opportunities if any. The study will fill an important gap by using various time series techniques, in investigating efficiency of stock prices market in Ghana.

1.7 Organization of the study

This research work is arranged into five chapters. To begin with, Chapter One covers statement of the problem, the background to the study, objectives of the study, research questions, scope of the study, the significance of the study and structure of the research.

Chapter Two consider the literature linked to the subject matter. It deals with the introduction, information on the stock market in Ghana, review of previous studies and chapter summary. Chapter Three, which borders research methodology, description of variables consider data sources and techniques of data processing. Chapter Four discusses analysis of data and results. It considers analysis, discussion, data presentation and interpretation of results, and Chapter five covers the summing up of the research, recommendations and conclusions.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section presents related material from diverse studies researched in the past and in different areas. It encompasses the introduction, theoretical literature, and empirical literature and the conclusion part. The main theories and principles of the efficient market hypothesis and asset returns on long memory behaviour is what the conceptual literature focuses on. Discussion of stock returns on long memory behaviour and the various ways of its measurement are being described. The methods of predictability of stock returns are explained and the performance of GSE is discussed. The Empirical Literature part will center on the various appropriate empirical studies embarked on long memory behaviour and predictability. Finally, the Conclusion will establish the gaps in the existing body of knowledge to warrant the need for further research.

2.1 History of the Ghana Stock Exchange

Financial reform which has been the hub for the progress accent on financial liberalization and deregulation led the launched in 1990 for Ghana Stock Exchange (GSE). Participation of domestic capital markets to foreign investors was as result of the partial capital account liberalization which helped to develop the market. Twentyone (21) firms were listed in 1996, with capitalization of USD1.5 billion. Eleven (11) years after the establishment of the GSE the market capitalization improved to USD 2.4 billion with the number of firms increased to thirty-two (32). Nevertheless, liquidity still maintained low as 3.4% match up to 1.1% ten (10) years previously. The stock market back almost 12% of total asset growth of listed firms from the period of 1995 to 2002. The stock market have significant role in financing firm‟s expansion in

Ghana by Adjasi and Yartey (2007).

The GSE remains small and illiquid, even though it has been a vital source of financing for corporate firms. Stock exchange can be defined as a financial market which is well "structured, regulated and organized where securities like (shares, notes, bonds and Treasury bill) are being traded at value determined by demand and supply". Corporate bodies and governments can raise capital from the stock exchange which fundamentally provides primary market by channelling investor‟s savings into useful ventures. Regardless of these structural obstacles, the GSE in terms of investment income carries vigorous growth performance, for instance, GSE showed an annual income in 2004 for 144% in U.S. dollar as against 30% income by Global Equity Index of MSCI, by seeing the stock market as one of the best performing markets in the world.

2.2 Theoretical review

2.2.1 The Efficient Market Hypothesis (EMH)

This attempt to clarify how securities exchange returns seems to fellow a random walk. The basis that a random walk seemed unordinary was on the grounds that, since the "Neo‐Classical Economic" hypothesis, in particular reference to the "Walrasian General Equilibrium Theory", propose that, markets should have a method to harmony in excess of the medium to long run and they should consider this via the procedure that identifies the clearing costs of markets to correctly coordinate demand as well as supply activity.

Fama (1965) examined EMH in his PhD research, and set its contemporary three‐kind structure in Fama (1970). Random walk was being clarified by EMH by appointing its event to instability i.e.; the presence without bounds, where future occasions are

unfamiliar to or mis-predicted by the market. The established Walrasian balance necessitates perfect information of the future to be realized, vulnerability brings about significant long_term variation from normal behaviour. EMH have three (3) primary types, of each turning out to be progressively more grounded in suggestion.

2.3.1.1 Weak form market efficiency

Historical prices and trading volume are contained in all the data which is being recorded to accurately reflect the current market price. Historical share prices are expected to reflect in the efficient market, which shows in the weakest form as of now incorporated into the pricing of assets. In this manner, no excess profits can be earned by basing investment approaches in the light of past returns. This suggests that, specialized examination which examines developments in past returns is pointless in foreseeing the future. Since past performance is now known to the market, the present circumstance stays unknown. This is the place where basic analysis gain awareness and might remunerate keen investors who use the organizations' financial statements to get their work done.

Historical data examines the weak form of efficiency investigation by utilizing statistical and econometrical techniques. Investigations with reference to DIV/P, P/E, market value and impacts on past information on book-value to-market equity and also specialized examination are pervasive in such investigation.

2.3.1.2 Semi_strong form market efficiency

Stages of efficiency bit by bit expand their confinements, so it is common for the following level to incorporate the previously expressed assumption. Notwithstanding historical data, which openly incorporate new information quickly into pricing consider

the semi-strong form of efficiency, this intimate‟s that, principal analysis will give up nothing.

Examining of efficiency for semi-strong form is like event studies. Rise of recent data more often than not appears as quarterly or yearly reports or events, for example, splits or new issuances, buy of treasury shares or acquisitions and mergers. The development of such reports ought to affect the markets to adapt rapidly. New information can estimate the speed and flow of the adaptation.

2.3.1.3 Strong form market efficiency

This type of market efficiency does not only incorporate the market price for all past and present information, however precisely represent the random walk and predicted future information because of what the future holds about mis-predictions by the market. Information asymmetry and transaction cost does not exist according to this form of market which accept that credit is linear in terms of cost and identical to all financial specialists. Obviously, none of the assertion is valid as a general rule yet modern markets approximate these assumptions in general.

There is considerable empirical evidence demonstrating that assertion, as a rule above long-run, no organization and to some extents group can reliably beat the market. Suggesting that, the market prices are dependably as genuine and reasonable as could be expected under the circumstances to the long term and in this manner the most grounded type of EMH generally is relevant, falling back to best case scenario in liberal capital Economies which semi_strong, for example, UK. It perceived the EMH as prerequisite of Neo_Classical Economic theory which obliges financial specialists to be

level-headed. It additionally, past price cannot be concentrated on behaviour of stock, thus settling on decision pertaining to investment decision. But strong and semi_strong form does not consider history information by any stretch of the imagination. This can imply that fund managers and market analysts work completely by chance (moreover along these lines do not merit the fortunes they are paid).

2.4 "The Capital Asset Pricing Model (CAPM)"

Sharpe (1970) has paid such a great amount to the improvement of the "CAPM" in Sharpe (1964) (that relies upon the "EMH") takes into account the ramifications of relaxing the assumptions supporting both theories:

"The outcome of pleasing such portions of the reality is liable to be disastrous in terms of the helpfulness of the resulting theory ... The capital market lines no more exist. Rather, there is a capital market curve – linear over a few ranges, maybe, however getting to be flatter as [risk] increments over different scopes. In addition, there is no single optimal blend of risky securities; the preferred mix relies on upon the investors' preferences ... The demise of the capital market line is taken after quickly by that of the security market line. The theory is in a shambles" (Sharpe 1970).

"Capital Asset Pricing Model" expects that, investors in general, would be agents who are utility efficient. It additionally accepts the assertion that every investor should act in a similar way. In this way, by collecting utilities, an optimal investment portfolio can be established and a Securities Market Line (SML) can be characterized. The CAPM consolidates returns of two (2) kinds; the return on the market portfolio and government

bonds and beta times, which have risk-free returns. The accompanying model is the premise of the following equation:

$$E(r_i) = r_f + \beta[E(r_m) - r_f]$$

$E(r_i)$ is "the expected return of the asset in question"; r_f is "the risk free return rate";

β "the sensitivity of the particular share to movements in the market return" and r_m being "the market risk". The β was previously defines as ;

$$\beta_i = \frac{Cov(r_i, r_m)}{\sigma_m^2}$$

Where σ_{m2} is "the variance of the market portfolio", r_i is "the return of the asset", and r_m is "the return of the market portfolio",.

2.5 The random walk hypothesis

The nonstop development of reputation of expert speculation magnates like Warren Buffett and Bernard Madoff depends on the way that the potential investor`s considers investment to be a quick and proficient approach to increase wealth. Malkiel (2007) describes investment as "a strategy for buying assets for increase benefit in a way of sensibly income predictable (profits, interest and rentals) or long term increase". With the goal investors should feel as though they are investing their money "wisely," many endeavor to settle on informed decision by assessing performance index, organization performance fund, general political and financial patterns, and proposals from trusted investment experts, amid other essential features (Kavalerchik, 2009). This examination

seeks to investigate what is normally recognized as the random walk hypothesis as defined by Lo and MacKinlay. This hypothesis, known as the

“random walk” expresses that, in any market that is efficiently informative, must not to be mistaken for a market that is Pareto-efficient market. Thus, price changes must not be forecastable on the off chance that, they are properly foreseen i.e., in the event that they completely fuse market participants‟ expectations as well as information (Lo and MacKinlay (2002). In other words, the “random walk hypothesis” declares that, "the historical backdrop of the development of prices of stock, contains no helpful information that will empower an investor reliably to outperform a buy-and-hold strategy when dealing with portfolios (Malkiel, 2007)". At long last, “random walk hypothesis” could be expressed: “pt = μ + pt-1 + ε t”, where pt signifies “the normal logarithm of a stock-return index” Pt with respect to time t, pt−1 is “the regular logarithm of a stock-return index Pt−1 at time t-1, μ is the expected change in price or float, and εt ought to be Independent and Identically Distributed (from now on IID) a strict white noise or random variables”.

2.5.1 Random Walk Type 1

This type of the random walk is straightforward and it expresses that all increments are autonomously tied around the same dispersion with the similar variance or mean. The theory gives a decent understanding of the conduct of random walk as a rule of Independent and Identically Distributed (IID).

2.5.2 Random Walk Type 2

The random walk of this part accepts that all growth is autonomous yet tied to various distributions. The IDD increases as it permits unconditional heteroscedasticity in the

increments in a broader case. At the end of the day, time-based variation is permitted that increments are independent in any of the form.

2.5.3 Random Walk Type 3

The last type of random walk has features of type two (2) of random walk hypothesis which necessitates uncorrelated increments. All types of random walk discussed have basis features of conditional variance and mean which is linearity with time. This means that a random walk development is non-stationary due to increasing variance and unbounded.

Along these lines, the fundamental economic guideline of the RWH is when information is right away mirrored in stock returns and continuous, then future returns variance will mirror just future news and will be independent of the return variance presently. Subsequently, information though is unusual thus; changes in price should likewise be random and unpredictable.

2.6 Unit root and long memory process

Unit root test is used to test the stationarity and variance ratio is used to test random walk while fractional integration/long memory is used to decide differencing parameter (d). Three different unit root models are utilized to examine the null hypothesis of a unit root: in particular, “Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test (1992)”, Phillips-Peron (PP) test (1988) and the “Augmented DickeyFuller (ADF) test (1979)”. These relate to test of the most restictive random walk theory (RW2). To begin, non-stationarity of the null hypothesis of the famous ADF unit root model. PP consolidates an option (nonparametric) strategy for managing serialized correlation while

investigating into any unit root in the form of assessing the "non-augmented Dickey-Fuller model" condition as well as altering the statistics of the test, that serial correlation is not affected by asymptotic distribution. At long last, KPSS utilizes a comparative autocorrelation adjustment to the Phillips-Peron, yet accepts that time series observed can be deteriorated keen on the total deterministic pattern; zero stationary error term with variance can be associated to random walk. In view of this, there is the examination of pattern stationarity, that is the null hypothesis, comparing to random walk meeting zero which gives out the hypothesis that the variance.

Global Economic and financial time series show trending behaviour or nonstationarity in the mean. Examples are exchange rates, asset costs and the levels of macroeconomic totals like real GDP. A vital econometric task is deciding the most proper form of the pattern in the data. Unit root examination can be utilized to figure out whether trending information ought to be initially regressed or first differenced on deterministic elements of time to render the data stationary. In addition, financial and economic theory frequently recommends the presence of long-run equilibrium connections among non-stationary time series variables.

Onour (2006) "utilized unit root and also, long memory of stock returns. These were from three Northern African developing markets: Morocco, Egypt and Tunisia utilizing every day stock returns. Findings of the research uncover a result of evidential value of a stationary short memory process, based on the three markets" returns. The researcher results suggest that, a shock that hits any of the above markets is not prone to continue for a prolonged time. Also, returns relating to the future can be better predicted utilizing recent lagged returns".

A definitive resolve of this research is to extend the rational implications of the long memory of stock, with spotlight on EMH and long memory behaviour to represent a portion of the essential behavioral variables influencing stock prices. Notwithstanding the statistical significance of its outcomes, this study does not serve as a proof of the EMH or as a counter illustration. It is conceivable that by enhancing the datasets, it could be affirmed that the EMH applies to the data in this specimen. Though, any investigation of the EMH cannot be generalized to the market at any given time, on the grounds that the EMH shows itself differently in various circumstances. As mentioned, riskier stocks will tend to encounter greater price volatility at a given level of information than less risky stocks. Amid a crisis, financial specialist desires will influence stock prices uniquely in contrast to a boom.

Demonstrating long memory in volatility has additionally attracted in extraordinary attention of consideration out of literature on finance recently. To discuss volatility of memory pattern, Ballie et al. (1996) proposed FIGARCH technique by developing the "IGARCH technique". This is a unique instance of "GARCH technique", taking into account the conditional variance. That endless determination inferred by the "IGARCH" technique, shows up excessively prohibitive and appears contrary to making it impossible to exact confirmation.

2.7 Empirical Review

2.7.1 Empirical Review studies on Advanced Markets

Greene and Fielitz (1977) analyze the day by day prices of a plethora of stocks recorded at "New York Stock Exchange" utilizing the established "rescaled range" and present long memory by validating its existence. Cheung and Lai (1995)

"recognize long memory by examining information from Japan, Italy, Spain and Austria markets. In addition, the finding did not reflect any variation to the decision to evaluate the techniques utilized. Specifically, results from both the modified "spectral regression" and "rescaled range "technique, was utilized to demonstrate the existence of long memory by "ARFIMA" model.

Interestingly, proof against long memory has likewise been accounted for in various empirical researches. For instance, Lo (1991) discovers no indication consistent with long memory in the US daily and monthly equity prices over several time periods, which include different sub-periods ranging between the 1962 and 1987 years. Mills (1993) scrutinized "UK stock prices monthly, beginning 1965 - 1990 with the returns showed that, the data is not dependent on long range". Again, Chow et al (1995) also are not successful in authenticating the proof of long memory in the US stock return between 1962 and 1991. That is, they have divided the information into dual subperiods and also setting controls with respect to seasonality in equity prices.

Lo and MacKinlay (1988) utilized a specification test commenced on a variance estimator by assessing 1216 weekly observation of daily index data between the period of September, 1962 to December, 1985. Their findings rejected the random walk hypothesis for the entire sample period and for all sub-periods.

Again, Lima and Tabak (2004) employed variance ratio techniques by "Lo and MacKinlay (1988)" and failed in the rejection of the "random walk hypothesis" for Hong Kong value market while the hypothesis for the Singapore business sector was rejected. The data utilized for both countries covered day by day returns of the Hang Seng Index for Hong Kong and the Straits Time Index for Singapore from the period

June, 1992 and December, 2000. Cheung and Coutts (2001) also utilized the "variance test" during the period January, 1985 to June, 1997, to establish the fact that "the random walk hypothesis" exist in "Hang Seng index" and weak-form efficient found in the market.

Random walk hypothesis found on "NYSE index" was analysed by Seiler and Rom (1997)" utilizing the "Box-Jenkins model". The duo utilized day by day prices of the index from 17th February, 1885 to 2rd June, 1962 and presumed that for the period under consideration, variance in price were totally random. The outcomes showed that on a month to month basis; January, July and August and on a week after week basis; Wednesday, Friday and Saturday all recorded expanded profit while Monday presented negative returns which is significant.

Phillips-Peron (PP) unit root and Johansen's co-integration model, utilized by Chan, Gup and Pan (1997) in assessing "the weak-form efficiency" over 16 global stock market involving Spain, Finland, Sweden, Germany, Switzerland, India, US, Italy, Norway, Australia, Belgium, Canada, Pakistan, Japan, Netherlands and UK. Utilizing data ranging from the period January, 1962 to December, 1992 for each of the stock series and 384 month-to-month examination was used by the researchers. Their outcomes uncover that, each stock market indices examined are exclusively "weakform" efficient with just couple of stock indices demonstrating confirmation of cointegration.

The existence of long memory was present in Huang and Yang (1995), using nine (9) selected equity markets form Asian as well as two (2) yardstick comparators, namely,

United States and United Kingdom, utilizing the altered "rescaled range statistic" and data of different frequency. It was found that in most cases the existence of "long memory" can be rejected, except for data from the UK. At long last, Resende and Teixeira (2002) in Brazilian stock market cannot find evidence of "long memory" for periods previously, then after the introduction of the Real Stabilization Plan.

2.7.2 Evidence from Emerging Economies without Ghana

Long memory in stock market data has vital consequences with regards to the market efficiency when securities are being priced. The "efficient market hypothesis (EMH)" gives the standard framework to examine and understand the complexities of data from equity. Though there is in existence various meanings of market efficiency,

Bachelier (1900) introduced the "random walk version" of the EMH, which was formalized by Fama (1965, 1970) and Osborne (1959) attests that, the requirement for any stock market"s efficiency, future returns cannot be predicted from currently existing data.

In any event, if equity information shows long memory then it exhibits important autocorrelation among distant observations. This suggests that the series realizations have a predictable element; and subsequently, past patterns in the information could be utilized to predict future returns. In this manner, "long memory" gives evidences against "efficient market hypothesis (EMH)" for the weak-form version.

A few studies have additionally focused on the estimation of correction biases brought about by thin and infrequent trading which is normal to small and emerging stock markets. Osamah and Ding (2007) utilized a "non-parametric variance ratio model" to

examine the efficiency using eight (8) emerging markets in the “Middle East and North Africa (MENA)”. Their outcome did not discredit the “random walk hypothesis”. In this manner it was concluded that there is “weak-form” efficient with respect to MENA markets. Then again the findings of Abdmoulah (2009) demonstrate the inverse. The researcher examined eleven Arab nations to be specific Dubai, Tunisia, Egypt, Jordan, Qatar, Saudi Arabia, Kuwait, Abu Dhabi, Oman, Morocco and Bahrain and found that all Arab stock markets were weak-form inefficient after applying daily information of the nation's securities exchange indices.

Samuels and Yacout (1981) additionally utilized autocorrelation strategies to test for proficiency on the Nigerian securities exchange. They observed that utilizing week after week prices, twenty-one (21) listed organisations on the NSE took after the random walk hypothesis the periods 1977 and 1979. The study of Olowe (1999) underpins findings of Samuels and Yacout (1981). Likewise, he utilized correlation analysis on month to month stock returns data between the period January 1981 and December 1992. His outcome demonstrates that, the Nigerian stock market is “weakform efficient”

Conversely, Mazviona and Nyangara (2013) gave evidence to hold the fact that, the Zimbabwean stock market is not “weak-form efficient”. The researchers utilized day by day closing returns of index spreading over from February, 2009 to June, 2012 and applied the autocorrelation, Q-statistic test and runs.

Utilizing the Ljung-Box Q and the unit root tests, Chang, Jegadeesh and Lakonishok (1996) tested EMH on the Taiwan stock market on the weak form by utilizing month to

month stock returns index data from 1967 to 1993. Their findings uncovered that, the Taiwan stock exchange takes after the "random walk" and is "weak-form efficient". Chang and Ting (2000) affirm the findings by Chang et al. (1996). They utilized week after week, month to month, quarter and annual prices of stock index between 1971 and 1996. Their outcome rejects the "random walk hypothesis" as week after week data was applied, however for month to month, quarterly and yearly value
- weighted market indexes the hypothesis failed to be rejected.

Existing literature reveals little analysis with respect to "time-series properties" of Africa Stock Markets ("ASMs") in spite of the expanding significance in terms of portfolio diversification, quite like markets of South-Eastern Asia as well as Latin America have turned out to be increasingly adjusted to that of United States of America and the European Markets. Also, as "ASMs" formed part of the quickest developing markets on the globe, several African markets excluding South Africa, stay very small by global standards (Yartey and Adjasi, 2007). Small size coupled with related lower levels of fund inflows; raise issues with respect to the efficiency of these markets and the procedure for determining prices.

Adnan and Erdost (2007) examined on "Long Memory", considering the volatile nature of the stock market returns of Turkey. The aim of their examination was to give extra information on the present of volatility and nature of the "long memory" in returns on stock, utilizing information from a emerging stock market, specifically the Istanbul Stock Exchange (ISE). Utilizing the "ARFIMA-FIGARCH" modelling method, the outcomes demonstrate the evidence of "long memory" in the Turkish stock prices, thus conflicting with the "weak-form market efficiency". The inference is that,

the stock index of Turkey (ISE-100), comprises of the impact of news and shock that had happened in the recent past.

Utilizing week after week data, Barkoulas et al (2000), report evidence to show that "long memory" in the securities exchange of the Greek for data spreading over ten (10) years. An evaluation of the "factional differencing parameter" of the "spectral regression" technique was estimated. Likewise, Barkoulas et al (2000) also accounted that, "ARFIMA model" gives better out-of sample forecasting accuracy in contrast with the benchmark linear (random walk) models.

In a seven nation investigation of mostly Asian nations during the period 1983 and 1998, Sadique and Silvapulle, (2001) documented evidence of "long memory" among the Asian`s stock markets. Nagayasu (2003) discovered equity returns for having "long memory" and volatility of "Nikkei" previously and after implementing the financial related reforms in Japan, recommending that the stock market of the Japanese stays inefficient in spite of the endorsement extensive reforms of the financial market. A study by Forgha (2012) introduced empirical evidence of the efficiency and volatility of stock returns in five stock markets in Africa in particular; Egypt, Kenya, Cameroon, Nigeria and South Africa. The methodology adopted was the Generalized Autoregressive Conditional Heteroskedasticity in Mean (GARCH-M), unit root, and variation ratio tests utilizing quarterly information for the period 2001 to 2010. The study established evidence of inefficiency of various degrees in the selected markets.

Additionally, Watundu et al (2015) conducted empirical examination of the "weakform" efficiency market hypothesis, using the Uganda Securities Exchange

(USE). Findings of this examination showed that, the exchange reports a “weak-form efficiency“”, based on Generalized Autoregressive Conditional Heteroscedasticity (GARCH), unit root tests, and the serial correlation tests. Daily information for fourteen (14) listed organizations for the period 4th January, 2005 to 7th August, 2012 was utilized. The discoveries demonstrate the presence of volatility clustering and also weak-form efficiency of the stock market.

Another study by Ntim et al (2011) likewise inspected the African stock markets in terms of weak-form efficiency. The reason for the study was to examine and analyse the “weak-form” efficiency. Under consideration are twenty-four (24) countries in Africa‟s continent stock prices indices. Also considered are eight (8) individual African countries“” stock return indices. Variance ratio tests was used taking into account Wright's (2000) ranks and signs were utilized for the analyses of “weakform” market efficiency of the thirty-two (32) stock price indices. All things considered, the findings were; independent of the test utilized; the returns of the entire
24 African continent stock return indices examined in the research were less not normally distributed as liked to the eight (8) individual national stock value indices analyzed. They likewise reported evidence of the African continent stock return indices comprising significantly better “weak-form” market efficiency over their national counterparts.

Mobarek and Keasey (2000) „utilized all prices of all organisations that are listed on the Dhaka Stock Exchange between the period 1988 and 1997 daily, for the purpose of inspecting how efficient the market was. Utilizing “non-parametric” and “parametric” models, it was established that shares returns deviate from the “random walk”. Their

outcome uncovered substantial lag period of autocorrelation co-efficient, which demonstrated that the stock exchange was “weak-form” inefficiency“. Conversely, Auer (2016) examined the issue of time-varying predictability for a sample of twenty-one (21) developing markets with a period from 1988 to 2015. The analysis reveals significant downward trends in the local Hurst coefficients of almost all markets. His findings clearly point out why a random walk is neither necessary nor a sufficient condition for rationally determined security prices and thus signs of predictability should not be interpreted as evidence for market inefficiency.

Akinkugbe (2005) researched the securities exchanges of Botswana and observed that, there were “weak-form” and “semi-strong form” efficient. 738 week by week stock index closing prices spanning between June, 1989 and December, 2003 was used as his data. He utilized “Augmented Dickey-Fuller”, “Autocorrelation” and “Phillip-Perron unit root model” and concluded that, the return series demonstrated no present of “serial correlation”. Findings of the two, that is, the unit roots models show stock returns are non-stationary, inferring that, the series take after the “random walk” and are “weak-form efficient”.

Benouda and Mezzez (2003) researched on automation of Tunisian Stock Exchange (TSE). The study utilized information comprising of closing prices and exchanging volume for thirty-eight (38) firms for a time frame of eight (8) years and led a study for the monthly relative method for 'trading volume' as a substitute for liquidity and stock price behaviour was analysed through examining an event study for the stock return. In any case, automation of the Tunisian Stock Exchange (TSE) did not have significant effect on efficiency. Alagidede and Panagiotidis (2009), researched on the modelling

stock returns in Africa`s emerging equity markets`. Markets namely, Kenya, Morocco, Egypt, Nigeria, Zimbabwe, South Africa and Tunisia were considered for their research. The validity of the random walk hypothesis was examined and rejected by employing a battery of tests indicating inefficiency on the markets.

Omuchesi et al (2014) examines the automation of the Nairobi Securities Exchange (NSE) in 2006 and expected as one of its objectives to enhance market efficiency. The reason for their research was to determine the impact of automation on market efficiency. Their findings purposed to observe the automation impact on efficiency market of the Nairobi Securities Exchange (NSE) utilizing month-by-month market prices from the closing NSE 20-Share index and month-by-month closing stock list from 2002 to 2012. A dual study period was considered; pre-automation period (January, 2002 to June, 2006) and post-automation period (July, 2008 to December, 2012). The study embraced a longitudinal research design. Their findings show that the introduction of the ATS had no statically significant impact on market efficiency at the Nairobi Securities Exchange. All said and done, the outcomes demonstrate that automation had not yielded the anticipated benefits in enhancing efficiency of the Nairobi Securities Exchange.

Concentrating on Africa emerging markets, Parkinson (1987), utilized month to month individual stock prices of firms and tested how valid the Nairobi Stock Exchange (NSE) in terms of the weak-form efficiency between 1974 to 1978. He utilizes “runs test” by measuring random walk hypothesis and discovered fifty (50) listed firms on the NSE, a significant forty-nine (49) indicated few numbers of the “runs” that was anticipated. Along these lines, the “random walk hypothesis” is rejected for these firms. Between

the periods 1979 and 1989, Dickinson and Muragu (1994) proceeded to conduct the examination work of Parkinson. This was done by figuring out if the NSE took after the "random walk". They utilized the "autocorrelation" and "Runs tests" and connected it to week-by-week prices of thirty (30) stocks that were mostly traded effectively. Their outcome negated Parkinson

(1984). They discovered that, their outcomes supported the "weak-form" market efficiency hypothesis in NSE.

2.7.3 Evidence from Ghana Stock Market Efficiency

Concentrating on the Ghanaian market, it could be argued that, very little has been done on determining the efficiency of the market. The vast majority of research examined however uncovers our market as "weak-form" inefficient.

Dewortor and Gborglah (2004), conducted research to established whether the stock market in Ghana is efficient enough to prevent investors from developing trading strategies based on historical prices. They utilized "serial" and "cross-sectional" correlation tests to ascertain the efficiency of the market. The outcome demonstrated; a larger share of daily stock returns is emphatically "serially correlated", regardless of whichever technique is applied. In additionally, contrasts amongst day-to-day and month to month "return correlation" were irrelevant. Returns reported quarterly had an inconsequential "positive correlation", yet the "cross-sectional" results gave evidence of substantial positively correlated relationship. Year by year returns were additionally observed to be relatively negative and which exists in Ghana, a price reversal phenomenon, yet insignificant in general. They finished up in view of the findings that, Ghana stock exchange, to a large extent is a "weak-form" inefficient.

The weak-form market efficiency was investigated by Appiah-Kusi and Menyah (2003) considering eleven African securities markets. The countries included, “Ivory Coast”, “Botswana”, “Kenya”, “Mauritius”, “Egypt”, “Morocco”, “Nigeria”, “Ghana”, “South Africa”, “Zimbabwe” and “Swaziland”. The research represented thin trading while figuring the returns taking into account “non-linearity” and “timevarying” volatility nature of the process of generating returns. They utilized week after week price index of stock data between 1989 and 1995. The researchers embraced the technique of “Miller, Muthuswamy and Whaley (1994)” to remove any effect of “thin trading” by assessing a moving normal technique that mirrors the number of non-trading days. The study also permitted alteration of the returns in like manner. Additionally, they utilized the “EGARCH-M model” to conduct the test on efficiency. The finding was that, except for Zimbabwe, Morocco, Egypt, Mauritius and Kenya, all six nations deviated from “weak-form” efficient. The outcome additionally demonstrated that; generation return method is “nonlinear” for the eleven (11) markets and in five (5) of selected markets, investor‟s request a “time-varying” risk premium for the risk being tolerated.

Simons and Laryea (2004) researched the efficiency of four (4) securities exchange indices from Ghana, South Africa, Mauritius and Egypt, between 1990 and 2003. They applied “serial correlation”, run, and the multiple variance rations tests. Their outcomes show that separated from South Africa, the market‟s index price behaviour was “weak-form” inefficient.

Frimpomg and Oteng-Abayie (2008), also scrutinized the weak-form efficient market hypothesis (EMH) on GSE an emerging market. Their research covered a period over

five (5) year from 1999-2004. GARCH (1, 1) and Random walk (RW) models were used for their analysis. The weak-form efficient market (random walk) hypothesis was rejected for the GSE, indicating that the market is inefficient.

Tweneboah, Amanfo & Kumah (2013), alternatively investigated the random walk behaviour of exchange rates in Ghana by using non-parametric and parametric variance ratio tests supported on signs and ranks utilizing monthly exchange rates of the GHS/USD pair. The researcher‟s findings presented convincing evidence that the exchange rate series is not in agreement with the random walk process and the weakform efficient market hypothesis. Tweneboah et al, (2015) again applied ARFIMA and FIGARCH models to analyze the long-run properties of real interest rates in Ghana. Estimates of the long memory parameter imply that shocks have long memory effects, though ultimately mean-reverting.

Utilizing some fairly extra vigorous techniques, Ntim, Oppong and Dunbolt (2007), reconsidered the weak-form efficiency hypothesis of the market of GSE. They utilized two types of information as part of their study. The first comprises closing prices of day-to-day “All Share Index” (ASI), while the second was day by day closing stock prices of twenty individual stocks. The two types of information crossed from 20th November, 1990 to 31st December, 2005. They took on variance ratio model by Wright (2000), and Lo and MacKinlay (1988) to figure out whether the series actually follow the “random walk”. Their outcome was blended. Variance ratio test by Lo and MacKinlay demonstrated that the ASI price series was in violation to “random walk” hypothesis results with respect to individual stocks were somewhat mixed. In spite of this, the after effects of the “Wright's test” was certain. However, they rejected the

"weak-form efficiency" of the Ghana Stock Exchange that is consistent with past research.

Alternatively, Mensah, Owusu-Antwi and Bokpin (2016) examined the GSE efficiency by exploring the day of the week effect, with respect to the Exchange. They utilized the GSE‟s All-share daily index data, between November, 1990 and August, 2012. They used a numerous techniques in particular; "generalized autoregressive" conditional "heteroskedastic", "dummy variable regression", "one-sample t-test" and "autoregressive" models in testing the day of the week impact exist with respect to the "Ghana Stock Exchange". The outcome presents the present of day-of-the-week impact with respect to the "Ghana Stock Exchange". A report of significant yields is seen on Tuesday, while minimum returns for Thursday. On Monday, Wednesday and Friday recorded significant positive returns, in any case, significant returns is caught by a "strong auto-regression" in their returns. This means returns on stock for the "GSE" are not completely random and that the efficient hypothesis of the market is not dependent on the exchange.

Ayentim, Mensah and Naa-Idar (2013) researched on the "weak-form efficiency" of firms that are listed on the GSE, by utilizing week after week closing prices on the GSE from January, 2007 to June, 2012. They utilized two distinctive "nonparametric" tests, in particular "Kolmogorov-Smirnov" test as well as "runs test" in figuring out if period-to-period changes in price take after a "random walk" and also figuring out whether "price series" are predictable. They gave the descriptive statistics of the "price series". It was found out that, prices from "GSE" did not take after "normal distribution".

Furthermore, results demonstrated that, the returns series indicated evidence of volatility clustering, meaning inefficiencies on the GSE.

Mensah, Pomaa-Berko and Adom (2014) utilizing the Unit Root, Random Walk and the GARCH techniques found that the "Ghana Stock Exchange" was "weakly inefficient" in the pre and post automation periods, recommending that, automating the "GSE" did not yield the required impact in the enhancement of the exchange‟s efficiency. The reason for their research was to explore the impact of automating the "Ghana Stock Exchange" on its efficiency within the framework of the weak-form "Efficient Market Hypothesis (EMH)" utilizing day-to-day market return, reported by the Ghana Stock Exchange All-Share index between 2006 and 2011.

2.8 Conclusion

All the previously mentioned theoretical and empirical works serve as a basis for further studies in the areas of long memory behaviour and predictability of stock prices. The Ghana Stock Exchange throughout past years has depicted inefficiencies to a large extent. The efficiency market‟s achievement has failed despite the fact that, significant improvement has been made with respect to the advancement of the exchange.

Osei (2002), examine EMH on Ghana Stock Market and concluded that, the market is inefficient regarding yearly earning information released by the firms listed on the exchange. His examinations cover "cumulative abnormal returns (CAR)" to estimate returns which span a 17 weeks‟ event window, amid yearly earnings releases. Dewortor and Gborglah (2004) concluded that the GSE to a large extent is a weakform inefficient.

They utilized “serial” and “cross-sectional” correlation tests to ascertain market efficiency. Ntim et al (2007) affirmed the results of Dewortor and Gborglah 2004 by utilizing Variance-Ratios Tests. Their finding was that stock returns, convincingly are inefficient in the “weak-form”. Mensah et al, (2016) analyzed how efficient the “Ghana Stock Exchange” is by exploring the “day-of-theweek” impact with respect to the Exchange utilizing the GSE All-share daily index data for the period, November 1990 and August 2012. Their study made use of a few methods in particular; “generalized autoregressive conditional heteroskedastic”, “dummy variable regression”, “one-sample t-test”, “autoregressive” models. Their outcomes on GSE signal that, stock returns are not completely random. Furthermore, the “efficient market hypothesis” does not hang on the exchange.

The “weak-form” efficiency was been researched by Ayentim et al (2013) on firms that are listed on the GSE. They utilized week by week closing prices on the GSE from January, 2007 to June, 2012. They also consider Kolmogorov-Smirnov test and runs test to figure out if period to period price changes take after a random walk furthermore to figure out whether price series are predictable. Their findings demonstrated that, the returns series evidence of volatility clustering which means that inefficiencies on the GSE.

Further empirical studies from Mensah et al (2014) utilizing the Unit Root, Random Walk as well as “GARCH” models and found that the Ghana Stock Exchange exhibit “weakly inefficient” in the pre and post automation periods, recommending that automation on the “GSE” did not yield the required effect in enhancing efficiency of trade from 2006 to 2011.

Thus, given the results of early studies on the efficiency of the GSE, there is a gap in the existing body of knowledge by pervious researches, base on the fact that none of the current studies have applied ARFIMA and FIGARCH models in their studies, with the exception of Tweneboah et al, (2015), where they utilize ARFIMA and FIGARCH to scrutinized the Long Memory Behaviour of Real Interest Rates in Ghana. Furthermore analyzing the efficiency of the Ghana Stock Exchange takes after the post automation of the exchange from 2010 – 2014 after Mensah et al (2014).

Along these lines, this study was intended to scrutinize the impact of long memory behaviour and predictability of stock price, taken into consideration the financial related firms (Banks) on the GSE with the period of 2010 to 2014 and furthermore, this research endeavours to fill a gap, that is, to the best of knowledge there has not been any study endeavouring to utilize together unit root, variance ratio, ARFIMA, and FIGARCH models, to examine the long memory parameter, so as to explore the weak-form inefficiency established by different researchers on the GSE.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The section covers the strategy followed to discover answers to the research questions to aid in achieving the objectives of the research which is to test for the long memory behaviour and predictability of stock prices in the Ghana Stock Exchange. This chapter presents the methodology, which covers data description and sources, and empirical modelling techniques.

3.1 Data sources and description

Data of secondary sources were employed to achieve the study‟s objectives. Secondary sources of data were taken from the Databank, a brokerage company in Ghana and data analysis will be of quantitative in nature. The primary comprises daily closing GSE All Share Index (ASI) price series and daily closing stock return series of individual listed stocks comprises the second class of data utilized. The financial firms listed on the GSE consist of value weighted index of ASI. The time frame consider on the ASI start its unique base of 31st December, 2010 and ends on 30th June, 2014 daily price series observation were analysed. Consistent with the nature of the study and research design, the use of the secondary source of data saved the time associated with data collection. The study makes use of daily time series data on closing stock prices of ASI and individual listed stocks of seven (7) financial firms
(banks) on the Ghana Stock Exchange.

It is critical to note that the study utilizes current information up to 2014 for our examination, which is imperative in the light of the fact that by utilizing current

information we will have the capacity to catch a portion of the changes and patterns that have happened after some time and may affect the efficiency on the share market. The same set of information is utilized to assess the long memory parameter using unit roots, variance ratio, ARFIMA, and FIGARCH techniques.

3.2 Statistical Tests for Market Efficiency

The research utilizes different statistical techniques, in particular variance ratio, Augmented Dickey-Fuller unit root, ARFIMA, and FIGARCH to scrutinize efficiency of a market. The information is under the control of variance ratio model to decide the extent of reliance amid successive profits for the Ghana stock Exchange. These statistical tests are talked about in each of the following sub-sections.

3.2.1 Unit root and stationarity tests

Different statistical tests have different assumptions which lead to the utilization of various types of data. Whereas some studies use integrated (unit root) data, others used stationary data. A stochastic process for a variable is stationary when its covariance and mean are time invariant. In most instances, if the variables cannot be stationary, estimation may lead to spurious results which would have no economic meaning. For this reason, the properties of the data generating process is usually determined in order to ensure that deductions based on the findings would be appropriate for forecasting.

There are a lot of tests for unit root and stationarity including the "(Dickey and Fuller, 1979), Augmented Dickey-Fuller (ADF) test"; "(Phillips and Perron, 1988) PhillipsPerron (PP) test"; "(Kwiatkowski et al., 1992) Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test" the Dickey-Fuller Test with GLS Detrending (DF-GLS) test(the

Zivot– Andrew (ZA) model (Zivot and Andrews, 2002) and(Elliott, Rothenberg, and Stock, 1996). In this study, two different tests are employed – the KPSS and ADF models are used. Null hypothesis of unit root exist in the ADF tests, whereas the KPSS has stationarity as null hypothesis.

3.2.2 Lo &MacKinlay Variance Ratio Parametric Tests

Basically, Lo and MacKinlay (1988, 1989) designed two VR tests for examining RW hypothesis; LM1 assuming homoscedasticity (i.e. independent and identically distributed process), and LM2 estimates robust against heteroscedasticity. If e_t is a time series involving T observations,e_1, e_2, ..., e_T of stock returns, the VR of the *q*difference, VR(q) is described as:

$$VR(q) = \frac{\partial^2(q)}{\partial^2(1)} \qquad (1)$$

Where the unbiased estimator of 1/q which is the variance of stock return *q*-th differences under the null is $\partial^2(q)$; the 1st difference of the variance is $\partial^2(1)$ of the stock return, q is the base lag (q =2, 4, 8 and 16 in this study). RW data generating process from the null hypothesis involving the variances for all *q*-th lags are normal to be the same to unity. According to LM (1988), the estimator

$$\partial^2(q) = \frac{1}{Tq}\sum_{t=q}^{T}(e_t + \cdots + e_{t-q+1} - q\bar{\mu})^2 \qquad (2.a)$$

Where$\bar{\mu} = \frac{1}{T}\sum_{t=1}^{T} e_t$ is the first difference of the unbiased estimator of the variance, thus the estimated arbitrary drift parameter.

$$\partial^2(1) = \frac{1}{T}\sum_{t=1}^{T}(e_t - \bar{\mu})^2 \qquad (2.b)$$

Therefore, normally distributed with unit variance and zero mean which is homoscedasticity assumption is under the null hypothesis of RW

$$LM_1(q) = \frac{VR(q)-1}{\phi(q)^{\frac{1}{2}}} \qquad (3.a)$$

Where the homoscedastic asymptotic variance of the VR is given as

$$\phi(q) = \frac{2(2k-1)(k-1)}{3k-T} \qquad (3.b)$$

The second model, LM2 which is robust against heteroscedasticity and non-normalities is given as follows:

$$LM_2(q) = \frac{VR(q)-1}{\phi^*(q)^{1/2}} \qquad (4)$$

With the test statistic which corresponding heteroscedasticity-consistent asymptotic variance defined as:

$$\phi^*(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-1)}{q}\right]^2 \delta_j \qquad (5.a)$$

and

$$\delta_j = \frac{\sum_{t=j+1}^{T}(e_t-\overline{\mu})^2(e_{t-j}-\overline{\mu})^2}{\sum_{t=1}^{T}(e_t-\overline{\mu})^2} \qquad (5.b)$$

Homoscedasticity and heteroscedasticity are two statistics measurements proposed by Lo and MacKinlay (1988) for examining individual VR estimates. The tests scrutinize the VR statistics for a several *q* values and reject the null in the event that it is rejected for some *q's*. Nonetheless, Chow and Denning (1993) claim that this successive technique prompts a larger than usual testing strategy. This contention has prompted the expansion of the individual tests to multiple VR comparison test (Chow and Denning, 1993) along with Wald-sort joint analysis (Cecchetti and Lam, 1994, Richardson and Smith, 1989). Once more, different contentions started on the way that the LM and multiple VR tests are estimated by their restrictive distributions, have

prompted some transformation of the traditional tests. Unquestionably, the asymptotic sample distribution of the VR statistic may possibly be a long way from ordinary in a finite sample displaying right skewness and severe bias. Cecchetti and Lam (1994) argues that the finite sample lacks may offer ascent to serious size distortions or else low power that can prompt misleading inferences, particularly when the sample size is not sufficiently substantial to validate asymptotic estimations. With the concentration on the aim of maintaining a strategic distance from this, some transformations for example, Wright (2000) precise VR tests in view of ranks and signal, Whang and Kim (2003) with a sub-sample methodology, Chen and Deo (2004, 2006) a power transformed VR statistic, and Kim (2006) a bootstrap strategy, among others have been proposed.

3.2.3 Fractional Integration Models

The usual technique designed to analyse the integration property of a series is unit root and cointegration tests. Such tests distinguish between *I*(1) and *I*(0) data generating processes. There exists a vast literature on cointegration tests and unit root used on stock return been measured by the time series properties (see Neely and Rapach (2008) for a review. However, cointegration tests and unit root experience the ill effects of low power, when the genuine model is constant. Likewise, the tests are excessively restrictive and do not tell much concerning true behaviour of variables with the exception of charactering it as *I(0)* or *I(1).*

Accordingly, a few analysts investigation for fractional integration in the ex ante and ex post stock return (Granger, 1980; Hosking, 1981 Granger and Joyeux, 1980). *I(d),*

$0 \leq d \leq 1$ is the fractionally integrated series. At the point where d = 1, the series is I(1), with shocks having infinite memory or lasting impacts. Where d = 0, the series is I(0), and shocks out to exist at a geometric rate; An intermediate incident happens where $0 < d < 1$: The series is mean-reverting, as in the *I(0)* case, yet shocks now vanish at a much slower hyperbolic (instead of geometric) rate. Series in which 0 <d < 1 display "long memory," mean-reverting behaviour, and can be significantly more persistent more to an exceptionally persistent *I(0)*series.

Volatility have a tendency to transform gradually after some period and as appeared in Granger, Engle and Ding (1993) amid others, impacts of a shock may take a significant period to perish. Hence the difference amongst unit root and stationary processes is by all accounts extremely restrictive. To be sure, exponential rate of decay can be linked to the propagation of shock in a stationary process (so that it just exhibits short-memory), whereas for a unit root process the persistence of shocks is endless. The ARFIMA specification is planned to bridge the gap between complete and short persistence in the contingent mean, in order for the short-run behaviour of the time-series is showed by the ARMA parameters, where as the fractional differencing parameter takes into account displaying the long-run dependence.

3.2.3.1 ARFIMA Model

Keeping in mind the end goal to show long memory in stock prices the ARFIMA (m, d, n) technique created by Hosking (1981) and Granger and Joyeux (1980) is utilized. As already talked about, this model has been widely employed to investigate the financial time series behaviour. The technique is been communicated as:

$$\square(\ )(1L\ \square L\ Y)^{d}{}_{t}\square\square\ \square(\ )L_{\ t} \qquad (6)$$

L denote the usual lag operator, $\phi(L)$ and $\theta(L)$ are the qth and pth degree polynomials in that order, and defined as $\phi(L) = 1 - \sum_{j=1}^{p} \phi_j L^j$ and $\theta(L) = 1 + \sum_{j=1}^{q} \theta_j L^j$. d is the differencing parameter which can be a fractional number, the roots of $\phi(L)$ and $\theta(L)$ be positioned outside the innovation sequence and the unit circle, ε_t is zero mean with a white noise and variance, σ^2.

3.2.3.2 FIGARCH Model

ARFIMA representation in squared errors (ε^2) which is the expansion of the FIGARCH (p, d, q) technique of Baillie *et al.* (1996). Generally demonstrating to this technique may be deduces after the standard GARCH process and expressed as below:

$$\phi(L)(1-L)^{\bar{d}} = \omega + [1 - \beta(L)]\nu_t \qquad (7.a)$$

ε_t^2 is the squared error of the GARCH process, $\nu_t = \varepsilon_t^2 - \sigma_t^2$ is mean zero serially uncorrelated error. $\{\varepsilon_t\}$ Process is integrated to be the "innovations" for the conditional variance σ_t^2. if $\bar{d} = 1$, the FIGARCH process turns out to be an included GARCH process. And If $\bar{d} = 0$, the FIGARCH (p, d, q) process trim down to a GARCH (p, q) process Reorganizing the expressions in Eq. (7.a) above, FIGARCH technique may be restate as below:

$$[1 - \beta(L)]\varepsilon_t^2 = \omega + [1 - \beta(L)](1-L)^{\bar{d}}\varepsilon_t^2 \qquad (7.b)$$

The conditional variance equation of σ_t^2 is computed as

$$\sigma_t^2 = \frac{\omega}{[1-\beta(1)]} + \left[1 - \frac{1-\phi(L)}{1-\beta(L)}(1-L)^{\bar{d}}\right]\varepsilon_t^2 \qquad (7.c)$$

$[1-\phi(L)]$ $[1-\phi(L)]$

That is,

$$\sigma_{t2} = \frac{\omega}{[1-\phi(1)]} + \frac{[1-\phi(L)]}{[1-\phi(L)]}\varepsilon_{t2} \quad (7.d)$$

Where $\phi(L) = \phi_1 L + \phi_2 L_2 .....$

Additionally, all the roots of $\phi(L)$ and $[1-\phi(L)]L$ and $d \in (0, 1)$lie down outside the unit circle. Other GARCH techniques are been captured by the FIGARCH (*p, d, q*) techniques and is equivalent with standard GARCH technique and the IGARCH process, where $\bar{d} = 1$ and $\bar{d} = 0$, in that order.

Whereas $\bar{d}$ confines long memory in the FIGARCH technique, its understanding is not the same to that reflected by the ARFIMA in the light of the fact the FIGARCH process cannot be covariance stationary other than severely stationary and ergodic for $0 \leq \bar{d} \leq 1$ and consequently the unconditional variance of σ_t cannot be show (Baillie, 1996). Baillie *et al.* notice the effect of a shock on conditional variance of FIGARCH (*p, d, q*) processes diminish at a hyperbolic rate when $0 \leq \bar{d} \leq 1$. Therefore, traditional GARCH model parameters show the long term dynamic which is considered by the short dynamic and the fractional integrated parameter *d*.

3.3 Software and Data Analysis

The above analysis cannot be done manually but with the help of statistical packages and computer applications. There are a number of applications for financial and economic modelling. In this study, Eviews version 9 and Oxmetrics Console version

6.2 has been used for all the analysis including the graphics. Microsoft Excel and also Microsoft Word were also used for the report of tables and figures.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This section shows the results of the tests conducted as well as discussions. The estimates are based on daily closing prices of seven (7) stocks listed on the GSE for the period 31.12.2010 – 30.06.2014. The data source is Data Stream. The data were changed into constantly compounded returns by taking the natural logarithm which is the first difference of the day-to-day closing prices as follows $r_t = \ln p_t - \ln p_{t-1}$ or p^t) ,

— where p_t the current return or the price at time t is, *ln* is the natural

$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right)$

logarithm, and p_{t-1} represent first lag of the price. The data did not capture nontrading days such as weekends and holidays. Thus, the return of a day modelling after a non-trading day is calculated via the closing return indices of the current trading day and the last trading day. The estimations and tests were analysed using Oxmetrics Console version 6.2. For the ARFIMA-FIGARCH model, the Ox Console version 6.2 together with the G@rch Console 4.2, were employed. All the consoles are part of Ox Econometric Software created by Jurgen A. Doornik.

4.2 Graphical Analysis

Keeping in mind the end goal to depict the visible time series elements of the stock prices and returns, the graphs of the individual series are presented in this section. Figure 1 is the graphs of the natural logarithm of the prices series. There is a specific

upward pattern within the series especially in the price series since 2012 denoting increases in stock prices. Figure 2 contains the graphs of the individual returns series.

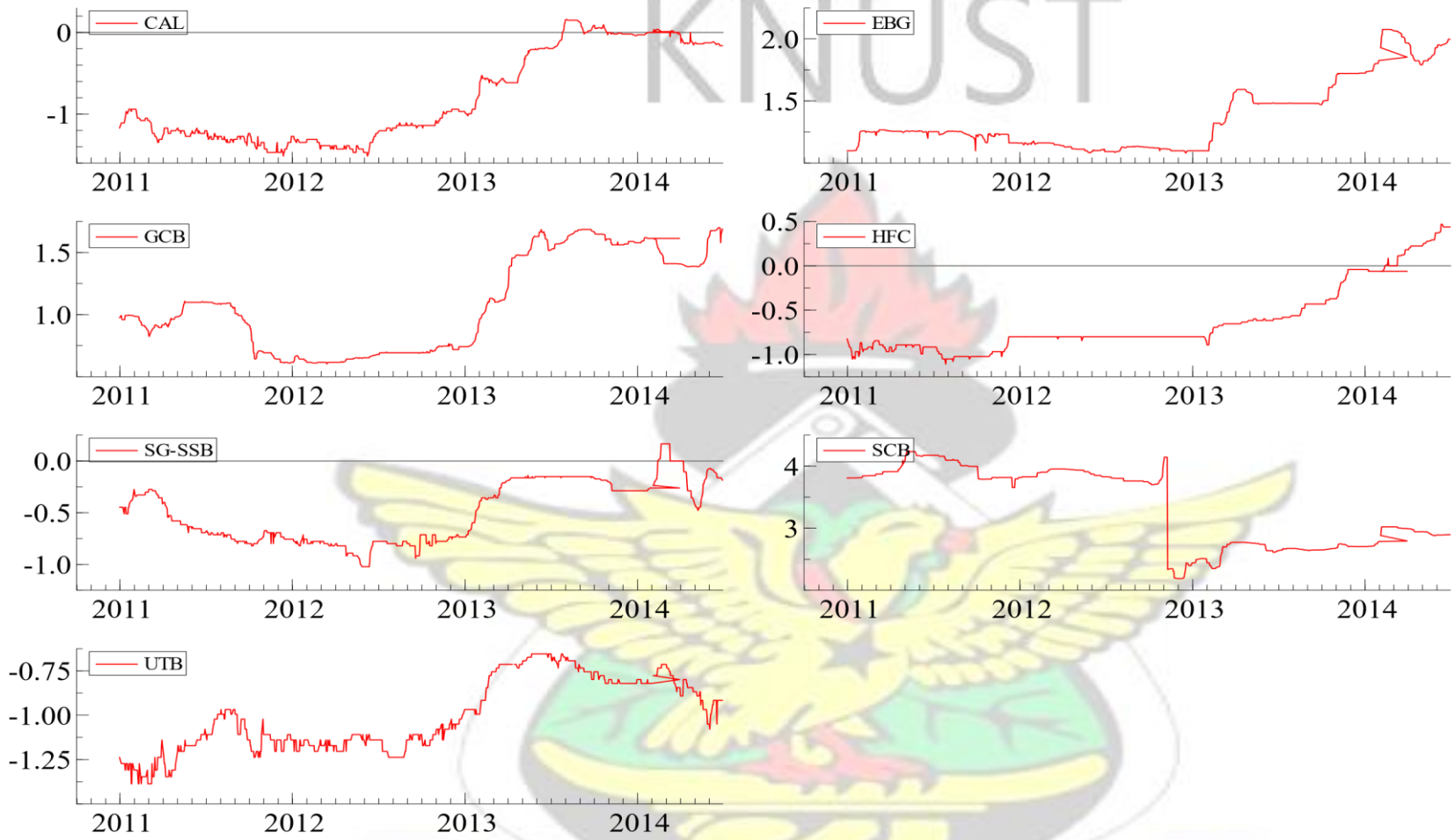

Figure 4.1:Graph of natural logarithm of stock prices

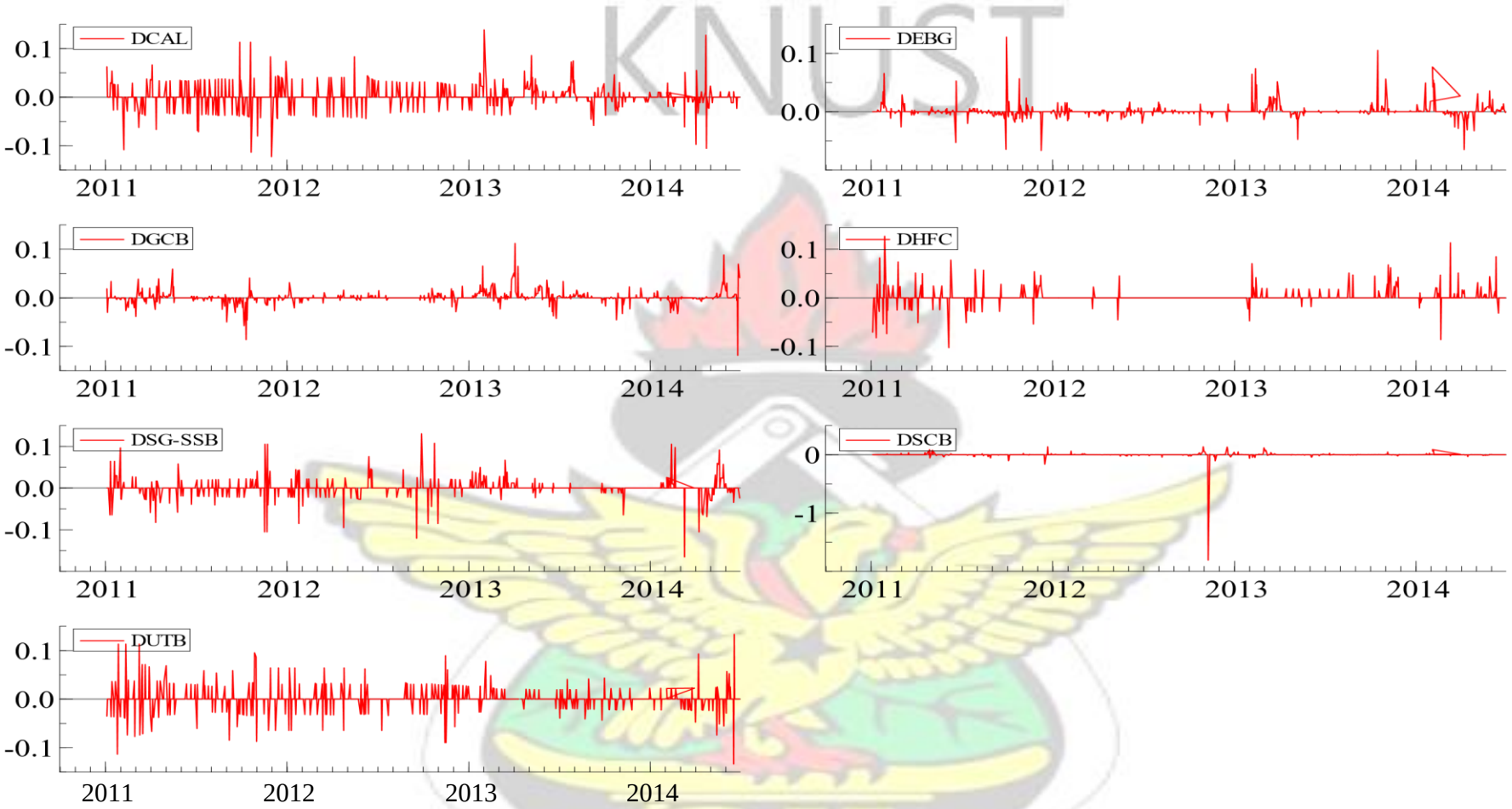

Figure 4.2: Graph of stock returns

4.3 Descriptive statistics

Following the graphical analysis, the researcher presents the descriptive/summary statistics or properties of the series in Table 1. In terms of mean or average returns, all the variables have positive returns except UTB which has negative returns. Quite interestingly, all the stocks have average returns of approximately 0.1 percent. UTB has a moderately high standard deviation 0.063, which demonstrates that the data points scatter or spread far or wide from the mean. All the series appear extremely non-normal. The returns distributions of SCB, UTB, and SG-SSB are negatively skewed. Once more, all the returns distributions show a high level of excess kurtosis (leptokurtic). The negative skewness suggests a higher probability of expansive declines in market portfolio returns than increments or substantial negative returns have a tendency to be bigger than the higher positive returns. Such skewness and kurtosis are basic elements in asset return distributions that are more than once observed to be leptokurtic. This behaviour shows that the returns have higher peaks than would be normal from typical distribution. Convincingly, the Jarque-Bera test for the null hypothesis of normality is rejected for the returns series at the 1 percent significance level. This recommends that all the variables deviate from the normal distribution. The Jarque-Bera analysis is a decency of-fit estimate away from normality, in view of the sample skewness and kurtosis, and is distributed as a chisquared with two degrees of freedom. The null hypothesis is a combine theory of both the excess kurtosis and skewness. The p-value is smaller than the 1% level of significance proposed rejected the null hypothesis. This demonstrates that the prices are not all around estimated by the normal distribution.

Table 4.1: Descriptive statistics

	SCB	CAL	EGL	GCB	HFC	UTB	SG-SSB
Mean	0.001433	0.001166	0.001481	0.000827	0.001456	-0.000881	0.000301
Median	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Maximum	0.118784	0.138836	0.135175	0.112117	0.126752	0.139762	0.130620
Minimum	-0.148420	-0.122602	-0.111226	-0.118470	-0.102654	-1.791759	-0.165514
Std. Dev.	0.018125	0.022546	0.019500	0.012666	0.015241	0.062803	0.021175
Skewness	-0.180106	0.225264	0.955671	0.270443	1.225059	-26.81215	-0.306468
Kurtosis	25.63035	10.98719	15.71166	28.40469	22.81868	766.2794	17.89739
Jarque-Bera	18462.79*	2306.603*	5955.509*	23271.78*	14372.81*	21101348*	8012.343*
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	1.239340	1.008664	1.280934	0.715536	1.259235	-0.762140	0.259958
Sum Sq. Dev.	0.283842	0.439201	0.328532	0.138608	0.200691	3.407842	0.387407
Observations	865	865	865	865	865	865	865

Notes: * indicate rejection at 1% significance levels.

4.4 Testing the random walk hypothesis

4.4.1 Unit root and variance ratio analysis

Keeping in mind the end goal to decide the integration properties of the series, two distinctive approaches were employed. The tests were the ADF and KPSS. Though the ADF test has a null hypothesis of unit root in opposition to the alternative hypothesis of stationarity, the KPSS test has a null speculation of stationarity. Both tests are carried out the in light of a regression on a constant and the outcomes are exhibited on Table 2. Findings rejected the null hypothesis of the ADF unit root test for all of the returns series. This proposes, all the returns series are stationary, since the entire test statistics completely deviate from the critical values. The null hypothesis that the variables are I(0) was rejected on account of the KPSS test for EGL and HFC at the 5% and 1% significant levels, individually. In this way, we conclude that EGL and HFC stock returns are not stationary since they have test statistics greater than the critical values indicating that the basic qualities and the series cannot be described as I(0) process. In opposition to the unit root test, the null hypothesis that a series is stationary is rejected if the test statistic exceeds the critical value, i.e., the series has a unit root.

Table 4.2: Unit root and stationarity tests

	SCB	CAL	EGL	GCB	HFC	UTB	SG-SSB
ADF	-17.18*	-30.04*	-12.52*	-9.58*	-28.56*	-29.18*	-10.08*
KPSS	0.18	0.23	0.50**	0.32	1.06***	0.24	0.14

Note: Present H0 and Ha of ADF and KPSS. ** and ***indicate rejection at 1% and 5% significance levels respectively

Critical values for ADF: -3.44 (1%), -2.86 (5%), & -2.57 (10%) and KPSS: 0.74 (1%), 0.46 (5%), & 0.35 (10%)

4.4.2 Variance ratio tests for random walk

Random walk (RW) hypothesis places that, for market efficiency, changes in succeeding return, take after a severe Gaussian random variable. Practically speaking, notwithstanding, a financial asset's return series is said to take after a random walk if successive residual increments are “Independent and Identically distributed (IID)”. This implies future return adjustments cannot be anticipated from past price changes. The null hypothesis is that the stock returns take after a random walk. Variance ratio (Lo and MacKinlay (1988), examined whether the time series of a natural logarithm is a pure random walk, afterwards the variance of its *k*-difference in a limited sample becomes linearly amid the distinction.

Table 3 shows the findings of the Lo and MacKinlay's (1988) parametric variance ratio test statistics over the full specimen time frame for the 7 stocks for 5-day, 10day, 20-day, 30-day and 60-day interims. LM reports variance ratios under presumptions of zero mean and no heteroskedasticity (homoscedasticity). The evidence recommends the null hypothesis of the price series are random walk processes is strongly rejected for all the stocks, at any of the intervals of *k* at the 1% significant level. By and large, test statistic diminishes as “k” increases, a disclosure that is steady with that of Lo and MacKinlay (1988). All the rejections fall within the right tail of the null distribution, proposing the existence of a “positive autocorrelation” in the series.

Table 4.3: Results of Lo and MacKinlay (1988) Parametric Variance ratio tests

	SCB	CAL	EGL	GCB	HFC	UTB	SG-SSB
k = 5	1.03788 [0.000]	1.55234 [0.000]	1.89610 [0.000]	1.21257 [0.000]	1.03788 [0.000]	1.03408 [0.0000]	1.22916 [0.000]
k = 10	1.25787 [0.000]	1.99415 [0.000]	2.62819 [0.000]	1.53850 [0.000]	1.25787 [0.000]	1.07356 [0.000]	1.63901 [0.000]
k = 20	1.37947 [0.000]	2.41937 [0.000]	3.49159 [0.000]	2.02110 [0.000]	1.37947 [0.000]	1.16007 [0.000]	1.83995 [0.000]
k = 30	1.40286 [0.000]	2.78595 [0.000]	3.81043 [0.000]	2.43460 [0.000]	1.40286 [0.000]	1.22176 [0.000]	1.77582 [0.000]
k = 60	1.38875 [0.000]	3.65749 [0.000]	5.27962 [0.000]	3.13591 [0.000]	1.38875 [0.000]	1.38753 [0.000]	1.53298 [0.000]

Null hypothesis: the series is a random walk

The issue as to asset returns are predictable and it has for some time been the subject of significant interest. One well known way to deal with noting this subject, Lo and MacKinlay (1988, 1989) covering variance ratio test, looks at the predictability of time series information by contrasting changes of differences of the data computed over dissimilar periods. On the off chance that we expect the data to follow a random walk, the variance of q-period different ought to be q times the variance of the oneperiod difference. Assessing the experimental evidence against or for this limitation is the premise of the variance ratio analyse.

4.4.3 Estimate of long memory/fractional integration parameter

Although the unit root and variance ratio tests establish evidence of non-random walk processes, they cannot determine the degree of integration. The unit root tests only distinguish between I(0) and I(1) variables. In this segment, we show the findings of the long memory (fractional integration) analysis performed for each of the seven (7) stock returns. The terms long memory, long-range dependence, strong dependence, or persistence can be used interchangeably. Specifically, as stated earlier, for each of these 7 series, we report the estimates of both the GPH and the Modified Log-Periodogram Regression for each of the sectors included in Table 4.4.

Based on the GPH and RHE, the fractional differencing parameter estimates are statistically significant for SCB, EGL, GCB, and SOGEGH, while the rest (CAL, HFC and UTB) are not statistically significant at the 1 percent significance level. In terms of magnitude, whereas CAL has negative parameter estimate, the rest are positive. All the significant parameters are positive and have been concentrated between 0.002 and 0.156. These findings suggest that the returns series are generally mean-reverting,

however, takes place at very slow speed. The results of the GPH log periodogram estimates indicate that CAL is anti-persistent since it had negative differencing parameters albeit insignificant. HFC and UTB are positive but statistically insignificant. The remaining four (4) stock returns series (SCB, EGL, GCB and SG-SSB) are positive and statistically significant at 1% level. The differencing parameter is either 0.1 or 0.2. According to the Robinson and Henry"s Gaussian semi-parametric estimates CAL, HFC and UTB are again not statistically significant since they have p-values greater than the preferred significance level. However, the remaining four (4) stock returns series (SCB, EGL, GCB and SG-SSB) are statistically significant at 1% level.

4.4.4 ARFIMA (*p, d, q*) models introduced by Granger and Joyeux (1980)

The parametric estimation for the returns series were derived by means of the Exact Maximum Likelihood Estimation of the OxMetrics 6 ARFIMA package, while the Time Series model (TSM hereafter) was used to obtain the long memory estimates via semi parametric methods. The ARFIMA model"s Exact MLE (Maximum Likelihood Estimate) in the OxMetrics 6 package was used (see Doornik and Ooms, 2003). The techniques with different orders are analysed for ARFIMA (*p*, *d*, *q*).

The fractional differencing parameter, d, which is the size of the mean equation, is considered by examining market efficiency. Table 4 shows the predominance of long memory in prices in GSE. All the stock measured in this study show evidence of long memory. The fractional differencing parameter estimates are determined somewhere around 0.013 to 0.856.

The findings of the ARFIMA (1, d, 1) model initiated by Granger and Joyeux (1980) presented on Table 4 also signify that the long memory parameter is significant at the 5 percent significance level for all the seven (7) series. All the measurements positive and ranges from 0.013 for CAL to 0.856 for UTB. The remained equities have the subsequent estimated d values: SCB (0.180), HFC (0.166), SOGEGH (0.270), GCB (0.286), and EGL (0.392). The results of the ARFIMA estimates point out that all the returns series have positive estimates that are statistically significant at the 5% level. None is anti-persistent and none is explosive.

UTB is non-stationary The FIGARCH component of the model incarcerates long

memory in the conditional variance (volatility).The differencing parameter, *d* estimated by the FIGARCH component is also statistically significant at the 5 percent level for all the variables. Again, none of the estimates is negative. The estimates range from 0.102 for SCB to 1.000 for UTB. The remaining estimates are EGL (0.268), GCB (0.465), CAL (0.556), SG-SSB (0.695), and HFC (0.719). FIGARCH Model showed evidence of long memory in volatility among stocks. In the GSE, the discoveries to great extent validate the present of long memory in volatility except of CAL (d 0.556), HFC (d 0.719), UTB (d 1.000) and SG-SSB (d 0.695) where the outcomes acquired demonstrate that volatility cannot have a predictable element. SCB, EGL and GCB have a fractional differencing value of 0.102, 0.268 and 0.465 separately which recommends a long memory element in volatility. At last, conditional variance equations which show long memory parameters are essentially not quite the same as zero over all stocks studied in this research. Accurately, the FIGARCH model exemplifies a positive limitation which affects on the validity of the estimated findings.

Nonetheless, the outcomes from CAL, HFC, SG-SSB and UTB cannot fulfil the positivity restraint of the FIGARCH method; hence, findings from these stocks should be translated circumspectly. The critical size of *d* and *d* acquired from this equation represents the significance of modelling long memory in GSE.

Moreover, the after effect of $d \neq 0$ from these technique`s is rather than our discoveries from the unit root tests that prompted a closure of $d = 0$. The estimates of the FIGARCH model suggest a generally statistically significant long memory parameter in the conditional variance of the returns series.

Table 4.4: Long memory/Fractional Integration tests

	SCB	CAL	EGL	GCB	HFC	UTB	SG-SSB
GPH	0.135* [0.000]	-0.002 [0.959]	0.156* [0.000]	0.204* [0.000]	0.026 [0.461]	0.002 [0.965]	0.100* [0.000]
RHE	0.092* [0.000]	0.020 [0.399]	0.122* [0.000]	0.181* [0.000]	0.032 [0.186]	0.014 [0.554]	0.061** [0.011]
ARFIMA	0.180* [0.000]	0.013** [0.033]	0.392* [0.000]	0.286** [0.022]	0.166** [0.021]	0.856* [0.000]	0.270** [0.041]
FIGARCH	0.102* [0.000]	0.556* [0.000]	0.268** [0.013]	0.465* [0.000]	0.719** [0.016]	1.000* [0.000]	0.695* [0.000]

Notes: Include intercept but no trend in unit root test, * and ** indicate rejection at 1% and 5% significance levels respectively; GPH = Log Periodogram Regression by Geweke and Porter-Hudak (1983); RHE = Gaussian semiparametric estimate by Robinson and Henry (1998)

Couple researches have indicated worries concerning the efficiency market of the GSE. Osei (2002) examined the reaction to yearly earnings announcements of the GSE. The research set up that the market was conflicting with the EMH. The finding was that, the GSE was inefficient regarding yearly earnings data discharged by the firms listed on the exchange. Frimpong (2008) additionally analyzed the weak form EMH on account of the GSE. The researcher concluded that the GSE is weakly inefficient. As per Frimpong (2008) the GSE is weakly inefficient as his outcomes with the random walk and GARCH models collectively rejected the existence of random walk in the DSI day by day market returns. Besides, his tests for nonlinearity demonstrated on the potency of the McLeod-Li and BDS model that the residuals of the market prices do not take after a random walk creating process. Henceforth the nonappearance of random walk reasons that the twists in asset pricing and risk show a characteristic inefficiency in the market. This suggests a considerable measure of stock returns on the GSE are either underestimated or exaggerated as the market is for the most part inefficient. From the EMH, it will hence not be an exercise in futility for interested expert to examine the stocks.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND POLICY RECOMMENDATIONS

5.1 Introduction

This section deals with summary of the research work and conclusion drawn based on the data analysis made in the previous chapter. Some recommendations are also made on conclusion of the research for investigating long memory behaviour and efficiency of the GSE.

5.2 Summary of Findings

The non-normalities are being demonstrated in the descriptive summary and examination of statistical prices which are endemic considering the market series. By and large, observation in terms of mean or average returns, all the variables has positive returns except UTB which has negative returns and also all the stocks have average returns of approximately 0.1 percent. UTB has a moderately high standard deviation 0.063 which represents that the data points spread wide from the mean. The returns distributions of SCB, UTB, and SG-SSB are negatively skewed. Again, all the returns distributions display a high degree of excess kurtosis (leptokurtic), defending the utilization with robust methodology. Besides, in accordance to earlier research and the Jarque-Bera test for the null hypothesis of normality is rejected for all the returns series at the 1 percent significance level.

Findings rejected the null hypothesis of the ADF unit root test for all of the returns series. Thus, all the returns series are stationary, since the entire test statistics completely deviate from the critical values. The null hypothesis that the variables are I(0) was rejected on account of the KPSS test for EGL and HFC at the 5% and 1%

significant levels, individually. This concluded that EGL and HFC stock returns are not stationary since they have test statistics greater than the critical values.

On variance ratio tests for random walk, the findings of the Lo and MacKinlay's (LM) (1988) parametric variance ratio test statistics over the full sample time frame for the 7 stocks for 5-day, 10-day, 20-day, 30-day and 60-day interims. The evidence recommends the null hypothesis of the price series are random walk processes is strongly rejected for all the stocks, at any of the intervals of *k* at the 1% significant level.

The findings of long memory and fractional integration parameter on GPH and RHE, the fractional differencing parameter estimates are statistically significant for SCB, EGL, GCB, and SOGEGH, while the rest (CAL, HFC and UTB) are not statistically significant at the 1 percent significance level. In terms of magnitude, whereas CAL has negative parameter estimate, the rest are positive. The results of the GPH log periodogram estimates indicate that CAL is anti-persistent since it had negative differencing parameters albeit insignificant. Whiles HFC and UTB are positive but statistically insignificant. On RHE findings estimates CAL, HFC and UTB are again not statistically significant; they have p-values greater than the preferred significance level. Though, the remaining four (4) stock returns series (SCB, EGL, GCB and SG-SSB) are statistically significant at 1% level.

The findings of the ARFIMA (1, d, 1) model initiated by Granger and Joyeux (1980) also signify that the long memory parameter is significant at the 5 percent significance level for all the seven (7) series. The results of the ARFIMA estimates point out that all the returns series have positive estimates that are statistically significant at the 5% level.

None is anti-persistent and none is explosive. UTB is non-stationary. The FIGARCH component of the model incarcerates long memory in the conditional

□ variance (volatility). The differencing parameter, *d* estimated by the FIGARCH component is also statistically significant at the 5 percent level for all the variables and none of the estimates is negative.

FIGARCH Model showed evidence of long memory in volatility among stocks. The findings to great extent validate the presence of long memory in volatility except of CAL (d □0.556), HFC (d □0.719), UTB (d □1.000) and SG-SSB (d □ 0.695) where the findings acquired presents that volatility cannot have a predictable element. SCB, EGL and GCB have a fractional differencing value of 0.102, 0.268 and 0.465 separately which recommends a long memory element in volatility.

In total, the findings of the ARFIMA-FIGARCH model propose that stock prices in GSE are portrayed by stochastic processes that predict element; this infers a different approach from the EMH recommending that important market data was just partially or step by step mirrored in stock return changes. This model of time dependence in stock prices can take into consideration historical data to be utilized to enhance the predictability of future prices. Evidence of long memory in stock price volatility in GSE is mixed, with evidence against and for long memory.

5.3 Conclusions

Long memory properties of GSE utilize in this research studies as a standard for EMH weak form version. It is vital on the premise that, economic development in line with

location of capacities in being influenced by handling data in efficient market. Besides, the results demonstrate the returns on most equity market in relation to volatility which are examined and it might suggest having risk management strategies and portfolio diversification. Specifically, financial speculators (investors) might find these outcomes valuable given that investment return has a dynamic driver significant of price volatility and the basic decider of risk premia in equity markets is likewise volatile.

The weak form efficient markets hypothesis has been given exact reassessment on GSE. The requirement for this reassessment has to a greater extent been progressive against the back drop of two principal subjects; that (1) prior studies experience the weak effects of methodological weakness and (2) market microstructure and regulatory development. It is enlightening to note that the call for empirically robust examination initiated from the idea that any acceptance or rejection EMH will have constrained inference unless it is based on substantial econometric model (Lo and MacKinlay, 1988).

The negative response or rejection to the weak form efficiency is reliable with past evidence, as well as hypothetically not amazing. The size of the GSE is similarly little, and ruled by little capitalization stocks. Related high average exchange cost, for example, brings about restricted market activity and liquidity. By and by, these are just enticing instead of empirical contentions. It is conceded that evidence from somewhere else (Appiah-Kusi and Menyah, 2003), have illustrated that, for instance, weak form efficient cannot be attributed to the size of a market. The rejection of the weak form efficiency is being clarified by the theoretical contentions, though not adequate. The rejection of the normality test depicts that, the market is not efficient which will lead to

the prediction in the market that eventually makes investors take advantage of the market. Comparable finding was acquired by Frimpong (2008).

Lo and MacKinlay (1988) test, which has uncertain evidence, considers two essential methodological module as an aide for further investigate, that the utilization of; (1) powerful strategy will never again be used for methodological extravagance, but instead a need, along with (2) a single dataset, whether some individual stocks and market index may not be sufficient if the evidence for or else against efficiency can be certain.

The inefficient market has significant implications for investors, both domestic and international. Knowledge of profitable arbitrage opportunities due to market predictability serves to attract investors to diversify from more efficient markets to invest on the GSE to increase their returns (Frimpong and Oteng-Abayie, 2008)

This outcome may recommend variation in the way data is handled in markets. In a real case scenario, GSE has less develop institutional, which is usually shallow and administrative systems when measure up to created markets (Yartey and Adjasi, 2007). Specifically, the dominance of equity prices of GSE have long memory which mirror arrange of elements that impact the handling of current data, for example, liquidity.

5.4 Recommendations

Predictability of stock prices on GSE has become a noteworthy economic ramification as evidence for financial speculators, yet as to mishandling will be productive subsequent to transaction cost which is obscure, which abandon for future examination. The regulatory and market microstructure change which has become a fundamental

policy induction for evidence is set out but so far have not able to sufficiently profound to bring about huge changes in the efficiency of the market.

Further approaches to determine the informational inefficiencies in GSE likewise identify with improvement the operational structure. For instance, Irving (2005) account that large portions of settlement processing and the exchanging in ASMs are accordingly inclined to a range of postponements (time slacks in reporting) and paper based and errors (identifying with the correctness of the presented data).

Approval of electronic trading platform, which takes into account the selection of a fundamental store framework that can enhance the accuracy in addition to speed the flow of informational in GSE, can be considered (Yartey and Adjasi, 2007). Moreover, market inefficiency on GSE to some degree might be connected to the absence of establishment of territorial (regional) securities exchanges. Without a doubt, Irving (2005) proposes that collaboration and mix of GSE may enhance the efficiency and liquidity of these markets. Thus, enhance the allocation and mobilization of capital and in a manner promote more productivity expansion. Adelegan (2008) examined the evidence of the advantageous impacts of securities exchange integration and discovered that territorially (region) incorporated securities exchanges markets for the most part have a tendency to create and grow quicker than their non regionally integrated partners. Alagidede (2011), also share the same sentiment indicating that, development of a domestic securities market can enlarge overall financial stability and development of related financial infrastructure, products and services, and improve financial intermediation through greater competition.

On the premise of this study, the researcher prescribes first and foremost that, investors should know in inefficient securities exchanges markets that, substantial increases are pretty much as likely as overwhelming misfortunes. To ensure a safe flow of data to market applicants and enhance the efficiency of the market, there is the need for the GSE to be transformed. Furthermore, vital elements that are not making the market efficient can be linked to the little number of listed organizations and the span of market capitalization. Along these lines, singular investors should centre their attention on stocks with greater exchanging activity and market capitalization. Besides, there has to be the decrease of exchange cost in order to enhance market exercises and thus liquidity.

GSE and the Securities and Exchange Commission (SEC) ought to undertake public training in stock exchange investment to help the expansion of the organizations listed on the GSE and support newly listed firms. Attempt ought to be made to get numerous firms listed on the stock exchange to improve competition. On the contrary, there can be inefficient markets for stocks in new companies, particularly for new companies in new industries that are not widely analyzed.

There has to be upgrade of financial confidence in SEC and GSE by reinforcing their administrative and authoritarian abilities. This will include preparing staff to uphold or perform market survey and financial controls. Extraordinary consideration ought to be taken in every approach decisions that specifically do not focus on the equity trade on GSE as it may result in indirect consequences.

REFERENCES

Abdmoulah, W., 2009, „„Testing the Evolving Efficiency of Eleven Arab Stock Markets, „Information Center in API-Working Paper Series 0907, Arab Planning Institute, Kuwait.

Adelegan, O.J., 2008, „„Can a Regional Approach Accelerate Stock Market Development? Empirical Evidence from Sub- Saharan Africa,"" IMF Working Paper 08/281, (Washington D.C: International Monetary Fund).

Adnan, K. and T. Erdost, 2007, „„Long memory in Turkish Stock Market Return and Volatility,"" Central Bank Review ISSN 1303-0701 print / 1305-8800.

Akinkugbe, O., 2005, „„Efficiency in Botswana Stock Exchange: An Empirical Analysis,"" The Business Review, 4 (2), 223-230.

Alagidede, P. and T. Panagiotidis, 2009„„'Modelling stock returns in Africa"s emerging equity markets,"" International Review of Financial Analysis, vol. 18, pp. 1–11.

Alagidede, P., 2011, „„Recession and Recovery: Whither Africa"s Emerging Financial Markets?"" Nova Science, New York.

Andersen, G. T. and T. Bollerslev, 1997, „„Intraday periodicity and volatility persistence in financial markets,"" Journal of Empirical Finance, 4 (1997) ,115-158.

Andersen, G. T. and T. Bollerslev, 1998, „„Answering the sceptics: Yes, standard volatility models do provide accurate forecast,"" International Economic Review, Vol. 39, No. 4 November, 1998.

Appiah-Kusi, J. and K. Menyah, 2003, '„Return predictability in African stock markets,"" Review of Financial Economics, vol. 12, no. 3, pp. 247–270.

AuerA. B., 2016, „„Emerging Markets Review, ""Hybrid journal, Issue No:Vol. 27, Elsevier.

Ayentim, D. T., A. E. Mensah, and F. Naa-Idar, 2013, „„Stock Market Efficiency of Ghana Stock Exchange: An Objective Analysis,"" International Journal of Management, Economics and Social and Sciences, 2(2), 54-75.

Bachelier, L., 1900, „„Theory of Speculation in the Random Character of Stock Market Price,"" Ed. P. Cootner. 17-78, Reprint, Cambridge: MIT Press.

Baillie, R. T., 1996, "Long memory processes and fractional integration in econometrics," Journal of Econometrics, 73(1), 5–59.

Barkoulas, J. T., C. F., Baum, and N. Travlos, 2000, „„Long memory in the Greek stock market,"" Applied Financial Economics, 10, 177-184.

Benouda, O.S. and D. H. Mezzez, 2003, „„The effects of automation on liquidity, volatility, stock returns and efficiency: evidence from the Tunisian stock market,"" Review of Middle East Economics and Finance, vol. 1, no. 2, pp. 141–154.

Breidt, F. J., N. Crato, and P. de Lima, 1998, "The detection and estimation of long memory in stochastic volatility," Journal of Econometrics, 83(1-2), 325 – 348.

Cecchetti D., S, and Lam, Pok-sang, (1994), Variance-Ratio Tests: Small-Sample Properties with an Application to International Output Data, Journal of Business & Economic Statistics, Vol. 12, No. 2. (Apr., 1994), pp. 177-186

Chan, K. C., B. E. Gup, and M. S. Pan, 1997, „„International Stock Market Efficiency and Integration: A study of eighteen nations,"" Journal of Business Finance & Accounting, 24(6), 803–813.

Chang, K. and K. Ting, 2000, „„A Variance Ratio Test of the Random Walk Hypothesis for Taiwan's Stock Market,"" Applied Financial Economics, 10(5), 525–532.

Chang, L. K. C., N. Jegadeesh, and J. Lakonishok, 1996, „„Momentum Strategies,""

The Journal of Finance, 51(5), 1681–1713.

Chen, W.W. and R. S. Deo, 2004, "Power transformations to induce normality and their applications, “Journal of the Royal Statistical Society, Series B, 66,117130.

Chen, W.W., and R. S. Deo, 2006, „„The variance ratio statistic at large horizons, ‘‘‘‘Econometric Theory22, 206-34.

Cheung, K.C. and J. A. Coutts, 2001, "A note on weak form market efficiency in security prices: Evidence from the Hong Kong stock exchange," Applied Economics Letters 8(6), 407-410.

Cheung, Y.W., and K. S. Lai, (1995), “A Search for Long Memory in International Stock Market Returns,” Journal of International Money and Finance, Vol. 14, pp. 597-615.

Chow, K. V. and Denning, K. C. (1993): “A Simple Multiple Variance Ratio Test”, Journal of Econometrics, 58, pp.385-401.

Chow, K.V., P. Ming-Shium, and R. Sakano, 1995, “On the long-term or short-term dependence in stock prices: Evidence from international stock markets,” Review of Quantitative Finance and Accounting, Vol. 6, No. 2, pp. 181-194.

Dewotor, F. S. and K. J. Gborglah, 2004, „„The Information Content of Stock Prices in Ghana,‘‘‘‘ Databank Research Paper, 2004.

Dickey, D. and W. Fuller, 1979, “Distribution of the Estimatorsfor Autoregressive Time Series with a Unit Root,”Journal of theAmerican Statistical Association,74, 427-431.

Dickinson, J. P. and K. Muragu, 1994, “Market Efficiency in Developing Countries: A Case Study of the Nairobi Stock Exchange,” Journal of Business Finance and Accounting, 21(1), pp.133-150.

Ding, Z., C.W.J. Granger, and R. F. Engle, 1993,,,,,A long memory property of stock market returns and a new model,"" Journal of Empirical Finance, 1: 83-106.

Doornik, J.A. and M. Ooms, 2003, "Computational aspects of maximum likelihood estimation of autoregressive fractionally integrated moving average models," Computational Statistics & Data Analysis, 42(3): 333-348.

Elliott, G., T. Rothenberg, and J. Stock, 1996,"Efficient Tests for an Autoregressive Unit Root," Econometrica, 64, 813-836.

Fama, E. F., 1965, ,,,,The Behavior of Stock Market Prices,"" Journal for Business, 38, 34-105.

Fama, E., 1970,,,,,Efficient Capital Markets: A Review of Theory and Empirical Work,"" Journal of Finance, 25(2), 383–417.

Fama, E., M. Jensen, and R. Roll, 1969, ,,,,The Adjustment of Stock Prices to New Information"" International Economic Review, 10, 1-21.

Forgha, N.G., 2012, ,,,,An investigation into the volatility and stock returns efficiency in African Stock Exchange Markets,"" International Reviews of Business Research Papers, Vol. 8.No.5 July 2012. Pp. 176-190.

Frimpong, J. M. and E. F. Oteng-Abayie, 2008,,,,,Market returns and weak - form efficiency: The case of the Ghana Stock Exchange,"" Munich Personal RePEc Archive, MPRA Paper No. 7582:1-9.

Frimpong, J. M., 2008, Capital Market Efficiency: An analysis of weak-form efficiency on the Ghana Stock Exchange. Journal of Money, Investment and Banking, 5, 5–12.

Geweke, J. andS. Porter-Hudak, 1983,,,,,The Estimation and Application of Long-Memory Time Series Models,"" Journal of Time Series Analysis, 4, 221–238.

Ghana Stock Exchange (2016). Review of stock market performance. Available at http://www.gse.com.gh/

Granger, C.W.J. and R. Joyeux, 1980, „„„An introduction to long memory time series models and fractional differencing,““ Journal of Time Series Analysis, No. 1, 15-29.

Granger, C.W.J., 1980, „„„Long memory relationships and aggregation of dynamic models,““ J. Econometrics 14, 227-8.

Greene, M.T. and B.D. Fielitz, 1977, "Long-term Dependence in Common Stock Returns," Journal of Financial Economics, Vol. 5, pp. 339-349.

Harvey, C. R., 1993, „„„Predictable Risk and Return in Emerging Markets,““ Review of Financial Studies,““ 8(3), 773-816.

Hosking, J.R.M., 1981,„„„Fractional differencing,““Biometrika, 68, 165–176.

Hsieh, D.A., 1991, „„„Implications of Nonlinear Dynamics for Financial Risk Management,““ Journal of Financial and Quantitative Analysis, 46(5), 131135.

Huang, B.W.O, and C. W. Yang, 1995, „„„The fractal structure in multinational stock return,““ Applied Economics Letters, 2. pp. 67-71.

Hurst, H.E., 1951, "Long-term Storage Capacity of reservoirs," Transactions of the American Society of Civil Engineers, Vol. 116, pp. 770-799.

Irving, J., 2005,„„„Regional Integration of Stock Exchanges in Eastern and Southern Africa: Progress and Prospects““ IMF Working paper WP/05/122.

Kavalerchik, R., 2009, „„„An analysis of the random walk hypothesis based on stock prices, dividends and earnings,““

Kim J.H., 2006, „„„Wild bootstrapping variance ratio tests", Economics Letters,92, 38-43.

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt, and Y. Shin, 1992, “Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root,” Journal of Econometrics,54, 159-178.

Lima, E.J.A. and M. Tabak, 2004,,,,,Tests of the Random Walk Hypothesis for Equity Markets: Evidence from China, Hong Kong and Singapore““ Applied Economics Letters, 11, 255–258.

Lo, A W. and A. C. MacKinlay, 2002,,,,,A Non-Random Walk Down Wall Street Princeton,““ NJ: Princeton University Press.

Lo, A. W., and A. C. MacKinlay, 1988, ,,,,Stock Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test, „The Review of Financial Studies, 41-66.

Lo, A. W.,1991,“Long-Term Memory in Stock Market Prices,” Econometrica, Vol. 59, pp.1279-1313.

Lo, A.W. and A. C. MacKinlay, 1989, "The size and power of the variance ratio test in finite samples: A Monte Carlo investigation", Journal of Econometrics, 40, 203-238.

Magnusson, M. A. and B. Wydick, 2002, “How Efficient Are Africa‟s Emerging Markets,” The Journal of Development Studies, 38(4), pp.141-156.

Malkiel, B.G., 2007,,,,,A random walk down Wall Street: The time-tested strategy for successful investing,““ Norton and Company, Inc., New York.

Mandelbrot, B.B., 1971, “When Can Price be Arbitraged Efficiently? A Limit to the Validity of the Random Walk and Martingale Models,” Review of Economics and Statistics, Vol. 53,pp. 225-236.

Mazviona, B.W. and D. Nyangara, 2013,,,,,A test of the weak form efficiency of the

Zimbabwe Stock Exchange after currency reform,"" International Journal of Business, Economics and Law, 2(2): 43-48.

Mensah, J. T., M. Pomaa-Berko, and K. P. Adom, 2014, Does automation improve stock market efficiency in Ghana"" African Review of Economics and Finance, Vol.6.

Mensah, L., G. Owusu-Antwi, and G. A Bokpin, 2016,,,,,Time your investment on the Ghana Stock Exchange,"" African Journal of Economic and Management Studies, 7(2), 256-267.

Miller, M. H., J. Muthuswany, and R. E. Whaley, 1994, "Mean Reversion of Standard and Poor"s 500 Index Basis Changes: Arbitrage-Induced or Statistical Illusion,"" Journal of Finance, 49, pp.479-513.

Mills, T.C., 1993,,,,,Technical analysis and the London Stock Exchange: Testing Trading Rules using the FT30,"" International Journal of Finance and Economics, 2, pp. 319- 331.

Mobarek, A. and K. Keasey, 2000,,,,,Weak form market efficiency of an emerging market: Evidence from Dhaka Stock Market of Bangladesh"" ENBS Conference. Oslo.

Nagayasu, J., 2003,,,,,A re-examination of the Japanese money demand function and structural shifts,"" Journal of Policy Modeling, 25 (June): 359–75.

Neely, C. J. and D. E. Rapach, 2008, "Real Interest Rate Persistence: Evidence and Implications."Federal Reserve Bank of St. Louis Review, 90(6), pp.609-41.

Ntim, C. G., K. K. Opong, J. Danbolt, and F. S. Dewotor, 2011,,,,,Testing the weak form efficiency in African stock markets,"" Managerial Finance, 37 (3), 195 - 218.

Ntim, C., K. K. Opong, and J. Danbolt, 2007,‘„An empirical re-examination of the weak form efficient markets hypothesis of the Ghana stock market using variance-ratios tests,““ African Finance Journal, vol. 9, no. 2, pp. 1–25.

Olowe, R. A., 1999, “Weak Form Efficiency of the Nigerian Stock Market: Further Evidence,” African Development Review, 11(1), pp.54-68.

Omuchesi, A. J., 2014,„„„the effect of automation on stock market performance: A case of Nairobi Securities Exchange.““

Onour, A. I., 2006, „„„Impact of oil price volatility on Gulf Cooperation Council stock markets‟ return““ OPEC Review,31(3), 171-189.

Osamah, M. A., and D. Ding, 2007, „„„A New Variance Ratio Test of Random Walk in Emerging Markets,““ Financial Review, 42(2), 303-317.

Osborne, M., 1959, „„„Periodic Structure in the Brownian Motion of Stock Prices,““ Operations Research, 10, 345-79.

Osei, A. K., 2002,„„„Asset Pricing and Information Efficiency of the Ghana Stock Market,““AERC Research Paper 115, African Economic Research Consortium, Nairobi.

Osei, K. A., 1998, “Analysis of Factors Affecting the Development of an Emerging Capital Market: The Case of the Ghana Stock Market,” African Economic Research Consortium, Research Paper 76.

Parkinson, J. M., 1984, “The Nairobi Stock Exchange in the Context of Development of Kenya,” Savings and Development, 8(4), pp.363-370.

Parkinson, J. M., 1987, „„„The EMH and CAPM on Nairobi Stock Exchange,““ East Africa Economic Review, 32, 105-110.

Phillips, P. C. B. and Perron, P., 1988, “Testing for Unit Roots in Time Series Regression,” Biometrika, 75, 335-346.

Poterba, J.M. and L. H. Summers, L.H., 1986,,,,,Mean reversion in stock prices: Evidence and implications,"""" NBER Working Paper no. 2343.

Resende, M., and N. Teixeira, 2002, "Permanent structural changes in Brazilian Economy and Long Memory: A Stock Market Perspective," Applied Economic Letter, Vol. 9, No.6, pp. 373-5.

Richardson, M. and T. Smith, 1989, ,,,,Tests of financial models in the presence of over-lapping observations,"""" Stanford University, Graduate School of Business and Fuqua School of Business, Duke University, November.

Sadique, S. and P. Silvapulle,2001,,,,,Long-Term Memory in Stock Market Returns: International Evidence"""" International Journal of Finance & Economics, 6 (2001), pp. 59–67.

Samuels, J. M. and N. Yacout, 1981,,,,,Stock Exchanges in Developing Countries. Savings and Development,"""" 5(4), 213-230.

Seiler, M. J. and W. Rom, 1997,,,,,A Historical Analysis of Market Efficiency: Do Historical Returns follow a random walk,"""" Journal of Financial and Strategies Decisions, 10(2), 49-57.

Sharpe, W., 1964,,,,,Capital asset prices: A theory of capital market equilibrium under conditions of risk,"""" Journal of Finance, 19, 425-442.

Sharpe, W., 1970, ,,,,Portfolio Theory and Capital Markets,"""" New York: McGraw-Hill

Simon, D. and S. Laryea, 2004,,,,,Testing the efficiency of selected African markets,"" Finance India, 20(2), 553-571.

Tweneboah, G., A. M. Adam, A. E. Dadzie, and G. K. Amoako, 2015, ,,,,Long Memory Behaviour of Real Interest Rates in Ghana,""""5 Journal of Business and Enterprise Development (2015), ISSN: 2026 – 500X, Published by School of Business, University of Cape Coast.

Tweneboah, G., A. N. Amanfo, and S. P. Kumah, 2013,,,,,Evidence of Market Inefficiency and Exchange Rate Predictability in Ghana, „African Finance and Economics Consult, 1.

Watundu, S., W. Kaberuka,N. Mwelu, and W. Tibesigwa, 2015,,,,,Testing for Volatility and Market Efficiency of Uganda Securities Exchange, „Journal of Research in Business, Economics and Management (JRBEM) ISSN: 2395-2210

Whang, Y- J. and J. Kim, 2003,,,,,A multiple variance ratio test using sub sampling"" Economics Letters 79, 225–230.

Wright, J. H., 2000, "Alternative Variance-Ratio Tests Using Ranks and Signs," Journal of Business and Economic Statistics, 18, pp.1-9.

Yartey, C. A. and C. K. Adjasi, 2007,,,,,Stock Market Development in Sub-Saharan Africa: Critical Issues and Challenges"" International Monetary Fund Working Paper, IMF WP/07/209, International Monetary Fund, Washington DC, African Department.

Zivot, E.and D. W. K. Andrews, 2002, ,,,,Further evidence on the great crash, the oilprice shock, and the unit-root hypothesis,""J. Bus. Econ. Stat. 2002, 20, 25–44.