UNIVERSITY OF GHANA

ASSESSING THE PERFORMANCE OF ACTIVE AND PASSIVE TRADING ON THE GHANA STOCK EXCHANGE

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL DEGREE IN FINANCE

JULY, 2015
DECLARATION

I do hereby declare that this work is the result of my own research and has not been presented either in whole or in part by anyone for any academic award in this or any other university. All references used in this work have been fully acknowledged. I bear sole responsibility for any shortcomings.

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CERTIFICATION

I hereby certify that this thesis was supervised in accordance with procedures laid down by the University.

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INTEGR PROCEAMUS
DEDICATION

I dedicate this thesis to Ms. Joyce H. Page for her unflinching support and faith in my abilities.
ACKNOWLEDGEMENT

My greatest thanks goes to Almighty God Jehovah who has sustained me through favorable and unfavorable times, making the successful completion of this thesis possible.

A special thanks to Joyce H Page for her encouragement and support throughout the program duration. All that I am and all that I ever hope to be I owe to her.

My deepest appreciation goes to my supervisors, Dr. Lord Mensah and Prof. Godfred A. Bokpin who took their time to guide me in the right direction and made constructive criticisms to make sure I did an excellent work. I am very grateful.

I am also highly indebted to all the lecturers in the Finance department who one way or the other contributed to my successful completion of my Mphil Programme.

I cannot end without saying thanks to my family and friends who made various sacrifices to get me to where I am now. May the good God Almighty richly bless one and all.
ABSTRACT
This paper sought to test the weak-form market efficiency of the Ghana Stock Exchange and to establish whether the application of technical trading rules like the Variable Moving Average (VMA) on the Composite Index (CI) would be profitable during the periods January 2011 to December 2014. The study also provides evidence that active trading on the GSE can be profitable and can outperform the buy-hold-strategy adopted by a passive trader or investor. To establish market efficiency, the random walk model is estimated using two different statistical methods, namely, the Augmented Dickey Fuller (ADF) Unit root test and the Lo & MacKinlay variance ratio test. Empirical results from the ADF unit root test and the Variance ratio test strongly reject the random walk hypothesis and evidently support previous empirical studies that the, Ghana Stock Exchange market is weak-form inefficient. To exploit the inefficiencies on the exchange, the study applied technical trading techniques called the Variable Moving Average (VMA). Five different variations of this rule i.e. (1, 50), (5, 50), (1, 150), (5, 150) and (2, 200) were applied to the index to investigate whether they would outperform the passive investment strategy. It was found that indeed the application of the VMA yielded positive returns and that out of the five combination of rules tested, four actually outperformed the results of a buy-and-hold strategy with the exception of the (2,200) rule. It was also found that employing technical rules with much shorter lengths yielded profits twice as much as the returns generated by a passive trader or investor who uses a buy-and-hold strategy.
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CHAPTER ONE

INTRODUCTION

1.1 Background of study

The Efficient Market Hypothesis (EMH) is an important concept which became widely known and accepted especially during the late 1950’s and has been heavily discussed in both finance and economic literature under random walk and rational expectations theory respectively (Jensen, 1978).

According to Fama (1965), the EMH posits that asset prices will fully and instantly reflect all new and available information. In other words the EMH suggests that it is impossible for an investor to earn excess returns using information such as the historical price of a stock to predict its future price (Degutis & Novickyte, 2014). The EMH therefore, does not support the idea that obtaining excess returns through active trading using technical analysis is possible and indeed profitable.

On the other hand, technical analysis hinges on the concept of using past price behavior and market data, such as volume to guide trading decisions in asset markets (Neely & Weller, 2011). The authors point out that technical analyst believe, that, the behavior of past price patterns in securities, like a stock, is likely to recur in the future. Therefore in order to predict stock prices one would have to develop the skill of determining historical patterns of price behavior in order to recognize instances of likely recurrence (Fama, 1965). So essentially, the concept of using technical analysis techniques revolves around having knowledge of previous price behaviors to predict the possible future behavior of any financial security.
The EMH concept plays an important role in Ghana’s financial market and in our economy as a whole as it helps in understanding how the equity markets function. But over the years, it has encountered a lot of criticisms and arguments refuting it. In fact, Campbell, Lo, & MacKinlay (1997) claim that fully efficient markets are rather unlikely to actually exist and that stock returns are to some extent predictable. Other research works, on the other hand, support the fact that stock market returns are predictable (Porterba & Summers, 1986; Lo & Mackinlay 1988).

Consequently, if the concept of successfully predicting future movements of a financial security using, for example, past prices holds true, then there is to some extent a shadow of doubt regarding the weak-form efficient market hypothesis. According to Mensah, Owusu-Antwi & Bokpin (2016), for a country like Ghana which is considered an emerging market, it is imperative to establish the efficiency or inefficiency of its stock market so that the most optimal investment strategies could be implemented thus equipping academicians and practitioners to be better informed.

For the purposes of our research work, therefore, an active investor as used in the study refers to an investor who uses technical analysis or technical trading techniques to time the market with the intention of outperforming the market index. This technique is premised on the belief that the capital market exhibits inefficiencies and anomalies which can be exploited.

On the other hand, a passive investor refers to one that builds a portfolio of securities to mirror the components of a market index like the Ghana Stock Exchange composite index and matches its performance. In other words the passive investor buys and holds a security for a certain period of time until he liquidates part or his entire portfolio. A passive investor is a proponent of the EMH.
1.2 Problem Statement

An important implication of the EMH is the theory of Random Walk (RW) which simply states that stock prices change randomly and in an unpredictable manner (Dewortor & Gborglah, 2004). The authors’ point out that, stock prices are pushed up or down to their intrinsic values with all available information and so any changes in prices must be in reaction to new information which consequently is also unpredictable. It follows logically then, that past price movements cannot be used to predict future price movements.

Currently, the EMH has become a significant part of finance and the numerous existing researches on this concept are evidence of the interest that the EMH has attracted in both the investment and academic fronts. (Mlambo & Biekpe, 2007).

However, the bulk of this evidence is from developed markets in the United States and Europe with results and conclusions being mixed (Groenewold & Ariff, 1998; Mobarek & Keasey, 2000). Kendall (1953) tested this random walk theory by looking at stock behavior over a period of time to determine whether there was a repeated pattern in price changes. He found that there was none. Fama, Jensen & Roll (1969) carried out an event study, and their results indicated a strong support to the fact that the stock the market is efficient. Kemp & Reid (1971) also found out that stock price movements were clearly non-random. However, LeRoy & Porter (1981) showed that stock markets have the tendency to exhibit extreme volatility and they reject market efficiency. Shiller (1981) showed that stock prices move too rapidly to be justified by subsequent changes in dividends.

Within the context of Africa, though, very little is known about the efficiency of our stock markets. Previous studies that have been done in Africa reveals some markets to be weak-form efficient and others weak-form inefficient using several methodologies and data

The random walk theory is an implication of the EMH and it basically connotes the idea that stock prices are unpredictable. In other words the price of a stock today has no effect on its future price. There are several studies that show evidence of deviations from the random walk on other markets which seems to suggest that the possibility of detecting patterns in the movement of stock prices for profit opportunities cannot be completely ignored.

Research to investigate the weak-form efficiency of the Ghana Stock Exchange (GSE) has been done by a few. Osei (1998) and Dewotor & Gborglah (2004) have investigated the weak-form efficiency in the price series of a number of listed stocks. Their results rejected the notion that Ghana is weak-form market efficient. Appiah-kusi & Menyah (2003) and Mlambo & Biepke, (2007) among others found Ghana to be weak-form inefficient. Most of these researchers used the conventional methods of testing for market efficiency such as the Runs test, Serial Correlation test, Autocorrelation test just to mention a few. The robustness of these tests however, is sometimes questioned (Hsieh, 1991). As such a measure of doubt is raised as to whether these results generated by these conventional tests will prove to be valid if an empirically robust methodology like the Lo and MacKinlay parametric variance-ratios test is applied. It follows that to a very large extent, conclusions that have been made regarding the EMH on the African Markets have not been consistent
and conclusive enough. Results are dependent on the choice of the estimation method and availability of data.

Therefore, it is imperative to examine if indeed deviations from the random walk exist on our markets using more robust test like the Lo and MacKinlay parametric variance ratios test employing the use of recent data. Contribution to literature will be made if we can also determine whether our market can be exploited for abnormal or excess returns.

The thrust of this paper therefore seeks to test whether the Ghana Stock Exchange Composite Index (GSE-CI) follow the random walk and whether it is weak-form market efficient. It also attempts to fill a gap, in that, to the best of knowledge no study has attempted to use technical trading rules like the Variable Moving Average (VMA) to exploit the weak-form inefficiency established by other authors on the GSE.

1.3 Objectives of the Study

The research specifically seeks:

1) To test the efficient market hypothesis on the GSE-CI during the period January, 2011 to December, 2014.

2) To determine whether active trading on the GSE can outperform the buy-and-hold strategy employed by a passive investor?

The following questions are consequently raised:

1) Does the GSE-CI follow the random walk and as such weak-form efficient for the period studied?

2) Can active trading on the GSE outperform the buy-and-hold strategy employed by a passive investor?
1.4 Significance of the Study

The concept of efficient market hypothesis (EMH) is very important in determining the performance and effectiveness of managers. If markets are weak-form efficient, shareholders and stakeholders can readily see the effectiveness of the appointed managers by observing the stock price. Management's decisions whether good or bad will instantly reflect on the share price. Therefore, since the main goal is for managers to maximize the company's share price, board of directors can assess management's performance through their share price movement.

The presence or absence of a random walk has important implications for investors, fund managers, trading strategies, the capital markets and consequently the financial and economic development of the economy as a whole (Worthington & Higgs, 2004). Trading strategies, for example, will be different if asset returns exhibit random walks.

A market following a random walk suggests that equity is being priced at an equilibrium level; the absence of random walk however implies that there are distortions in the pricing of securities. This has crucial implications for the allocation of capital within an economy and hence overall economic development.

1.5 Chapter Disposition

The study adopts a five-chapter organization format under the headings: Introduction, Literature Review, Research Methodology, Empirical Results and Analysis of Findings and Summary, Conclusion and Recommendations.

The first chapter addresses introductory issues including the background to the study, the objectives of the research, the research problem and the significance of the study. It also
provide a justification for the objectives and outline the scope and chapter organization of the study.

Chapter two reviews literature pertinent to this study. A brief overview of the history of the Ghana Stock Exchange since its inception and the remarkable growth it has experienced over the years will be highlighted. It addresses both theoretical and empirical literature of similar works relevant to this research. The study also gives a brief overview of the concept of the Efficient Market Hypothesis (EMH), the Random Walk Hypothesis and Technical Analysis with a discussion on some Technical Trading Rules.

Chapter three discusses the methodological issues of the study. It examines the methodological framework connected with testing market efficiency and estimating the random walk model. Again the Technical Trading Rules to be employed in exploiting inefficiencies in the market is explained. The source of data, analysis techniques to be employed, presentation and discussion of the empirical results obtained is also dealt with in this chapter. This is to done in relation to the specific objectives of the study, ensuring that the right statistical parameters are employed in interpreting results.

In Chapter four, the empirical results be presented and discussed.

Chapter five concludes the study and recapitulates the major research findings, discussions and policy recommendations. The Chapter also spells out the limitations of the study and suggests areas for future research.
CHAPTER TWO

LITERATURE REVIEW

2.1 Brief Overview of the Ghana Stock Exchange

The contribution of the capital markets to economic growth is very crucial as their development is key for the mobilization of domestic and international capital for both the private and public sectors (Alagidede, 2011). As such, a well-functioning financial market is a prerequisite to the growth and development of emerging economies (Mensah et al. 2016). It also provides an exit strategy for investors and entrepreneurs in that it gives them the opportunity to recoup their initial investments through an initial public offering (Ayentim, Mensah & Naa-Idar, 2013).

Secondly, the market also plays the roles of facilitating capital inflows for both direct and portfolio investments (Watson, 2009). Potential investors have exhibited keen interest in portfolio investment because of its developed nature over the years and the ability to diversify investments.

Thirdly, the capital market provides liquidity for both foreign and domestic investors, helping them to transfer their short-term securities to the long term capital market (Fama, 1970).

Last but not least the capital markets is considered as an effective way to get access to public savings, which could lead to the reduction of inflation pressure, thereby providing an additional route for foreign investment. Long-term capital for the expansion of listed companies and financing projects could be achieved through the development of a capital market (Mookerjee & Yu 1999; Tan, 2004).
2.2 Development of the Ghana Stock Exchange (GSE)

The Ghana stock market although relatively small in size, is one of the active and vibrant stock markets in Africa (Dewortor & Gborglah, 2004). Under the direction of the International Monetary Fund (IMF), economic reforms were implemented beginning in the 1980’s which had economic liberalization and private enterprise as its main focus. This actually provided an incentive to develop an active stock exchange in Ghana (Dewortor & Gborglah, 2004).

The Ghana Stock Market was incorporated in July 1989 and started its trading operations in 1990 with 11 listed companies and one government bond (Frimpong, 2008). Since its inception, the GSE has gone through quite a number of reforms with the view of enhancing efficiency, improving liquidity and positioning the exchange in a more attractive and competitive way so as to attract issuers and investors (Bowers, 2008).

For example, in 2009, the GSE migrated to a fully automated electronic system in order to enhance and facilitate higher trading volumes. Again in 2013, the GSE Securities Depository Ltd merged with Bank of Ghana’s Central securities Depository for a rather more efficient and coordinated system of operations. According to the GSE’s official website, Secondary listing of Government of Ghana’s ten year Eurobond of US$1billion was successfully completed in August 2013 and GHS101.57million 17.5% seven year bond also listed for the first time. A New Market dedicated for small and medium size companies and start-ups (Ghana Alternative Market) was also launched in that same year.

As a result of years of operations, the GSE today is the main and only capital market in Ghana and is dubbed one of the best exchanges in sub-Sahara Africa (Mensah et al. 2016). There has been remarkable increase in market capitalization on the Ghana Stock exchange since its inception as a result of foreign capital inflows and increased investor
confidence due to economic reforms. In 1990 market capitalization was at GH¢ 6.4 million and in just a little over two decades, market capitalization of the exchange stood at GH¢61,158.29 million as at December 2014 market data from the Ghana Stock Exchange.

Currently the number of listed firms on the exchange is now 36 with two corporate bonds. There are two major indices for the exchange namely, the GSE All Share Index and the Databank Stock Index. Other indices which supplement the major ones include the Strategic African Securities Limited (SAS) index, the SAS financial Index and the SAS manufacturing Index.

Firms listed on the exchange stems from several key sectors of the economy. These include banking, manufacturing companies, oil, brewing and mining. Recently however, policies to enhance institutional development has been the main focus due to the role that the GSE plays when it comes to raising domestic and international capital for economic development (Frimpong, 2008).

**Figure 2.1: Trends in Market Capitalization of the GSE (GH MILLION)**
As shown in Figure 2.1, we see that market capitalization between 2001 and 2012 increased significantly, albeit, a decline of 11% in 2009, partly due to the global economic crunch.

Also from the figure 2.1, we observe that market capitalization more than doubled from 2010 to 2012 from GH¢ 20,116.70 million to GH¢ 57,264.22 million – a 184 per cent increase and this could have been as a result of new listings on the exchange (e.g. Tullow Oil Plc) in 2011. As at end of December 2014, market capitalization stood at Gh¢ 64,352.40 million in 2014.

The performance and growth of the trading index too cannot be overemphasized. It was rated as the top of all the other African markets because of the outstanding performance gain of 58 per cent in the year 2009 (GSE, 2009).

**Figure 2.2: Trend in the number of listed companies on the GSE.**

![Graph showing the trend in the number of listed companies on the GSE.](source: GSE website)
From the above Figure 2.2, we see a steady increase in the number of firms that listed on the Ghana Stock Exchange. The number of listed companies has more than tripled since the inception of the exchange in 1990.

2.3 Theoretical Framework

This study highlights three main concepts in the field of finance, namely, the Efficient Market Hypothesis (EMH), the Random Walk Hypothesis (RWH) and Technical Analysis.

2.3.1 The Concept of Efficient Market Hypothesis

Arguably there is no other concept or theory that has caught the attention of both finance practitioners and economist other than the EMH. It is a concept premised on informational efficiency, and refers to the market’s ability to respond instantly to news or information translating it into prices.

The idea of the EMH has its roots as early as the start of the twentieth century when Bachelier (1900) and Cowles (1993) made a significant empirical research contribution to this topic. However it was not until 1960’s that Fama (1970) examined the theoretical and empirical literature in EMH.

Fama (1970) who is considered to be the father of EMH formalized this hypothesis and indicated that a market is called efficient if prices of a financial asset fully and instantly reflect all available information. In other words, any information that could be used to predict stock performance has already been priced in the current level of the stock. We might illustrate it this way: assuming there is information which informs us that a stock is underpriced and as such offers a profit opportunity, investors will generally flock to
purchase the stock immediately based on this information. By so doing, they push the price of the stock up to a fair value where only ordinary rate of return is attained (Kane, Bodie & Marcus, 2003).

In more recent times, Malkiel (1992) extends further Fama’s definition by saying that first, in an efficient market, stock prices will not be affected by revealing information to all participants and secondly that, it is impossible to make excess returns by trading on this set of information.

Jensen (1978) explains the efficient market hypothesis in three ways, namely, Weak, semi-strong and strong forms.

First, a market is weak-form efficient, if all the information regarding past prices and trading volumes is reflected in the current stock price. It suggests that under this form, the only set of information available is the historical prices of the stock and that should not offer any clue of future price changes. No chart analysis based on only historical prices can achieve excess returns.

Second, a market is semi-strong efficient, if all publicly available information is reflected in the stock price. Thus, an investor cannot make excess returns by taking advantage of publicly known information because when new information is made public, it is instantly processed into a security’s price.

Third, a market is called strong-form efficient if current security prices instantly and fully reflects all known information, including inside or private information. For the purposes of this study, we will be focusing mainly on the weak-form market efficiency.
2.3.2 The Concept of Random Walk Hypothesis (RWH)

One of the collary of the Efficient Market Hypothesis is the Random walk theory. According to Campbell et al. (1997), there are several definitions for random walk, depending on the nature of increments, and the dependence that exists between increments in different distinct time intervals.

2.3.2.1 Random Walk Type 1

This is the simplest form of the random walk hypothesis and it assumes that all increments are independently drawn from the same distribution with the same mean and variance. The assumption of Independent and Identically Distributed (IDD) provides a good insight into the behavior of random walk in general.

2.3.2.2 Random Walk Type 2

The second type of random walk assumes that all increments are independent but can be drawn from different distributions. It is a more general case than independent and identically distributed increments as it allows unconditional heteroskedasticity in the increments. In other words, time-based fluctuation is allowed in any of the form as long as the increments are independent.

2.3.2.3 Random Walk Type 3

This is a more general version of random walk hypothesis type 2 and only requires uncorrelated increments. It is noteworthy to say that all three types of random walk share common properties of linearity with time in both the conditional mean and variance. This is an indication of a random walk process which is non-stationary because of unbounded and increasing variance.
Malkiel (1992) in a more basic form defines random walk as one in which future steps or directions cannot be predicted on the basis of past history. He indicates that when the term is applied to the stock market, it implies that short-run changes in security prices are unpredictable. So if stock prices are moving up and down in response to new information, and this new information is also unpredictable, then the stock price will also move unpredictably. In providing evidence to support the notion of randomness in stock prices, the original empirical work looked at measures of short-run serial correlations between successive stock price changes which is to say that generally, the way a stock price behaved in the past is irrelevant in determining how it will behave in the future (Malkiel, 2003).

Thus, the underlying economic principle of the RWH is that if information is instantly reflected in stock prices and it is uninterrupted, then tomorrow’s price change will reflect only tomorrow’s news and will be independent of the price changes today. News however is unpredictable and so consequently, price changes must also be unpredictable and random. As a result, prices fully reflect all known information such that even uninformed investors buying a diversified portfolio at prices given by the market, will only obtain a rate of return and not abnormal profits. (Malkiel, 2003).

2.3.3 Concept of Technical Analysis

Technical analysis is the use of past price market data, such as volume, to guide trading decisions in asset markets (Neely & Weller, 2011). These decisions are often generated by applying trading rules to historical price data.

In its simplest form, technical analysis relies on information about past price movements to forecast future price trends. These decisions are often generated by applying simple
rules to historical price data. For example a technical trading rule may suggest that a stock be purchased if its price has increased more than 1% from its value five days earlier. Technical analysts argue that their method to trading gives them opportunities to profit from changes in the overall sentiment or psychology of the market (Neely, Weller & Dittmar, 1997).

Technical analysis is considered by most people to be the original form of investment analysis, dating back to the 1800's (Brock, Lakonishok & LeBaron, 1992). The use of trading rules to exploit patterns in stock prices has been in existence for a long time. The widespread and successful use of technical analysis however contradicts the Efficient Markets Hypothesis which holds that no trading strategy should be able to generate excess returns on publicly available information such as past prices.

Pring (1991) reveals three core principles that influence the behavior of technical analysts. The first is that price movement and transaction volume discounts everything. In other words, the way price moves is a reflection of the trend created by market participants as a result of greed, fear, hopes, knowledge and optimism.

The second principle is that asset prices move in trends. This is very important to the success of technical analysis because the existence of trends indicates predictability and as such traders are able to profit by buying assets when the price is rising and vice versa.

Neely (1997) provides an example of why markets are likely to trend. He noted that in self-fulfilling way, investors or traders believe that an asset price is going to rally and by acting upon this belief, the asset is caused to rise, independent of other factors.

The third principle of technical analysis is that history repeats itself. This assumption seeks to suggest that because the physiological or emotional makeup of investors hardly
changes. Active traders will tend to react in a similar way when confronted by similar conditions. This implies that they will tend to react the same way to the same market conditions and therefore subsequent movement in price is likely to be similar. The goal therefore is to determine signals or patterns in a current market by analyzing past market signals. To illustrate, say a stock is peaked at say GHc 70 before it sold off at say Ghc 60, the analyst believe that Ghc 70 will become a reference point where they can anticipate to sell the stock if it rises again to that level.

And so using the above principles, technical analysts try to identify major trends and reversals of trends. These methods are explicit and actually infer future price changes from those of the recent past.

According to Neely & Weller (2011), there are many types of technical analysis and many ways to analyze current and past price and volume data into trading decisions. However two types of techniques that are often employed by technical analysts to distinguish trends from shorter-term movement of prices and to identify reversals are charting and mechanical techniques.

Charting involves graphing the history of prices over some period to predict future patterns from past patterns. It is a very subjective technique that requires the analyst to use judgment and skill in recognizing and interpreting patterns.

On the other hand mechanical rules or system indicators, impose consistency and discipline on the technician by requiring him to use rules based on mathematical functions of present and past prices.
2.4 Empirical Literature on Efficient Market Hypothesis and Random Walk Hypothesis

There has been a considerable number of research work that have examined random walks in the world’s stock markets and most empirical studies have presented evidence to support this concept. Most studies test this hypothesis by comparing the current returns on a particular security to the returns of that same security over a previous period. It follows then that the random walk hypothesis will hold true if the correlation were to be zero.

One of the first tests of the RWH was developed by Kendall (1953). His work found series of price changes to be linearly independent using autocorrelation as a means of measure. This implied that these series may be characterized by random walks. Similar results were found by Cootner (1962); Fama (1965) and Fama & Blume (1966) who found that that price changes occurs as a result from the new information received. Therefore stock prices that follow a random walk exhibit statistical independence (Leroy 1989).

Osborne (1959) in his paper revealed the reason behind the economic principle underlying the independence of successive price changes. He claims that the decisions of active investors in an individual security are independent, which is the main reason why we see independent price changes.

Earlier research test of the weak-form EMH are primarily concerned with the predictability power of past returns. Following Fama’s theory and work on the EMH, a great number of researches have aimed to test the validity of the weak-form EMH. Most of these studies have been done on developed markets.
2.5 Evidence from Developed Markets

Generally the presence of positive or negative serial correlation is cited as evidence against market efficiency. These serial correlations in stock returns essentially deviate from the null hypothesis usually tested that there is no serial correlation. Positive serial correlation implies predictability of returns in the short horizon, whereas negative autocorrelation indicates predictability in the long horizon (Fama 1991).

Poterba & Summers (1986) did a market efficiency test in the United States and 17 other countries and found that there were positive serial correlations at short horizons and negative serial correlations at long horizons.

Conrad & Kaul (1988) using weekly returns of the NYSE stocks examined the nature of expected return movements. Their results showed a positive but small serial correlation in weekly returns.

Fama & French (1988) reveal that there is negative serial correlation in long horizon stock returns. In contrast, Lo & MacKinlay (1988) found rather significant positive serial correlations for weekly and monthly returns. The reason for the rejection of random walk is explained by the fact that long holding-period returns are significantly negatively serially correlated and this is an indication that the longer-horizon return is predictable from past returns (Fama & French, 1988).

Recent test of market efficiency used the variance ratio test instead of the more traditional methods that were used earlier on. Lo & MacKinlay (1988) used a specification test premised on a variance estimator by examining 1216 weekly observations of daily index data between the period September 1962 to December 1985. Their findings reject the random walk hypothesis for the entire sample period and for all sub-periods.
On the other hand, Lee (1992) using data spanning from 1967 to 1988 in ten industrialized countries including the United States, United Kingdom, Netherlands, France, Italy, Belgium, Japan, Australia, German and Switzerland, examined whether weakly stock returns of these countries follow the random walk employing the use of variance ratio test. He finds that most of these countries’ weekly return series follow the random walk model.

Using 3 to 12 months holding period returns, Jegadeesh & Titman (1993) conclude that stock prices are characterized by momentum such that a good stock performance is continued and otherwise. They used 3 to 12 months holding period returns and found that the performances of individual stocks are highly unpredictable, but then when portfolios were constructed for the best performing in the recent past, they seemed to outperform other stocks with enough profit opportunities. They claim that this phenomenon happens because the estimated autocorrelations of the studies are usually close to zero indicating that the predictive ability of returns is not statistically significant. It follows then that while the study provides evidence of weak-form market inefficiency, it does not prove the existence of profitable trading opportunities.

In examining the stochastic nature of stock indices, Choudhry (1994) used the Augmented Dickey Fuller and KPSS unit root tests and the Johansen’s cointegration tests on monthly stock indices from the period 1953 to 1989 in the United Kingdom, United States, Italy, Canada, Germany, France, and Japan. His results showed that all these developed markets seem to contain a stochastic trend (a unit root) implying non-stationarity in the levels of the price index. The presence of a unit root for these seven series provides evidence that these markets follow the random walk process and are market efficient.
Seiler & Rom (1997) examined whether the NYSE index followed the random walk hypothesis using the Box-Jenkins test. They used daily returns of the index from February 17, 1885 to July 2, 1962 and concluded that for the period under consideration, changes in price were completely random. They used the same data to investigate whether there is a month or a day of a week that shows returns to be non-uniformly distributed. The results indicated that on a monthly basis; January, July and August, and on a weekly basis; Wednesday, Friday and Saturday all recorded increased earnings while Monday presented significant negative returns.

Chan, Gup & Pan (1997) tested for the weak-form efficiency using Phillips-Peron (PP) unit root and Johansen’s cointegration test across 18 international stock markets including Australia, Belgium, Canada, Finland, Germany, India, Italy, Japan, Norway, Pakistan, Netherlands, Spain, Sweden, Switzerland, US and UK. They used data covering the period January 1962 to December 1992, for each of the stock series and 384 monthly observations. Their results reveal that that all stock market indices examined are individually weak form efficient with only a few of stock indices showing evidence of cointegration with others.

Worthington & Higgs (2004) also tested for randomness using data from sixteen developed countries including Austria, Denmark, Belgium, Finland, Germany, Greece, France, Italy, Ireland, Norway, Netherlands, Portugal, Spain, Sweden, Switzerland, the United Kingdom and four emerging stock markets namely, Czech Republic, Hungary, Poland and Russia. They used daily returns of stock indices from the period December 31, 1987 to May 28, 2003, and December 30, 1994 to May 28, 2003 for the four emerging markets. They used various methods including serial correlation, Runs test, Augmented Dickey Fuller, Phillips-Peron and KPSS unit root test and multiple variance ratio tests to
investigate whether the random walk hypothesis holds in major European developed markets. Their results showed that Germany and Netherlands are weak-form efficient under both serial correlation and Runs tests, while Portugal, Ireland and the United Kingdom are efficient under one test or the other. However the rests of the markets were found not to follow a random walk. When the variance ratio test was used to test for randomness, it was seen that the null hypotheses of homoscedasticity and heteroskedasticity were not rejected in the United Kingdom, Germany, Ireland, Hungary, Portugal and Sweden. However in the case of France, Finland, Netherlands, Norway and Spain, the null hypothesis of random walk was rejected under the assumption of homoscedasticity but not heteroskedasticity. The existence of random walk makes it impossible to forecast future price movement using historical prices on markets such as the United Kingdom, Germany, Sweden, Portugal and Ireland.

2.6 Evidence from Emerging Economies

Extant literature on EMH have focused on the major US and European stock market with little focus on emerging markets especially those in Africa. This is as a result of the size of these emerging markets and lack of adequate information to draw satisfying conclusions (Dewortor & Gborglah, 2004). However, more recently several emerging stock markets have experienced tremendous growth with most markets evolving from shallow and illiquid markets to sizeable and liquid markets with the potential of being integrated into the world financial system (Yilmaz, 2001).

Studies related to market efficiency in these markets have focused on the predictability of stock market returns and the determination of whether such markets exhibit the random walk. Huang (1995) examines the efficiency of nine Asian stock markets namely: Hong Kong, Malaysia, Japan, Indonesia, Korea, Singapore, Thailand, Philippines and Taiwan by
applying the variance ratio estimating technique under the assumptions of homoscedasticity and heteroskedasticity. Data used consist of weekly stock index returns between the periods 1988 to 1992. He found out that with the exception of Indonesia, Japan and Taiwan, the remaining markets do not follow the random walk hypothesis and thus he rejected the hypothesis of weak-form efficiency.

Using the runs and autocorrelation test, Laurence (1986) test the weak-form efficiency on the Kuala Lumpur Stock Exchange (KLSE) of Malaysia and the stock exchange of Singapore (SES). Daily data of individual stocks were used between the periods 1973 to 1978 for both exchanges. His results revealed that both markets were weak-form inefficient. The results of Laurence (1986) contradict that of Barnes (1986) who conducted similar test on the KLSE and found that it was weak-form efficient. His test was applied to thirty companies and six sector indexes on the KLSE from 1975 to 1980.

Harvey (1995) studied the stock returns predictability and volatility of eight Asian, three European, six Latin American, and two African emerging stock markets and found the presence of strong serial correlation in the stock returns which is an indication of market inefficiency.

Urrutia (1995) used both variance ratio test of Lo & MacKinlay (1988) and runs tests to examine the presence of random walk behavior in four Latin American emerging markets namely, Argentina, Brazil, Chile, and Mexico. Monthly stock index prices were employed from the period December 1975 to March 1991. In his results, the variance ratio test rejected the random walk hypothesis for all four markets, while the runs test failed to reject the null hypothesis. He however concluded that the four Latin American emerging stock markets are weak-form efficient based on the runs test result. The study of Ojah & Karemera (1999) is in line with the result of Urrutia (1995). They tested the random walk
on the same four emerging markets using the variance ratio of Lo & MacKinlay (1988), multiple variance ratios of Chow & Denning (1993) and runs test. They applied these methods to monthly stock prices index between the periods December 1987 to May 1997. Their result showed that with the exception of Argentina, the other three markets do not follow the random walk.

Again Lima & Tabak (2004) employed Lo & MacKinlay (1988) variance ratio techniques and failed to reject the random walk hypothesis for Hong Kong equity market while the hypothesis for the Singapore market was rejected. The data used for both countries covered daily returns of the Hang Seng Index for Hong Kong and the Straits Time Index for Singapore from the period June 1992 to December 2000. Their work was confirmed by Cheung & Coutts (2001) who also used the variance ratio test during the period January 1985 to June 1997 to establish the fact that Hang Seng index follows the random walk hypothesis and is weak-form market efficient.

In the same vain, Mobarek & Keasey (2000) used daily prices of all listed companies on the Dhaka Stock Exchange in Bangladesh, from 1988 to 1997 to examine the weak form efficiency of the market. Using both parametric and non-parametric tests they found that share prices do not follow the random walk model. Their result revealed significant autocorrelation co-efficient at different lag periods which indicated the exchange was weak form inefficiency.

Chung (2006) used daily returns from February 21, 1992 to December 30, 2006 from the Chinese stock market. The study revealed that Chinese stock markets were not weak form efficient, since the four statistical methods that were used to test for market efficiency, namely, serial autocorrelation test, non-parametric runs test, variance ratio test, and Augmented Dickey-Fuller unit root test rejected the random walk hypothesis.
In the Middle East, Butler & Malaikah (1992) investigated weak-form efficiency in Kuwait and Saudi Arabian stock markets through autocorrelation tests. Their results show that there is inefficiency in the Saudi Arabian stock market, but not in the Kuwait market. They argue that factors contributing to market inefficiency in the Saudi market included market fragmentation, trading and reporting delays, and the absence of official market makers.

A more recent study on the same market by Abraham, Fazal & Sulaiman (2002) confirms earlier studies. Employing the use of variance ratio test and runs test they tested the random walk behavior and efficiency of Kuwait, Saudi Arabia and Bahrain from October 1992 to December 1998 using weekly index values. After estimating the true index-correction for infrequent trading, their results showed that they cannot reject the random walk hypothesis for Saudi Arabia and Bahrain markets. The Kuwait market on the other hand failed to reject the test of randomness in the price series.

Markets in Jordan have been found to be weak-form efficient but other research work on markets like Turkey and Israel have been found to show conflicting results. An example can be found in the papers of Claessens, Dasgupta & Glen, (1995) and Karemera, Ojah & Cole, (1999).

Employing the Ljung-Box Q, the runs and the unit root tests, Chang, Jegadeesh & Lakonishok (1996) tested the weak form of the EMH using monthly stock price index data on the Taiwan stock exchange from 1967 to 1993. Their result revealed that the Taiwan stock market follow the random walk and is weak-form efficient. The study by Chang & Ting (2000) confirms the findings by Chang et al. (1996). They used weekly, monthly, quarterly and yearly stock price return index from 1971 to 1996. Their result rejected the
random walk hypothesis when weekly data was applied but for monthly, quarterly and yearly value-weighted market indexes the hypothesis failed to be rejected.

Poshakwale (1996) test the market efficiency and day of the week effect on the Bombay Stock Exchange (BSE) in India using daily data for the period January 1987 to October 1994. He finds that the distribution of prices does not follow a normal distribution. He uses runs and serial correlation tests to confirm the behavior of the series. He found that the tests provide evidence of the absence of random walk in the price series of BSE. Furthermore, the runs and serial correlation tests prove that the stock prices of on BSE is of a non-random nature. Consequently, he concludes that the Indian stock market is not weak-form efficient.

Some studies have also focused on the measurement of correction biases caused by thin and infrequent trading which is common to emerging and small stock markets. Osamah & Ding (2007) used a non-parametric variance ratio test to examine the efficiency of eight emerging markets in the Middle East and North Africa (MENA). Their result did not invalidate the hypothesis of a random walk. Thus they concluded that the MENA markets are weak-form efficient. On the other hand the result of Abdmoulah (2009) indicates the opposite. The author studied eleven Arab countries namely, Saudi Arabia, Kuwait, Tunisia, Dubai, Egypt, Qatar, Jordan, Abu Dhabi, Bahrain, Morocco and Oman and found that all Arab stock exchanges were weak-form inefficient after applying daily data of the country’s stock market indices.

Focusing on Africa emerging markets, Parkinson (1987), used monthly prices of individual stocks of companies and tested the validity of the weak-form efficiency of the Nairobi Stock exchange (NSE) for the period 1974 to 1978. He uses runs test to estimate the random walk hypothesis and found that out of the 50 companies listed on the NSE, 49
showed few numbers of the runs that was expected. Thus, the random walk hypothesis is rejected for these series. From 1979 to 1989, Dickinson & Muragu (1994) continued with the research work of Parkinson by determining whether the NSE followed the random walk. They used the autocorrelation and Runs tests and applied it to weekly price data of the thirty most actively traded stocks. Their result contradicted that of Parkinson (1978). They found that their results supported the weak-form market efficiency hypothesis in NSE.

Samuels & Yacout (1981) also used autocorrelation techniques to test for efficiency on the Nigerian stock market. They found that using weekly prices, 21 listed firms on the NSE followed the random walk hypothesis between the periods 1977 to 1979. The study of Olowe (1999) supports the findings of Samuels & Yacout (1981). He also used correlation analysis on monthly stock returns data over the period January 1981 to December 1992 and his result shows that the Nigerian stock market is weak form efficient.

In contrast to the works of Samuel & Yacout (1981) and Olowe (1999), Akpan (1995) examined whether or not the Nigerian stock market was weak-form efficient and also assessed the risk implications of investing in the market. He used time series data of stock market price indices within the period 1989 to 1992. His findings show evidence to reject the hypothesis of Weak-Form efficiency of the NSE.

In Egypt, Mecagni & Sourial (1999) employed the GARCH estimating techniques to show that the Egyptian stock market indicated significant departures from the efficient market hypothesis when it was applied to the four indices on the exchange.

Chiwira (2001) investigated the random walk hypothesis on the Zimbabwe stock exchange between the periods 1995 to 1999 and found that it failed to reject the hypothesis and thus the exchange was concluded to be weak-form efficient. In contrast, a more recent study by
Mazviona & Nyangara (2013) provided evidence to support the fact that the Zimbabwean stock exchange is not weak-form efficient. The authors used daily closing prices of index spanning from February 2009 to June 2012 and applied the autocorrelation, runs and Q-statistic test.

Simon & Laryea (2004) employed a battery of tests including autocorrelation, auto regression analysis, variance ratio, K-S normality test and the runs tests to investigate the weak-form market efficiency on four African countries, namely, Ghana, Mauritius, Egypt and South Africa. They used weekly and monthly data series from 1990 to 2003 and found that with the exception of South Africa, the stock markets of Ghana, Mauritius and Egypt are weak-form inefficient. They also go further by using predictive models such as ARIMA models to exploit the inefficiencies by forecasting future returns. They therefore conclude that, given the fact that Ghana, Mauritius and Egypt are weak-form inefficient, potential investors in these markets could earn abnormal returns by timing the markets based on historical stock prices.

Appiah-Kusi & Menyah (2003) tested the weak-form market efficiency of eleven African stock markets including Botswana, Egypt, Ghana, Ivory Coast, Kenya, Mauritius, Morocco, Nigeria, South Africa, Swaziland, and Zimbabwe. In his study he accounted for thin trading when calculating the returns allowing for non-linearity and time-varying volatility in the return generating process. They used weekly stock price index data for the period 1989 to 1995. They adopted the model of Miller, Muthuswamy & Whaley (1994) to remove the impact of thin trading by estimating a moving average model that reflects the number of non-trading days and allowed adjustment of the returns accordingly. They also used the EGARCH-M model for the efficiency test. They found that with the exception of Egypt, Kenya, Mauritius, Morocco, and Zimbabwe, the other six countries
were not weak-form efficient. Their result also showed that the return generation process is nonlinear in all the eleven markets, and in five of the markets, investors demand a time-varying risk premium for the risks they bear.

Akinkugbe (2005) investigated the stock markets in Botswana and found it to be weak and semi-strong form efficient. His data included 738 weekly closing prices of the stock index for the period June 1989 to December 2003. He employed the use of Autocorrelation, Augmented Dickey-Fuller and Phillip-Perron unit root tests and concluded that the return series showed no presence of serial correlation. The results of both the unit roots tests show non-stationarity for stock returns implying that the series follow the random walk and are thus weak-form efficient.

Magnusson & Wydick (2002) utilize a partial-autocorrelation test to examine the behavior of monthly closing prices of eight African stock markets indices, namely, Ghana, Cote d’Ivoire, Kenya, Botswana, Mauritius, Nigeria, South Africa and Zimbabwe. They compared the results with nine Asian and Latin American markets. Their findings indicate that six out of the eight investigated African stock markets indices were weak-form efficient from 1989 to 1998. Ghana and Zimbabwe were found not to be weak-form efficient. Their findings for Ghana and Botswana are consistent with those by Magnusson & Wydick (2002).

Smith, Jeffris & Ryoo (2002) and Jefferis & Smith (2005) have also tested the nature of price on a group of African stock markets indices. Smith et al. (2002) used Chow and Denning’s multiple variance-ratios test to investigate the weak-form market efficiency of eight African countries by applying weekly stock market index series data from 1990 to 1998. The notion of weak-form efficiency is rejected in all countries except South Africa. On the other hand, Jefferis & Smith (2005) employed a GARCH model to examine serial
dependence in weekly stock indices of the same group of countries from 1990 to 2001. Their findings support that of Smith et al (2002). Meanwhile in Zimbabwe, Chiwira (2001) studied weak-form efficiency of listed stocks on its exchange and concluded that the market is efficient. This is an indication that some of the studies in Africa have drawn mixed and contrasting conclusions.

Mlambo & Biekpe (2007) investigated the weak-form efficiency of ten African stock markets including Egypt, Kenya, Zimbabwe, Morocco, Mauritius, Tunisia, Ghana, Namibia, Botswana and Cote d’Ivoire using daily data for periods between January 1997 and May 2002. With the exception of Namibia, Kenya and Zimbabwe, a significant number of stocks rejected the random walk hypothesis.

Enowbi, Guidi & Mlambo (2009) also tested the weak form efficiency of four African stock markets namely Egypt, Morocco, South Africa and Tunisia, using daily data from January 4, 2000 to March 26, 2009. The results indicate that none of the markets followed the random walk hypothesis with the exception of the South African stock market. The finding that Egypt is weak-form market inefficient is consistent with earlier study of Asal (2000) who also found the Egyptian Stock Exchange to be weak-form inefficient from 1992 to 1996. He however claimed in his research that Egypt was moving towards efficiency.

2.7 Previous Researches on Ghana Stock Market Efficiency

Narrowing the scope to Ghana, it could be said that very little has been done on determining the efficiency of our market. Most of the studies conducted however reveals Ghana to be weak-form inefficient.
One of the earliest studies on market efficiency as it relates to the Ghana Stock Exchange is by Osei (2002). His objective was to determine the market efficiency of the Ghana Stock Market by looking at the characteristics of asset pricing and the response to annual earnings announcements of the exchange. He analyses cumulative abnormal returns (CAR) to measure abnormal returns over a 17-week event window during the annual earnings releases. He found that the market moves up when the news released is good and down when its bad news over the period before the event announcement date. He argues that this phenomenon is inconsistent with the EMH and concludes that the Ghana Stock Market is inefficient with respect to annual earnings information released by the companies listed on the exchange.

The study by Dewortor & Gborglah (2004) is conducted to establish whether the stock market in Ghana is efficient enough to prevent investors from developing profitable trading strategies based on historical prices. They used serial and cross-sectional correlation tests to establish market efficiency. Their result indicated that majority of daily stock returns are positively serially correlated irrespective of the method applied. Also the differences between daily and monthly return correlation were insignificant. Quarterly returns were insignificantly positively correlated but the cross-sectional results provided evidence of significant positive correlation. Yearly returns were also found to be negatively correlated that a price reversal phenomenon exists in Ghana but insignificant on the whole. They concluded based on the results that the Ghana stock market is to a large extent weak-form inefficient.

Using a rather more robust methods, Ntim, Oppong & Dunbolt (2007), re-examined the weak-form efficient market hypothesis of the GSE. They used two types of data in the study. The first consists of daily closing prices of the All Share Index (ASI) and the second was the daily closing stock price series of twenty individual stocks. Both data types
spanned from 12\textsuperscript{th} November 1990 to 31\textsuperscript{st} December 2005. They adopt the Lo & MacKinlay (1988) and Wright (2000) variance ratio test to determine if the series indeed follow the random walk. Their result was mixed. While the Lo & MacKinlay variance ratio test showed that the ASI return series violated the random walk hypothesis, results regarding individual stocks were rather mixed. However the results of the Wright’s test were conclusive. They however reject the weak-form efficiency of the GSE which is consistent with previous studies.

In a different dimension, Mensah et al. (2016) examined the efficiency of the Ghana Stock Exchange by investigating the day of the week effect on the Exchange using the GSE All-share daily index data from November 1990 to August 2012. They utilized several techniques namely; one-sample t-test, dummy variable regression, autoregressive and generalized autoregressive conditional heteroskedastic models to test whether day of the week effect exist on the GSE. Their results reveal the presence of day of the week effect on the GSE. They report that high returns are seen on Tuesday and low returns on Thursday. Monday, Wednesday and Friday also recorded significant positive returns, however, significant returns is captured by a strong auto-regression in the returns. This is an indication that stock returns on the GSE are not completely random and that the efficient market hypothesis does not hold on the exchange.

Ayentim et al. (2013) investigated the weak-form efficiency of listed firms on the Ghana Stock Exchange (GSE) by using weekly closing prices on the GSE from January 2007 to June 2012. The study uses two different non-parametric test namely Kolmogorov-Smirnov test and runs test to determine whether period to period price changes follow a random walk and also to determine if price series are predictable. They provided the descriptive statistics of the return series and found that returns from GSE did not follow
normal distribution. Again the results indicated that the returns series showed evidence of volatility clustering which is an indication of inefficiencies on the GSE.

More recently, Mensah, Adom, & Pomaa-Berko (2014), assessed the impact of automation on the efficiency of the GSE. Using daily stock returns data form 2006 to 2011, they applied the variance ratio test, the unit root test and GARCH (1,1) to determine whether after the automation the stock market followed the random walk. It was found that even after the introduction of automation on the GSE, it still remained inefficient. They however argued that the GARCH model revealed that the number of market participants involved in the market has increased even though GSE continued to remain inefficient after the automation.

Tweneboah, Amanfo & Kumah (2013) in a different dimension tested the random walk behavior of exchange rates in Ghana by using parametric and non-parametric variance ratio tests based on ranks and signs using monthly exchange rates of the GHS/USD pair. Their results provided conclusive evidence that the exchange rate series is inconsistent with the random walk process and the weak-form efficient market hypothesis.

Based on the above facts and results from other authors who have tested market efficiency of the GSE on an aggregate level, we can generally conclude that:

- The Ghana Stock Exchange over the years has been found to exhibit market inefficiencies to a large extent and that market efficiency has not been attained even though significant improvements have been made regarding the development of the exchange.
- The evidence suggests that the GSE is predictable making it inefficient.
2.8 Empirical Literature on Technical Analysis

Research conducted on technical trading rules in academic literature can be divided into two major areas: Filter rules and Moving Average rules. Earlier research focused on Filter rules. This rule involves buying a security if it had risen by a certain percentage on the last period or selling it if its price has decreased by a certain percentage on the last period (Fama & Blume 1966). Most of the technical trading rules have been applied both on developed markets and emerging markets.

Alexander (1961) was one of the first to examine the profitability of this kind of rule on individual stocks and his results showed profitable. He used daily stock returns from the Standard and Poor Industrials and the Dow Jones Industrial Average (DJIA) from 1897 to 1959 employing the use of 11 filter rules. In his later study, Alexander (1964) included transaction costs and found that the profit generated by the same strategy was not sustainable or reduced drastically.

Fama & Blume (1966) confirmed this conclusion when they employed the Filter rule technique to the daily closing prices of 30 individual stocks listed on the Dow Jones Industrial Average (DJIA) over a six-year period beginning January 1958. Their result indicated that only 4 out of 30 stocks had positive average returns after commissions. They also realized that the technical trading rule they applied proved to be inferior compared to the buy-and-hold strategy after commissions were factored in. They argued that the authenticity of the technical analysis is doubtful because results could not be justified theoretically. Sweeney (1988) re-examined the results of Fama & Blume (1966) for another period and found that, depending on the level of transaction costs, filter rules still yielded profitable results in contrast to what Fama & Blume (1966) concluded.
Van Horne & Parker (1967) analyzed 30 stocks listed on the New York Stock Exchange (NYSE) over the same six-year period. Their result revealed that no trading rule that was applied to the data earned a return greater than the buy and hold strategy on the same index.

Additionally, Jensen & Benington (1970) analyzed alternative technical trading rules over a period from 1931-1965 on NYSE stocks and found further confirmation that technical trading rules do not outperform the buy and hold strategy.

Levich & Thomas (1993) give evidence of the conclusion drawn by Sweeny (1988). They examined data from January 1976 to December 1990 and found that applying filter rules to the data, they yielded average excess returns of 8.1% per annum across six filters for the JPY and GBP and CHF currencies. However also found that the profitability for three MA rules MA (1, 5), MA (5, 20) and MA (1,200) were much higher.

At the beginning of the nineties, research on technical analysis focused more on Moving Average (MA) rules and also dealt with issues that were relevant for early empirical studies such as data snooping and allocation of transaction cost.

Brock et al. (1992) investigated moving average rules on the daily data which spanned from 1897 to 1986 of the Dow Jones Industrial Index and reported the results for all rules that were generated. They found that these rules were profitable and that the signals generated by these were able to generate abnormal returns when compared to the average buy-and-hold strategy. They employed moving averages of length 1, 2 and 5 days for the short period and 50 to 200 days for the long period moving average. The result of Brock et al. opened up the way for further research in support of technical analysis as a forecasting tool especially in markets that may be considered less efficient.
Bessembinder & Chan (1995) replicated Brock et al. (1992) study in six Asian markets including Malaysia, Thailand, Taiwan, Hong Kong and Japan. Their results revealed that the technical trading rules used were quite successful in the emerging markets like Malaysia, Taiwan and Thailand. However, that could not be said of a more developed market like Japan and Hong Kong.

Hudson, Dempsey & Keasy (1996) also replicated Brock et al. (1992) and test the efficiency of the UK stock market for the period 1935 to 1994. They found profitable results with the moving average strategies but it was established that profits were highly insignificant when transaction costs were considered.

Ratner & Leal (1999) examined the predictability of the Variable Moving Average (VMA) trading rule in ten Latin American and Asia Stock Markets using data that spanned from 1982 to 1995. The results of their studies found that using technical trading rules generated significantly higher profits especially in Taiwan, Thailand and Mexico compared to using the buy-and-hold strategy.

Levich & Thomas (1993) and Kho (1996) also considered moving average strategies on a different asset class, namely the currency futures. It was found that both studies proved to be profitable even when transaction costs were accounted for.

The majority of academic studies on technical analysis have employed daily data; however, more recently some studies have used higher-frequency data (Osler, 2003). Kozhan & Salmon (2010) use tick-by-tick data for the GBP/USD pair for separate periods in 2003 and 2008. They find that a trading rule based on a genetic algorithm can earn significant profits net of transaction costs in 2003 but that these profits disappear by 2008.
According to Fama & French (1995), testing technical analysis trading rules is a means to find out whether or not there is independence within the stock price movements, thus giving evidence either for or against the predictability of a stock price. As such other studies have also tested the EMH in both developed and emerging markets by employing the use of technical analysis trading rules.

Allen & Karjalamein (1999), demonstrated empirically that technical analysis does not have validity and as such cannot predict future price movements. Kavajecz & Orders (2004) also investigated the validity of technical analysis. In their study, they strongly dismissed technical analysis and claimed it was inconsistent with the Efficient Market Theory. Not many in academia agree with this perspective. For example, Lo, Mamaysky & Wang (2000) present a strong defense for technical analysis given their profession as financial economists. They used daily returns of stocks on the New York Stock Exchange and NASDAQ from 1962 to 1996 and use the most sophisticated computational techniques to look for price patterns. They found that the most common patterns stocks are double tops and bottoms – a type of chart pattern often used by chartist. They however conclude that these chart patterns offer only marginal positive returns and there is a great chance that these returns might vanish after transaction costs have been factored.

The evidence provided by literature seems to suggest that the application of technical trading rules have generated mixed results. The debate as to whether technical analysis could be used to gain excess returns is still ongoing. It could be seen however that these trading strategies have mainly been applied to developed markets. On the Ghana market, no research to the best of our knowledge has been made in relation to the application of technical trading rules to exploit the inefficiencies that have been found on the GSE.
CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Data Source and Description

To test for weak-form efficiency on the Ghana Stock Exchange (GSE), the study utilizes data primarily consisting of daily closing prices of the Composite Index (CI) on the GSE. The CI is a volume weighted index of the average closing prices of all listed equity on the GSE. The period under consideration for the data begins from January 4th 2011 and ends December 31st 2014. It is crucial to note that the study uses a more recent data up to 2014 for our analysis which is very important because by using recent data we will be able to capture some of the changes and trends that have occurred over time and might have an impact on the efficiency on the stock market of Ghana.

The same set of data is used to examine the profitability of technical trading rules using the variable moving average technique.

The natural log of the relative price is computed for the daily intervals to produce a time series of continuously compounded returns. Continuously compounded returns is the preferred method to discrete returns because its unit-free and allows daily returns of the index to be compared across assets. It also has the additional benefit of being time-additive. A time series of continuously compounded return $r_t$, is given as follows:

$$ r_t = \log \left( \frac{x_t}{x_{t-1}} \right) * 100 $$

where $x_t$ and $x_{t-1}$ represent the stock index price at time $t$ and $t-1$, respectively. The index price has been adjusted for dividends already and as such the study did not include dividends in the calculation of the returns.
3.2 Evaluating the Random Walk Hypothesis

The study adopts the strict Random Walk Model (RWM) in testing the weak-form of the EMH. As such we will consider the hypothesis that the GSE-CI return series follow a random walk.

The random walk (RW) hypothesis posits that in an efficient market, successive price changes follow a strict Gaussian random variable (Ntim et al., 2007). Accordingly, a financial asset’s price series is said to follow a random walk if successive residual increments are independent and identically distributed (IID) which is the simplest and strongest version of the RWH. This means that future price changes cannot be predicted from historical price changes. Campbell et al. (1997) demonstrate that a financial asset’s price series is said to follow a random walk, if,

\[ x_t = x_{t-1} + \mu + \varepsilon_t, \quad \varepsilon_t \sim \text{IID N}(0, \sigma^2) \]  
\[ r_t = \Delta x_t = x_t - x_{t-1} = \mu + \varepsilon_t \]

where \( x_t \) refers to the price of log of the financial asset’s return series under consideration, (i.e., the price of the GSECI) at time (day) \( t \); \( \mu \) is an arbitrary drift parameter; \( r_t \) is the change in the index, \( \varepsilon_t \) is a random disturbance term satisfying \( \text{E}(\varepsilon_t) = 0 \), \( \sigma^2 \) is constant and \( \text{E}(\varepsilon_t \varepsilon_{t-g}) = 0 \), for all \( t \) and \( \text{IID N}(0, \sigma^2) \) means that the residual term \( (\varepsilon_t) \), is independently and identically distributed with zero mean and unit variance \( (\sigma^2) \).

The independence of the increments implies not only that the increments are uncorrelated, but any nonlinear functions of the increments are also uncorrelated. In other words, if the
conditional distribution of \( (X_t) \) is normal, then there will always be a positive probability that \( (X_t) < 0 \) (Campbell et al. 1997).

It follows that the RW hypothesis to be tested is as follows:

**H\(_0\):** The GSEASI follows a random walk (Is weak-form efficient)

**H\(_1\):** The GSEASI does not follow a random walk (Is weak-form inefficient)

The null hypothesis of a random walk model is tested using statistical techniques including variance ratio and unit root tests.

### 3.3 Statistical Tests for Market Efficiency

In this study, we use two statistical methods, namely a variance ratio test and an Augmented Dickey-Fuller unit root test to examine market efficiency. The data is subjected to a variance ratio tests to determine the level of dependency among successive returns on the Ghana stock Exchange.

The variance ratio tests according to Lo & MacKinlay (1988), allows for the testing of all three forms of the random walk hypothesis which makes it much more powerful and reliable. Test for unit root which is a necessary condition for random walk is also used to determine if the series is difference or trend stationary. These statistical tests are discussed more closely in each following sub-sections.

#### 3.3.1 The Augmented Dickey-Fuller Unit Root Test (ADF)

Degutis & Novickyte (2014) confirm that market efficiency could be analyzed by running unit root tests for a time series of stock returns. This statistical technique was developed by Dickey & Fuller (1981) and is the most commonly employed test to determine the existence of unit root. The test is based on the assumption that if a time series has a unit
root, then it does not follow a deterministic process and is therefore, hard to predict. Consequently we can say that the stock market follow the random walk and is weak-form efficient if there is evidence of a unit root.

The standard Dickey-Fuller (DF) test is much more appropriate for a series generated by an autoregressive process of order one, AR(1). However if the series follows an AR \( p \) process where \( p > 1 \), the error term in the standard DF test will be auto-correlated and that will invalidate the use of the DF test distribution, which is based on the assumption that the error term is white noise. To account for this problem, the Augmented Dickey-Fuller (ADF) test includes additional lagged difference terms (Dickey and Fuller, 1981).

The ADF unit root test of the null hypothesis of non-stationarity is expressed in the following regression equation:

\[
\Delta x_t = a_0 + \alpha_1 t + \gamma_0 x_{t-1} + \gamma_1 \Delta x_{t-1} + \gamma_2 \Delta x_{t-2} + \cdots + \gamma_p \Delta x_{t-p} + \epsilon_t
\]

(4)

where \( \Delta \) represents first differences, \( x_t \) denotes the log of the price for the market index at time \( t \), \( \gamma \) are coefficients to be estimated, \( p \) is the number of lagged terms, \( t \) is the trend term, \( \alpha_1 \) is the estimated coefficient for the trend, \( a_0 \) is the constant, and \( \epsilon \) is white noise.

To determine the significance of the estimated \( \gamma \) coefficients, the ADF unit root test statistic is computed for each estimated coefficient.

The test statistic to be used is:

\[
DF_t = \frac{\hat{\gamma}}{SE(\hat{\gamma})}
\]

(5)

The above can be compared to the critical value for the Dickey–Fuller Test. If the estimated test statistic is greater than the critical values in absolute terms, then we reject
the null hypothesis of random walk and conclude that there exist no unit root which is an indication of stationarity and the absence of random walk.

### 3.3.2 Lo & MacKinlay’s Variance Ratio Test (LM VR)

Lo & MacKinlay (1988) developed a more robust test called the Variance Ratio (VR) test to identify whether a financial time series truly follows random walk process or not. The variance ratio tests whether the variance of the increments in a random walk is linear in the sampling lag. It examines the uncorrelated residual in series under the assumptions of both homoscedastic and heteroskedastic random walks.

Many researchers including Ayadi & Pyun (1994), Huang (1995), Chang & Ting (2000), Darrat & Zhong (2000), Lee, Chen & Rui (2001), Urrutia (1995) and Grieb & Reyes (1999) used Lo–MacKinlay VR tests to examine the random walk hypothesis especially in emerging stock markets and this is mainly because according to Lo & MacKinlay (1988), it is demonstrated to be more reliable and more powerful than the unit root.

According to the LM variance ratio test, if the return series of a market index is random, the variance of qth-period return is q times the variance of a single-period return. Hence, for a random walk process, the variance computed at each individual lag interval q should be equal to unity. Rejecting the null hypothesis that the variance ratio equals one suggests that there is evidence of serial correlations in returns, mean reversion in time series, and return predictability.

Also, the test is based on the assumption that the variance of increments in the random walk series is linear in the sample interval so that if a series follows a random walk process, the variance of its q-differences would be q times the variance of its first differences, that is,
\[ Var(X_t - X_{t-1}) = q \cdot Var(X_t - X_{t-1}), \text{ where } q \text{ is a positive integer} \] (6)

The variance ratio \( VR(q) \) is then determined as follows:

\[ VR(q) = \frac{\frac{1}{q} Var(X_t - X_{t-q})}{Var(X_t - X_{t-1})} = \frac{\sigma^2(q)}{\sigma^2(1)} \] (7)

where \( VR(q) \) is the variance ratio of GSE’s returns \( q \)th difference, \( \sigma^2(q) \) is the unbiased estimator of \( \frac{1}{q} \) of the variance of GSE’s returns \( q \)th differences, under the null hypothesis, \( \sigma^2(1) \) is the variance of the first-differenced GSE returns series, and \( q \) is the number of days of base observations interval or lag, (where \( q \) could be any equally spaced integer greater than one according to (LM, 1988). The estimated variance, values for all \( q \)th lags, under the null hypothesis are expected to be equal to unity if the observed series truly follow a random walk.

For a sample size of \( nq + 1 \) observation \((X_0, X_1 \ldots X_{nq})\), the formulas for computing \( \sigma^2(q) \) and \( \sigma^2(1) \) are given in the following equations:

\[ \sigma^2(q) = \sum_{t=q}^{nq} \frac{(x_t - x_{t-q} - q\mu)^2}{h} \] (8)

Where \( h = q \cdot (nq + 1 - q) \cdot (1 - \frac{q}{nq}) \) and \( \mu \) is the estimated arbitrary drift parameter or the sample mean of \( (x_t - x_{t-1}) \) and is defined as:

\[ \mu = \frac{1}{nq} \sum_{i=1}^{nq} (x_t - x_{t-1}) = \frac{1}{nq} (x_{nq} - x_0) \] (9)

\[ \sigma^2(1) = \sum_{t=q}^{nq} \frac{(x_t - x_{t-q} - \mu)^2}{nq - 1} \] (10)

Now Under the assumption of homoscedasticity and heteroskedasticity increments, two standard normal test-statistics, \( Z(q) \) and \( Z^*(q) \) respectively, developed by Lo & MacKinlay (1988), are calculated by the equation below:
\[ Z(q) = \frac{VR(q) - 1}{(\phi(q))^{0.5}} \sim N(0, 1) \quad (11) \]
\[ Z^*(q) = \frac{VR(q) - 1}{(\phi^*(q))^{0.5}} \sim N(0, 1) \quad (12) \]

Where \( \phi(q) \) is the asymptotic variance of the variance ratio under the assumption of homoscedasticity, and \( \phi^*(q) \) is the asymptotic variance of the variance ratio under the assumption of heteroscedasticity, where \( \phi(q) \) is given as:

\[ \phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)} \quad (13) \]

\[ \phi^*(q) = \sum_{j=1}^{q-1} \left[ \frac{2(q-j)}{q} \right]^2 \theta(j) \quad (14) \]

where \( \theta(j) \) is the heteroskedasticity-consistent estimator and computed as follows:

It is important to emphasize that for the random walk hypothesis to hold, \( VR(q) = 1 \) for all \( q \).

It should be noted that the rejection of random walk under homoscedasticity could be as a result of either heteroskedasticity or autocorrelation existence in series (Worthington & Higgs 2004).

If the heteroskedastic random walk is rejected, then there is proof that there exists the presence of autocorrelation in series (Worthington & Higgs, 2004). Furthermore, if calculated variance ratio is less than one then it would imply negative serial correlation, whereas a variance ratio greater than one would indicate positive serial correlation (Darrat & Zhong 2000). We consequently conclude that returns are predictable if variance ratio is greater than one. The study conducts the variance test for lags 2, 4, 8, and 16 days in line with Lo and MacKinlay’s.
3.4 Evaluating Technical Analysis

The study adopts the variable length Moving Average trading rules formulated by Brock et al (1992). These trading rules are used to exploit the inefficiencies established on the GSE-CI and to also test its profitability when applied to the GSE-CI.

3.4.1 Variable Length Moving Average (VMA)

One of the oldest and yet simplest technical trading rules is the Moving Average (MA) rule. They are a series of partial mean of prices \( Y \) over the previous \( k \) days and it is a measure of stock price momentum. It is also often used to smooth out price and volume fluctuations into a less distorted trend. The moving average at time \( t \) is constructed as follows:

\[
MA_t^k = \frac{1}{k} \sum_{i=t-k}^{t} Y_i
\]  

(15)

In this paper we examine a version of the simple MA i.e the Variable Length Moving Average (VMA). This is made of two simple moving averages with short and long periods.

As a trading rule, buy (sell) signals are generated when the short-term moving average exceeds (falls below) or crosses above (below) the long-term moving average by a specified percentage band. If the shorter term MA crosses the long-term MA, it is an indication that changes in price trend have occurred. If the band is 0%, the VMA rules classify every day into either buy or sell day which is the case in this study.

The use of bandwidth is to avoid the emission of false signals when the short-term and long-term moving averages are close to each other and also to reduce the number of trades which reduces transaction costs. In this study we do not use any specific band in line with
the report of Ratner (1999) who indicates that while a band may be reasonable for a developed market there are no major differences in terms of performance whether or not a band is used especially in volatile emerging markets. In other words if a trading rule can be profitable without band then it is likely to be profitable with one.

Five variations of the rules are evaluated and they are: (1, 50), (1, 150), (5,50), (5,150) and (2, 200), where the first number in the parentheses signifies the number of days for the short-term moving average and the second number denotes the number of days for the long-term moving average. There are several combinations of the moving average trading rule used in practice, but the study uses these ones outlined above because according to Brock et al. (1992), they are the most popular and mostly employed by technical analyst.

A buy position is a long position in the stock and a buy signal is indicated when the short moving average exceeds the long moving average.

The buy and sell signals are generated as follows:

\[
\frac{\sum_{t=1}^{S} R_{i,t}}{S} > \frac{\sum_{t=1}^{L} R_{i,t-1}}{L} = \text{BUY}
\]

\[
\frac{\sum_{t=1}^{S} R_{i,t}}{S} < \frac{\sum_{t=1}^{L} R_{i,t-1}}{L} = \text{SELL}
\]

where \( R_{i,t} \) is the daily return in period \( S \) (1, 2, or 5 days), and \( R_{i,t-1} \) is the return used to compute the long average over period \( L \) (30, 50, 150 or 200 days. The buy position is maintained until a sell signal is indicated by the long position exceeding the short position. A rule is determined to be profitable if the average buy minus sell (buy-sell) signal is positive and is said to be effective if it outperforms an alternative buy- and-hold or the mean daily return achieved by applying technical trading rules within the holding period is greater than the mean daily return of the index within that same period.
A pictorial representation of the possible signals that could be generated by the various technical trading rules namely, (1, 50), (1, 150), (5, 50), (5,150) and (2, 200) have been shown below.

**Figure 3.1: Signals generated by the (1, 50) rule**

A graphical view of 1 and 50-day MA crossover

The blue and red arrow show where BUY and SELL signals are generated respectively.

**Figure 3.2: Signals generated by the (1,150) rule**

A graphical view of 1 and 150-day MA crossover

The blue and red arrow show where BUY and SELL signals are generated respectively.
Figure 3.3: Signals generated by the (5,150) rule

A graphical view of 5 and 150-day MA crossover

The blue and red arrow show where BUY and SELL signals are generated respectively

Figure 3.4: Signals generated by the (2,200) rule.

A graphical view of 2 and 200-day MA crossover

The blue and red arrow show where BUY and SELL signals are generated respectively
CHAPTER FOUR

EMPIRICAL RESULTS AND ANALYSIS OF FINDINGS

4.1 Descriptive Statistics for the Ghana Stock Exchange CI

A summary of descriptive statistics for all stock returns series on the GSE for the entire sample period of January 2011 to December 2014 are presented in the table below:

Table 4.1: Summary Descriptive Statistics for GSE-CI

<table>
<thead>
<tr>
<th>Time Series</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSECI</td>
<td>0.000834</td>
<td>0.005437</td>
<td>0.027209</td>
<td>-0.027053</td>
<td>0.489217</td>
<td>7.752165</td>
</tr>
</tbody>
</table>

The table below is the descriptive statistics for continuously compounded daily stock index returns for the GSE. These include the mean, standard deviation, maximum and minimum values. A value for the Jarque-Bera normality test is also depicted. Estimates are given for the full sample period beginning January 2011- December 2014.

From the Table 4.1, it can be seen that the GSE-CI return series is significantly different from zero and has a positive mean return behavior.

The standard deviation which is a measure of a financial asset’s return volatility is high with respect to the mean and implies that the stock market of Ghana exhibits high volatility in the market returns.
Generally the values for skewness and kurtosis are zero (0) and three (3) respectively to show that the observed distribution is normally distributed. From table 4.1 however the study reports a positive skewness in the distribution of the index return series. This is an indication that there is greater chance of large increases in returns than decreases implying long right tail for the distribution. Similarly, the null hypothesis of kurtosis test statistic cannot be accepted at any reasonable significant level for the series. The kurtosis value of 7.75 is large which indicates extreme leptokurtic distributions. The evidence of high kurtosis value is also consistent with previous findings in emerging economies (Worthington & Higgs, 2004) and (Hassan et al. 2006).

The calculated Jarque-Bera (JB) statistic is also used to provide evidence for a normally distributed return series. Under the null hypothesis of normal distribution the JB should be equal to zero. Inferring from table 4.1, the large positive JB value is evidence against normality in the return series of the GSECI.

The rejection of the null hypothesis of normality is consistent with previous studies such as Mlambo, Biekpe & Smit (2003) who observe that emerging market returns are not normally distributed and also that of Appiah-Kusi & Menyah (2003). Evidence of non-normality also follows conventional theory (e.g. Fama, 1970). Most importantly it gives us solid reason to use non-normality and in particular, heteroskedasticity-consistent methodology such as the Lo and MacKinlay parametric variance-ratios tests, if the test for evidence of market efficiency is to be robust.

4.2 Unit Root Test Results

The Augmented Dickey-Fuller test is used to test the null hypothesis of a unit root. Before the estimation of the ADF model the graph below gives us a bird’s eye view of the
behavior of the log transformation price series as to whether there are significant trends within it.

**Figure 4.1: Trends in the returns of the GSE-CI series**

![Graph showing trends in the returns of the GSE-CI series](image)

Figure 4.1 shows clearly that there is an upward trend over time within the price series. Also we can see that the data generating process fluctuates around a non-zero average mean which suggests that in our model specification it will be appropriate to include a time trend and a constant.

Also the graph below graphically suggest that the behavior of the index series is one of stationary which further reveals that the series may have some predictive components.
Augmented Dickey-Fuller unit root test was performed by including intercept and a time trend for the whole sample period from 2011 to 2015. The results of Augmented Dickey-Fuller for a unit root for the GSE are presented given in the Table 4.2 below:

<table>
<thead>
<tr>
<th>Test Critical Values</th>
<th>t - Statistic</th>
<th>Prob*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% level</td>
<td>-13.4414</td>
<td>0.0000</td>
</tr>
<tr>
<td>5% level</td>
<td>-3.96739</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-3.41438</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-3.12932</td>
<td></td>
</tr>
</tbody>
</table>

The table reports the results of the Augmented Dickey Fuller unit root test for the Ghana Stock Exchange Composite return Index between the periods January 2011- December 2014. The optimal lag length for the ADF is selected with the Schwartz Info Criterion and maximum lag is set to 21. The ADF test is done in levels.

From Table 4.2 above it is noted that the ADF test statistic absolute value of 13.44 is greater than the critical values at 1%, 5% and 10% significant levels, strongly rejecting the
null hypothesis of a unit root at the index level. This implies that the GSE-CI price series examined is stationary and that some stochastic and trend components have been identified in the series. It follows then, that, there exist some evidence of random walk components in the GSE-CI series.

However, as indicated earlier stationarity is a necessary but not sufficient condition for a random walk hypothesis to hold. To provide further evidence that the GSE-CI violates the random walk, a more robust test is carried. The result for the Lo & MacKinlay Variance ratio test is provided below.

### 4.3 Lo & MacKinlay Variance Ratio Test Results

The results of the variance ratio tests for the GSEASI for full sample period are reported in Table 4.3. VR (q) represents the variance ratio of the returns, Z (q) and Z*(q) represent the statistics of the variance ratio under the assumption of homoscedasticity and heteroskedasticity, respectively. The variance ratio test is conducted for various lags of q (i.e., 2, 4, 8, and 16 days) for the price series

<table>
<thead>
<tr>
<th>Number of lags</th>
<th>q=2</th>
<th>q=4</th>
<th>q=8</th>
<th>q=16</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VR (q)</strong></td>
<td>0.4958</td>
<td>0.2793</td>
<td>0.1328</td>
<td>0.0746</td>
</tr>
<tr>
<td><strong>Z (q)</strong></td>
<td>(-15.8408)</td>
<td>(-12.1033)</td>
<td>(-9.2106)</td>
<td>(-6.6050)</td>
</tr>
<tr>
<td><em><em>Z</em> (q)</em>*</td>
<td>{-9.9655}</td>
<td>{-8.3571}</td>
<td>{-6.8812}</td>
<td>{-5.3036}</td>
</tr>
</tbody>
</table>

Notes: The variance ratios for q-day returns, VR (q), are reported in the third row. Z (q), variance ratio test statistics assuming homoscedasticity, are reported in the parentheses ( ), Z*(q), variance ratio test statistics, heteroskedasticity-consistent, are reported in the brackets [ ].
Results in Table 4.3 indicate that all of the test statistics for either assuming homoscedasticity or heteroskedasticity-consistent at any number of q (i.e. 2 4 8 16) is significant at 1% and 5% significant level. The null hypothesis that variance ratio is not statistically different from one is rejected since the variance ratio for all the chosen aggregation intervals, \((q = 2, 4, 8, 16)\), be equal to one. Therefore, the null hypothesis of random walk is strongly rejected for the market index series.

The variance ratios of returns on indices are less than one for all q and seem to be decreasing with q, indicating some form of negative autocorrelation. This non-random walk pattern based on variance ratio test is consistent with results similar to that of Campbell et al. (1997).

### 4.4 Empirical Results of the Variable Length Moving Average Trading Rules

The unit root test and the LM variance ratio test carried out indicate that the GSE-CI does not follow the random walk hypothesis and is thus market inefficient. This implies that an active trader could take advantage of these inefficiencies and attempt to outperform the performance of a buy-and-hold investment and thus generate excess returns by timing the market. Below are the results of a Moving Average technical trading rules employed by an active trader or investor.
### Table 4.4: Results from the Application of Variable Moving Averages Trading Rule

<table>
<thead>
<tr>
<th>TRADING RULE</th>
<th>AVERAGE DAILY RETURN (%)</th>
<th>TOTAL RETURN FOR THE PERIOD (%)</th>
<th>AVERAGE DAILY RETURN FOR ASI (%)</th>
<th>TOTAL RETURN OF ASI FOR THE FULL PERIOD (%)</th>
<th>N(BUY)</th>
<th>N(SELL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1,50)</td>
<td>0.170</td>
<td>156.5394</td>
<td>0.0833</td>
<td>76.7571</td>
<td>635</td>
<td>286</td>
</tr>
<tr>
<td>(5,50)</td>
<td>0.1161</td>
<td>165.6827</td>
<td>0.0833</td>
<td>76.7571</td>
<td>635</td>
<td>282</td>
</tr>
<tr>
<td>(1,150)</td>
<td>0.1330</td>
<td>80.7491</td>
<td>0.0833</td>
<td>76.7571</td>
<td>603</td>
<td>0</td>
</tr>
<tr>
<td>(5,150)</td>
<td>0.0968</td>
<td>79.1101</td>
<td>0.0833</td>
<td>76.7571</td>
<td>590</td>
<td>227</td>
</tr>
<tr>
<td>(2,200)</td>
<td>0.1090</td>
<td>73.7148</td>
<td>0.0833</td>
<td>76.7571</td>
<td>578</td>
<td>97</td>
</tr>
</tbody>
</table>

Notes: Results from applying trading rules shows the results for the five variable moving average tests for different MA lengths for the full sample period from January 2011 to December 2014.

Column 1 of Table 4.4 refers to the different forms of the rule defined by the length of the short and long MA periods. Columns 2 and 3 refer to the mean daily returns after the signals have been generated and the total returns the rule generates for the whole period respectively. The 4th and 5th column shows the mean daily returns for the GSE-CI during the period under consideration and the total returns that it makes for the whole period respectively. Columns 6 and 7 respectively refer to the number of buy and sell signals for the varying rules.

From the table it is seen that the daily average buy-and-hold strategy is 0.0833 percent with a total return for the whole period to be 76.75 percent. On the average a passive investor who mimics the performance of the GSE-CI index will make an annual return on investment of 19.19%.
The number of buy signals exceeds the number of sell signals by approximately more than 50% for each of the trading rule and this is consistent with the fact that the GSE market has been in an uptrend during the period under consideration a rising market (Brock et al. 1992). Also out of the five different trading rules evaluated, four were profitable and actually outperformed the GSE-CI which means that about 80% of the trading rules employed outperformed the buy-and-hold strategy within the period considered.

In general our results indicate that the trading rules (1, 50) and (5, 50) yielded higher daily returns of 0.17 and 0.1161 respectively which are more than twice the returns that would have been generated by a buy-and-hold strategy.

The total return produced by applying for example the (5, 50) rule will be 165.82% for the whole period. Consequently it suggests that on the average an active trader would have made 41.46% per annum which is significantly different and well above the buy-and-hold strategy return of 19.19% per annum. The active trader is therefore not only profitable by employing the use of the technical rule, but is also making an excess gain of 22.27%.

We also see, that, the average returns of these strategies increases when the length of the long period Moving Average decreases. In other words, the shorter the time length of the Moving Average employed, the higher the returns. Consequently, strategies with a long average 150 days all yield returns which are significantly different from a buy-and-hold strategy. This finding is consistent with the study by (Campbell, 1997).

The stunning results revealed above indicates that, an active investor who was timing the market using these variable moving average trading rules would have outperformed an investor who was just mimicking the index. An active trader’s return without accounting for transaction cost would have been approximately more than twice the return of a passive investor.
Based on the EMH, any indication that excess return returns could be generated through technical analysis makes the market inefficient. Therefore, this study provides evidence of market inefficiency on the Ghana Stock Market within the period considered.
CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

The premise on which the weak-form Efficient Market Hypothesis is based on is that successive stock prices are independently and identically distributed and that historical stock prices have no predictive ability to forecast future stock prices.

Empirical studies on the weak-form efficient market hypothesis in emerging markets have been intensively investigated, especially in recent years. The results from these studies are mixed. Indeed, some studies show evidence of empirical results that reject the null hypothesis of weak-form market efficiency, while others report evidence to support the weak-form efficiency.

This paper has sought to establish the efficiency of the Ghana Stock Exchange based on the theoretical and empirical literature that is reviewed using current data that spans from January 2011 to December 2014. The random Walk Hypothesis model has been evaluated on the GSE-CI using daily closing prices under the period considered.

In order to test the random walk hypothesis on the GSE, two different statistical methods were employed, namely, the Augmented Dickey Fuller (ADF) Unit root test and the Lo & MacKinlay variance ratio test.

The ADF unit root test showed stationarity in market return series which is an indication of the weak-form market inefficiency of the GSE. The robust parametric Lo & MacKinlay variance test results provided further evidence that the composite index violates the random walk hypothesis for the full sample period considered.
Motivated by the fact that no study, to the best of our knowledge has exploited the inefficiencies that have been established on the Ghana Stock Market by previous authors, we also examined whether an active investor who applies technical trading rules to time the Ghana Stock market will be profitable in excess compared to a passive investor who mimics the returns of the index by adopting the buy-and-hold strategy.

Thus to exploit whether the CI showed some predictive abilities, we employed the use of a technical trading rule called the Variable Moving Average (VMA). Five different variations of this rule i.e. (1, 50), (5, 50), (1, 150), (5, 150) and (2, 200) were applied to the index to demonstrate whether they would result in profitability on the exchange.

5.2 Conclusion

The empirical results provided in this study thus far, indicates that the GSE-CI does not follow the random walk hypothesis and thus the Ghana Stock Market is indeed weak-form market inefficient. The results from the ADF test show that the return series of the CI is stationary, which is an indication of the existence of predictive pattern. The Lo & MacKinlay variance ratio test also point to the fact that there exist positive autocorrelation in the daily return series.

The descriptive statistics and preliminary tests indicate non-normality in the CI return series which further suggests that the data generating process of the series contain autocorrelated increments. The series is also found to be characterized by excess kurtosis, positive skewness and large standard deviations, and inherent leptokurtic characteristics. Our findings of deviations from the random walk hypothesis are in line with previous research that has found Ghana to be weak form inefficient. Also the results in this paper are consistent with the general assumption that developing economies like Ghana are
informationally not efficient as compared to developed countries indicating an absence of random walk. This implies that most of the stocks on the GSE are either undervalued or overvalued as a result of the inefficiency. Other reasons for the apparent inefficiency on the GSE could be attributed to the following non exhaustive factors:

- Lack of adequate knowledge by both investors and the general populace regarding the positive role the stock market plays in the overall economic development of our nation
- High transaction cost on the exchange
- Limited privatization of state-owned companies and market reforms
- Lack of competition and liquidity on the exchange as a result of very few listed firms leading to small market capitalization and turnover on the exchange
- Insufficient regulatory framework governing the operations of the exchange
- Insufficient profitable businesses with good prospects for the future, thus no strong incentive to be listed on the exchange since it will have no effect on their continued growth
- Macroeconomic policies that favor savings and borrowing from banks as opposed to securities investments and raising capital from the public.

Again, the deviation from the random walk hypothesis on the GSE exchange is further proof that there are exploitable profit opportunities. Thus, the application of the variable moving average trading rule on the Ghana stock market to exploit these inefficiencies was very successful and profitable. Our results showed that an active investor who timed the market using these rules would prove to be not only profitable compared to a passive investor who buys and holds stocks within the same time period, but would also generate excess returns.
Four out of the five rules tested generated excess returns compared to the return made by a passive investor. It was found that Moving averages that employed shorter length days e.g. (1, 50) and (5,50) rules proved to be much more profitable and generated excess returns. Employing much shorter time lengths yields profits twice as much as a buy-and-hold strategy.

As illustrated in this paper we conclude that an active investor who actively times the market has the potential of generating excess returns with the right combination of technical analysis techniques and a measure of assumed risk. However such an investor would have to deal with the challenges of frequently modifying and testing trading strategies that will do well in different market conditions. Also an active investor need to beware of how cost associated with research, trading fees and other operational expenses could impact his investment decisions and overall performance.

On the other hand, for an investor who is risk averse and has very limited time to actively manage his portfolios, adopting a passive buy-and-hold strategy will be ideal. He would however have to deal with his inability to have full control over his portfolio since he will not be making decisions as to which securities to buy or sell.

To adopt a passive or active investment strategy therefore one needs to understand the core concepts of each approach and carefully weigh the strengths and weaknesses of each strategy before choosing which one suits his or her investment profile.

5.3 Policy Implication and Recommendations

According to Malkiel (2003), an economy has the tendency to move towards efficiency if existing inefficiencies are exploited consistently. As such incentives for research in Fund management and investment analysis should be provided by the government to both
private and public asset and investment management companies. In an area that is very technical, this will help fund managers and investment analysts to find innovative ways to exploit the inefficiencies we have in the market by being able to identify under-and-over priced assets and effectively building portfolios to maximize returns for investors at any given level of risk. This will eventually drive the market towards efficiency and will attract more investors (both foreign and domestic) to the Ghana Stock Market.

A sound, adequate and comprehensive program of education regarding the stock market should be rolled out regularly to improve upon the general awareness of the benefits of our stock market among stakeholders including investors, intermediaries, investment advisors, regulators and the general public. Financial education should be more impounded in the curriculum of our educational institutions especially at the secondary level to help young ones and by extension future investment advisors appreciate the complexities of the stock market and thus develop the desire to analyze complex financial concepts such as options and futures.

Again, there should be some kind of fiscal incentive like a differential taxation favoring listed firms who want to list on the GSE. This will encourage more business to list on the exchange and will go a long way to improve liquidity, market capitalization and turnover and eventually help the market to move towards efficiency.

The dissemination of information through the GSE has been very slow and unresponsive. Therefore there should be a practical way through which information could be disseminated effectively and widely. For example stock market reports should be released on a regular and timely fashion through the print and electronic media and not only on the a few websites or communication media. An exclusive news service for the exchange could be setup to ensure high quality and reliable information which will help investors
and fund managers to be better equipped to take spur-of–the-moment decisions that will benefit investors and investment firms alike.

Several policy changes intended to make the stock exchange more vibrant and efficient should be carried out and these include regulatory bodies ensuring the facilitation of increased memberships on the GSE, reducing the restrictions on trading of securities on the exchange, reducing the transactional cost and other fees that comes with listing on the exchange. This will influence more companies to readily list on the bourse thus helping to make the market more liquid and active.

Again to foster investor confidence and instill discipline, the regulatory bodies like the Securities and Exchange Commission (SEC), need to firmly enforce standard regulatory requirements including market surveillance and rigorous investigations to root out companies that may not be contributing to the overall efficiency of the market through their operations.

The government needs to take care to implement macroeconomic policies that seek to instill investor confidence in the markets. Policies should be implemented to reduce the current high interest and inflation rates and high public debts since it create doubts on the minds of both domestic and international investors as to the stability of the economy, eventually affecting the development and efficiency of the stock market and the overall economic welfare of the nation.

5.4 Limitation

In evaluating the profitability of the technical trading rules, our study did not adjust for trading costs and as such there could be a possibility this can have a significant influence on our test results. Also characteristics such as thinness and discontinuity in trading,
market fragmentation, trading and reporting delays and absence of official market makers could affect the comparability of our study.

5.5 Further Research

This study paves the way for a host of future research. Future research can exploit the inefficiencies on the exchange using other innovative technical trading rules like the Moving Average Convergence Divergence (MACD) concept and Breakout strategies. The application of these simple technical rules could be applied to individual stocks rather than a share index. A uniform transaction cost should be considered and factored into calculating returns generated by the trading rules. Our study was limited to the short term statistical properties of historical prices of stocks due to thin liquidity but in the future an area that could be researched into is the long-term effects as identified on other markets. Questions such as whether the stock market of Ghana exhibit mean reversion properties and whether investors in Ghana overreact when making investment decision could be answered in future research.
REFERENCES


