TESTING THE WEAK-FORM OF THE EFFICIENT MARKET HYPOTHESIS ON THE JOHANNESBURG STOCK EXCHANGE AFTER THE GLOBAL FINANCIAL CRISIS

BY

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Keywords

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Random walk

Market efficiency

RESI 10

FINI 15

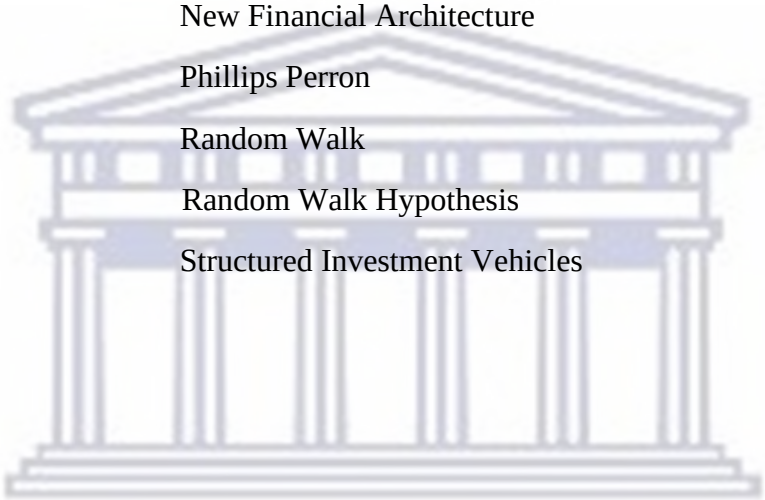
INDI 25

Technical analysis

Fundamental analysis

List of Acronyms

ADF	Augmented Dickey-Fuller
ALSI	All Share Index
CDOs	Collateralized Debt Obligations
CLOs	Collateralized Loan Obligations
EMH	Efficient Market Hypothesis
JSE	Johannesburg Stock Exchange
MBSs	Mortgage-Backed Securities
NFA	New Financial Architecture
PP	Phillips Perron
RW	Random Walk
RWH	Random Walk Hypothesis
SIVs	Structured Investment Vehicles



Abstract

The efficient market hypothesis (EMH) is a controversial theory in Finance. Advocates of the EMH argue that it provides a basis for understanding financial markets while critics suggest that the hypothesis is unreasonable in its assumptions of the real function of these markets. Although the EMH may not be perfect, it provides a sufficient baseline against which financial markets may be analysed. Over the past couple of years, academics have broadly examined the EMH in both developing and developed financial markets. However, limited research has been done on African markets. Therefore, this study examines the weak-form EMH of the Johannesburg Stock Exchange (JSE) after 2008 to ascertain the impact the 2008 global financial crisis had on its efficiency. This study analysed the JSE using weekly and monthly returns of the three major indices (RESI 10, FINI 15, INDI 25) as well as the individual companies under these indices from 30th January 2009 to 30th January 2019. Analysis was carried using various statistical tests i.e., runs test, variance ratio test, unit root tests, and a GARCH model which revealed mixed results.

Results of the unit root tests (ADF and PP) confirm that the JSE is weak-form efficient when both the weekly and monthly data of the indices and individual companies are analysed. The results of the runs test reveal that all the weekly and monthly data apart from the weekly data of the companies under RESI 10 index exhibit weak-form efficiency. The variance ratio test confirms weak-form inefficiency when weekly data is used while the monthly data confirms weak form-efficiency of the JSE and shows that the market moves from periods of efficiency to periods of relative predictability. The results of the GARCH model on the other hand confirm the weak-form efficiency of the JSE when both the weekly and monthly data of the indices are analysed. However, a look at the weekly and monthly data of the individual companies reveals mixed results of the weak-form efficiency of the JSE. Results display that all companies under the FINI 15 and INDI 25 indices, except those under the RESI 10 index exhibit weak-form inefficiency. These results reveal that the JSE is not purely weak-form efficient and goes through cycles of efficiency and inefficiency. Therefore, an active portfolio

management strategy is recommended to investors because of the possibility of achieving excess returns.

Declaration

I declare that ***Testing the Weak-Form of the Efficient Market Hypothesis on the Johannesburg Stock Exchange after the global financial crisis*** is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Collin Mugga Ggayi October 2021

Signed:……

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Chapter 1: Introduction

1.1 Introduction

The Efficient Market Hypothesis (EMH) has been the centre of debate in financial literature over the past decades. The EMH states that share prices incorporate all information that is publicly available. A market in which prices adjust immediately to account for all available information is efficient (Fama, 1970). Kolb and Rodriguez (1992) as well, describe it as one whereby prices adjust immediately after the emergence of new information. Therefore, changes in price reflect the economic value of this new information. Financial markets maintain efficiency due to the immense number of traders always trying to exploit mispriced securities. Recent financial development has shown that securities from emerging markets are of great importance in the portfolios of international investors and this has created an increase in the research done on the weak-form efficiency of these markets.

However, the majority of the existing studies (Njuguna (2016), Emenike (2017), Tokić et al. (2018)) done on the weak-form EMH have generally tested absolute efficiency which involves the application of different types of statistical tests on one index, for example, the All-Share Index (ALSI) or one sector for a full sample period. Campbell et al. (1997) highlight that testing absolute efficiency is not an explanatory technique of ascertaining the weak-form efficiency of a financial market. Unlike absolute efficiency, relative efficiency on the other hand measures the efficiency of different indices and sectors of a given market which provides a more explanatory technique of determining the weak-form efficiency of a financial market. Although testing relative efficiency is more superior to absolute efficiency, it has not been widely used by the majority of the researchers. More so, given that the JSE has overcome the 2008 global financial crisis, it is of great importance to explore the weak-form efficiency of the JSE and its different sectors after the occurrence of the global financial crisis. This study aims at doing this by applying a different set of methodology to analyse the weekly, and monthly returns of the Resource 10 (RESI 10), Financial 15 (FINI 15) and Industrial 25 (INDI 25) indices as well as the individual companies that fall under these indices for the period 30th January 2009 to 30th January 2019. This will be done using statistical tests i.e., runs

test, variance ratio test, unit root tests and the GARCH (1,1) model. Since different indices are being analysed in this paper, relative efficiency is being tested which implies that the results will be informative and will provide a basis for comparing the weak-form efficiency across the different sectors of the JSE. This will help in providing a conclusive result on the JSE's weak-form efficiency as well as assess the possibility of an investor earning an abnormal return.

1.2 Background to the Study

Financial markets offer investment alternatives to investors and therefore contribute to the development of a country. Singh (1997) notes that they provide a boost to an investors' domestic savings as well as increase the quality and quantity of investment. Furthermore, Wuyts (2007) asserts that they provide liquidity ability to the owners of assets which in turn increases the willingness of investors to participate in the market since they can buy and sell stocks easily at a lower cost. This contributes to the competitive price determination of various assets. The ability of a stock market to perform these roles, among several others, effectively determines whether it is efficient or inefficient.

The question of whether markets are efficient is central to finance and has been heavily debated since the seminal paper of Fama (1965a). Although controversy still exists today, most of the studies have shown a huge development in stock market efficiency over the years. This growth has been linked to the development in technology which enables share prices to quickly incorporate all publicly available information. Yang et al. (2008) observe this trend in their study on the Korea Exchange showing that information is reflected faster as compared to the past due to the development of communication such as high-speed internet, worldwide broadcasting systems, and mobile technologies. Ciner (2002) also argues that automation of markets has enhanced the efficiency of the Toronto Stock Exchange indicating how the predictive power of price variability disappears. These studies do not provide a promising picture of whether stocks are fully efficient but only highlight the increase over the years. In addition to this, investors are still able to make an abnormal return today.

According to Antoniou et al. (1997), stock market efficiency is significant because it allows the prices of securities to absorb all available information which in turn provides perfect signals for efficient capital allocation. This creates the foundation of the EMH because if it holds, it demonstrates that stocks always trade at their intrinsic value. Therefore, an investor has no advantage of making an abnormal return from acquiring information but only through investing in an asset with high risk (Fama and Litterman 2012).

However, Grossman and Stiglitz (1980) highlight that it is difficult for prices to perfectly absorb all the available information due to high costs and if it did, those who spend resources to access this information would find it impossible to be compensated. It should be noted that the EMH relies on certain assumptions that do not reflect the real world, for example, the presence of perfectly competitive markets, rational investors that are risk-averse profit maximisers. Therefore, this implies that financial markets are highly imperfect and highly unpredictable.

Lee et al. (2002) note that not only is information the important factor but also how the market participants react to it. As noted by Malkiel (2003), this implies that in the short term, financial markets should follow the random walk. The random walk is described as the past price movement of a security being unable to predict its future movement. A price increase or decrease today does not guarantee an increase or decrease in the day that follows. Seminal studies on the random walk hypothesis by Fama (1965b) showed outstanding departures from randomness which were both insufficient and inconclusive.

Extant literature relating to the efficiency of financial markets has proved that the less developed markets are less efficient than the developed markets. This is attributed to the higher transactional costs in the emerging markets, information availability and thinner trading coupled with low liquidity in the emerging markets (Sharma & Thaker, 2015). In highly efficient markets, information is availed to all traders at the same time hence insider trading is limited.

The level at which the stock market incorporates information is what differentiates the various forms of the EMH. Fama (1970) broke down the EMH into three forms pointing out that they include the weak-form, semi-strong form and strong form.

The weak-form states that all past publicly available information is incorporated in stock prices. This form holds today due to the inconsistent performance of technical analysts. However, the evidence of predictability of returns has provided a valid argument against this form as discussed later in this paper. Fama (1991) further extended the concept of weak-form efficiency to involve the predictability of future returns using accounting variables.

The semi-strong EMH states that the current stock price changes adjust to past information as well as new public information. This cuts out the possibility of attaining superior returns using trading rules. The strong form EMH asserts that changes in stock prices occur to immediately account for both the publicly and privately available information. (Maverick 2020). However, Seyhun (1986) provided adequate proof that insiders can make superior returns through trading on information that has not been fully incorporated into security prices. This scenario affects the market participant's reaction to news and events which causes security prices to deviate. Therefore, the market becomes too volatile to be efficient since market participants are human and not consistently rational (De Bondt et al., 2008).

Most studies have used the semi-strong form as the basis of their research however, research has recently involved the weak-form. Owing to this reason, this study focuses on examining the weak-form efficiency of the JSE. The weak-form efficiency of a financial market can be examined by using the random walk hypothesis to apply it to either general indices or individual securities. This concept was promoted to its prominence in economics and investments by scholars such as Fama (1965a) and Malkiel (1973). The random walk hypothesis asserts that market prices move randomly which makes it impossible to predict price movements.

The concept of the EMH has become prominent today mainly due to various factors like globalization, free movement of investments across national boundaries as well as the huge capital inflows from the developed economies. Furthermore, emerging markets in Africa are vastly growing today, for example, the JSE, Nigeria stock exchange, Egyptian stock exchange. Several studies have been conducted on the weak-form efficiency of African stock markets, especially the JSE since it is the biggest on the African continent (Jefferis & Smith (2005), Appiah-Kusi and

Menyah (2003)). These studies have not been conclusive and have revealed mixed results of efficiency. For this reason, it is relevant to examine the weak-form efficiency of the JSE. It should be noted that this study is unique because it is the only one that has focussed on the RESI 10, FINI 15 and INDI 25 indices as well as the individual companies under these indices.

1.3 Research Problem Statement

The weak-form of the EMH has been vastly investigated by different researchers on various stock exchange markets, for example, Njuguna (2016) on the Nairobi Securities Exchange, Šonje et al. (2011) on the Croatia and US stock markets. However, a few studies like Phiri (2015) have been centred on the JSE. The majority of these studies on the JSE have been conducted using statistical tests like runs test, autocorrelation and unit root tests. These statistical tests have been conducted using data (historical closing prices) of the indices of the JSE mainly the ALSI. Furthermore, little attention has been put on the analysis of the individual securities of the JSE which has provided inconclusive results on its weak-form efficiency.

This study aimed at examining the weak-form efficiency of the JSE from 30th January 2009 to 30th January 2019 a period after the 2008 global financial crisis using both weekly and monthly data (historical closing prices). Note should be taken that no study has been conducted on the JSE that has analysed the RESI 10, FINI 15 and INDI 25 indices as well as the individual companies under these respective indices. This study, therefore, employed statistical tests to analyse data of the different indices of the JSE and the different individual companies under these indices. Furthermore, this study used the GARCH (1,1) model to examine the volatility of the JSE as financial markets usually undergo shocks. This helped the researcher understand whether the JSE persistently responds to these shocks i.e., whether the consequences of a new shock on stock returns will continue for a long or short period and if old information in terms of past prices is of any importance. This will help an investor deduce the probability of earning an abnormal return considering the weak-form efficiency of the JSE.

1.4 Research Questions and Objectives

1.4.1 Research Questions

- Do the JSE indices (RESI 10, FINI 15, INDI 25) all conform to weak-form market efficiency after the 2008 global financial crisis?
- Do the individual companies under the JSE indices (RESI 10, FINI 15, INDI 25) all conform to weak-form market efficiency after the 2008 global financial crisis?

1.4.2 Objectives

- To review the extent of literature in the context of stock market efficiency and forms of efficiency.
- To explore the variables that affect stock market efficiency.
- To examine the criticisms of the EMH as well as the alternative theories that have been formulated.
- To understand whether an investor could formulate different trading strategies that would beat the market, i.e., achieve excess returns above the market.
- To find out whether the JSE indices exhibit weak-form efficiency after the occurrence of the global financial crisis.
- To find out whether the individual companies under the JSE indices exhibit weak-form efficiency after the occurrence of the global financial crisis.

1.5 Research Hypotheses

This study used four different methods that are, unit root tests, variance ratio tests, runs test and the GARCH model. These methods were used to analyse both weekly and monthly data of the different indices of the JSE (RESI 10, FINI 15, INDI 25) as well as the different individual companies that fall under these indices. These methods were used to test the different null and alternative hypotheses. The following null and alternative hypotheses listed below were used to generally guide this study.

1.5.1 Null Hypotheses

H_0: The RESI 10 index is weak-form efficient when all four different methods are analysed.

H_0: The FINI 15 index is weak-form efficient when all four different methods are analysed.

H_0: The INDI 25 index is weak-form efficient when all four different methods are analysed.

H_0: The individual companies under the respective JSE indices (RESI 10, FINI 15, INDI 25) are weak-form efficient when all four different methods are analysed.

1.5.2 Alternative Hypotheses

H_1: The RESI 10 index is not weak-form efficient when all four different methods are analysed.

H_1: The FINI 15 index is not weak-form efficient when all four different methods are analysed.

H_1: The INDI 25 index is not weak-form efficient when all four different methods are analysed.

H_1: The individual companies under the respective JSE indices (RESI 10, FINI 15, INDI 25) are not weak-form efficient when all four different methods are analysed.

1.6 Significance of the study

Many authors have explored the weak-form efficiency of different security markets following the seminal studies of Osborne (1962) and Fama (1965a). However, this literature has mainly focused on developed countries such as the USA and has provided contradicting results. In this regard, and as an effort to reduce the severity of these conflicts, this study aims at adding to the already present literature by conducting various statistical tests and time-varying techniques that have been conducted on various financial markets but have received less recognition in studies conducted in South Africa.

The significance of the study is that it explores the weak-form efficiency of the JSE after the global financial crisis of 2007-2008. The results from this study will further be compared to studies that have been conducted on the JSE as well as different developing and emerging markets. Since the EMH claims that it is highly unlikely for an investor to gain an advantage, this study will benefit an investor because it will assess one's probability of earning an abnormal return without necessarily investing in an asset with high risk.

1.7 Delimitations of the Study

This paper examines whether the JSE is weak-form efficient by investigating whether security prices exhibit randomness and the probability of an investor earning an abnormal return. The study aims to examine both statistical tests (unit root tests, run test, variance ratio tests) in the random walk tradition and the GARCH model. It will compare the results of the statistical tests with the time-varying GARCH model. This comparison is based on the understanding that statistical tests have weak theoretical foundations.

In addition, the study was delimited to the three indices of the JSE i.e., INDI 25, FINI 15, RESI 10 and this is because they drive the performance of the JSE. According to SA Shares (n.d.), the JSE is split into three sectors with companies broken down into similar fields. These fields are the SA resources, SA financial and SA industrials. The indices highlighted above contain the top-performing companies in these similar fields. In addition, an article by Bronkhorst (2012) highlighted that the biggest percentage of the top-performing companies on the JSE determined by market capitalization, fall under the indices highlighted above.

Furthermore, the study used the individual share price information for companies that fall under these three indices to compare the different parts of the market.

1.8 Outline of the Study

The research is organized as follows. The first chapter begins with a presentation of the background of the study, the research problem, and objectives, as well as the research hypothesis.

The second chapter discusses the literature on the overview of the global financial crisis focusing mainly on its causes and the impact it had on South Africa. The chapter then focuses on the EMH and presents literature comprising of the concept of the EMH, forms of the EMH, the debate between fundamental efficiency and technical efficiency, comparison between the value and growth factors as investment styles. This chapter goes on to highlight the criticisms and alternate theories that have been formulated against the EMH and closes by presenting several studies that have been done on developed markets, emerging markets, and the JSE.

The third chapter focuses on the methodology used to analyse data and justifies the choice of variables used.

The fourth chapter lays out the findings generated using the prior described research methods.

The fifth chapter concludes the study by presenting a discussion on the findings as they apply to the research hypothesis, a discussion of the findings in relation to other studies that have been conducted on the JSE, emerging, and developed markets. The chapter finally closes by providing recommendations to various stakeholders of the JSE such as academics, investors, regulatory authorities as well as managers and highlighting areas of further research.

1.9 Conclusion

This chapter commenced with a presentation of the introduction, background of the study and research problem statement. This was followed by a presentation of the research questions, research objectives, and research hypotheses that were used to guide the study. The chapter then concluded with a presentation of the significance of the study, delimitations of the study and outline of the study. The following chapter will explore the literature on the global financial crisis and the theory of the EMH.

Chapter 2: Literature Review

2.1 Introduction

This chapter commences with a discussion of the overview of the global financial crisis focusing on how it was caused and the impact it had on the economy of South Africa, especially the financial markets. The global financial crisis had adverse effects on the share and bond markets in South Africa and this is seen as their net purchases by non-residents dipped. Furthermore, bond prices declined as well as the demand and supply of rand-denominated bonds in Japanese and European markets declined. Given that the financial markets in South Africa were able to overcome the global financial crisis, it is key to understand whether the JSE moved to levels of weak-form efficiency or inefficiency after the crisis.

This chapter will proceed to focus on the EMH theory by starting with a presentation of the concept of the EMH theory and thereafter discuss the random walk theory and mean reversion in stock prices. This will be followed with a presentation of the different forms of the EMH, a debate between fundamental and technical efficiency as well as a comparison between the two different investment styles i.e., the value factors and growth factors. The chapter will close with a discussion of the criticisms and alternative theories of the EMH as well as the empirical evidence on the EMH.

2.2 An Overview of the Global Financial Crisis

A financial crisis can be described as a situation where asset prices take a steep decline in value, businesses and consumers find difficulty paying their debts as well as an experience of liquidity shortages by financial institutions (Kenton & Scott, 2021). Financial crises can be differentiated in the way they affect the economy as well as their causes. Davis (2003) highlights that the commonest type of crisis that occurs is usually based on bank failures, and this usually happens due to trading and loan losses. A recent example of this is the global financial crisis that occurred in 2008.

This crisis caused a big shock to the global financial system and almost collapsed the world's banking system. One of the world's most prominent financial institutions known as *the "*Lehman Brothers*"* filed for bankruptcy on the 15th of September 2008 and this marked the inception of the crisis. The crisis first hit the banking and financial system of the United States and spilt over into Europe. Many economists have proposed different theories on how financial crises occur, their causes and effects, as well as how to prevent them. However, to this day a conclusion has not been reached and financial crises continue to be a common situation of the world economy. In the next section, the causes of the 2008 financial crisis are presented.

2.2.1 Causes of the Global Financial Crisis

Various factors have been linked to the cause of the crisis. The major cause of the crisis was the enormous debt burden amassed by the western and especially US households in the years before the crisis broke out. This excessive debt burden came about due to the quick increase in mortgage loans i.e., the subprime loans provided to low-income households (Huwart & Verdier, 2013). These loans comprised of high interest rates and long repayment periods mainly because they selected modest households that would have difficulty maintaining the repayment schedule. At the commencement of their issuance, these loans had low interest rates to attract clients. However, as time went on, the interest rates significantly increased. These subprime loans were transformed into securities that were merged with other secured mortgage loans which were traded on the security market. This presented banks with three advantages i.e., reducing their mortgage credit risks, being very profitable as well as spreading the risks throughout the financial system. As banks searched for an increase in profitability, the trading of these securities multiplied. The problem came later when many households that had taken up these subprime loans had difficulty in fulfilling their repayment schedules due to the brutal increase in their monthly repayments. Therefore, the securities directly connected to these loans quickly lost their value and this reduced the confidence banks had in these financial products, which caused them to stop transacting. In the short run, major banks found themselves totally or nearly bankrupt.

The current financial regime known as the New Financial Architecture (NFA) exercised flawed practices that created unreasonable motives that produced excessive risk, aggravated booms, and generated crises. This is mainly because the growing securitisation of mortgages produced income to mortgage brokers and banks who sold the loans, rating agencies that approved them, and investment bankers who bundled these loans into securities. Each of these parties had a valid reason to maximise the movement of these loans, whether they were sound or not. These profits and bonuses led to an increase in leverage which maximised risk. It should be noted that bonuses were still paid out even during years of losses. For example, in 2008, losses skyrocketed, yet Wall Street bonuses were over US$18 billion, which was close to the same as in 2004 when there was a boom (DiNapoli, 2010). According to Gapper (2008), the total fees from 2003 to 2008 were estimated at US$2 trillion.

Credit rating agencies as well were affected by perverse incentives. Financial institutions were prohibited from possessing lowly rated assets (rated less than AAA) from any of the credible rating agencies. Due to this, rating agencies were paid by investment banks such as Lehman and Merrill Lynch to highly rate illiquid financial products because of the high demand for high ratings. These products included collateralized debt obligations (CDOs), mortgage-backed securities (MBSs), and collateralized loan obligations (CLOs). The profits made by these agencies depended on whether they kept these banks happy. If one agency gave realistic ratings to these securities while others did not, its profit would drop. Most of the income earned by rating agencies was from rating these financial products such as CDOs and MBSs. For example, in 2005, it was approximated that more than 40 per cent of the revenue from Moody, a highly rated rating agency was from rating financial products. In pursuit of their profits, rating agencies failed to do what they were supposed to do, i.e., they disguised financial risk instead of exposing it (Lewis & Einhorn, 2009).

Financial innovation led to the creation of financial products that were so complicated as well as non-transparent to be priced correctly (Crotty, 2009). For example, financial products like high power CDOs were challenging to value because many mortgages appeared in more than one of the underlying CDOs. This

made it challenging to develop a realistic formula to handle this calculation. CDOs were rated incorrectly by rating agencies and in turn, these CDOs became the new complex, illiquid, exotic, market to model rather than market to market financial products. CDOs were highly demanded during the boom because they allowed one to borrow money cheaply, receive high returns, and were attractive because of the high ratings they carried. However, no one knew the true value of these securities when the housing boom collapsed, and defaults rose which caused their liquidity and demand to quickly disappear. Prices of CDOs plummeted and they could only be sold at a huge loss when the crisis hit.

In the late 1990s, regulators allowed banks to hold securities of high risk as off-balance-sheet items with no requirement of financial resources to maintain them. This motivated banks to design entities that were off-balance-sheet, for example, structured investment vehicles (SIVs) to purchase mortgage-related assets that did not require any regulatory capital requirements. According to Reilly (2008), by the end of 2007, companies like Citigroup and JP Morgan Chase & Co. each held nearly US$1 trillion in SIVs that were off-balance-sheet. SIVs were expected to be independent establishments that originating banks earned income from, but these banks did not commit to them. However, when the housing problems occurred, the value of CDOs and MBSs collapsed, which sparked off a mass departure from the asset-backed commercial paper market. With the absence of this funding, banks had to transfer these impaired assets to their balance sheets.

High system-wide leverage grew due to the structural flaws of the NFA. This is partly because the US Securities and Exchange Commission (SEC) came up with a rule that required investment banks to preserve a debt to capital ratio of less than 12 to 1 in 1975. This was later raised to 40 to 1 in 2004 due to pressure from big investment banks led by Henry Paulson the chairman of Goldman Sachs' and later Treasury Secretary (Weissman et al., 2009). According to Goodhart (2009), before the crisis, many European banks held leverage ratios of 50 or more. With such high leverage rates, any major drop in the prices of assets would activate a threatening deleverage process. This is exactly what happened when mortgage defaults increased. The de-leveraging process froze credit markets and through this, the NFA had finally pushed the global economy to the border of total wipe out.

In conclusion, it can be argued that the globalisation and deregulation of financial markets, merged with the instant financial innovation initiated by the government, were responsible for creating an environment that sparked off this financial crisis. Due to the adverse impact that the crisis had on the economies of various countries, it shook the foundations of the modern-day financial theory which claimed that financial markets were efficient. This thesis, therefore, investigates the effect of the crisis on the efficiency of the JSE.

2.2.2 The Impact of the Global Financial Crisis on South Africa

The tipping of the 2008 global financial crisis happened when Lehman Brothers declared bankruptcy in September 2008, which activated a global banking crisis (Morton & Blair, 2020). The recession was precipitated at the end of the third quarter of 2008, with the full impact being felt in 2009. In this thesis, South Africa is the focal point as I explore the effect the crisis had on its economy, mainly focusing on its financial market known as the Johannesburg Stock Exchange (JSE).

In early 2007, before the crisis broke out, South Africa was projecting future growth as it had just undergone an extensive period of persistent growth. Zini (2008) notes that South Africa was coming from a time of economic expansion. The Government was budgeting for a moderate surplus for the first time since 1994. This was simply because revenue collection targets had been outdone by the national revenue service (Steyler & Powell, 2010). Steyler and Powell (2010) further highlight that the economy had steadily grown and by 2007 it was nearing the 6 per cent level required by the government's policy goals to halve the poverty and unemployment level by 2014. When the crisis broke out in 2008, the government changed from forecasting growth to speculating a contraction of the economy in that year.

When the global financial crisis broke out in 2008, it was expected that there would be minimal impact on Africa because the continent was not well incorporated into global financial markets. However, according to Kershoff (2009), the tightening of bank lending standards, as well as financial markets, were responsible for channelling the crisis into the economy. Rena & Msoni (2014) further highlight that real investment and capital flows, as well as declining prices of exports and a decline in the size of exports, were responsible for the contagion of the crisis into

Sub-Saharan Africa, especially South Africa. This had a serious effect on the economy of South Africa as it led to a decrease in real growth rate by 4 to 4.5 percentage points (Osakwe, 2010). Analysts misread the crisis because of two main reasons. Firstly, the effect of the crisis on the real sector and its possibility of transferring into developing countries through trade and capital flows was underestimated mainly because of the uncertainty concerning the extent of losses accumulated by financial institutions in developed economies (Pisani-Ferry & Santos, 2009). Secondly, the function of international bank ownership in the contagion of the financial crisis to African countries was not fully accepted by most (Osakwe, 2010). The ownership of banks by foreign countries was quite high which made African countries prone to the repatriation of resources by these banks as a reaction to the crisis.

South African banks were not directly exposed to the U.S mortgage market, however, they were affected by the crisis. This is because banks and financial institutions in the developed world experienced a collapse in their respective share prices which was carried on to South African banks (Kantor, 2018). Additionally, declines in the value of corporate and government debt strongly harmed banks and financial institutions in the developed world which in turn hurt the South African economy. Being a middle-income economy, South Africa was unable to survive the contagion of the crisis because its economy is dependent on financial services and the exportation of manufactured goods and minerals like gold and platinum. The effects of the crisis led to a decline in commercial credit and consumer demand as well as a decline in export and import volumes. However, according to Faith (2015), through the trade linkages, security markets and stiffening of bank lending standards, the financial crisis was transferred into the South African economy.

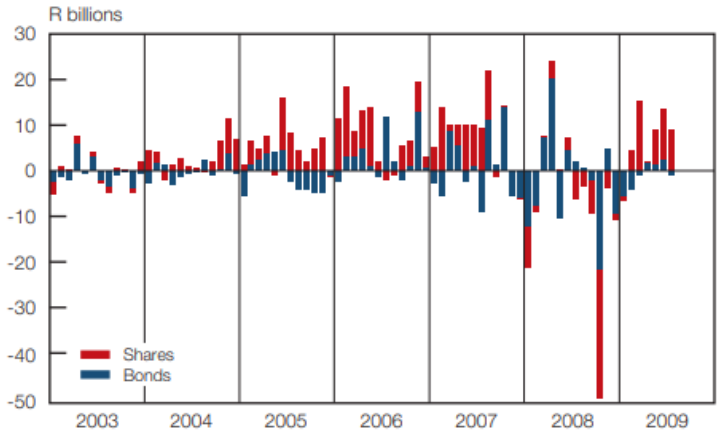
South Africa was among the hard-hit economies during the crisis because it experienced a recession for the first time in 17 years. The country encountered a massive slump in economic growth. This heavy plunge in the GDP growth rate was mainly brought about by the decline in output from manufacturing industries, mining, financial, real estate as well as wholesale and retail trade sectors (Rena & Msoni, 2014). In an article by Morton & Blair (2020), they highlight that while the mean growth for developing countries was 2.8 per cent, South Africa's economy

contracted by -1.5 per cent. This contraction was in between the global figure of -0.1 per cent and -3 per cent averaged by the developed economies. However, the recession was shallower than that of other countries mainly because South Africa did not witness any great bank failures and the plunge was neutralized by the strong growth in the manufacturing industry and oil prices.

The overall level of real economic activity dropped in the fourth quarter of 2008. This was witnessed through the decline in building plans passed, a decline in the sales of new vehicles and passenger cars as well as electricity generated (South Africa Reserve Bank, 2009). Furthermore, the production capacity decreased as well in December 2008 to 83 per cent up from 85 per cent in September 2008.

Financial markets in South Africa took a hit because of the crisis. According to the South African Reserve Bank (2009) September quarterly bulletin, there was a decrease in the demand and supply of rand-denominated bonds in the Japanese Uridashi and European bond markets due to the decline in economic activity as well as a decrease in liquidity of global financial markets. This saw a dip from R8.9 billion in the first seven months of 2008 to R8.7 billion in the first seven months of 2009 of the net redemptions of rand-denominated bonds issued in the European market fall. The interest in rand-denominated debt issued in the Japanese market dipped as net issuance was 69 per cent lower than the net issuance for the same period in 2009. It should be noted that despite the higher bond yields, non-residents were not interested in the bond and share market of South Africa. As shown in Figure 1 below, the net purchases of bonds and shares by non-residents declined massively during the last quarter of 2008 when the crisis broke out and continued throughout the first quarter of 2009.

Figure 1. Net purchases of shares and bonds by non-residents



Source: SARB Quarterly Bulletin, September 2009, p.42

Since modernisation, the mining sector has been key for the growth of the South African economy. There was a massive decline in the global demand for mineral and mining products from South Africa due to the subsequent tightening of fiscal policies in industrialized countries. This in turn resulted in excess supply as well as severe job losses in the mining sector (Rena & Msoni, 2014). There was a fall in the prices of major minerals such as platinum and gold, with platinum falling from US$2230 to about US$ 820 per ounce in the first quarter of March and gold falling from US$ 1030 in the first quarter of 2008 to US$ 750 in the last quarter of 2008 (Rena & Msoni, 2014).

As earlier mentioned, the government was looking at halving the unemployment rate by 2014. The government had planned to introduce the controversial macro-economic austerity strategy aimed at reducing unemployment by achieving a growth rate of 6 per cent. However, even though unemployment had never dropped below 20 per cent, it rose to 21.9 per cent in early 2008 (Steyler & Powel, 2010). In 2009 unemployment rose to 24.3 per cent. By the first quarter of 2010, 171,000 jobs had been lost and this saw the unemployment rate rise to 25.2 per cent. Due to South Africa being a major destination for migrants from other African countries, this had a significant knock-on effect on smaller neighbouring countries through trade linkages and worker remittances.

South Africa's economic performance had significantly progressed, but the global financial crisis jeopardised all the attempts to reduce poverty and boost growth.

Although the crisis was externally induced, it massively affected South Africa as economic activity slowed down. Through higher financing costs, corporations were directly affected and indirectly through the reduced turnover because of the adverse effects the crisis had on their customers. Due to the decrease in world trade, job loss in some industries, and high production costs, exports were under pressure. Since the global financial crisis was mainly spread to South Africa through the financial services sector, this research investigated whether the financial market of South Africa, i.e., the Johannesburg Stock Exchange (JSE) was able to maintain efficiency after the global financial crisis.

This section gave an overview of the global financial crisis that highlighted its causes and looked at the effect the crisis had on South Africa. The next section will focus on presenting a broad review of literature on the EMH theory

2.3 An Overview of the Efficient Market Hypothesis

The EMH has been widely accepted and considered as an essential analytical approach in the field of finance. This is mainly because the EMH is used as the primary theory for many theoretical models as well as empirical studies of security prices. The theoretical foundations of the EMH rely on three arguments i.e., investor rationality, arbitrage, and collective rationality. Investor rationality implies that when new information is availed to investors, they update their beliefs. Arbitrage is used by some rational investors to get rid of pricing errors and in this case, the average investor does not necessarily matter but rather the marginal investor who is responsible for setting prices. Therefore, even though all investors are not rational, the market can act rationally through arbitrageurs correcting mispricing. For example, if a random purchase positively affects the price of a security, a random sale will in turn negatively affect it mainly because the chances of these two occurrences are the same (Shleifer, 2000a).

Due to the free motion of investments over national boundaries, globalization, and the high capital inflows from the developed economies, the concept of the EMH is of great importance today. Most of the empirical studies that have been conducted on the EMH have been conducted in developed countries i.e., with the American and European markets reporting weak-form inefficiency mainly (Sharma & Thaker,

2015). The later studies that have been carried out on both developing and emerging markets have provided mixed results, for example, studies by Njindan Iyke, (2019), Awiagah and Sup, (2018), Guidi and Gupta (2013). This has been attributed to the technological advancement that has eased the circulation of information to the market participants in developed markets compared to those in emerging markets. For this reason, some may argue that developed markets are more efficient than emerging markets.

Information about market efficiency enables investors to draw up investment strategies. Through various studies done during different periods, market efficiency and inefficiency in the same stock market has been confirmed. Stock markets during 2000-2013 experienced a dot com bubble. From 2000 to 2001, a boom was experienced which was followed by a recessionary period from 2008 to 2010. Previous research on the JSE for example, Knight et al. (1985) concluded that information is incorporated slowly into share prices. However, the JSE has undergone a great transformation to increase information dissemination, limit insider trading and reduce transaction costs which are supposed to modify its efficiency. This transformation has been achieved through the issuance of "The Guidelines on the Dissemination of Price Sensitive Information" and a subsequent introduction of SENS (Stock-Exchange News Service) in August 1997 as well as the introduction of InfoWiz in May 2002. These systems have enabled stakeholders to increase value by meeting their need for information.

This section presented a brief overview of the EMH theory. The objective of the following section is to present a review of existing literature on the EMH by presenting the emergence of EMH over the recent decade.

2.4 The Concept of the Efficient Market Hypothesis

The EMH theory came alive with the first publication in 1900, a PhD thesis by Bachelier (1900) titled "*The Theory of Speculation*." He examined the performance of different shares on the La Bourse (Paris Stock Exchange) and dissolved that there was an identical and independent distribution of price changes. However, Bachelier's work received little attention at its inception and only became important

among other researchers at the beginning of the 1930s. Studies by Cowles and Jones (1937) revealed how economic series and stock prices in the US fluctuated randomly, but they went unnoticed by researchers up until the late 1950s. In 1956, Bachelier's paper was brought to light through Paul Samuelson who acknowledged him as a forerunner in his thesis on option pricing.

The pillars of the EMH were established by the original papers of Cootner (1964) and Samuelson (1965). However, the development and prominence of the EMH theory were done by Fama (1965a) through his PhD thesis. He argued that an active market is comprised of intelligent and informed investors who are responsible for the appropriate pricing of securities. He further broke down three conditions that should be in place for market efficiency to hold. These include no transaction costs, access to all relevant information by all parties without cost and incorporation of all available information in the current price. Reilly (1989) further classifies an efficient market as one whereby the introduction of new information causes a sudden change in the prices of securities and the risks involved are included in the current security prices. Salas-Molina et al. (2021) similarly describe an efficient market as one where prices adjust immediately at the discovery of new information. This information is broken down into two brackets, i.e., fundamental, and non-fundamental or technical.

Fundamental information relates to the economic state of a company such as yields as noted by Cochrane (1991) and macroeconomic fundaments such as exchange rates, interest rates as noted by Yamani (2020). Non-fundamental information from sources like news, on the other hand, does not have any direct relationship with the security but influences the security's price. Examples are the Lehman Brothers' bankruptcy in 2008 that sparked the global financial crisis as noted by Caballero and Krishnamurthy (2008) as well as the 9/11 terrorist attacks.

It should be noted that studies of efficiency have been done on derivative markets such as options and futures markets, stock markets, bond markets, and foreign exchange markets. Examples include Liu (2013) on the bond market in South Africa, Matebejana et al. (2017) on the Botswana foreign exchange market as well

as Njindan Iyke (2019) on the Indonesian foreign exchange market. This thesis centres on examining the efficiency of stock markets by focusing on the JSE.

Market efficiency can be appraised using three different terms and they include operational efficiency, allocative efficiency, and pricing efficiency, also known as informational efficiency. Pilbeam (2010) breaks them down as follows.

Operational efficiency refers to the cost efficiency of financial markets in terms of charges to investors. It considers the cost, speed, and reliability of transactions conducted on the stock market. The market operations should preferably be kept at a low cost. This can be developed by increasing the competition between brokers and market makers to ensure that they do not earn excess profits. Operationally efficient markets can help improve the overall effectiveness of investment portfolios because capital can be allocated without the high cost of friction which reduces the risk/reward profile of a portfolio. In an attempt to understand whether a financial market is operationally efficient, we must ask if that market offers trading mechanisms that are low-cost and reliable. Furthermore, we must understand the expanse of transaction costs (commissions, bid-ask spread, the market impact of trade, etc.) as well as how long it takes to execute orders and settle a trade. It should be noted that operational efficiency in financial markets takes place when transaction costs and fees are lowered. In conclusion, the greater the operational efficiency of a market, the more profitable it is for a company or investment, and this is because they can generate higher returns for the same or lower cost.

Allocative efficiency refers to the efficiency in which financial markets allocate scarce funds to the most productive uses. In the ideal world, resources are scarce, therefore one must come up with techniques that allocate the scarce resources to where they can be most productive i.e., firms that can achieve the best marginal returns. Allocative efficiency presumes that the market is already informationally and operationally efficient. This is because it assumes that security prices fully incorporate information as well as react to changes in this information, and the non-income producing expenses such as transaction fees are reasonably priced or non-existent. As such, prices are accurate signals for the allocation of resources. Firms

whose securities bear the same level of risk can access new funds at the same costs and funds from investments offering a lower rate of return and can be directed to more profitable investments (Fischel, 1978). It should be noted that an allocative efficiency market has no imperfections hence it does not exist in practice. However, it can be contained in markets to a greater or lesser extent.

While operational and allocative efficiency are desirable, literature has mainly concentrated on pricing or informational efficiency. According to Aktan et al. (2017), informational efficiency represents the amount of information incorporated in the prices of financial securities and how the prices of financial securities adapt to new information. Security prices should be equal to their true value if prices do reflect what is known about firms.

Fama (1970) highlights that no analysis can result in one earning an abnormal return in an informationally efficient market. He highlighted that if all market participants receive equal returns, a market can be efficient whether the investor is an expert or a beginner. Malkiel (2003) concurs with Fama by highlighting the impossibility of earning an abnormal return no matter the type of analysis conducted i.e., whether technical analysis whereby future prices are forecasted by examining past security prices. This implies an inexistence of arbitrage opportunities that allow excess returns without excess risk.

There is a tendency of financial markets to move towards efficiency through market participants making full use of arbitrage opportunities available and due to price competition among market participants. As market participants exploit these arbitrage opportunities, profit opportunities are eliminated as share prices are forced to move to their efficient values hence the market shifts to equilibrium (Njuguna, 2016). However, most economists do not approve that an investor who constantly takes risks to earn an abnormal return are the cause of efficient markets. If markets are indeed efficient, this would not be the case. Markets may however become more efficient due to the emergence of the internet as well as easy access to the readily available information.

Lehman (1990) questions how markets are able to absorb all available information into the value of stock prices if investors do not have access to the same information. Grossman (1976) as well highlighted that if prices completely disclose all existing information, then the search for information by market participants when deciding on which stocks to sell or buy has no valid reason. Grossman and Stiglitz (1980) as well questioned how stock prices fully reflect all information if no investor looks for it. These debates have led to a growth in the literature attempting to re-evaluate the concept of market efficiency.

If all information available is incorporated into the market price, it reflects the value of the security, and this is broken down in the equation below.

$$\boldsymbol{P_t \cong V_t \equiv \sum_{i=1}^{\infty} \frac{E_t(D_{t+i})}{(1+r)^i}} \quad (1)$$

Where:

$\boldsymbol{V_t}$= fundamental value of the share at time t.

$\boldsymbol{E_t(D_{t+i})}$=**e**xpected dividend based on the available information at time t.

r= appropriate risk-adjusted discount rate for expected dividend stream.

i= up to infinity since a share is a persistent instrument.

As market participants trade in the market, the information they hold is reflected in the share's market price, hence trading acts as a transmission of information from traders into the prices (Grossman, 1976). Mabhunu (2014) in his paper demonstrates how trading transfers information from the market participants into prices by evaluating a market where market participants or traders have diverse information. Each trader predicts as to P_{t+1} (share price in period *t+1*) in the period *t* (current period), decides how much stock to hold which in turn dictates P_t, the current price that depends on the information gathered by all traders.

He further assumes that if the i^{th} trader observes y_i (their estimate of the future price) where,

$$y_i = P_{t+1} + e_i \quad (2)$$

e_i is the noise term that deters any trader from knowing the true value of the future price P_{t+1} and if we have n traders, the current price would be a function of $y_1, y_2, \dots, y_n$ (each trader's predicted price P_{t+1}). This can be expressed in the equation below.

$$P_t = P_t(y_1, y_2, \dots, y_n) \quad (3)$$

Where n>1.

A competitive pricing system is therefore expected to systematically accumulate all information from market participants in that the equilibrium price summarises all information available to the market participants. It should be noted that if a trader notices they can make returns by following the market price as they would if they bought y_i, they will not be motivated to invest in y_i. They will invest less in information and accept market prices as the representative of the changes in the value of stocks and will select them based on their risk appetite. Therefore, the current price becomes noisy since information is not the basis of the price generating process and this contributes to a collapse in the efficiency of a financial market (Black, 1986).

However, it does not take long until a few traders realise the inconsistency in the pricing system. It can be noted that if a trader notices the absence of a certain piece of information in the price, he is motivated to reveal and trade it. As more traders do this, informational and market efficiency is restored. This happens because of the arbitrage forces that come into play and however much individuals behave irrationally, these forces usually keep the price within the security's worth.

This section presented the concept of the EMH and looked at the emergence of the EMH theory. The following section will look at concepts of the random walk theory, mean reversion in stock prices. This is important because these theories describe the behaviour of stock prices in financial markets and help an investor understand whether stock prices can be predicted.

2.4.1 The Theory of the Random Walk

The random walk theory was introduced by Bachelier in 1900 and it suggests that security prices change randomly in an unpredictable way. The extent to which stock prices fluctuate is determined by the firm level and market-wide information reflected in the stock prices. Malkiel (2003) further notes that the random walk states that the price change of tomorrow will only factor in tomorrow's information and will not be correlated to today's price change if the motion of information is not restricted and instantly incorporated in stock prices. Traditionally, changes in price are greatly predictable with lower market efficiency. Therefore, if prices move randomly, analysts find it challenging to predict the future stock price. This is represented as follows.

$$P_{t+1} = n + P_t + E_{t+1} \quad (4)$$

Where.

$\boldsymbol{P_{t+1}}$= Price of share at time t+1.

$\boldsymbol{n}$=Expected price change

$\boldsymbol{P_t}$=Price of share at Time t

$\boldsymbol{E_{t+1}}$= Random Error Term with zero mean and finite variance

Ko and Lee (1991) state that the market is efficient if the random walk model holds. Economists have gained substantial scrutiny in the long-run time-series properties of security prices by mainly focusing on whether security price changes can be described as random. Historically, a big number of academics mainly economics and statisticians have adhered to the theory of random walks in stock markets as their approach to market analysis. In Fama's two articles, "Behaviour of Stock Market Price" and "Random Walk in Stock Market Price," he states that a market is efficient when the stock price is a good estimator of its intrinsic value (Fama 1965a:90-94; Fama, 1965b:56). Alternatively, a market is efficient when it comprises rational agents. These include the competition of profit maximising

agents predicting the future price of individual securities (Fama, 1965b:56). Therefore, information will be absorbed in actual prices in an efficient market, immediately due to this competition.

However, uncertainty exists surrounding the instantaneous adjustment of new information and this has two implications according to Fama (1965b). The first is that security prices tend to over adjust initially to changes in intrinsic value as they under adjust. Secondly, the lag in the absolute adaptation of actual prices to successive new intrinsic values will be an independent, random variable with the adaptation of actual prices at times happening before and sometimes after the occurrence of the event which is the basis of the change in intrinsic value. (Biswal, 2014).

It should be noted that it is unlikely for the random walk hypothesis (RWH) to provide a precise interpretation of the performance of stock market prices (Fama, 1965b). This is because however much sequential price changes may be stringently dependent, the actual amount of dependence may not be significant to be important. What may be categorized as not important is reliant on the situation at hand. For the security investor, the benchmark is obvious: The random walk assumption of independence is only valid if past stock price changes cannot be used to increase profits and a simple buy and hold strategy will be as good as any complex mechanical method or trading strategy used for timing the purchase and sale of that security.

Over the years there has been a growing debate among various scholars on whether the presence of a random walk in a financial market implies market efficiency. Fama came up with the first logical connection between empirical results of the random walk model and stock price variations. He assumed that sophisticated investors who use their skills to predict the future intrinsic value of securities using available information do exist. If these investors have enough capital, their actions of purchasing undervalued assets and selling overvalued assets move prices to their true values as well as eradicate any chance of earning a profit. Connecting these results with the RWH, he added that because of the random arrival of information, security prices must fluctuate randomly.

Leroy (1976) criticized Fama's revelation highlighting its redundancy mainly because any empirical test of the EMH is necessarily a joint test[1]. Fama (1976) responded to Leroy by adjusting his definition and acknowledging that any test of the EMH was a test of market efficiency as well as the equilibrium model used by traders. Leroy (1973) and Lucas (1978) came up with theoretical evidence that the EMH and RWH are two different ideas and concluded that the RWH is neither required nor sufficient for an efficient market. Samuelson (1973) as well highlighted that some agents make profits contrary to the original definition of the EMH.

In conclusion, evidence shows that markets are predictable to a certain extent. However, in the real world with transaction costs and taxes, predictability can exist without the presence of profitable opportunities. Studies on the EMH and random walks are of high value mainly because they can disclose certain information on market efficiency.

2.4.2 Mean Reversion in Stock Prices

Financial experts and researchers have examined different approaches to explore stock price behaviour. This is because many financial experts, as well as econometricians, have questioned the whole basis of the assumptions of the EMH (Trypsteen, 2017). It is therefore of great importance to explore the different theories that can forecast the behaviour of the market. De Bondt and Thaler (1985) put forward the theory of mean reversion.

Mean reversion involves the assumption that a stock's price tends to move back to its average price over time. This indicates that stock prices tend to move toward their long-run average values. Ahmed et al. (2018) highlight that security prices go back to their mean after reaching a specific extreme point. Mean reversion can be broken down into short-term and long-term reverting processes. Ribeiro et al. (2017) note that if a stock returns to its average value in one month, it is referred to

[1] A joint test implies that on any financial market, any investigation of efficiency examines the the asset-pricing model used to price securities on the market as well as the notion of efficiency at the same time. This basically means that any empirical validation can be due to either the fact that the market is efficient (or inefficient) or that the model used is appropriate (or inappropriate) for the test. Such a joint test therefore implies that market efficiency is not per se testable (Campbell et al., 1997, Fama, 1976).

as a short-term mean reversion process. However, if the stock returns to its average value after one year, it is referred to as long-term mean reversion.

The explanations connected to mean reversion in stock prices are firmly linked to the matter of stock market efficiency. The EMH contradicts with mean reversion since one of the implications of the EMH is that price changes are completely random, and one cannot forecast the price pattern. If stock prices follow the mean reversion phenomenon, it is possible to use past information to effortlessly predict the future returns of the stocks. Poterba and Summers (1988) highlighted that the irrational behaviour of noise trades which results in stock prices taking wide movements from their intrinsic value is the major cause of mean reversion.

Due to the theory of mean reversion, many investors believe that one can make a profit from the time series of prices by focusing perfectly on some patterns in securities therefore it is a form of market inefficiency. It should be noted that the existence or inexistence of mean reversion has several implications. Mohammadi (2017) highlights that due to mean reversion, investors are provided with opportunities to make an abnormal return by simply buying stocks when they are at their lowest prices and selling them when they become lucrative. Vlaar (2005) argues that stock prices can highly improve the attractiveness of equity investments for pension funds due to mean reversion. This is because if mean reversion of stock prices occurs, low returns are accompanied by higher expected future returns which could invigorate pension funds to invest in equity after a crash in the security market.

For a long period, economic literature has attempted to find out whether stock prices reveal mean reversion in the long run. Many econometric theories have been brought forward to explain the concept of mean reversion and while some studies have found strong evidence against it, others have found strong evidence in support of it.

Fama and French (1988) and Poterba Summers (1988) were the first to conduct a study to examine the occurrence of mean reversion by studying the memory pattern of security returns. They deduced that past prices predict the future values of securities, which is evidence of a mean reversion process in US stock prices. Other

researchers were doubtful of these results, for example, Lo and Mackinlay (1988) reported in their study that the rejection of the RWH could not be attributed to the stationary mean-reverting models. Richardson and Stock (1989) as well as Richardson (1993) observe that the results of Fama-French and Poterba-Summers may be reversed after small sample biases are corrected.

Research has not only been carried out in the US but also on the international stage. Richards (1997) found proof of long-term winner-loser reversals in equity prices for sixteen countries. Chaudhuri and Wu (2003) found proof of mean reversion in seventeen emerging markets and calculated the speed of mean reversion. They concluded that after 30 months equity returns return to their previous mean values in emerging markets. Balvers et al. (2000) also revealed mean reversion in annual equity indices of eighteen developed markets and demonstrated that with the use of a parametric contrarian investment strategy, one can predict annual equity returns with the use of the mean reversion property.

Following the previous discussion, there is an ongoing debate on whether stock prices follow a RWH or a mean reversion process. Several researchers have resolved that mean reversion differs in different markets or regions and that the time factor is as well vital in its investigation (Kuttu, 2017).

In conclusion, mean reversion has a role to play in market efficiency. This is seen as its existence enables investors to predict future stock prices. This enables them to have an opportunity to make excess profits, which disagrees with the theory of market efficiency. The inexistence of mean reversion on the other hand implies that stock prices are random which makes it impossible for investors to predict future stock prices. This makes it impossible to make excess profits, which is in line with the theory of market efficiency. Therefore, one can use tests of mean reversion to test the efficiency of a financial market. The question of "whether markets are informationally efficient" is of high interest today. Fama (1970) breaks down informational efficiency into three forms. These are described in detail in the following section.

2.5 Forms of the Efficient Market Hypothesis

2.5.1 Weak-form EMH

The weak-form of the EMH can be described as a model in which all past information is absorbed into the stock prices. The concept of the weak-form EMH is also known as the random walk theory and was pioneered by Economics Professor Malkiel (1973) in his book titled *A Random Walk Down Wall Street.* According to Rehman et al. (2018), the random walk theory implies that changes in security prices are not connected. Therefore, it is impossible to predict the future movement of a security's price using its past price.

The major principle of the weak-form EMH is the impossibility of finding price patterns and taking advantage of price movements. An abnormal return cannot be earned because the current stock price would have absorbed all past information. Furthermore, this information is free and available to investors, which implies that there are no mispriced stocks. Due to this, the weak-form EMH does not consider technical analysis useful and highlights that fundamental analysis can as well be inaccurate at times.

Technical analysis is a financial analysis method that is based on the concept of using past data to anticipate future price movements. Campbell et al. (1997) define it as a strategy to investment management that is built on past market statistics, mainly on volumes and prices. Technical analysis is built on the idea that prices move in trends therefore one must recognize a trend reversal at an early stage and ride it until it reverses (Niroomand et al., 2020).

However, technical analysts claim that there is more to their trade than just tracking these movements and state that the forces of demand and supply mainly influence the market value of shares. These forces are as well determined by rational and irrational factors like market participants. Therefore, prices react to not only changes in their intrinsic value but also people's behaviour. An example exists whereby if a stock experiences recent highs or lows, the market is sent into a race. This is because surging prices usually arouse greed, falling prices cause fear, and unchanging prices cause disinterest, which will send the market into either a race

or draw it to a price station. One should be able to identify these races and stations as they happen and then configure their trade appropriately. Empirical studies have been conducted on weak-form efficiency by testing the random walk on security prices to determine whether market prices do strictly contain randomness. If prices of securities exhibit randomness, the market is weak-form efficient and if they do not exhibit randomness, the market is weak-form inefficient.

Over a short period, it has been found that security prices tend to have momentums. This means that an increase or decrease in the market price today will be followed by the same movement tomorrow and for some time to follow. According to Malkiel (2003), there are two clarifications for the continuity of this momentum. The first is linked to the behavioural effects of market participants. A gradual rise in market prices raises investor expectations, which causes a provisional conception that the market prices will go up continuously and through this, they are sucked into the market because of a bandwagon effect. Shiller (2000) highlights that psychological practices that led to irrational excitement were responsible for the rise in the US stock market during the late 1990s.

The second clarification is linked to the slow response to new information by investors. It has been observed that investors tend to underreact towards new information and tend to not adjust their expectations usually when a company's return has been beating the market. Fama et al. (1969) examined 940 split events from 1927 to 1959 and realised that in the first 3 to 4 months after the announcement, a substantial number of positive abnormal returns occurred, and this shows the slow adaptation of prices to information.

However, these short-term factors should not be taken as indications of an inefficient market. The statistical reliance that gives rise to momentum is usually small and unlikely to enable investors to recognise excess returns. Payment of transaction costs limits the ability of an investor to come up with a momentum-based trading strategy to outperform a buy and hold strategy. Lesmond et al. (2004) found that relative strength strategies are not successful in obtaining excessive returns because of the transaction costs required for their implementation.

Secondly, the behavioural effect of slow reaction to new information and bandwagon effects seems reasonable, but evidence of its occurrence in the stock market is negligible. Fama (1998) examined a number of events such as the announcement of stock splits, mergers, dividends, etc. to determine the slow reaction of stock prices to information. He concluded that underreaction to information happens as regularly as overreaction and that post-event occurrence of excessive returns is as recurrent as post-event reversal. The momentum exhibited by stock prices cannot be depended on as a way of earning an abnormal return because these predictable patterns tend to disappear. Schwert (2003) identifies two reasons for this. One is that researchers are always working to challenge wisdom by finding a sample and technique that will challenge the EMH. Secondly, professionals learn about these predictable patterns quickly and utilize them to the point that they are no longer profitable.

Over the long term, studies have found that stock prices exhibit mean reversion. Mean reversion states that stock prices eventually return to their long-term mean, i.e., if there is an unexpected rise or drop in stock prices, they will eventually return to the point they were at before. Several studies conducted have supported this notion, for example, Poterba and Summers (1988) found a considerable size of mean reversion in stock market returns over a long period.

The existence of mean reversion in the long run has been accredited to the trend of overreaction of market prices. De Bondt and Thaler (1985) assert that prices fluctuate in an orderly manner from their intrinsic values and later display mean reversion because investors are exposed to signals of pessimism and optimism. They further highlighted that companies that experience positive returns for 3 to 5 years go on to experience negative returns and vice versa holds. This means that investors usually invest due to an increase in a security's returns for a specific period without accounting for the long-term mean reversion.

2.5.2 Semi-strong Form EMH

The semi-strong form of the EMH is described as a model in which all public information is incorporated in the current stock price. Bodie et al. (2005) state that the publicly available information comprises past prices, fundamental data on the

balance sheet composition, accounting practices and earnings forecasts of the company. This implies that the market comprises characteristics and indications of both the weak and the semi-strong forms. Investors, therefore, cannot maximize fundamental analysis to make excessive returns but can only use information not available to the public to gain an advantage over the market.

Fundamental analysis is defined as an investment tool applied to discover a security's fair value through the examination of related financial and economic factors. This involves anything that can affect the value of a security, i.e., both macroeconomic and microeconomic factors. Fundamental analysis is heavily dependent on financial statements and the reason for this is to establish whether the security is undervalued or overvalued. Not only does the analyst estimate the share's intrinsic value, but also its relative value. Relative value evaluations entail Price/Cash Flow Ratio, Price/Earnings Ratio, among others. This also allows one to ascertain if a share is trading at a discount or premium regarding other shares or its historical performance. This is done because investors are always looking at buying the shares that are considered to be cheap and selling those that are overvalued. Skilful fund managers are believed to outperform the market by using fundamental analysis, however, studies have shown a failure to exceed the return which the market suggests, for example, Michael (1968) concluded in his study that the overall returns earned by mutual fund managers were roughly zero per cent excess return per year.

The semi-strong form of the EMH relies on how fast new information is reflected in stock prices. Studies have shown a split between the two i.e., some claim that the market reacts quickly to event announcements while others claim the market reacts slowly to event announcements. Research has been conducted on events such as dividend announcements, mergers, and acquisitions, etc. and it has been concluded that they all influence the market prices differently.

The announcement of a merger usually ends up in an increase in the market price. Keown and Pinkerton (1981) examined the speed at which the market reflects the release of this information and found that it reacts quickly i.e., about 10 to 15

minutes after the announcement. This shows that after the announcement of a merger, there is no abnormal price change.

Knight et al. (1985) in their study investigated the influence of an earnings announcement on the stock price. They found that an earnings announcement was not fully reflected in the stock price. This was seen as the market was unable to predict poor results before they were released but instead overestimated the decrease in earnings and this was accompanied by an upward effort to correct the stock price. Furthermore, for companies announcing excellent results, the reaction on the stock price happened after the event announcement. Rendleman et al. (1982) revealed that an unexpected earnings announcement was not fully incorporated in the stock price therefore one had the opportunity to earn an abnormal return by simply purchasing the stocks of companies with positive earnings.

However, a study conducted by Ball and Brown (1968) evaluating the effect of accounting earnings on market prices showed that 12 months before the earnings announcement, the stock prices moved gradually towards the direction of successive earning changes. By the announcement date, the price adjustment had been completed by 85 to 90 per cent and this shows that earnings data could not be applied to profitable trading because it had been incorporated in the stock prices.

Bhana (1990) ascertained that stock prices failed to adapt to information as it became available to the public. The stock prices constantly overreacted to negative events and this deviation lasted up to a year which was enough for arbitrageurs to use to maximize profits. However, an overreaction for positive events was inconsistent and short-lived. In this regard, Page and Way (1992) understand that this overreaction was mostly rectified in the second and third years of the event, hence one could still acquire an abnormal return during this period.

Caution should be taken when interpreting the results and conclusions from these event studies because of the difficulty in isolating the impact of one event from another. The study reference above shows that overreaction could last up to three years. However, given the difficulty to isolate events from one another, it is controversial whether the influence of one event can be tracked for such a long period.

In conclusion, the above studies show that the implications of the semi-strong form include the following. All available public information is incorporated in market prices, and it is easily accessible by everybody hence it is impossible to formulate a strategy to beat the market consistently. This further suggests that neither technical analysis nor fundamental analysis is important. Lastly, stock prices are believed to adjust quickly to all publicly available information.

However, studies as well have shown that the semi-strong form of the EMH has been impeded by various factors. Firstly, this information could be difficult and costly to obtain which creates information asymmetry since some investors will have access to it and others will not. One may find it difficult to separate the information from noise which could bring difficulty in interpretation. "This hypothesis implies that investors who base their decisions on any important new information after it is public, should not derive above-average risk-adjusted profits from their transactions considering the cost of trading because the security price already reflects all new public information" (Reilly & Brown, 2003:176). Barnes (2009) highlights that the crucial point about the semi-strong form is that not only does it refer to publicly available information but also acknowledges that inside information exists and those who have access to it can outperform the stock market.

2.5.3 Strong-Form EMH

The strong-form of the EMH posits that all information, i.e., both public and private information, is absorbed in the current stock price, hence an investor cannot gain an advantage on the market. In addition to this information, the stock prices integrate the historical information of the stock prices. From this, one can argue that the strong form has the weak-form and semi-strong form of the EMH embedded in it. The integration of private information into stock values is key to the strong-form EMH and it investigates the ability of investors to obtain an abnormal return from this information.

The difference between the strong-form and semi-strong form of the EMH is that in the former no one should have an opportunity to make profits even when trading on private information. In other words, insiders are unable to gain by buying the shares of a company ten minutes before an announcement of a profitable acquisition

is made publicly. This implies that the market anticipates future developments which are reflected in the stock price. However, it should not be shocking if people that possess private information (insiders) make superior profits while trading in their firm's stock. Researchers such as Cornell and Sirri (1992), Meulbroek (1992) have documented the ability of insiders to gain an advantage by showing the tendency of stock prices to go up after intensive share purchase by insiders and to fall after intensive sales by insiders. Bodie et al. (2014) question the ability of other investors to gain an advantage by following trades made by insiders. This is because for example the JSE offers a service known as Stock Exchange News Services (SENS) which requires all insiders to register and publish their trades within two business days. This information, therefore, becomes public once published hence one is no longer able to make a profit.

Early studies like Finnerty (1976) have found that insiders were able to outperform the market by simply dropping the unprofitable assets and investing in the profitable ones. Furthermore, early beneficiaries of new public information have an outstanding chance to beat the market (Dimson & Mussavian, 1998). This can be shown in a study conducted by Bhana (1990) who examined the importance of the buy and sell suggestion by firms and analysts. Sell suggestions continuously underperformed the market. Buy suggestions provided an abnormal return, meaning shares are undervalued, and this can be linked to an analyst's possession of new public information or private information.

From the studies broken down above, it can be noted that insider trading can be profitable, however, the abnormal return gained cannot overcome the transaction costs. It should be noted that most tests of the strong-form EMH are based on the performance of mutual funds due to the regulation of inside information. This prevents the information from leaking, which makes it difficult to test the reaction of market prices to this information. Jones (2004) highlights that one can investigate the strong-form efficiency by examining the performance of traders with access to private information.

This section presented the difference between the forms of the EMH. The following section will proceed to discuss the debate between fundamental efficiency and

technical efficiency that came to light after the occurrence of the global financial crisis.

2.6 Fundamental Efficiency vs Technical Efficiency

There has always been some confusion created when the EMH is discussed. The three-word sentence that "Markets know best" used by Fama (1965, 1970) is the simplest way to convey how this hypothesis has been misunderstood in two different ways. It can be looked at from two perspectives: either markets tell the truth or cannot beat them. According to Hyme (2004), the EMH debate was distorted by the confusion created by these two meanings.

After the global financial crisis, there was an emergence of great controversy because the crisis seemed to have compromised the proposal that stock markets could be efficient. The Economist (2009) published an article that tried to investigate the allegations made against economists after the crisis. It highlighted that the theory of the EMH made people overconfident in financial markets because it assumed that security prices stuck to their fundamental value. This article justified the criticism of the EMH because the EMH did not explain the existence and solution to asset price bubbles and crashes in the market. This was looked at as a problem that could not be solved if people still believed in a theory that claims asset bubbles and crashes do not happen.

Lucas (2009) came up to defend the EMH theory by highlighting that, "if one possessed a formula that was able to predict crises a week before they occurred, the formula would become part of publicly available information and prices would fall a week earlier." This demonstrates that existence of bubbles and crashes exist, hence they cannot be simply speculated away. However, Lucas did not answer the question of "How could we prevent the occurrence of bubbles" but rather answered another question of "Could we forecast bubbles?" which left the argument hanging in the balance.

A similar debate can be accessed during Eugene Fama's reaction to Justin Fox's book. Fox (2009) in his book "The Myth of the Rational Market" is built on the premise that the current economic problems i.e., the financial crisis of 2008, was

largely influenced by the blind acceptance of the EMH that encourages market participants to accept stock prices as the best approximation of value. It goes on to show that due to this, market participants failed to fully investigate the true value of assets which brought about bubbles in asset prices. Fama (2009) reacted to this and pointed out that market participants do not follow the EMH theory but depend on the suggestion that market prices can be forecasted because 80 per cent of mutual funds are actively managed. This meant that the EMH could not have been responsible for the financial crisis because hardly anyone believes in it. He added that banks and investment banks could have prevented the crisis if they took market efficiency more seriously.

However, note should be taken that Fox's book did not focus on passive management as the source of the crisis at all but rather an investigation about the financial theory and developments of the financial industry long before the crisis. Fox neither puts any blame on the RWH nor the advanced version of this idea that dictates that security prices are unpredictable, hence one cannot make a profit consistently based on stale information. Fox rather accuses the side of the EMH theory that claims asset prices reflect their intrinsic values correctly at any given time.

[2]This controversy shown above led to the development of two different tales of efficiency. According to Thaler (2009), the EMH is comprised of two elements, i.e. "The No Free Lunch" and "Price is Right." The "Price is Right" principle uses words from Fama (1970) and says asset prices will fully absorb available information hence providing accurate signs for resource allocation. The "No Free Lunch" principle says that market prices are difficult to forecast which makes it impossible to outperform the market after accounting for risk. Charron (2016) proposes to label the "No Free Lunch" element technical efficiency simply because investors use the technical analysis investment method to apply it. On the other hand, he calls the "Price Is Right" element fundamental efficiency because it

[2] The two components of efficiency developed by Thaler (2009) had already been expressed four years earlier by Bourghelle et al. (2005) in French i.e., "efficience technique" to mean technical efficiency which Thaler labeled "No Free Lunch component and "efficience informationnelle" to mean fundamental efficiency which Thaler labeled "Price is Right component.

accounts for asset prices reflecting their fundamental value. Technical efficiency asserts that an investor's best strategy is to construct a portfolio as representative of the market trend as possible rather than attempt to guess. This means passive portfolio management is a superior strategy to active portfolio management. However, the principle of fundamental efficiency asserts that asset prices reflect their intrinsic value.

From the debates earlier talked about, we can conclude that the criticized efficiency was the Price Is Right component (fundamental efficiency) and the advocated one was the No Free Lunch component (technical efficiency). Critics of efficiency were seen to say that fundamental efficiency did not hold, to which advocates of efficiency answered that technical efficiency did hold. This simply implies that to the advocates of efficiency; technical efficiency means fundamental efficiency. In short, they looked at the fact that prices were unpredictable for one to conclude that prices are right. Shiller highlighted this as "one of the most remarkable errors in the history of economic thought." (Shiller, 1984:459). [3]This is because prices can be unpredictable and still wrong.

According to Leroy (1989), for technical efficiency to mean fundamental efficiency, it requires no less than the rational expectations hypothesis, which implies that market participants use readily available information to make conclusions about future occurrences. Shiller (1989) rejects this inference by showing in his article that stock prices being unpredictable is compatible with a model that accounts for investors' withdrawal from rationality. Shiller does not necessarily show that prices continuously move from their fair value, but that technical efficiency does not automatically suggest that investors are rational. He assumes that rationality of investors' means fundamental efficiency which is the basis of behavioural finance that claims security prices move from their intrinsic value due to investors' not being rational. The point Shiller was making was that

[3] Difficulty in testing this component appears because of what Fama (1991) refers to as the joint hypothesis problem. This means it is hard to reject the claim of prices are right unless one comes up with a theory of how prices are supposed to behave.

stock prices are determined by investors' psychology and their tendency to follow fads.

At this point, one can highlight that the debate is about whether technical efficiency implies fundamental efficiency. Friedman (1953) highlights that the only way to test the validity of a hypothesis is by testing a proposition against data. To test this proposition, Fama (1976) illustrates that a model of equilibrium is needed. "In an efficient market, the true expected return on any security is equal to its equilibrium expected value" Fama (1976: 144). Due to this assumption, he came up with two types of tests: tests to examine whether trading rules give an abnormal return and tests examining whether an investor can use a particular piece of information to earn an abnormal return selecting a specific piece of information. Fama specifies that the model chosen is not necessarily limited by the condition of market efficiency. Whichever model one selects, technical efficiency is always being tested to answer the question of whether market participants can outperform the market by employing a trading strategy based on available information.

To test for technical efficiency, one must examine how price changes respond to information while to test for fundamental efficiency, one must examine how price changes are defined by fundamental factors. Information is taken as the starting point in the first case, while the price is taken as the starting point in the second case and the mere fact that almost all efficiency tests take information as the starting point, it goes to tell us that all these tests are technical efficiency tests.

However, research has been done to test the rationality of market behaviour using volatility tests which examine the volatility of stock prices. Two pioneering studies were conducted by Shiller (1981) whereby he examined a model in which stock prices are the present discounted value of future dividends and the other study by Leroy and Porter (1981) used an identical model and applied it to the bond market. These studies disclosed that changes in security prices can both be caused by the rational and irrational beliefs of investors.

Keynes (1936) asserts that the EMH is seen as inaccurate if the rational decision-making process is led by full knowledge of factors determining the decision. This is because of the uncertainty factor which limits an investor from knowing the

future cash flows and the appropriate discount rate. Due to the uncertainty factor, individuals start basing their opinions on their fellow group members. Shleifer and Summers (1990) emphasize this and highlight that two types of investors exist. One being the rational arbitrageurs who trade using information available and the second being the noise traders that act due to imperfect information. The latter is usually responsible for prices moving from their equilibrium values, however, this is stabilised by arbitrageurs. Shleifer and Summers (1990) further argue that the presumption of perfect arbitrage is unrealistic due to the fundamental risk and unpredictability of future resale prices and due to this they conclude that securities answer to changes in beliefs that are not fully vindicated by information.

The lack of tests of fundamental efficiency is mainly because of the various measures of intrinsic value and separate ways of differentiating between important and unimportant information as well as which price changes should be analysed. Cochrane (2011) attributes this to the impossibility of an academic or regulator to fully explain the price movements in the market and that nobody knows what the fundamental value is. If one acknowledges this explanation, fundamental efficiency is not only difficult but highly impossible.

Most of the literature on efficiency has been done on technical efficiency whereby the starting point is information. This has seen the biggest part of behavioural finance accepting this approach and diverging by interpreting an abnormal return in psychological ways (Shleifer, 2000b).

This section presented the debate between fundamental and technical efficiency as well as the different views of the advocates and critics of the EMH. The following section will present a brief comparison between the two different investment styles (value factors versus growth factors).

2.7 Value Factors Vs Growth Factors

In the world of investing, the principle of classification exists whereby investors take on specific strategies to sustain and increase their returns (Graham & Dodd, 1934). This principle of classification is known as style investing in the investment world. Bourguignon and De Jong (2003) argue that personal or organizational characteristics, as well as economic behaviour, are responsible for an investors' desire to pursue a specific style.

There are various investment style approaches in the stock market mainly because it only requires two contradicting bodies sharing the same attributes to formulate an investment style. This is mainly because investors bear different beliefs on which style can provide higher returns in the short and long term. There are several popular styles recognized in financial markets, and these are large-cap versus small-cap stocks, momentum versus contrarian, among others. However, there exists one long-lasting and popular style which investors have failed to agree on, and this is the value factors vs growth factors. (Bourguignon & De Jong, 2003).

The value factor is based on investing in securities that are trading below their intrinsic value (Stagnol et al., 2021). Here investors buy value stocks. Graham and Dodd (1934) say, "these are stocks whose price to book, price to earnings and/or price to cash flow are low relative to the market average." This happens due to the poor past performance of these securities, which leads to an increase in the belief that this performance will carry on in the future. According to Hillier et al. (2010), these stocks are no longer favoured by investors. However, Fama and French (1998) assume that these stocks are trading at low prices because value companies are in distress.

Many investors as well believe that the market overreacts to any news and as a result leads to stock price changes that do not accurately portray the underlying fundamentals of the company. According to the EMH, no strategy can provide an investor with an abnormal return because the stock price should be equal to its intrinsic value. However, investors who carry out value investing believe that the stock price is priced incorrectly in the short run, and in the long run, it will return to its intrinsic value. In this regard, the market is inefficient because investors who

identify these stocks can make excess returns when the value stocks are correctly priced.

The growth factor is based on the belief of investing in stocks that are trading at a premium compared to their fundamentals like earnings, book value, etc. Investors undertaking this style of investment buy growth stocks. According to Bourguignon and De Jong (2003), "these are stocks whose earnings expectation and growth rates are higher than the market averages and usually continue to rise further." According to Lakonishok et al. (1994), "these stocks have had a historic outstanding performance and are expected to continue doing so in the future." Investors that buy growth stocks expect to obtain returns when these companies' market value rises.

Growth investors choose firms based on the expectation that the companies' value will likely increase in the long term. This means they are usually priced relatively quickly because of their significantly higher growth rate. Investors in the long run can make returns from investing in growth stocks and this regards the market as less efficient.

There is still an ongoing debate on whether value stocks can outperform growth stocks by providing a higher risk-adjusted return. Bauman et al. (1998) in their study debate that value stocks on average usually produce higher risk-adjusted returns. However, they claim that growth portfolios in some cases generate higher returns on a risk-adjusted basis. However, Yen et al. (2004) as well highlight that value stocks tend to produce higher risk-adjusted returns compared to growth stocks.

When the performance of value stocks betters that of growth stocks, a value premium exists (Capaul et al., 1993). The value premium is described as the difference between the returns obtained from value stock portfolios and growth stock portfolios (Bauman & Miller, 1997). The higher the value premium, the higher the preference of value stocks by investors because they will produce higher returns than growth stocks (Bird & Casavvechia, 2007). If the value premium is zero, it indicates that the purchase of value stocks and growth stocks yields the same returns (Capaul et al., 1993). When it lies below zero, it indicates that a value

discount exists and this means that growth stocks produce higher returns compared to value stocks (Brown et al., 2008).

Various scholars have concluded that in terms of both total returns and return per unit of risk value stocks tend to outperform growth stocks. This can be explained from a rational and behavioural standpoint.

From a rational standpoint, Fama and French (1993) highlight that the significance of the value premium is because it is a reward for bearing higher risk. The higher risk is attributed to the notion that value stocks trade at a discount and are expected to pick up to become value-added. Hence an investor would require a higher premium because the riskiest firms being lowly priced would have a lower price-to-book ratio and would appear more appealing in terms of valuation (Stagnol et al., 2021).

However, Lakonishok (1994) looked at the performance of the value and growth factor over time to understand if the value factor is indeed riskier than the growth factor. The results revealed that the value factor performed about the same and sometimes better during the recession. In addition, it contradicted the declaration that value stocks are riskier by outperforming the growth strategy in times of severe market declines.

From a behavioural standpoint, scholars highlight that due to overreaction and expectation errors made by investors in returns, it contributes to the existence of value premiums. De Bondt and Thaler (1985) assert that investors' overreaction to past events such as announcements is responsible for the higher returns generated by value stocks. This makes the value stocks become lowly priced and rebounded while the growth stocks experience the reverse. Lakonishok (1994) is also in support of this theory. Furthermore, these scholars assume that in addition to this overreaction, investors tend to project past earnings too far in the future which results in an overestimation of growth stocks and underestimation of value stocks, which means that when rebounding occurs, value stocks tend to generate higher returns than growth stocks.

In conclusion, from the point of view of the EMH, the rational explanation of the value premium does not confirm that markets are inefficient. The EMH asserts that investors can obtain better performance by investing in securities with higher risk. Since the advocates of the rational explanation assert that value portfolios are associated with a higher risk in relation to growth portfolios, the anomaly dissolves to some degree. From a behavioural standpoint, the value premium infers that markets are inefficient. This is because people are irrational and process information differently, which leads to temporary or permanent inefficiency of the market.

This section discussed the two different investment styles (value factors vs growth factors). This will be followed by a presentation of the criticisms of the EMH, alternative theories that have been formulated as well as the different types of financial market anomalies.

2.8 Criticisms and Alternative Theories of the EMH

2.8.1 Criticisms of the EMH

This section focuses on the criticism of the EMH by looking at the most relevant cases discussed. As noted earlier, the EMH nullifies the advantage of one undertaking technical or fundamental analysis because of the impossibility to outperform the market. However, not all market participants could confirm that they failed to beat the market during their search for extra returns. Many authors, for example, De Long et al. (1990) and Shleifer (2000a) have highlighted a number of inconsistencies over the years.

EMH has been criticised because of its theoretical and practical limitations (Ball, 2009). These are broken down as follows.

1. The EMH strongly ignores the supply side of the information i.e., the amount of available information, where it stems from (accounting reports, government statistical releases or statements made by managers), rate of occurrence of extreme events etc. The theory only focuses on the demand side since it says investors will trade on readily available information to the point where they cannot acquire any gains.

2. The EMH assumes that all information is replicated in it as an impartial product that is of the same meaning to all investors. However, investors have access to different information and bear different beliefs. Their actions on how to react to this information are dependent on their beliefs.
3. In the EMH, the processing of information is presumed to be costless which leads to immediate and accurate incorporation of this information into the prices. It should be noted that the cost of modifying this information is not accounted for in the EMH.
4. The EMH is still unclear about the function of transaction costs regarding market efficiency. This is because it assumes that one does not incur costs while operating in financial markets. Stock markets are considered to be of low cost but not fully costless. One is torn between whether to judge the market as efficient because of the presence of pricing errors that are not eliminated because of the high transaction costs of exploiting them or whether to judge the market as inefficient because of pricing errors that exist due to transaction costs.
5. The EMH does not talk about the problem of investor taxes. Investors are taxed on dividends, capital gains, but until today the result of this taxation on the price of securities and investors expected returns are not fully known.

Owing to the above limitations, financial markets at times will incorrectly value securities (Shiller, 2000). This is because imperfect information exists in the economy and it is unlikely that information given to market participants is consistent and accurately interpreted (Dow, 1983). This shows that information imbalance alone can curb the EMH model.

Malkiel (2003) highlights that momentum investing, which is a mixture of both technical and fundamental analysis, is a critique of the EMH because it claims that price patterns persist over time. Momentum investors believe that there should be zero serial correlation among security prices in a truly efficient market, but several studies such as the research by Lo et al. (2000) and Lo and MacKinlay (1999) have witnessed short-term serial correlations which implies the likelihood of a price pattern. However, these studies could be statistically significant and not economically significant because investors will later

incorporate new information into their decisions. For example, when knowledge of the January effect became public, investors took advantage of it, and it later disappeared. Momentum strategies are only good for a few markets as they will generate performance in some and underperformance in others.

The EMH faces a problem of theoretical inconsistencies (Leković, 2018). The market would cease to be efficient if all participants in each financial market believed it is efficient. This is because no specific examination of securities would be done i.e., disclosure of overvalued and undervalued assets would not exist. Leković (2018) further highlights that the market participants must be compensated for their efforts to make the market efficient, however, the EMH nullifies the probability of earning an abnormal return. Therefore, the existence of a financial incentive is essential for achieving market efficiency yet at the same time it conflicts with the EMH.

Another ideology that challenges the EMH is that fundamental analysis can be able to predict outperformance and underperformance in the future. Ratios like dividend yield, price to earnings are used by investors to forecast the future stock prices, meaning they cease to be random. However, Malkiel (2003) highlights that this can only be done in the short run, and one cannot always consistently forecast security performance. This shows that these anomalies that occur in the short run do not necessarily violate the EMH because their predictive power ceases to exist in the long run. The theory of behavioural finance further criticises the EMH by arguing that investors' decision making is affected by other psychological factors because they are not entirely rational.

The above criticisms highlight that an investor can make excess returns from investing in the stock market. This is of interest to this thesis because it has been highly debated that in efficient markets, there is no possibility of one making excess returns. Due to this, this thesis will investigate the weak-form efficiency of the JSE as well as an investor's possibility of earning an abnormal return by investing in the JSE.

The next section examines behavioural finance as well as alternative theories that have been put forward to replace the EMH.

2.8.2 Behavioural Finance Theory

Traditional theories of finance have been built on the reliance that investors are rational, and the efficiency of the market. However, some of the financial environment has currently started to believe that investors at times are irrational. Price fluctuations, as well as economic crises, have led scholars to question the rationality of investors. According to Yildirim (2017), "behavioural finance is described as the study of the psychological effects and their influence on financial decision making as well as the market." Lo (2004) highlights that market participants under behavioural finance take on excessive risk because they are not rational and due to this, the theory centres on how they understand and react to information before making investment decisions. This is important in that it explains why market anomalies occur as well as the comprehension of financial market efficiency (Kourtidis et al., 2011).

Academic finance has heavily progressed from the times when the EMH theory was widely approved by all financial economists. Thirty years after the rise of the EMH theory, behavioural finance gained prestige and popularity (Shiller, 2003). It emerged as a debatable field to explain the anomalies of the EMH. Researchers believed that some financial occurrences could be better described and understood by models where agents were not fully rational (Barberis & Thaler, 2003). It should be noted that the presence of irrational investors alone is not sufficient to render financial markets inefficient. This is because when these irrationalities affect prices, intelligent arbitrageurs can take advantage of the profit opportunities which push prices back to their fair values. However, some scholars argue that in practice arbitrageurs' actions are restricted and not enough to push prices to match their intrinsic value. This argument is important because if prices are right (price=intrinsic value), easy profit opportunities do not exist. However, the reverse does not hold and if behaviourists are right about the limited arbitrage activity, the lack of profit opportunities is not proof of the efficiency of a market.

As noted earlier, EMH assumes that the rationality of investors exists in investment decision-making while behavioural finance assumes that investors are at times irrational. Behavioralists like Rieger (2012) and Sahi et al. (2013) debate that

markets are at least weakly predictable and point out that small traders continuously lose money due to certain behaviours that are not the focus of the EMH. These are broken down as follows.

Representativeness is a judgment based on stereotypes whereby one draws conclusions from little data (Shefrin & Statman, 2000). This leads market participants to conclude that the stock market changes as a bear or bull market without accounting for the likelihood that particular sequences are rare. Investors can as well be more pessimistic about the past losers and more optimistic about the past winners which may conclude that the recent trend in price movements will continue. Investors may also only focus on stocks that have been recently performing well. Statman and Solt (1989) note that due to representativeness, investors think that good companies make good stocks. This implies that investors can overreact to new information due to representativeness i.e., basing their predictions heavily on new information.

Overconfidence is a bias whereby an investor or market participant has too much faith in one's skills, abilities, knowledge, and received information causing excessive trading and risk-taking. It can be broken down into two forms i.e., miscalibration whereby one is clueless about the likely outcomes and better than average effect where one believes they are better than the average. Events anticipated to occur usually occur only 80 per cent of the time and events that have a very low chance of happening usually occur approximately 20 per cent of the time (Fischhoff et al., 1977). Plous (1993) highlights that overconfidence is prevalent and more potentially catastrophic in the investment decision making process.

Regret aversion is likely to make people repeat actions to avoid the pain caused by a poor investment decision. This can lead to an investor selling winners too early and holding onto losers for a while which is described as the disposition effect (Shefrin & Statman, 1985). If an investor sold a stock recently and later finds out it reached a new high, he no longer feels like he made a successful trade even though he made a good return from it. Strahilevitz et al. (2011) in their study concluded that an investor that has experienced regret from a certain stock is less likely to buy it again.

Conservatism is another bias that occurs when the available data is insufficient to support strong conclusions. It is the opposite of representativeness and according to Pompian (2006), it involves people sticking to their prior views and refusing to accept new information. Investors tend to underreact due to conservatism however, if the pattern persists, they slowly alter their prior views and may overreact leading to underweighting of the long-term average (Ritter & Warr, 2002). Wu et al. (2009) studied the behaviour of investors in the Taiwan Stock Exchange and empirically established that underreaction in the market was due to the conservatism bias, while overreaction was due to the representativeness bias.

Mental accounting is a set of psychological techniques employed by people to keep track of financial activities, and it usually leads investors to view each investment separately (Thaler, 1999). This usually presents a risk whereby an investment portfolio misses out on opportunities like tax swaps. Mental accounting lacks diversification and according to Shefrin and Statman (2000), investors use mental accounting to rival investment goals with asset allocations.

Forecasting errors easily influence the investment decision making process. Kahneman and Tversky (1973) in their experiments highlighted that people highly base their forecasting process on recent experiences compared to prior beliefs. This usually results in investors making extreme forecasts because they are uncertain of their information. De Bondt and Thaler (1990) assert that the P/E effect can be described by extreme earnings expectations. When the forecasts of a firm's future earnings are high, usually due to recent good performance, they are liable to be too high relative to the impartial prospects of a firm. This culminates into a high initial P/E outcome and poor successive performance when the investors realize their error.

The herding mentality influences the rationality of investors because they tend to replicate what other investors are doing. Investors do not do their independent analysis or use their information but rather do what others are doing (Banerjee, 1992). An investor can be said to herd if they were planning to invest without knowledge of other investors' decisions but then pulls out when they receive information that others have decided not to do so.

Anchoring usually occurs when one relies on pre-existing or irrelevant information to estimate the value of a security which in turn influences an investment decision. Kahneman and Tversky (1974) highlight that investors begin with an initial value and tweak from it. This modification is usually insufficient and owing to this bias, one can incline towards holding an asset that has lost value.

In an attempt to illustrate the pervasiveness of these biases, Lo (2007) formulates an example modified from a study by Kahneman and Tversky (1979). If one is presented with two investment alternatives, A and B, whereby A yields a guaranteed profit of US$350,000 and B is a lottery ticket yielding US$1 million with a probability of 25 per cent and US$0 with a probability of 75 per cent. Investment A has an expected payoff of US$350,000, which is higher than that of B, but because one has a chance of receiving US$1 million or US$0, it may not be meaningful. In such a situation, it comes down to personal preference. Most individuals will prefer A to B, a behaviour characterized as risk aversion.

However, if one is presented with two other choices C and D, where C presents a sure loss of US$750,000 and D is a lottery ticket presenting US$0 with a 25 per cent probability and a loss of US$1 million with 75 per cent probability. Many financial decisions, in this case, would choose the lesser of the two losses however most subjects would go for D even though it is riskier. Individuals are usually more risk-seeking when faced with a choice between two losses and not risk-averse as in the case of A *vs* B. This can be responsible for investors making poor financial decisions.

These biases listed above affect the investment decisions made by investors, however, some believe they can be reduced through incentives. On the other hand, no study has shown that rationality violations are solved by simply increasing incentives. Behavioural finance has captured academic attention through not only enhancing stagnating finance theories but also enhancing them to the extent that it is considered the new dominant model of financing. However, despite the increase in acceptance of behavioural finance as the new dominant model, it has been criticised on several matters. Bodie et al. (2005) highlighted some of these criticisms which include the following.

Investors are always interested in the existence of profit opportunities. However, the explanations of efficient market anomalies by behavioural finance do not provide guidance on how one can take advantage of any existing irrationality. Investors question if returns can be made from mispricing and the behavioural literature is completely quiet on this point.

Financial economists still debate heavily about the strength of behavioural finance. Many are inclined to believe that the approach is heavily unstructured in that it allows every anomaly to be explained by a combination of irrationalities. While it is easy to duplicate a behavioural explanation for any anomaly, critics like Fama prefer to see a compatible behavioural theory that can describe a number of anomalies. Fama (1998) argued that it is not advisable to abandon market efficiency in favour of behavioural finance simply because of the existence of certain anomalies that cannot be well explained by the modern financial theory. He gave two reasons for this, the first being that the anomalies uncovered tended to appear to be as often overreaction by investors as underreaction. The second was that these anomalies tend to disappear, either as the methodology of the study was improved or as time went by.

However, his first criticism presents an incorrect perspective of the psychological presentation of behavioural finance. It is not surprising that research on financial anomalies fails to reveal such a proposition since there is no fundamental psychological proposition that people tend to always underreact or overreact. His second criticism is as well weak because the mere fact that anomalies at times switch signs or disappear, does not provide evidence that markets are fully irrational.

In conclusion, behavioural finance has provided exposure to better study investor behaviour, but it is not yet perfect because the concept is merely a collection of ideas that are descriptive but not exhaustive. More studies need to be conducted to highlight the limitations of the behavioural finance theory to further refine it into a good theory. In this regard, Sharma (2014) notes that until this happens, behavioural finance is only a theoretical framework that has many positive sides in the subject

of stock market study, thus it needs more clarification and exhaustive analysis to replace the EMH theory.

As discussed above, behavioural finance adds to the already available knowledge of financial markets by utilising the EMH theory to make its argument hence supporting the theory it criticises (Ball, 2009). Although the EMH is criticised by behavioural finance, there seems to exist an intersection between the two models. Therefore, researchers need to pledge towards finding a replacement theory for the EMH and if this is done, behavioural finance will have a clear understanding of how markets truly work. This could be the Adaptive Market Hypothesis formulated by Lo, (2004) or a related theory.

2.8.3 The Adaptive Market Hypothesis Theory

Economics suggested an alternative approach due to the methodological differences between the EMH and behavioural finance in an attempt to reconcile the two theories. The adaptive market hypothesis links the literature of the behavioural finance theory to that of the weak-form of the EMH. According to Daniel & Titman (1999), the adaptive market hypothesis theory asserts that in a market where information is not fully incorporated in the prices, the market will adjust to correct the past pricing anomaly.

According to Lo (2004), "prices reflect as much information as dictated by a combination of economic conditions and the number and nature of market participants in the economy." A market is anticipated to be highly efficient if multiple market participants for example pension funds, hedge fund managers, retail investors, among others, are competing for scarce resources within that market. In contrast, a market will be less efficient if a small number of market participants are in competition for many resources in a given market.

Market efficiency is therefore a characteristic that changes constantly as time goes by and across markets. Under the adaptive market hypothesis, investment strategies experience sequences of profitability and loss as a reaction to changing business environment, several competitors moving in and out of the industry, type, and

expanse of profit opportunities present. As these opportunities shift, so do the affected market participants.

Lo (2004) develops various assumptions of the adaptive market hypothesis in his paper by firstly agreeing with Simon (1955) about bounded rationality. Here, investors are not always searching for optimization because of the expense and level of skill required by an investor to attain it. Investors are rather trying to survive or achieve satisfactory performance. Secondly, when the new information influences the market, investors lack the intelligence to make the correct reactions and usually make errors because they find some information either misleading or hard to obtain instantly. The diversity of investors brings about competition due to the need to avoid elimination, hence they must change their earlier strategies. Sharp investors make it a point to learn from others in an attempt to achieve excess returns.

Recent research in the field of neuroeconomics has highlighted an essential link between rationality and emotion in decision-making, hinting that the two are rather complementary than contradictory (Grossberg & Gutowski, 1987). Lo and Repin (2002) assert that in the processing of financial risks, emotional responses are an important element, and one essential element of a professional trader's skills is their ability to direct their emotions unconsciously or consciously in specific ways during specific market conditions.

Emotion enhances the effectiveness with which market participants acquire knowledge from the past and their environment. Through generations of natural selection, unsuccessful traders are wiped out of the market after experiencing a certain level of losses. Only those investors or traders that adjust to the environment can endure in the financial markets. Despite all the realistic beliefs of the adaptive market hypothesis, it cannot be valid without any implications on the stock market and market participants, therefore, it is important to highlight some of them (Lo, 2012).

Firstly, there exists a risk to reward relationship which becomes unstable as time goes on. This is mainly because this trade-off is dictated mainly by the number and preferences of market participants in the financial market as well as economic features like regulatory institutions and tax laws (Lo, 2004). Since these factors

move over time, the risk-reward relation is jeopardized because risk preferences are not constant all the time, i.e., when investors are afraid of the market, they prefer to hold more of their money in the bank instead of taking up risky assets that reduce the average returns. The reverse of this holds as well. Due to the natural selection forces, the history of the market is important regardless of whether all available information is reflected in the prices. The trend of past prices still influences the risk preferences of investors and unsuccessful investors are highly likely to be eliminated from the market.

Secondly, arbitrage opportunities present themselves as an implication of the adaptive market hypothesis. Unlike the EMH which implies that information is available and incorporated in stock prices making it impossible to gain an advantage, the adaptive market hypothesis argues that information asymmetry exists, hence asset prices do not adjust quickly. However, Lekhal & El Oubani (2020) highlight that from time to time, opportunities of earning an abnormal return may present themselves but eventually disappear as they are taken advantage of. Grossman and Stiglitz (1980) highlighted that the absence of arbitrage opportunities does not give investors the incentive to gather information which leads to the collapse of the price discovery aspect of financial markets. The adaptive market hypothesis implies the existence of more complicated market dynamics with cycles as well as panics, trends, bubbles, and crashes. Therefore, unlike the EMH which argues that active portfolio management is of no value, the adaptive market hypothesis justifies active portfolio management. A few studies have examined this profitability within the adaptive market hypothesis framework. For example, studies by Al-Khazali and Mirzaei (2017), Xiong et al. (2019), Shi and Zhou (2017) have revealed that the anomalies can be better described by the adaptive market hypothesis rather than the EMH and that arbitrage opportunities tend to fluctuate over time.

Thirdly, investment strategies tend to fluctuate i.e., performing well in certain environments and poorly in others. Unlike the EMH whereby profitability of strategies formed to exploit arbitrage opportunities are eliminated by competition, the adaptive market hypothesis asserts that such strategies can decline and later become profitable when market conditions become favourable for those trades. Lo

(2004) in his study shows this by his findings exhibiting a larger rolling first-order autocorrelation of monthly returns in the early period of the sample and later becoming smaller as the stock market becomes efficient. According to the EMH, these autocorrelations should strictly be zero at all times. Therefore, for one to be able to survive under the adaptive market hypothesis, one should hold a high degree of innovation. Contrary to the EMH whereby expected returns are positively correlated with the degree of risk, the adaptive market hypothesis relationship between risk and reward varies over time and one can only acquire consistent returns through adapting to the ever-changing market situations.

In conclusion, the AMH theory requires a greater deal of research to render it operationally meaningful, however, even at this early stage, it is clear that an evolutionary framework can accommodate many of the differences between the EMH and behavioural finance theories. These theories demonstrate that markets can still be efficient when they make valuation errors, have irrational market participants and when the stock prices undergo greater volatility. Since the EMH is not a perfect theory, alternative theories like behavioural finance and adaptive market hypothesis complement it to fully understand the functionalities of financial markets. It is, therefore, more beneficial for these theories to be viewed as symbiotic other than individually dominant.

This section presented a detailed review of the criticisms of the EMH and alternative theories that have been created against the EMH. The following section presents empirical evidence on the weak-form EMH i.e., studies that have been done on weak-form efficiency in developed markets, emerging markets and concludes with studies that have been conducted on the JSE.

2.9 Empirical Evidence on Efficient Market Hypothesis

This section commences with a review of the primary studies that investigated the EMH. It further looks at how the RWH has been employed as a foundation to advance empirical studies that have revealed results consistent with the weak-form EMH. This section goes on to look at the recent studies of the weak-form EMH that have been carried out on the developed, emerging markets and culminates with a

review of studies conducted on the JSE. These studies are reviewed to show the importance of this research to current and previous studies.

The EMH has been enhanced through several studies that have caught the attention of policymakers, researchers, and regulators over the past couple of years. Several studies have investigated this hypothesis by applying different tests compared to the previous ones. Early studies took advantage of correlation tests to examine the RWH in past and present returns of the same security. As earlier mentioned, the first tests of RWH were developed by Cowles and Jones (1937) where they established the presence of significant serial correlation in the averaged time-series indices of stock prices in the US market. Several researchers went ahead to utilize the correlation tests of Cowles and Jones to investigate the market. Cowles (1960) revisited his findings in his earlier study (Cowles & Jones, 1937) to correct his error brought about by averaging but still found mixed temporal dependence results. Working (1960) goes on to show that the use of averages can bring about autocorrelations that were not present in the original series. However, in a study by Cootner (1962), he concludes that the stock market does not follow a RWH, and this is supported by Osborne (1962) by showing that stocks are usually traded in concentration bursts. It should be noted that most of the studies mentioned above have investigated the EMH using time analysis and serial correlation. Due to this, this thesis applies a different methodology to investigate this hypothesis on the JSE.

It should be noted that most of these studies as well have investigated the same hypothesis using a different methodology. For example, Alexander (1964) highlighted that technical analysis via filter strategies cannot achieve abnormal earnings after transaction costs are taken into consideration. Fama (1965b) investigated 30 individual stocks of the Dow Jones Industrial Average (DJIA) using the autocorrelation, runs test, and filter methods. His autocorrelation findings show a low level of positive correlation while the runs test shows a smaller number of runs than the expected runs. This confirms the weak-form efficiency of the DIJA. Fama and Blume (1966) report additional evidence that filters failed to outperform the buy and hold strategy.

Osborne (1977) in his study examined the RWH and the results rejected it. Beja (1977) highlights that a real market cannot be efficient. Grossman and Stiglitz (1980) highlight that due to the high cost of acquiring information, prices cannot absorb the available information perfectly making it impossible for a market to be perfectly informationally efficient. Various researchers have rejected the random walk pattern in the US market for example Fama and French (1988) and Lo and Mackinlay (1988). However, Leroy (1989) highlights that security price changes do follow a random walk due to the random nature of the information.

From the above literature, it can be concluded that the results of previous studies on market efficiency especially on the weak-form have revealed different results over time due to sensitive factors like the period of the study, index and methodology used as well as the country studied. It is, therefore, crucial to update the current literature by adding new regions, sectors and indices when investigating the RWH. It is for this reason that this study looks at three indices (RESI 10, FINI 15, INDI 25) to investigate the validity of the RWH on the JSE.

2.9.1 Studies on Weak-Form Efficiency

Fama (1970; 1995) developed the RWH hypothesis as a test for market efficiency. Due to this, previous studies on market efficiency have included the RWH. Researchers like Fama (1965b) have used statistical tools such as runs test and serial correlation to test the RWH. Studies to examine the weak-form EMH have been undertaken after Fama (1991) used the predictability power of variables like firm size, dividends, and interest rates to test the RWH. Most of these studies have focused on developed markets compared to emerging markets. Emerging markets and developed markets share different characteristics, for example, emerging markets are classified by shallow trading, low liquidity, large price fluctuations as well as uninformed investors who have access to unpredictable information (Angelovska, 2018). Studies that have been done on both developed and emerging markets are reported in the following sections.

2.9.1.1 Evidence from Developed Markets

This section presents a review of studies that have recently been conducted on the weak-form efficiency of developed markets.

Worthington and Higgs (2004) examine the weak-form efficiency of sixteen developed markets (Austria, Denmark, Belgium, Finland, Germany, France, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK) and four emerging markets (Czech Republic, Poland, Hungary, and Russia) using daily prices. They use a combination of tests i.e., three types of unit root tests (ADF, PP, and KPSS) as well as runs test, and multiple variance ratio tests. They report that the serial correlation and runs tests reveal the weak-form efficiency of Germany and the Netherlands. However, only one test was able to prove that Ireland, Portugal, and the UK markets were efficient. The ADF and PP unit root tests rejected the RWH in all markets studied, while the KPSS unit root test failed to reject the RWH in all countries except the Netherlands, Portugal, and Poland. Under the variance ratio test, Germany, the UK, Ireland, Portugal, Hungary, and Sweden failed to reject the homoscedasticity and heteroskedasticity RWH. On the other hand, the homoscedasticity RWH was rejected for the Netherlands, Finland, France while the heteroskedasticity RWH failed to be rejected for Spain and Norway. In conclusion, a strict RWH was satisfied in the developed markets of the Netherlands, Norway, France, Finland, and Spain while only Hungary among the emerging markets satisfied the RWH.

Righi and Ceretta (2011) investigated the US and Latin American stock markets (Argentina, Mexico, and Brazil) to examine whether they follow the RWH and applied the variance ratio test using daily prices. They divided their study into three subperiods i.e., after, before, and during the subprime crisis of 2007-2008. The results of the Latin markets failed to reject the RWH and were confirmed to be weak-form efficient. However, the US market rejected the RWH during the period of the crisis hence weak-form inefficient.

Singh et al. (2016) tested the weak-form efficiency in carbon-efficient stock market indices of the US, Japan, Brazil, and India. They used daily and monthly data for the period 1st October 2010 to 31st December 2015 to apply the Kolmogorov-

Smirnov and Shapiro Wilk test. The results of these tests revealed that all the four countries follow the random walk when daily data is used hence confirming their weak-form efficiency. However, monthly data confirmed the random walk in all the markets except Japan.

Showalter and Gropp (2019) tested the weak-form efficiency in US stock markets by randomly selecting 100 securities on the S&P 500 from 1st January 2008 to 1st January 2018. The researchers used daily returns to apply the ADF tests, variance ratio tests and implemented five machine learning algorithms to implement a trading platform. The findings of the statistical tests revealed potential stationarity hinting at a possibility of technical evaluation while little predictive power was found in the machine learning models.

Neifar (2020) investigated the weak-form efficiency of the conventional and Islamic markets in Canada using monthly data from August 2008 to April 2014 by using nonlinear and linear unit root tests. The goal of their research was to understand whether the conventional market would be more or less efficient than the Islamic one. They went on to analyse two different indices, i.e., the Dow Jones Islamic Canadian Price Index (DJICPI) and the Conventional Canadian Stock Index (CCSI). The results of their study showed that both indices follow a random walk which indicated the weak-form efficiency of the stock markets.

The above studies on weak-form efficiency in developed markets have motivated the researcher to use a combination of different tests of weak-form efficiency that have been applied to recent studies. Furthermore, seeing as recent studies on weak-form efficiency in the developed markets have included emerging markets as well, the researcher in this project extends the literature review to include the updated findings of weak-form efficiency in emerging markets.

2.9.1.2 Evidence from Emerging Stock Markets

Emerging stock markets have received increasing recognition from both investors and researchers. This is attributed to the phenomenal growth these markets have undergone since the early nineties. Furthermore, emerging markets are lowly correlated to developed markets and their returns are more predictable due to systematic patterns. This section of the literature review looks at the latest studies on the weak-form efficiency in emerging markets.

The number of studies conducted on the RWH and weak-form efficiency of emerging markets has significantly increased due to liberalization in these economies. Angelovska (2018) tested the weak-form efficiency of the Macedonian stock exchange using daily returns on a sample spanning from 4th January 2005 to 2nd April 2018. The researcher concluded that the Macedonian stock market is weak-form inefficient with the application of a random walk model and GARCH (1,1) model.

Tokić et al. (2018) investigated the weak-form efficiency of the stock markets in Croatia, Serbia, Slovenia, and Slovakia using daily data from 1st January 2006 to 31st January 2016. The researchers applied several tests i.e., serial correlation test, runs test, ADF test, unit root tests, variance ratio tests, and a test of the January effect. The results confirmed that all markets were weak-form efficient except Serbia that provided mixed results which confirmed its weak-form inefficiency.

Sarkar, (2019) tested the weak-form efficiency using daily returns of two stock exchanges in India (Bombay stock exchange and National stock exchange) for the period 1st January 2015 to 31st December 2018. With the use of the Kolmogorov-Smirnov Goodness of Fit, runs test, ADF and PP tests of stationarity, the researcher concluded that the two stock exchanges are both weak-form inefficient therefore an investor is able to predict future price movements.

Emenike and Kirabo (2018) investigated the weak-form efficiency of the Uganda Securities Exchange (USE) using daily data for the period 1st September 2011 to 31st December 2016. The researchers applied both linear serial dependence tests (Ljung-box Q tests and autocorrelation function) and nonlinear tests (autoregressive

conditional heteroscedasticity Lagrange multiplier). The results of the linear models showed evidence of weak-form efficiency while the results of the non-linear models showed evidence against weak-form efficiency of the USE which concluded that future returns of the USE can only be predicted using non-linear models and fundamental analysis while linear models and technical analysis are worthless for predicting future returns.

Hawaldar et al. (2017) examined the weak-form efficiency of individual stocks listed on the Bahrain Bourse for the period 2011 to 2015. They applied the autocorrelation test, Kolmogorov-Smirnov Goodness of fit test, and runs test. However, their study revealed mixed results with the Kolmogorov-Smirnov Goodness of fit test confirming that the market follows a random walk, the runs test revealing that the share prices of seven companies do not follow the random walk and the autocorrelation test revealing that share prices generally exhibit low to moderate correlation. From these mixed results, the researchers highlighted that it is complicated to decide whether the Bahrain Bourse is weak-form efficient.

Several recent studies have been done to investigate the RWH on African stock markets. For example, Gbalam and Johnny (2019) using daily, weekly, and monthly data applied the Jarque-Bera test for normality and graph representations, unit root tests of stationarity and random walk to investigate the weak-form efficiency of the Nigeria stock exchange. The daily, weekly, and monthly results of the study revealed that the Nigeria stock exchange exhibits the random walk, hence it is weak-form efficient.

Dickinson and Muragu (1994) applied the serial correlation and runs test to examine the weak-form efficiency of the Nairobi Stock Exchange (NSE) and found it to be weak-form efficient. However, Parkinson (1987) examined the weak-form efficiency of the NSE using monthly prices to apply the runs test and found it to be weak-form inefficient. Njuguna (2016) applied the unit root tests, serial correlation test, variance ratio test and runs test to investigate the weak-form efficiency of the Nairobi Securities Exchange (NSE). He used both daily and weekly data and he reported mixed findings. The results of the serial correlation test, unit root tests,

runs test deemed the NSE weak-form inefficient, however, the variance ratio test deemed it weak-form efficient.

Awiagah and Sup (2018) examined the weak-form efficiency of the Ghana stock exchange using daily, weekly, and monthly data for a twenty-eight-year period ranging from 1990 to 2017. They applied the following tests, unit root tests, Ljung-Box unit autocorrelation test, variance ratio test, and runs test which all rejected the RWH concluding the weak-form inefficiency of the Ghana stock exchange.

From the studies listed above, studies done on emerging markets (Tokić et al. (2018), Emenike and Kirabo (2018), Njuguna (2016)) have revealed contradictory results. This is because it is expected for emerging stock markets to behave more inefficiently compared to developed ones. Although these differences between emerging and developed markets exist, some of the emerging markets are not as inefficient as others.

Emerging markets do not have a high level of sophistication and organization in terms of structure and investor behaviour. Due to this, emerging markets tend to be more inefficient in the weak-form. Developed markets can as well be expected to be inefficient because there would be no need to analyse the information required to make better investment decisions if everyone believed that they were fully efficient, and this would eventually make the market inefficient. Therefore, stock markets cannot fully be categorized as inefficient or efficient.

In conclusion, from the literature review on developed and emerging markets, most of the research carried out on emerging markets has not focused on stock markets in Africa. To try and fill this gap, this study is focused on examining the weak-form efficiency of the JSE. The next section looks at studies that have been conducted to test the weak-form efficiency of the JSE.

2.9.1.3 Studies Conducted on the JSE

There have been a couple of studies conducted on the JSE to test its efficiency and they have provided mixed findings.

Zhang et al. (2012) investigated the weak-form efficiency of markets in South Africa, Morocco, Egypt, Kenya, and Tunisia using univariate and panel-based unit tests with Fourier functions over the period of January 2000 to April 2011. The results confirmed the RWH in South Africa, Kenya, Tunisia, and rejected the RWH in Egypt and Morocco.

Phiri (2015) with the use of both linear and non-linear unit root tests examined the efficiency of the JSE. The study investigated the weak-form efficiency of five generalized indices of the JSE for the period 31st January to 16th December 2014 using weekly data. The linear unit root tests accepted the weak-form efficiency of the JSE, while the non-linear unit root tests rejected it.

Grater and Struweg (2015) employed both the PP and ADF tests using monthly data to investigate whether the JSE followed a random walk for the period 1999 to 2014. The results of both tests proved that for the period analysed, the JSE did not follow a random walk, hence was weak-form inefficient.

Heymans and Santana (2018), using daily index values for the period 3rd July 1997 to 3rd March 2015 investigated the weak-form efficiency of the JSE by analysing the different subindices of the JSE to find out whether they go through cycles of efficiency or inefficiency. The study applied the variance ratio test, automatic chow-denning, joint variance ratio test and the joint sign test to a sample of stock indices. The results revealed the weak-form efficiency of the JSE all-share index and that all indices tested move from periods of efficiency to periods of relative predictability. Indices bearing established companies are efficient compared to their younger counterparts. In showing that some of the sub-indices are inefficient for long periods, this study shows why active portfolio management is still carried out.

Abakah et al. (2018) analysed weekly data to investigate the weak-form efficiency of South Africa, Egypt, Ghana, Nigeria, and Mauritius markets using weekly data for the period 2000 to 2013. The study employed the newly developed non-linear

Fourier unit root test to test the RWH for the five markets. The results of the study revealed that the South Africa, Nigeria, and Egypt markets follow the RWH hence weak-form efficient while the Ghana and Mauritius markets do not follow the RWH hence weak-form inefficient.

Kiran et al. (2019) examined the weak-form efficiency of the BRICS (Brazil, Russia, India, China, and South Africa) stock markets using daily data for the period 2000 to 2018. They sub-divided the period into post-crisis and pre-crisis periods and employed both nonparametric and parametric tests of efficiency i.e., Autocorrelation function, Ljung-Box test, Hurst exponent, and the Runs test. The results of their study revealed the presence of time-varying efficiency hence concluding that the JSE is weak-form efficient for the whole sample period.

All the studies highlighted above are proof that the weak-form efficiency of the JSE is still inconclusive. From the studies listed above, the weak-form efficiency of the market could be highly affected by elements like the tests applied, the period examined as well as the frequency of the data used i.e., whether daily, monthly, or weekly. Note should be taken that only a few current studies have focused on the JSE without analysing different financial markets. In addition, no study has analysed the RESI 10, FINI 15, INDI 25 indices as well as the individual companies under these respective indices. It is because of the above reasons that this study will examine the weak-form efficiency of the JSE by analysing the RESI 10, FINI 15, INDI 25 indices as well as the individual companies under these respective indices. This will be done with the use of both weekly and monthly data to provide an informed conclusion on the weak-form efficiency of the JSE and create an understanding of whether investors or market participants can make an abnormal return.

2.10 Conclusion

This chapter commenced with an overview of the global financial crisis that highlighted the causes of the crisis and examined the impact the crisis had on South Africa.

The next section of this chapter discusses the concept of the EMH. It commenced with a presentation of the historical background on the concept, how it has gradually risen in focus among different scholars as well as highlighting the theory of the random walk and mean reversion. This was followed by a detailed breakdown of the different forms of the EMH and a presentation of the debate between fundamental efficiency and technical efficiency.

The chapter then presented a brief comparison between the investment styles (value and growth factors). The subsequent section looked at the criticisms of the EMH and the alternative theories that have been formulated. Here I discussed the various reasons as to why the EMH is not considered a valid theory according to the critics and the alternative theories that have been formulated to account for some of these criticisms. For example, the Behavioural Finance theory that looks at the behaviours investors' practice that may make them lose money, the Adaptive Market Hypothesis theory that was formulated to link the EMH theory with the Behavioural Finance theory. The literature review closes with the presentation of the different studies that have been conducted on developed markets, different emerging markets, as well as the JSE.

Chapter 3: Research Methodology

3.1 Introduction

The purpose of this study is to investigate the weak-form efficiency of the JSE. This chapter presents the methodology that has been applied to come to a complete conclusion. It includes the research approach, philosophy, design, sample data and tests that were used in analysing the data collected.

3.2 Research Approach

A quantitative approach is used in this study as it is useful in the assessment of statistical data to discover patterns and bring to light facts in research (DeFranzo, 2011). Golafshani (2003) highlights that the researcher using a quantitative research approach applies quantitative measures and experimental methods to test a hypothesis. Bryman (2001) further highlights that a quantitative research approach strongly emphasises numbers and figures during the collection and analysis of data. The use of statistical data for research analysis and descriptions further reduces the time and effort the researcher would have invested in describing the result. Time and effort are reduced because the data can be calculated by a computer using different statistical programs like SPSS (Gorard, 2001). Due to the above reasons, this research employed a quantitative research approach to investigate the weak-form efficiency of the JSE.

3.3 Research Philosophy

Rocco et al. (2003) define a research philosophy as a world view i.e., it is a basic set of beliefs that guide a researcher's inquiry. Saunders et al. (2009) highlight that there are four different categories of research philosophies namely: Positivism, Realism, Interpretivism and Pragmatism. This study employed a positivism research philosophy. A positivism research philosophy relies on quantifiable observations that lead to statistical analyses. Furthermore, the role of the researcher in a positivism research philosophy is limited to mainly data collection and interpretation. In addition, a researcher who assumes a positivism approach is independent of his or her research and is purely objective. In short, studies based

on this approach consider the world to be external and objective and are based purely on facts.

This study employed a positivism research philosophy because it was limited to data collection and interpretation of the weekly and monthly historical prices of the JSE indices (RESI 10, FINI 15, INDI 25) as well as the weekly and monthly historical share prices of the individual companies under these respective indices. The final element of positivism in this study is that the process of research was conducted in a value-free way which according to Saunders et al. (2009) means that the researcher was independent and neither affected nor was affected by the research subject. It should be noted that in this study, the researcher did not and was not affected by the data collection process.

3.4 Research Design

MacMillan and Schumacher (2001) highlight, "a research design is a plan for selecting subjects, research sites, and data collection procedures to answer the research question(s)." They further highlight that the main goal of a good research design is to provide credible results. Research design can be broadly categorized as conclusive research and exploratory research. Burns and Bush (2006) define an exploratory research design as one where information is gathered in an informal and unstructured manner. This research design is not restricted to one specific research approach and may use either a qualitative or quantitative research approach.

Conclusive research design on the other hand is formulated to assist the researcher in deciding, evaluating, and choosing the better course of action in a specific situation. Conclusive research design uses larger sample sizes, statistical tests, advanced analytical techniques, quantitative rather than qualitative techniques compared to exploratory research (Nargundkar, 2008). Therefore, a conclusive research design was adopted in this study. This is because the study analysed both the weekly and monthly historical prices of the JSE indices (RESI 10, FINI 15, INDI 25) as well as the weekly and monthly historical share prices of the individual companies under these respective indices for a ten-year period. In addition, various

statistical tests like the unit root tests, variance ratio test, runs test and the GARCH (1,1) model were applied to examine the weak-form efficiency of the JSE.

3.5 Sample Data

The research used historical data collected from databases such as Bloomberg terminal, S&P CapIQ as well as online websites like Investing.com and Yahoo Finance. [4]Secondary data in the form of spreadsheets containing weekly and monthly historical closing prices for the different sample indices and individual companies were collected and used in this study.

The data comprised of both weekly and monthly observations for the period 30th January 2009 to 30th January 2019. This period is sufficient to examine the weak-form efficiency of the JSE after the global financial crisis. The sample data series comprised of the JSE indices (RESI 10, FINI 15, INDI 25) as well as the individual companies under these respective indices. Each of these time series sourced constituted a total of 522 weekly and 121 monthly observations of the historical returns. All this data was obtained from public databases hence there was no need for ethical clearance.

This study is based on the three major indices of the JSE that are the Resource Index (RESI 10), Financial Index (FINI 15), and the Industrial Index (INDI 25). These three indices were selected because they act as a proxy for All-Share Index (ALSI) and as benchmarks that gauge the performance of the different market segments of the JSE. For example, the RESI 10 index gauges the performance of the resource sector, the FINI 15 gauges the performance of the financial sector and the INDI 25 index gauges the performance of the industrial sector. Furthermore, these indices were selected because the sectors they represent are leading indicators of economic conditions and may be regarded as significant business-cycle predictors. According to Bodie et al. (2014), business cycle characteristics play an important role in

[4] The research used closing prices rather than the adjusted closing prices to calculate index returns. This is because while the adjusted closing prices account for other factors such as stock splits or new stock offerings that might affect the index price after the market closes, the closing prices represent an index's raw price at the time the market closes.

estimating the severity and timing of economic recessions and/or global financial crises.

Furthermore, the study analysed the individual companies that fall under these indices. Non-probability sampling, a method whereby a sample is selected by the researcher based on subjective judgment, was purposively used in the selection of the individual companies under the different indices as selecting companies by random would not have enabled the research to have a representative sample. Non-probability sampling was done by selecting the current top-performing companies under these indices based on their market capitalization. However, it should be noted that the companies under these indices keep changing with some dropping out of the indices based on their performance. Therefore, the individual companies selected were supposed to have met a criterion of maintaining themselves under the respective index for 80 per cent of the study period of 30th January 2009 to 30th January 2019 i.e., all companies selected were under the respective indices for 80 per cent or more of the study period and did not drop out. These companies are listed below under their respective index.

Under the RESI 10 Index, the top-performing companies selected include, Anglo American Platinum Limited (AMS), Anglo Gold Ashanti Limited (ANG), BHP Group PLC (BHP), Gold Fields Limited (GFI). Under the FINI 15 Index, the top-performing companies selected include Absa Group Limited (ABG), First Rand Limited (FSR), Sanlam Limited (SLM), Standard Bank Group (SBK). Finally, the top-performing companies under the INDI 25 companies include British American Tobacco PLC (BTI), Compagnie Financière Richemont SA (CFR), MTN Group (MTN), Naspers Limited (NPN).

3.6 Measures for Data Analysis

The data that was analysed comprised of the historical index value prices of the different indices as well as historical share prices of the different companies highlighted under the respective indices. The research calculates these returns logarithmically because asset returns are not normally distributed and calculations using simple returns do not account for the effects of compounding. Furthermore, investors chase profits in form of returns and not prices (Wang & Vergne, 2017).

Therefore, the following equation listed below was used to generate continuously compounded returns.

$$r_t = \text{In}\left(\frac{P_t}{P_{t-1}}\right) * 100 \qquad (5)$$

Where:

r_t= Return of the price indices at time t

P_t= Closing price at time t

P_{t-1}= Closing price at time $t-1$

In= Natural log

This study adopted the use of natural logarithm of price returns from the study conducted by Njuguna (2016) on the weak-form efficiency of the Nairobi Securities Exchange as well as the study by Abakah et al. (2018) on the weak-form efficiency of five African stock markets.

The following sub-sections cover the four tests that were used to investigate the weak-form efficiency of the JSE.

3.6.1 Unit Root Tests

Unit root tests are a method the study employed, and they are commonly applied to ascertain whether a financial variable follows a random walk. This is because the EMH demands randomness of return series and therefore the presence of a random walk implies unpredictability of stock prices. Unit root tests will be employed in this study to investigate the stationarity of the time series and understand if they follow a random walk.

There are a couple of different types of unit root tests, but this study employed only two types i.e., the Phillips-Perron test (PP) and the Augmented Dickey-Fuller test (ADF). These two were tested using weekly and monthly data of the three indices namely RESI 10, FINI 15, INDI 25 as well as the companies under these indices.

Both of the unit root tests (ADF and PP) included both the intercept as well as the trend and intercept which were run using the E-views software.

The Augmented Dickey-Fuller test is used because it takes care of possible serial correlation in the error terms by adjusting the original Dickey-Fuller (DF) test. This is done by adding the lagged difference terms of the regressand. Furthermore, the ADF test incorporates several lagged values of the dependent variable to negate the possibility of autocorrelation.

The Phillips-Perron test is employed in this study because it manages serial correlation in the error terms without adding lagged difference terms with the use of non-parametric statistical methods. The main difference is that the ADF test is prone to the possibility of specification errors whilst the PP test eliminates the consequences of serial correlation.

Both tests will be carried out using the following equation.

$$\Delta Y_t = a_0 + \gamma Y_{t-1} + a_1 + \sum_{i=1}^{p} \beta_I \Delta\gamma Y_{t-1} + u_t \qquad (6)$$

Where:

Δ=represent first differences.

Y_t=the log of a price index.

a_0=the constant.

a_1=constant coefficient for the trend.

t=trend term.

p = number of lagged terms.

γ *and* β_I = coefficients to be estimated.

u_t= Error term.

The ADF and PP tests employed in this study will examine the following null and alternative hypotheses whereby:

H_0: ρ= 1 which states that the time series contain a unit root i.e., non-stationary.
H_1: $\rho \neq 1$ which states that the time series do not contain a unit root i.e., stationary.

The above null and alternative hypotheses are used to analyse the results of the ADF and PP test to provide a conclusion on whether the return series follow a random walk i.e., are stock prices unpredictable and is today's price independent of tomorrow's price? This will be used to provide a conclusive result on the weak-form efficiency of the JSE.

According to Kapusuzoglu (2013), the t-statistics obtained from running each of these tests is used to either fail or reject the null hypothesis. The null hypothesis will be rejected if the t-statistic acquired is greater than the critical value and the null hypothesis will fail to be rejected if the t-statistic is lower than the critical value. The t-statistics acquired are then compared to the critical value at 1%, 5% and 10% significance levels. Failure to reject the null hypothesis implies the market (JSE) is weak-form efficient while rejection of the null hypothesis implies that the market (JSE) is weak-form inefficient.

It should be noted that the unit root test is not a sufficient condition for the random walk but for the random behaviour of time series and that is why it is employed by many researchers for example Sultan et al. (2013) and Shaker (2013). The presence of a unit root in a time series implies that it is non-stationary i.e., behaving in a random fashion that supports the weak-form EMH.

3.6.2 Variance Ratio Test

There are a couple of different types of variance ratio tests. However, this study employed the variance ratio test proposed by Lo and Mackinlay (1988) because it aims at testing the randomness of stock returns. This test is argued to be more powerful compared to others like the unit root test and usually produces results with a higher degree of accuracy (Mobarek & Fiorante, 2014). Scholars have argued that this test is not prone to errors that occur due to false autocorrelation that appears due to non-synchronous trading (Fuss, 2005). The variance ratio test used in this study applied the equation below that was summarised by Karemera et al. (1999).

$$S_t = \mu + S_{t*1} + u_t \quad (7)$$

Where:

S_t= the log of the equity return series at time t.

μ= a drift parameter.

u_t= the random error term.

The usual stochastic assumption on μ_t is the Gaussian error structure, $E(u_{t)} = 0$ and $E(u_t{}^2) = \sigma_u{}^2$

The variance ratio test applied in this study examined the following null and alternative hypotheses whereby:

H_0 = VR(q) =1 which states that the market under study follows the random walk and is weak-form efficient.

$H_1 \neq$ VR(q) ≠1 which states that the market under study does not follow the random walk and is weak-form inefficient.

The above null and alternative hypotheses are used to analyse the results of the variance ratio test to provide a conclusion on whether the return series follow a random walk i.e., are stock prices unpredictable and is today's price independent of tomorrow's price? This will be used to provide a conclusive result on the weak-form efficiency of the JSE.

The variance ratio test was employed using the E-views software. The software used a data specification requiring it to be an exponential random walk. The test specification was calculated using the log returns and it as well included demean data that allows for drift. The asymptotic normal probabilities were selected, and the test periods used were 2, 4,8,16. No further options were specified.

The null hypothesis will be rejected if the p-value is below the 5% level of significance hence concluding that the market (JSE) does not follow the random walk and is weak-form inefficient. On the other hand, the null hypothesis will fail to be rejected if the p-value is above the 5% level on significance hence concluding that the market (JSE) follows the random walk and is weak-form efficient.

3.6.3 Runs Test

According to Urquhart & Hudson (2013), "the runs test is a non-parametric test that investigates the randomness of a series of stock returns." A run is defined by Siegel (1956), as "a succession of identical symbols which are followed or preceded by different symbols or no symbol at all." This test is different from the serial correlations test because it does not need to use normally distributed returns. This makes it suitable unlike statistical tests of significance that assume normality when it does not exist like the serial correlations test which can easily produce misleading results (Urrutia, 1995).

Borges (2010) highlights, "the runs test is based on the notion that if price changes follow the random walk, the actual number of runs should not be far from the expected number of runs." In this study, runs were determined as a series of positive (+) or negative (-) price changes over the period selected. A run exists when two or more successive changes are the same for example (++ or --). If a series of positive or negative runs is disrupted by a negative or positive run, the run ends and a new one begins.

Wallis and Roberts (1956) carry out the runs test using the formula given below.

$$m = \frac{\{N(N+1) - \sum_{i=1}^{3} n_i^2}{N} \quad (8)$$

Where:

m = the total number of expected runs

N = total number of runs

n_i^2 = sample size of each category of price change

For a large number of observations (N>30), the sampling distribution of m is approximately normal and the standard error of σ_m is given by:

$$\sigma_m = \left\{ \frac{\sum_{i=1}^{3} n_i^2 [\sum_{i=1}^{3} n_i^2 + N(N+1) - 2N \sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)} \right\}^{1/2} \quad (9)$$

And the standard normal Z-statistic to test the hypothesis is:

$$Z = \frac{R \pm 0.5 - 3}{\sigma_m} \quad (10)$$

Where:

R = actual number of runs

m = expected number of runs

0.5 = continuity adjustment.

The following null and alternative hypotheses are tested by the runs test.

H_0: Successive changes in the price of the time series are random.

H_1: Successive changes in the price of the time series are not random.

The above null and alternative hypotheses are used to analyse the results of the runs test to provide a conclusion on whether the return series follow a random walk i.e., are stock prices unpredictable and is today's price independent of tomorrow's price? This will be used to provide a conclusive result on the weak-form efficiency of the JSE.

If the number of runs is below the expected runs i.e., R≤ m, the Z-value will be negative, and this is an indication of the presence of positive serial correlation. On the other hand, if the number of runs exceeds the expected runs i.e., R≥ m, the Z-value will be positive, which is an indication of the presence of negative serial correlation.

The presence of a positive serial correlation in a return series shows the positive dependence of stock returns and this implies the violation of the RWH. Therefore, the null hypothesis of the return series is rejected. On the other hand, the presence of negative correlation in the return series shows the negative dependence of stock returns which implies the observation of the random walk hypothesis and therefore failure to reject the null hypothesis.

The runs test was conducted using Microsoft Excel because it is not accessible on the E-views software. Randomness was tested for all the time series on level data.

3.6.4 AR (1)-GARCH (1,1)-Model

This research employs a Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model. Autoregressive describes a feedback mechanism in which recent observations are reflected into the present. Heteroscedasticity represents differing volatility dispersion and conditional refers to the dependence on the most recent observations. The GARCH model was first introduced by Bollerslev (1986) then defined and developed by Emerson et al. (1997) to examine volatility in returns. It has been very successful in describing the behaviour of financial return data mainly because it can capture both volatility clustering and unconditional return distributions. This model (AR (1)- GARCH (1,1)) is advantageous compared to a simple linear regression model because it investigates the correlation between past and current returns as well as considers the changing variance of the error structure of the model. Furthermore, this model is advantageous because it explains the trade-off between stock returns and risk which is a familiar trait in emerging stock markets. Furthermore, the GARCH (1,1) model allows for a time-variant conditional variance and nonlinearities in the generating mechanism. Although there has been an introduction of various extensions to the GARCH (1,1) model to account for asymmetry effects, Brooks and Burke (2003), Mala and Reddy (2007) highlight that the basic GARCH (1,1) model is sufficient to capture all the volatility clustering and unconditional return distribution with heavy tails present in the data. This model was mainly employed in this study because the efficiency of emerging markets tends to evolve over time as the markets continuously strengthen their regulatory environment. The estimation of this model involves the estimation of two distinct specifications, one for the conditional mean and the other for the conditional variance. A number of studies have employed the GARCH (1,1) model for example Guermezi and Boussaada (2016), Ugurlu et al. (2014). The GARCH (1,1) model can be expressed as follows.

Mean Equation: $r_t=\beta_0+\beta_1 r_{t-1}+\gamma\sigma^2+e_t$ (11)

Variance Equation: $\sigma_t^2=a_0+a_1\varepsilon_{t-1}^2+a_2\sigma_{t-1}^2$ (12)

$e_t \sim N(0, \sigma_t^2)$ (13)

Where:

r_t= stock market return.

σ_t^2= the time-varying conditional variance.

β_0, β_1 and γ are intercept, AR (1) is the coefficient and risk premium parameter respectively in the mean equation.

a_0, a_1, a_2 are the intercept, coefficient of the lag of the residual and the coefficient of the last period's forecast variance, respectively.

ε_t= a gaussian innovation with zero mean and time-varying covariance σ_t^2

The coefficients listed above issue the long-run estimates of the mean and conditional variance equations. Bahadur (2010) highlights that if the summation of a_1 and β_1 is greater than or very close to one, the market is inefficient, and it shows high persistence in volatility clustering. However, if it is not close to one, this shows low persistence in volatility clustering and the market is deemed efficient.

3.6.4.1 Applying AR (1)- GARCH (1,1) Model

For the AR (1)- GARCH (1,1) Model to be deemed a good/fit model, certain assumptions need to be in place i.e., the ability of the model to provide reliable results on the weak-form efficiency of the JSE. The following assumptions are highlighted below, and different post-diagnostic tests are conducted to check if they hold.

Assumption 1: No serial correlation in residual

For the AR (1)- GARCH (1,1) model to be deemed good, there must be an absence of serial correlation. The existence of serial correlation can be determined by applying several different statistical tests, however, this study employed the Ljung Box test. This is used to test the following null and alternative hypotheses.

H_0: There is no serial correlation in residuals.

H_1: There is a serial correlation in residuals.

Assumption 2: Absence of ARCH effect

For the AR (1)- GARCH (1,) Model to be deemed good, there must be an absence of an arch effect in the residual. The Heteroskedasticity test was applied to determine the absence of an arch effect and the following null and alternative hypotheses were tested.

H_0: There is no arch effect.

H_1: There is an arch effect.

The aim of this chapter was to break down the different statistical approaches applied in this study. The unit root tests, variance ratio tests and runs test were employed to determine the presence of stochastic and non-stochastic processes (whether stock prices exhibit a random walk). The GARCH model was employed to examine whether stock prices exhibit volatility clustering i.e., whether persistence of the amplitudes of price changes occurs due to large changes in stock prices clustering together. It should be noted that the overall aim of this methodology was to examine whether stock prices follow a random walk and provide a conclusion on the weak-form efficiency of the JSE. Furthermore, all the data (historical index value prices and share prices) and statistical tests used in this study are from public databases hence no ethical clearance is needed.

3.7 Conclusion

This chapter provided an in-depth assessment of the methods implemented, as well as the procedure that the research followed to empirically present the relationships within the variables of interest. This chapter also gave a brief background of the different tests applied in the research as well as an explanation of the potential results from the research. The proceeding chapter presents the analysis of results using the methods discussed above.

Chapter 4: Empirical Results

This study aims at understanding whether the JSE is weak-form efficient. This was done by running different tests that helped establish if the JSE follows a random walk and whether an investor can earn an abnormal return by investing in it. This section, therefore, presents a detailed discussion of the results generated from the various research methods applied. The analysis starts with a graphical discussion, followed by a discussion of the unit root test, variance ratio test, runs test and GARCH model results.

4.1 Graphical Illustration

This section examines the behaviour of the weekly and monthly data of the JSE indices for the period 30th January 2009 to 30th January 2019. The data used in this illustration is the weekly and monthly closing prices of the three indices of the JSE i.e., RESI 10, FINI 15 and INDI 25. This is done to show the overall performance of these indices during the period under study and to understand whether the time series exhibit stationarity or non-stationarity. The presence of stationarity implies that the market exhibits mean reversion. Stationarity simply means that the time series (stock prices) do not change over time and mean reversion means that stock prices tend to move back to their average price over time. The presence of mean reversion implies that market participants can predict the future price of a security which makes it possible for one to earn an abnormal return and this confirms the weak-form inefficiency of the JSE. Figures 1 and 2 show the individual performance of the different indices and they are presented below with a brief discussion of their financial performance over the study period.

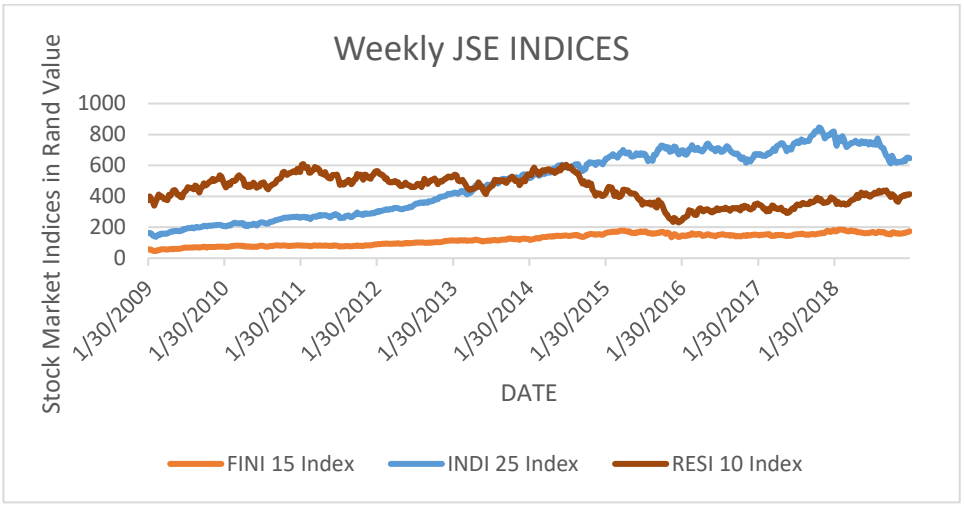


Figure 2. Movements among the stock indices' prices

This figure displays the weekly closing price movements of the sample stock indices denominated in Rand values between the period of January 2009 to January 2019. The data used in the figure above is indexed to 100 to a common starting point of 30th of January 2009.

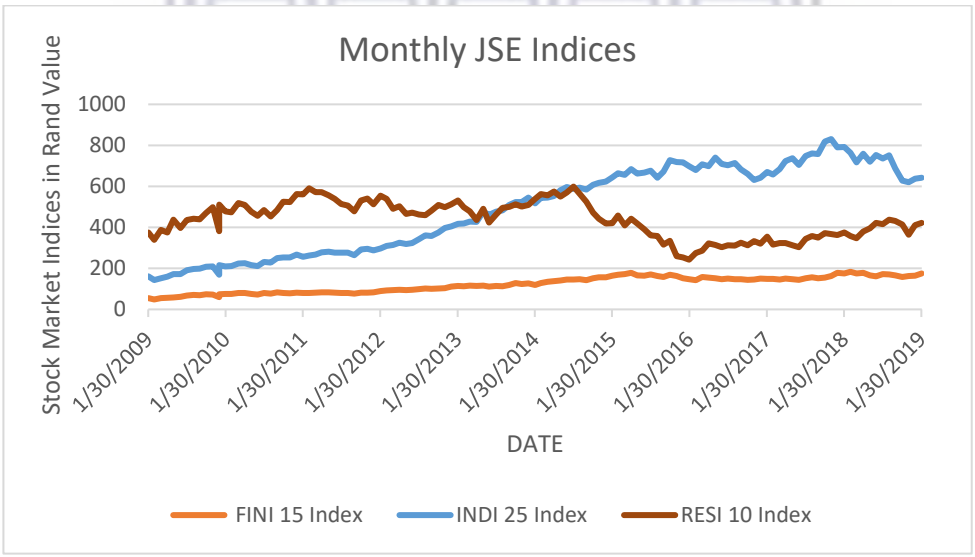


Figure 3 Movements among the stock indices' prices

This figure displays the monthly closing price movements of the sample stock indices denominated in Rand values between the period of January 2009 to January 2019. The data used in the figure above is indexed to 100 to a common starting point of 30th of January 2009.

Figures 2 and 3 although use different data frequencies have a similar graphical illustration. From the figures above, it is clearly shown that the indices do not indefinitely stay in downtrends or uptrends. They are always prone to trend changes with some being more volatile than others. As shown in Figures 2 and 3, the FINI 15 Index is less volatile compared to the RESI 10 and INDI 25 Indices. It can also be seen that the INDI 25 Index is negatively correlated to both the RESI 10 and INDI 25 indices.

The graphs showing the stationarity of the time series of the JSE indices were drawn with the help of Eviews. In addition, the graphs presented below were conducted using both weekly and monthly data of the JSE indices for the period 30th January 2009 to 30th January 2019. An investigation of stationarity in these time series helps in understanding whether the JSE exhibits a random walk which helps determine its weak-form efficiency. The presence of stationarity means the market does not exhibit a random walk hence determining its weak-form inefficiency. The graphs investigating the stationarity of the JSE are presented below.

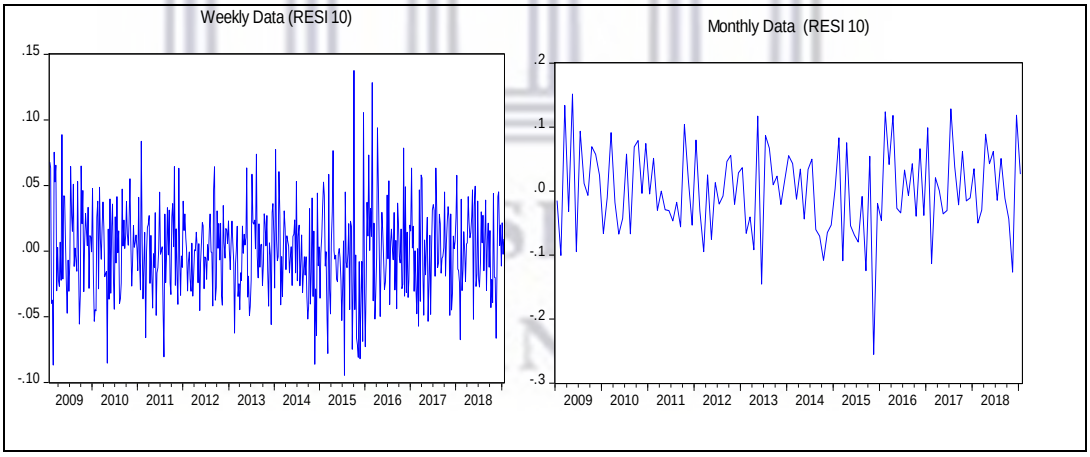


Figure 4. Stationarity Test of the RESI 10 Index

Figure 4 is plotted using weekly and monthly log returns to account for the effects of compounding. This figure shows that the RESI 10 index exhibits stationarity when both the weekly and monthly data are analysed. This implies that the time series exhibit mean reversion therefore the future prices of a security are predictable by an investor, hence can earn an abnormal return.

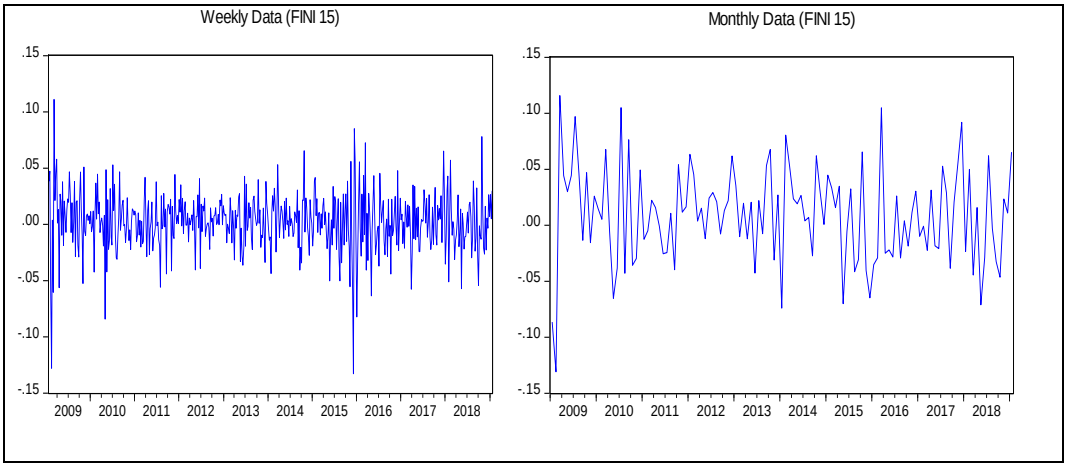


Figure 5. Stationarity Test of the FINI 15 Index

Figure 5 is plotted using weekly and monthly log returns to account for the effects of compounding. This figure shows that the FINI 15 index exhibits stationarity when both the weekly and monthly data are analysed. This implies that the time series exhibit mean reversion therefore the future prices of a security are predictable by an investor, hence can earn an abnormal return.

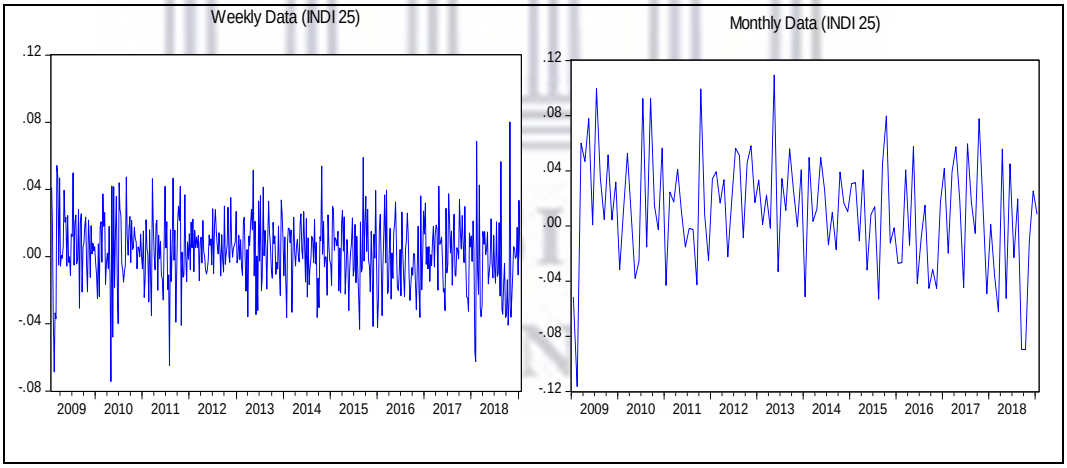


Figure 6. Stationarity Test of the INDI 25 Index

Figure 6 is plotted using weekly and monthly log returns to account for the effects of compounding. This figure shows that the INDI 25 index exhibits stationarity when both the weekly and monthly data are analysed. This implies that the time series exhibit mean reversion, therefore the future prices of a security are predictable by an investor, hence can earn an abnormal return.

Figures 4 to 6 are plotted using the log returns calculated using the formula in (Chapter 3 section 3.6) to account for the effects of compounding. The continuously

compounded returns of all the three indices point towards stationarity around the mean and appear to be mostly mean reverting. The presence of mean reversion implies that predictability of future prices of a security is possible in this market and market participants can earn an abnormal return which is against the random walk and EMH theory. Therefore, from these stationarity test graphs, it is concluded that the JSE does not exhibit a random walk which concludes its weak-form inefficiency. This means the future price of a security can be predicted by an investor which makes it possible to earn an abnormal return.

Although these graphs show different uptrends and downtrends in all three indices, it is difficult to conclude whether these movements are random or predictable and for this reason, the tests that follow in the next sections are conducted to provide a conclusive result on the JSE's weak-form efficiency.

4.2 Unit Root Tests

Although there are various groups of unit root tests, this study employed the Augmented Dickey-Fuller test (ADF) and Phillip Perron test (PP). These tests were applied to examine the stationarity of the time series which would help in determining if it follows a random walk and this would be used to make an informed conclusion on the weak-form efficiency of the JSE. The null and alternative hypotheses for both these unit root tests are:

$H_{0:}$ $\rho=1$ The time series contains a unit root i.e., non-stationary.

H_1: $\rho\neq 1$ The time series does not contain a unit root i.e., stationary.

The key in the table below is used to define the use of the asterisks in relation to the different significance levels used in the unit root test.

Key		
Level of significance	**Decimal (P-value)**	**No. of asterisks**
10%	0.1	*
5%	0.05	**
1%	0.01	***

Note: The asterisks represent how the null hypothesis will be rejected at different significance levels.

4.2.1 Augmented Dickey-Fuller (ADF) Test and Phillips-Perron Unit Root Test Analysis of the Results of the JSE Indices

The ADF test and PP test are carried out using weekly and monthly data for the three different JSE indices (RESI 10, FINI 15, INDI 25). Using the ADF test, both the weekly and monthly results reveal that the t-statistics for both intercept, trend and intercept are significant at the 1% level hence the null hypothesis is rejected. This means that the time series have no unit root and are stationary which implies that they do not behave randomly. From these results, it is concluded that the JSE is weak-form inefficient since it does not exhibit a random walk. This means that an investor can predict the future price of a security which makes it possible to earn an abnormal return and this is against the EMH theory. The weekly and monthly results of the ADF test are displayed in Table 1 below.

Similar results are reported for the PP Test. Both the weekly and monthly results show that the t-statistics values for both intercept, trend and intercept are significant at the 1% significance level for all the indices and due to this, the null hypothesis is rejected. This means that the time series have no unit root and are stationary which implies that they do not behave randomly. From these results, it is concluded that the JSE is weak-form inefficient since it does not exhibit a random walk. This means that an investor can predict the future price of a security which makes it possible to earn an abnormal return and this is against the EMH theory. The weekly and monthly results of the PP test are displayed in Table 1 below.

Table 1. ADF and PP Test Results of the JSE Indices

Series (Observations)	Data	ADF T-statistic		PP T-statistic	
		Intercept	Trend + Intercept	Intercept	Trend + Intercept
RESI 10 Index	Weekly	-23.184***	-23.168***	-23.334***	-23.323***
FINI 15 Index	Weekly	-16.207***	-16.280***	-25.163***	-25.527***
INDI 25 Index	Weekly	-23.621***	-23.839***	-23.791***	-25.060***
RESI 10 Index	Monthly	-13.538***	-13.450***	-13.323***	-13.292***
FINI 15 Index	Monthly	-11.791***	-11.901***	-11.876***	-12.178***
INDI 25 Index	Monthly	-11.939***	-12.569***	-11.944***	-12.949***

Table 1 above displays the weekly and monthly results of both the PP and ADF tests for the JSE indices. The null hypothesis is rejected because the number of asterisks for both tests show that the t-statistic is significant at the 1% level. This means that the JSE indices do not exhibit randomness and are stationary which concludes that the JSE is weak-form inefficient.

4.2.2 Augmented Dickey-Fuller Test (ADF) and Phillips-Perron Unit Root Test Analysis of the Results of the Companies under the RESI 10, FINI 15 and INDI 25 Indices

The ADF and PP tests are carried out using weekly and monthly data for the companies that fall under the RESI 10, FINI 15 and INDI 25 Indices.

Using the ADF test, both the weekly and monthly results show that the t-statistics for both intercept, trend and intercept for all the companies under the RESI 10 Index (Anglo American Platinum Limited, Anglo Gold Ashanti, BHP Group PLC, Gold Fields Limited) are significant at the 1% level. Due to this, the null hypothesis is rejected. From these results, it is concluded that the JSE is weak-form inefficient since it does not exhibit a random walk. This means that an investor can predict the future price of a security which makes it possible to earn an abnormal return and this is against the EMH theory.

Using the PP test, both the weekly and monthly results show that the t-statistics for both intercept, trend and intercept for all the companies under the RESI 10 Index (Anglo American Platinum Limited, Anglo Gold Ashanti, BHP Group PLC, Gold Fields Limited) are significant at the 1% level. From these results, it is concluded that the JSE is weak-form inefficient since all the companies do not exhibit a random walk. This means that an investor can predict the future price of a security which makes it possible to earn an abnormal return and this is against the EMH theory. The companies under the RESI 10 index were analysed using the ADF and PP test and their weekly and monthly results are displayed in Table 2 below.

Table 2. Weekly and Monthly Results of the ADF and PP Test for the Companies under the RESI 10 Index

Series (Observations)	Data	ADF T-statistic		PP T-statistic	
		Intercept	Trend + Intercept	Intercept	Trend + Intercept
AMS	Weekly	-22.161***	-22.148***	-22.160***	-22.147***
ANG	Weekly	-22.116***	-22.100***	-22.115***	-22.099***
BHP	Weekly	-25.412***	-25.396***	-26.131***	-26.139***
GFI	Weekly	-23.506***	-23.485***	-23.518***	-23.498***
AMS	Monthly	-11.491***	-11.457***	-11.479***	-11.449***
ANG	Monthly	-10.506***	-10.472***	-61.157***	-66.056***
BHP	Monthly	-12.812***	-12.785***	-12.680***	-12.656***
GFI	Monthly	-11.172***	-11.133***	-11.180***	-11.140***

Table 2 above displays the weekly and monthly results of both the ADF and PP tests for all the companies under the RESI 10 index. The null hypothesis is rejected because the number of asterisks for both the ADF and PP tests show that the t-statistic is significant at the 1% level. This means that the companies under the RESI 10 index do not exhibit randomness and are stationary which concludes that the JSE is weak-form inefficient.

Using the ADF test, both the weekly and monthly results show that the t-statistics for both intercept, trend and intercept for all the companies under the FINI 15 Index (Absa Group Limited, First Rand Limited, Sanlam Limited, Standard Bank Group) are significant at the 1% level. From these results, it is concluded that the JSE is weak-form inefficient since all the companies do not exhibit a random walk. This means that an investor can predict the future price of a security which makes it possible to earn an abnormal return and this is against the EMH theory.

Using the PP test, both the weekly and monthly results show that the t-statistics for both intercept, trend and intercept for all the companies under the FINI 15 Index (Absa Group Limited, First Rand Limited, Sanlam Limited, Standard Bank Group) are significant at the 1% level. From these results, it is concluded that the JSE is weak-form inefficient since all the companies do not exhibit a random walk. This means that an investor can predict the future price of a security which makes it

possible to earn an abnormal return and this is against the EMH theory. The companies under the FINI 15 index were analysed using the ADF and PP test and their weekly and monthly results are displayed in Table 3 below.

Table 3. Weekly and Monthly Results of the ADF and PP Test for the Companies under the FINI 15 Index

Series (Observations)	Data	ADF T-statistic		PP T-statistic	
		Intercept	Trend + Intercept	Intercept	Trend + Intercept
ABG	Weekly	-25.712***	-25.701***	-25.712***	-25.700***
FSR	Weekly	-17.159***	-17.148***	-26.418***	-26.400***
SLM	Weekly	-19.068***	-19.092***	-25.836***	-26.137***
SBK	Weekly	-25.986***	-25.966***	-25.991***	-26.031***
ABG	Monthly	-11.052***	-11.039***	-11.109***	-11.116***
FSR	Monthly	-12.725***	-12.739***	-12.891***	-13.005***
SLM	Monthly	-12.478***	-12.637***	-12.478***	-12.846***

Table 3 above displays the weekly and monthly results of both the ADF and PP tests for the companies under the FINI 15 index. The null hypothesis is rejected because the number of asterisks for both the ADF and PP tests show that the t-statistic is significant at the 1% level. This means that the companies under the FINI 15 index are stationary and do not exhibit randomness which concludes that the JSE is weak-form inefficient.

Using the ADF test, both weekly and monthly results show that the t-statistics for both intercept, trend and intercept for all the companies under the INDI 25 Index (British American Tobacco PLC, Compagnie Financière Richemont SA, MTN Group, Naspers Limited) are significant at the 1% level and due to this, the null hypothesis is rejected. From these results, it is concluded that the JSE is weak-form inefficient since all the companies do not exhibit a random walk. This means that an investor can predict the future price of a security which makes it possible to earn an abnormal return and this is against the EMH theory.

Using the PP test, both weekly and monthly results show that the t-statistics for both intercept, trend and intercept for all the companies under the INDI 25 Index (British American Tobacco PLC, Compagnie Financière Richemont SA, MTN Group,

Naspers Limited) are significant at the 1% level and due to this, the null hypothesis is rejected. From these results, it is concluded that the JSE is weak-form inefficient since all the companies do not exhibit a random walk. This means that an investor can predict the future price of a security which makes it possible to earn an abnormal return and this is against the EMH theory. The companies under the INDI 25 index were analysed using the ADF and PP test and their weekly and monthly results are displayed in Table 4 below.

Table 4. Weekly and Monthly Results of the ADF and PP Test for the Companies under the INDI 25 Index

Series (Observations)	Data	ADF T-statistic		PP T-statistic	
		Intercept	Trend + Intercept	Intercept	Trend + Intercept
BTI	Weekly	-24.451***	-24.604***	-24.432***	-24.596***
CFR	Weekly	-23.601***	-23.841***	-23.722***	-24.336***
MTN	Weekly	-24.091***	-16.233***	-24.545***	-25.112***
NPN	Weekly	-25.123***	-25.164***	-25.501***	-25.689***
BTI	Monthly	-11.027***	-11.334***	-11.026***	-11.366***
CFR	Monthly	-13.140***	-14.086***	-12.951***	-14.139***
MTN	Monthly	-13.094***	-13.736***	-12.894***	-13.670***
NPN	Monthly	-12.377***	12.526***	-12.427***	-12.750***

Table 4 above displays the weekly and monthly results of both the ADF and PP tests for the companies under the INDI 25 index. The null hypothesis is rejected because the number of asterisks for both the ADF and PP tests show that the t-statistic is significant at the 1% level. This means that the JSE indices are stationary and do not exhibit randomness which concludes that the JSE is weak-form inefficient.

In conclusion, time series cannot exhibit randomness if they do not possess a unit root. It should be noted that even though the existence of a unit root is not a sufficient condition for the random walk, it is a mandatory condition, and this implies that time series cannot behave randomly if they do not possess a unit root. Therefore, based on the results of both the ADF and PP test, the null hypothesis is

rejected, and it is concluded that the JSE is a weak-form inefficient market during the period of 30th January 2009 to 30th January 2019.

4.3 Variance Ratio Test

The variance ratio test was applied in this study to examine the randomness of stock returns. If stock returns are random, this means that one cannot predict the future price of a stock which makes it impossible to make an abnormal return, hence the market (JSE) is weak-form efficient. This test was carried out using weekly and monthly returns for the three different indices of the JSE (RESI 10, FINI 15, INDI 25) as well as the individual companies under these indices. This test gives two results, namely the individual tests and joint tests. The individual test results apply to the individual test periods stated while the joint test results provide the tests of the joint null hypothesis for all test periods.

The variance ratio test was applied to examine the null and alternative hypotheses listed below.

H_0 = VR(q)=1 The market under exhibits a random walk hence weak-form efficient.

$H_1 \neq$ VR(q) $\neq$1 The market under study does not exhibit a random walk hence weak-form inefficient.

4.3.1 Analysis of the Weekly and Monthly Results of the JSE Indices

This section analyses the weekly and monthly results of the variance ratio test for the RESI 10, FINI 15 and INDI 25 indices. The results are interpreted in detail below.

4.3.1.1 Analysis of the Weekly Results of the JSE Indices

The joint test result of the RESI 10 index is statistically significant at 5% since its p-value (0.0000) is below alpha (0.05) hence the null hypothesis is rejected. Similarly, the results of the individual test for all the periods (2,4,8,16) of the RESI 10 index reject the null hypothesis as their p-values are below the 5% level of significance. This means that the weekly return series of the RESI 10 index do not exhibit randomness hence the JSE is weak-form inefficient. This implies that an investor can earn an abnormal return by predicting the future price of a security.

The joint test result of the FINI 15 index is statistically significant at 5% since its p-value (0.0000) is below alpha (0.05) hence the null hypothesis is rejected. Similarly, the results of the individual test for all the periods (2,4,8,16) of the FINI 15 index reject the null hypothesis as their p-values are below the 5% level of significance. This means that the weekly return series of the FINI 15 index are not random hence the JSE is weak-form inefficient. This implies that an investor can earn an abnormal return by predicting the future price of a security.

The joint test result of the INDI 25 index is statistically significant at 5% since its p-value (0.0000) is below alpha (0.05) hence the null hypothesis is rejected. Similarly, the individual test for all the periods (2,4,8,16) of the INDI 25 index reject the null hypothesis as their p-values are below the 5% level of significance. This means that the weekly return series of the RESI 10 index are not random hence the JSE is weak-form inefficient. This implies that an investor can earn an abnormal return by predicting the future price of a security. The weekly joint test results of the variance ratio test for all the JSE indices are reported in Table 5 and the weekly individual test results for all the JSE indices are reported in Table 6 below.

Table 5. Joint Test Results of the Variance Ratio Test based on Weekly Data of the JSE Indices

Series (Observations)	**Joint tests (Values)**		**Df**		**Probability**	
	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)
RESI 10 Index (Weekly)	5.970980	35.712252	139	4	0.0000	0.0000
FINI 15 Index (Weekly)	7.295673	57.96383	153	4	0.0000	0.0000
INDI 25 Index (Weekly)	5.636326	33.15019	158	4	0.0000	0.0000

Table 6. Individual Test Results of the Variance Ratio Test based on Weekly Data of the JSE Indices

Series (Observations)	Period	z-Statistic (Weekly)	Probability (Weekly)
RESI 10 Index (Weekly)	2	-5.970980	0.0000
	4	-4.878715	0.0000
	8	-3.537690	0.0004
	16	-2.504779	0.0123
FINI 15 Index (Weekly)	2	-7.295673	0.0000
	4	-4.754900	0.0000
	8	-3.657118	0.0003
	16	-2.556867	0.0106
INDI 25 Index (Weekly)	2	-5.636326	0.0000
	4	-5.104194	0.0000
	8	-3.647765	0.0003
	16	-2.552941	0.0107

In conclusion, from the weekly results of the variance ratio test displayed in Tables 5 and 6 above, it is seen that the p-values of all the indices of the JSE for both the joint and individual tests are below the 5% critical values. This implies that all the weekly return series of the respective indices do not behave randomly. Due to this, the null hypothesis of the study is rejected and confirms that the JSE is a weak-form inefficient market hence an investor can earn an abnormal return because he can predict the future price of a security.

4.3.1.2 Analysis of the Monthly Results of the JSE Indices

The joint test result of the RESI 10 index is statistically significant at 5% since its p-value (0.0086) is below alpha (0.05) hence the null hypothesis is rejected. However, the results of the individual test for the periods (4,8,16) of the RESI 10 index are above the 5% level of significance as their respective p-values (0.5081, 0.5306, 0.6658) are below alpha (0.05), other than the first period (2) which is below the 5% level of significance as it has a p-value (0.0022) that is below alpha (0.05).

The joint test result of the FINI 15 index is statistically significant at 5% since its p-value (0.0354) is below alpha (0.05) hence the null hypothesis is rejected. However, the results of the individual test for the periods (8,16) of the FINI 15 index are above the 5% level of significance as their respective p-values (0.0572, 0.1692) are above alpha (0.05), other than for the first and second period (2,4) which are below the 5% level of significance as their respective p-values (0.0272, 0.0090) respectively that are below alpha.

The joint test result of the INDI 25 index is statistically significant at 5% since its p-value (0.0001) is below alpha (0.05) hence the null hypothesis is rejected. However, the results of the individual test for the periods (8,16) of the INDI 25 index are above the 5% level of significance as their respective p-values (0.0801, 0.2810) are above alpha (0.05), other than for the first and second period (2,4) which are below the 5% level of significance as their respective p-values (0.0000, 0.0049) are below alpha. The monthly joint test results of the variance ratio test for all the JSE indices are displayed in Table 7 and the monthly individual test results of all the JSE indices are displayed in Table 8 below.

Table 7. Joint Test Results of the Variance Ratio Test based on Monthly Data of the JSE Indices

Series (Observations)	**Joint tests (Values)**		**Df**		**Probability**	
	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)
RESI 10 Index (Monthly)	3.066418	26.55168	21	4	0.0086	0.0000
FINI 15 Index (Monthly)	2.612979	7.297371	39	4	0.0354	0.1210
INDI 25 Index (Monthly)	4.166309	18.24558	45	4	0.0001	0.0011

Table 8. Individual Test Results of the Variance Ratio Test based on Monthly Data of the JSE Indices

Series (Observations)	Period	z-Statistic (Monthly)	Probability (Monthly)
RESI 10 Index (Monthly)	2	-3.066418	0.0022
	4	-0.661803	0.5081
	8	-0.627037	0.5306
	16	0.431931	0.6658
FINI 15 Index (Monthly)	2	-2.208848	0.0272
	4	-2.612979	0.0090
	8	-1.902087	0.0572
	16	-1.374644	0.1692
INDI 25 Index (Monthly)	2	-4.166309	0.0000
	4	-2.813286	0.0049
	8	-1.750188	0.0801
	16	-1.077979	0.2810

In conclusion, from the monthly joint test results of the variance ratio test displayed in Tables 7 and 8 above, it is seen that the p-values of all the indices of the JSE for both the joint and individual tests are below the 5% critical values. This implies that the monthly return series of the respective indices do not exhibit randomness. Due to this, the null hypothesis of the study is rejected, and it is confirmed that JSE is not a weak-form efficient market, hence an investor can earn an abnormal return because he can predict the future price of a stock.

However, a look at the individual test of the variance ratio test reveals mixed results of weak-form efficiency. Some periods of the different indices fail to reject the null hypothesis as their p-values are above the 5% level of significance while other periods reject the null hypothesis as their p-values are below the 5% level of significance. This shows that financial markets can exhibit weak-form efficiency during certain periods and weak-form inefficiency during other periods. Therefore, from the use of the monthly individual results, we conclude that for the period studied, the JSE exhibits weak-form efficiency during certain periods and weak-form inefficient during other periods during the study period of 30th January 2009 to 30th January of 2019. This means that there are opportunities for an investor to

make an abnormal return during certain periods of weak-form inefficiency because one can predict the future price of a stock. However, during certain periods, an investor cannot earn an abnormal return because it is impossible to predict the future stock price.

4.3.2 Analysis of the Weekly and Monthly Results of the Companies under the RESI 10, FINI 15 and INDI 25 Indices

This section analyses the weekly and monthly results of the variance ratio test for the companies under the RESI 10, FINI 15 and INDI 25 indices. The results are interpreted in detail below.

4.3.2.1 Analysis of the Weekly Results of the Companies under the RESI 10 Index

The joint test results of all the companies under the RESI 10 index (Anglo American Platinum Limited, Anglo Gold Ashanti Limited, BHP Group PLC, Gold Fields Limited) are statistically significant at 5% since they all have a p-value of 0.0000 which is below alpha (0.05) hence the null hypothesis is rejected. Similarly, the results of the individual tests for all the periods (2,4,8,16) of the respective companies under the RESI 10 index have p-values that are below the 5% level of significance hence the null hypothesis is rejected. This means that the weekly return series of the RESI 10 index do not exhibit randomness hence the JSE is weak-form inefficient. This implies that an investor can earn an abnormal return by predicting the future price of a security. The weekly joint test results of the variance ratio test of the companies under the RESI 10 index are reported in Table 9 and the weekly individual test results of the RESI 10 Index are displayed in Table 10 below.

Table 9. Joint Test Results of the Variance Ratio Test based on Weekly Data of the Companies under the RESI 10 Index

Series (Observations)	Joint tests (Values)		Df		Probability	
	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)
AMS (Weekly)	6.543020	43.23371	132	4	0.0000	0.0000
ANG (Weekly)	4.662726	24.70988	119	4	0.0000	0.0001
BHP (Weekly)	8.000028	68.66341	148	4	0.0000	0.0000
GFI (Weekly)	6.446051	46.04653	116	4	0.0000	0.0000

Table 10. Individual Test Results of the Variance Ratio Test based on Weekly Data of the companies under the RESI 10 Index

Series (Observations)	Period	z-Statistic (Weekly)	Probability (Weekly)
AMS	2	-6.543020	0.0000
	4	-4.861388	0.0000
	8	-3.447930	0.0006
	13	-2.480240	0.0131
ANG	2	-4.662726	0.0000
	4	-4.533490	0.0000
	8	-3.125893	0.0018
	16	-2.287710	0.0222
BHP	2	-8.000028	0.0000
	4	-5.180707	0.0000
	8	-3.683483	0.0002
	16	-2.542689	0.0110
GFI	2	-6.446051	0.0000
	4	-4.072556	0.0000
	8	-3.116733	0.0018
	16	-2.197221	0.0280

In conclusion, based on the weekly results of the variance ratio test displayed in Tables 9 and 10 above, it is seen that the p-values for both the joint and individual

tests of all the companies under the RESI 10 index are below the 5% critical values. This implies that all the weekly return series of the respective indices do not behave randomly. Due to this, the null hypothesis of the study is rejected, and it is confirmed that the JSE is a weak-form inefficient market, hence an investor can earn an abnormal return because he can predict the future price of a stock.

4.3.2.2 Analysis of the Weekly Results of the Companies under the FINI 15 Index

The joint test results of all the companies under the FINI 15 index (Absa Group Limited, First Rand Limited, Sanlam Limited, Standard Bank Group) are statistically significant at 5% since they all have a p-value of 0.0000 which is below alpha (0.05) hence the null hypothesis is rejected. Similarly, the results of the individual tests for all the periods (2,4,8,16) of the respective companies under the RESI 10 index have p-values that are below the 5% level of significance hence the null hypothesis is rejected. This means that the weekly return series of the FINI 15 index do not exhibit randomness hence the JSE is weak-form inefficient. This implies that an investor can earn an abnormal return by predicting the future price of a security. The weekly joint results of the variance ratio test of the companies under the FINI 15 index are reported in Table 11 and the weekly individual test results of the FINI 15 Index are reported in Table 12 below.

Table 11. Joint Test Results of the Variance Ratio Test based on Weekly Data of the Companies under the FINI 15 Index

Series (Observations)	**Joint tests (Values)**		**Df**		**Probability**	
	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)
ABG (Weekly)	5.316783	28.41186	141	4	0.0000	0.0000
FSR (Weekly)	8.936711	88.10006	152	4	0.0000	0.0000
SLM (Weekly)	6.906132	48.29699	145	4	0.0000	0.0000
SBK (Weekly)	6.382990	41.19103	131	4	0.0000	0.0000

Table 12. Individual Test Results of the Variance Ratio Test based on Weekly Data of the companies under the FINI 15 Index

Series (Observations)	Period	z-Statistic (Weekly)	Probability (Weekly)
ABG	2	-5.316783	0.0000
	4	-4.422301	0.0000
	8	-3.438603	0.0006
	16	-2.506345	0.0122
FSR	2	-8.936711	0.0000
	4	-5.495284	0.0000
	8	-3.735832	0.0002
	16	-2.460809	0.0139
SML	2	-6.906132	0.0000
	4	-5.073892	0.0000
	8	-3.600914	0.0003
	16	-2.564073	0.0103
SBK	2	-6.382990	0.0000
	4	-4.722557	0.0000
	8	-3.395407	0.0007
	16	-2.452140	0.0142

In conclusion, based on the weekly results of the variance ratio test displayed in Tables 11 and 12 above, it is seen that the p-values for both the joint and individual tests of all the companies under the FINI 15 index are below the 5% critical values. This implies that all the weekly return series of the respective indices do not behave randomly. Due to this, the null hypothesis of the study is rejected, and it is concluded that the JSE is a weak-form inefficient market, hence an investor can earn an abnormal return because he can predict the future price of a stock.

4.3.2.3 Analysis of Weekly Results of the Companies under the INDI 25 Index

The joint test results of all the companies under the INDI 25 index (British American Tobacco PLC, Compagnie Financière Richemont SA, MTN Group, Naspers Limited) are statistically significant at 5% since they all have a p-value of 0.0000 which is below alpha (0.05) hence the null hypothesis is rejected. Similarly, the results of the individual tests for all the periods (2,4,8,16) of the respective

companies under the RESI 10 index have p-values that are below the 5% level of significance hence the null hypothesis is rejected. This means that the weekly return series of the INDI 25 index are not random hence the JSE is weak-form inefficient. This implies that an investor can earn an abnormal return by predicting the future price of a security. The weekly joint results of the variance ratio test of the companies under the INDI 25 index are reported in Table 13 and the weekly individual test results of the INDI 25 Index are reported in Table 14 below.

Table 13. Joint Test Results of the Variance Ratio Test based on Weekly Data of the Companies under the INDI 25 Index

Series (Observations)	**Joint tests (Values)**		**Df**		**Probability**	
	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)
BTI (Weekly)	4.863722	25.26030	151	4	0.0000	0.0000
CFR (Weekly)	4.678645	23.89619	142	4	0.0000	0.0001
MTN (Weekly)	4.579019	21.19697	112	4	0.0000	0.0003
NPN (Weekly)	7.240410	52.75653	163	4	0.0000	0.0000

Table 14. Individual Test Results of the Variance Ratio Test based on Weekly Data of the companies under the INDI 25 Index

Series (Observations)	Period	z-Statistic (Weekly)	Probability (Weekly)
BTI	2	-3.992809	0.0001
	4	-4.863722	0.0000
	8	-3.537341	0.0004
	16	-2.408296	0.0160
CFR	2	-4.357707	0.0000
	4	-4.678645	0.0000
	8	-3.393315	0.0007
	16	-2.467790	0.0136
MTN	2	-4.579019	0.0000
	4	-3.855172	0.0001
	8	-3.057113	0.0022
	16	-2.204067	0.0275
NPN	2	-7.240410	0.0000
	4	-5.623842	0.0000
	8	-3.865999	0.0001
	16	-2.737121	0.0062

From the weekly results of the variance ratio test displayed in Tables 13 and 14 above, it is seen that the p-values for both the joint and individual tests of all the companies under the INDI 25 index are below the 5% critical values. This implies that all the weekly return series of the respective indices do not behave randomly. Due to this, the null hypothesis of the study is rejected, and it is concluded that the JSE is a weak-form inefficient market hence an investor can earn an abnormal return because he can predict the future price of a stock.

4.3.2.4 Analysis of Monthly Results of the Companies under the RESI 10 Index

The monthly joint and individual test results of the companies under the RESI 10 index provide mixed results. The monthly joint results of the variance ratio test of the companies under the RESI 10 index are reported in Table 15 below.

Table 15. Joint Test Results of the Variance Ratio Test based on Monthly Data of the Companies under the RESI 10 Index

Series (Observations)	Joint tests (Values)		Df		Probability	
	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)
AMS (Monthly)	1.412127	3.454401	27	4	0.4972	0.4848
ANG (Monthly)	3.019786	9.350730	29	4	0.0101	0.0529
BHP (Monthly)	3.608433	13.92385	31	4	0.0012	0.0075
GFI (Monthly)	2.097266	5.191701	25	4	0.1363	0.2682

The joint test results of the companies under the RESI 10 index provide mixed results as seen in Table 15 above. They show that the two companies, Anglo American Platinum Limited and Gold Fields Limited have p-values of 0.4972, 0.1363 respectively which are above alpha (0.05) hence failure to reject the null hypothesis for these two companies. However, the joint test results also show that the other two companies, Anglo Gold Ashanti Limited and BHP Group PLC have p-values of 0.0101, 0.0012 respectively which are below alpha (0.05) hence the null hypothesis for these two companies is rejected.

The monthly individual test results of the RESI 10 index are reported in Table 16 below.

Table 16. Individual Test Results of the Variance Ratio Test based on Monthly Data of the companies under the RESI 10 Index

Series (Observations)	Period	z-Statistic (Monthly)	Probability (Monthly)
AMS	2	-0.621308	0.5344
	4	-1.412127	0.1579
	8	-0.939655	0.3474
	16	-0.503182	0.6148
ANG	2	-3.019786	0.0025
	4	-2.195488	0.0281
	8	-1.646938	0.0996
	16	-1.120531	0.2625
BHP	2	-3.608433	0.0003
	4	-2.358149	0.0184
	8	-1.704671	0.0883
	16	-1.196248	0.2316
GFI	2	-1.751582	0.0798
	4	-2.097266	0.0360
	8	-1.378413	0.1681
	16	-1.000278	0.3172

The individual test results show varying results for the different companies under the RESI 10 index as seen in Table 16 above. The individual results of Anglo American Platinum Limited for all the periods (2,4,8,16) are above the 5% level of significance as they have p-values of 0.5344, 0.1579, 0.3474, 0.6148 respectively, hence failure to reject the null hypothesis is rejected.

The individual test results of Anglo Gold Ashanti for the periods (8,16) are above the 5% level of significance as they have p-values of 0.0996, 0.2625 respectively which are above the 5% level of significance, hence failure to reject the null hypothesis. However, the periods (2,4) are below the 5% level of significance as they have p-values of 0.0025, 0.0281 respectively, hence the null hypothesis is rejected.

The individual test results of BHP Group PLC for the periods (8,16) are above the 5% level of significance as they have p-values of 0.0883, 0.2316 respectively, hence

failure to reject the null hypothesis. However, the periods (2,4) are below the 5% level of significance as they have p-values of 0.0003, 0.0184 respectively, hence the null hypothesis is rejected.

The individual test results of Gold Fields Limited for the periods (2,8,16,) fail to reject the null hypothesis as their p-values of 0.0798, 0.1681, 0.3172 respectively are above the 5% level of significance. However, period (4) rejects the null hypothesis as its p-value of 0.0360 is below the 5% level of significance.

From the analysis of the monthly results of the companies under the RESI 10 index, it is confirmed that the JSE exhibits a random walk during some periods and predictability during others. This means that an investor can earn an abnormal return during certain periods of weak-form inefficiency because it is possible to predict the future price of a stock. However, during certain periods of weak-form efficiency, an investor cannot earn an abnormal return because it is impossible to predict the future stock price.

4.3.2.5 Analysis of Monthly Results of the Companies under the FINI 15 Index

The monthly joint and individual test results of the companies under the RESI 10 index provide mixed results. The monthly joint results of the variance ratio test of the companies under the FINI 15 index are reported in Table 17 below.

Table 17. Joint Test Results of the Variance Ratio Test based on Monthly Data of the Companies under the FINI 15 Index

Series (Observations)	Joint tests (Values)		Df		Probability	
	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)
ABG(Monthly)	2.641951	9.321074	33	4	0.0326	0.0536
FSR (Monthly)	2.115568	5.148880	45	4	0.1306	0.2724
SLM (Monthly)	3.692746	13.71470	40	4	0.0009	0.0083
SBK (Monthly)	3.358806	14.06668	30	4	0.0031	0.0071

The joint test results of the companies under the FINI 15 index in Table 17 above show that the two companies, Sanlam and Standard Bank Group have p-values of 0.0083, 0.0071 respectively which are below alpha (0.05) hence we reject the null hypothesis for these two companies. However, they also show that the other two companies i.e., Absa Group Limited and First Rand Limited have p-values of 0.0536, 0.2724 respectively which are above alpha (0.05), hence we fail to reject the null hypothesis for these two companies.

The monthly individual test results of the FINI 15 Index are reported in Table 18 below.

Table 18. Individual Test Results of the Variance Ratio Test based on Monthly Data of the companies under the FINI 15 Index

Series (Observations)	Period	z-Statistic (Monthly)	Probability (Monthly)
ABG	2	-2.015768	0.0438
	4	-2.641951	0.0082
	8	-1.602720	0.1090
	16	-1.154125	0.2484
FSR	2	-1.239806	0.2150
	4	-2.115568	0.0344
	8	-1.842162	0.0655
	16	-1.287555	0.1979
SML	2	-3.692746	0.0002
	4	-2.808800	0.0050
	8	-1.965278	0.0494
	16	-1.382211	0.1669
SBK	2	-3.358806	0.0008
	4	-1.772269	0.0763
	8	-1.170294	0.2419
	16	-0.599499	0.5488

The individual test results show varying results for the different companies under the FINI 15 index as seen in Table 18 above. The individual results of Absa Group Limited for the periods (8,16) are above the 5% level of significance as they have

p-values of 0.1090, 0.2484 respectively, hence failure to reject the null hypothesis. However, the periods (2,4) are below the 5% level of significance as they have p-values of 0.0438, 0.0082 respectively, hence the null hypothesis is rejected.

The individual test results of First Rand Limited for the periods (2,8,16) are above the 5% level of significance as they have p-values of 0.2150, 0.0655, 0.1979 respectively, hence failure to reject the null hypothesis. However, period (4) is below the 5% level of significance as it has a p-value of 0.0344, hence the null hypothesis is rejected.

The individual test results of Sanlam Limited for the period (16) fail to reject the null hypothesis as its p-value of 0.1669 is above the 5% level of significance, hence failure to reject the null hypothesis. However, the periods (2,4,8) reject the null hypothesis as their p-values of 0.0002, 0.0050, 0.0494 respectively are the same or below the 5% level of significance, hence the null hypothesis is rejected.

The individual test results of Standard Bank Group for the periods (4,8,16,) fail to reject the null hypothesis as their p-values of 0.0763, 0.2419, 0.5488 respectively are above the 5% level of significance, hence failure to reject the null hypothesis. However, period (2) rejects the null hypothesis as its p-value of 0.0008 is below the 5% level of significance, hence the null hypothesis is rejected.

From the analysis of the monthly results of the companies under the FINI 15 index, it is concluded that the JSE follows a random walk during some periods and predictability during others i.e., experiences weak-form efficiency during certain periods and weak-form inefficiency during other periods. This means that an investor can earn an abnormal return during certain periods of weak-form inefficiency because it is possible to predict the future price of a stock. However, during certain periods of weak-form efficiency, an investor cannot earn an abnormal return because it is impossible to predict the future stock price.

4.3.2.6 Analysis of Monthly Results of the Companies under the INDI 25 Index

The monthly joint and individual test results of the companies under the INDI 25 index provide mixed results. The monthly joint results of the variance ratio test of the companies under the INDI 25 index are reported in Table 19 below.

Table 19. Joint Test Results of the Variance Ratio Test based on Monthly Data of the Companies under the INDI 25 Index

Series (Observations)	Joint tests (Values)		Df		Probability	
	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)	Max/z/	Wald (Chi-Square)
BTI (Monthly)	4.788430	26.93151	39	4	0.0000	0.0000
CFR (Monthly)	2.428858	6.761158	34	4	0.0592	0.1491
MTN (Monthly)	2.530277	8.472961	25	4	0.0448	0.0757
NPN (Monthly)	2.411391	7.025260	42	4	0.0621	0.1346

The joint test results of the companies under the INDI 25 index in Table 18 above show that the two companies, Compagnie Financière Richemont SA and Naspers Limited are above the 5% level of significance as they have p-values of 0.0592, 0.0621 respectively, hence failure to reject the null hypothesis for these two companies. However, the joint test results also show that the other two companies, British American Tobacco PLC and MTN Group are below the 5% level of significance as they have p-values of 0.0000, 0.0448, hence the null hypothesis is rejected.

The monthly individual test results of the INDI 25 Index are reported in Table 20 below.

Table 20. Individual Test Results of the Variance Ratio Test based on Monthly Data of the companies under the INDI 25 Index

Series (Observations)	Period	z-Statistic (Monthly)	Probability (Monthly)
BTI	2	-4.788430	0.0000
	4	-2.673623	0.0075
	8	-1.768602	0.0770
	16	-1.155703	0.2478
CFR	2	-2.428858	0.0151
	4	-1.592674	0.1112
	8	-1.350063	0.1770
	16	-0.912611	0.3614
MTN	2	-2.530277	0.0114
	4	-1.374571	0.1693
	8	-1.231405	0.2182
	16	-0.924534	0.3552
NPN	2	-2.357555	0.0184
	4	-2.411391	0.0159
	8	-1.662926	0.0963
	16	-0.841342	0.4002

The individual test results show varying results for the different companies under the INDI 25 index as seen in Table 20 above. The individual results of British American Tobacco PLC for the periods (8,16) are above the 5% level of significance as they have p-values of 0.0770, 0.2478 respectively, hence failure to reject the null hypothesis. However, the periods (2,4) are below the 5% level of significance as they have p-values of 0.0000, 0.0075 respectively, hence the null hypothesis is rejected.

The individual test results of Compagnie Financière Richemont SA for the periods (4,8,16) are above 5% level of significance as they have p-values of 0.1112, 0.1770, 0.3614 respectively, hence failure to reject the null hypothesis. However, period (2) is below the 5% level of significance as it has a p-value of 0.0151, hence the null hypothesis is rejected.

The individual test results of MTN Group for the periods (4,8,16) are above the 5% level of significance as they have p-values of 0.1693, 0.2182, 0.3552 respectively, hence failure to reject the null hypothesis. However, period (2) is below the 5% level of significance as it has a p-value of 0.0184, hence the null hypothesis is rejected.

The individual test results of Naspers Limited for the periods (8,16) are above the 5% level of significance as they have p-values of 0.0963, 0.4002 respectively, hence failure to reject the null hypothesis. However, the periods (2,4) are below the 5% level of significance as they have p-values of 0.0184, 0.0159, hence the null hypothesis is rejected.

From the analysis of the monthly results of the companies under the INDI 25 index, it is concluded that the JSE follows a random walk during some periods and predictability during others i.e., experiences weak-form efficiency during certain periods and weak-form inefficiency during other periods. This means that an investor can earn an abnormal return during certain periods of weak-form inefficiency because it is possible to predict the future price of a stock. However, during certain periods of weak-form efficiency, an investor cannot earn an abnormal return because it is impossible to predict the future stock price.

In conclusion, based on the monthly joint test results and the individual test results, the p-values of the different companies under the different indices provide mixed results. The joint results of some of the companies namely, Absa Group Limited, Anglo American Platinum Limited, Gold Fields Limited, First Rand Limited, Compagnie Financière Richemont SA, Naspers Limited show that their p-values are above the 5% level of significance hence failing to reject the null hypothesis. This means that these companies exhibit weak-form efficiency, and an investor is unable to earn an abnormal return because he cannot predict the future stock price. However, the joint test results of other companies namely, Anglo Gold Ashanti Limited, BHP group PLC, Sanlam Limited, Standard Bank Group, British American Tobacco PLC, MTN Group show that their p-values are below the 5% level of significance, hence rejecting the null hypothesis. This means that these

companies exhibit weak-form inefficiency, and an investor can earn an abnormal return by being able to predict the future stock price.

However, a further look at the individual results of the variance ratio test results reveals mixed results of weak-form efficiency of the different companies. All the companies have periods where their p-values are above the 5% level of significance and periods where their p-values are below the 5% level of significance. This shows that the null hypothesis is not rejected in some periods and rejected in other periods. This reveals that these companies under their respective indices exhibit weak-form efficiency during certain periods and weak-form inefficiency during other periods. From this, we conclude that for the period under study (30th January 2009 to 30th January 2019), the JSE is weak-form efficient during certain periods and weak-form inefficient during other periods. This means that the JSE is not perfectly weak-form efficient and that pricing irregularity, as well as predictable patterns, can appear over time and even persist for short periods.

In conclusion, from the analysis of the monthly results of the companies under the JSE indices, it is revealed that the JSE follows a random walk during some periods and predictability during others i.e., experiences weak-form efficiency during certain periods and weak-form inefficiency during other periods. This means that an investor can earn an abnormal return during certain periods of weak-form inefficiency because it is possible to forecast the future price of a stock. However, during certain periods of weak-form efficiency, an investor cannot earn an abnormal return because it is impossible to forecast the future stock price.

4.4 Runs Test

The runs test was performed using Microsoft Excel to examine whether the weekly and monthly returns of the different indices as well as different individual companies under these indices behave randomly. The following null and alternative hypotheses were used to analyse the runs test.

$H_{0:}$ Successive price changes are random.

$H_{1:}$ Successive price changes are not random.

4.4.1 Analysis of the results of the Runs Test of the JSE Indices

The runs test results show that all the time series of the JSE other than the RESI 10 weekly index have positive Z values which imply that the total observed runs are greater than the expected runs. This suggests there is a negative correlation within these indices. The existence of a negative correlation means that there is negative dependence of share prices and indicates the existence of the random walk hypothesis i.e., the series exhibit randomness. Based on these findings, I fail to reject the null hypothesis and conclude that the JSE exhibits weak-form efficiency. The weekly and monthly results of the runs test of the JSE indices are displayed in Table 21 below.

Table 21. Runs Test Results of the JSE Indices Based on Weekly and Monthly Data

Series (observations)	Expected Runs (m)	Positive Runs	Negative Runs	Total Observed Runs (R)	Z statistic
RESI 10 (Weekly data)	261.94	126	125	251	-0.959
FINI 15 (Weekly data)	258.78	137	136	273	1.262
INDI 25 (Weekly data)	258.78	132	132	264	0.463
RESI 10 (Monthly data)	61.17	35	35	70	1.6221
FINI 15 (Monthly data)	60.01	31	31	62	0.373
INDI 25 (Monthly data)	57.53	31	31	62	0.874

Table 21 above displays the weekly and monthly results of the runs test for the JSE indices. The results show that all the time series other than the RESI 10 weekly index have higher total observed runs than expected runs. Due to this, the Z-statistic for all the time series other than RESI 10 weekly index is positive, and this indicates an existence of negative correlation which implies that the time series exhibit a random walk.

4.4.2 Analysis of the results of the Runs Test of the Companies under the RESI 10 Index

The weekly results of the runs test show that all the time series of the companies under the RESI 10 index have negative Z values which indicate that the total observed runs are less than the expected runs. This suggests that there is a positive correlation within the weekly data of the companies under this index which implies that there is positive dependence of share prices. This reveals the inexistence of the RWH i.e., the inexistence of randomness in the series.

The monthly results of the runs test show that all the time series of the companies under the RESI 10 index have positive Z values which indicate that the total observed runs are greater than the expected runs. This suggests that there is a negative correlation within the monthly data of the companies under this index which implies that there is negative dependence of share prices. This reveals the existence of the RWH i.e., the series exhibit randomness. The weekly and monthly results of the runs test of the RESI 10 index are reported in Table 22 below.

Table 22. Runs Test Results of the Companies under the RESI 10 Index Based on Weekly and Monthly Data

Series (observations)	Expected Runs (m)	Positive Runs	Negative Runs	Total Observed Runs (R)	Z statistic
AMS (Weekly)	261.81	122	121	243	-1.640
ANG (Weekly)	261.02	126	125	251	-0.881
BHP (Weekly)	261.14	128	128	256	-0.452
GFI (Weekly)	261.14	130	129	259	-0.188
AMS (Monthly)	60.98	32	32	64	0.553
ANG (Monthly)	60.98	32	31	63	0.370
BHP (Monthly)	60.98	30	31	61	0.003
GFI (Monthly)	60.93	33	33	66	0.9300

Table 22 above displays the weekly and monthly results of the runs test for the companies under the RESI 10 index. The weekly results show that all the time series of the companies under the RESI 10 index have lower total expected runs than observed runs. Due to this, the Z-statistic for all the time series is negative, and this

indicates an existence of a positive correlation which implies that the time series do not follow a random walk.

The monthly results on the other hand show that all the time series of the companies under the RESI 10 index have higher observed runs than total expected runs. Due to this, the Z-statistic for all the time series is positive, and this indicates an existence of negative correlation which implies that the time series do not follow a random walk.

4.4.3 Analysis of the results of the Runs Test of the Companies under the FINI 15 Index

The weekly results of the runs test show that all the time series of the companies under the FINI 15 index have positive Z values which means that the total observed runs are greater than the expected runs. This suggests that there is a negative correlation within the weekly data of the companies under this index which implies that there is negative dependence of share prices. This reveals the existence of the RWH i.e., the series exhibit randomness.

The monthly results of the runs test show that all the time series of the companies under the FINI 15 index have positive Z values which means that the total observed runs are greater than the expected runs. This suggests that there is a negative correlation within the monthly data of the companies under this index which implies that there is negative dependence of share prices and indicates the existence of the RWH i.e., the series exhibit randomness. The weekly and monthly results of the runs test are reported in Table 23 below.

Table 23. Runs Test Results of the Companies under the FINI 15 Index Based on Weekly and Monthly Data

Series (observations)	Expected Runs (m)	Positive Runs	Negative Runs	Total Observed Runs (R)	Z statistic
ABG (Weekly)	260.73	140	139	279	1.610
FSR (Weekly)	259.21	132	131	263	0.336
SML(Weekly)	260.89	133	132	278	0.361
SBK (Weekly)	261.25	140	140	280	1.648
ABG (Monthly)	261.19	139	139	278	1.479
FSR (Monthly)	57.25	29	29	58	0.147
SML (Monthly)	58.98	31	31	62	0.573
SBK (Monthly)	60.85	31	31	62	0.211

Table 23 above displays the weekly and monthly results of the runs test for the companies under the FINI 15 index. The results show that all the time series have higher total observed runs than expected runs. Due to this, the Z-statistic is positive, and this indicates an existence of negative correlation which implies that the time series follow a random walk.

4.4.4 Analysis of the results of the Runs Test of the Companies under the INDI 25 Index

The weekly results of the runs test show that all the time series of the companies under the INDI 25 index other than Naspers Limited have positive Z values which means that the total observed runs are greater than the expected runs. This suggests that there is a negative correlation within the weekly data of the companies under this index which implies that there is negative dependence of share prices and reveals the existence of the RWH i.e., the series exhibit randomness.

The monthly results of the runs test show that all the time series of the companies under the INDI 25 index other than British American Tobacco PLC have positive Z values which means that the total observed runs are greater than the expected runs. This suggests that there is a negative correlation within the monthly data of the companies under this index which implies that there is negative dependence of share prices and indicates the existence of the RWH i.e., the series exhibit

randomness. The weekly and monthly results of the runs test of the INDI 25 index are reported in Table 24 below.

Table 24. Runs Test Results of the Companies under the INDI 25 Index Based on Weekly and Monthly Data

Series (observations)	Expected Runs (m)	Positive Runs	Negative Runs	Total Observed Runs (R)	Z statistic
BTI (Weekly)	260.31	131	131	262	0.149
CFR (Weekly)	259.97	140	139	279	1.680
MTN (Weekly)	262.0	148	148	296	2.980
NPN (Weekly)	257.57	127	127	254	-0.318
BTI (Monthly)	60.18	28	29	57	-0.592
CFR (Monthly)	59.93	32	33	65	0.946
MTN (Monthly)	61	34	35	69	1.467
NPN (Monthly)	31	31	62	73	0.734

Table 24 above displays the weekly and monthly results of the runs test for the JSE indices. The weekly results show that all the time series other than that for Naspers Limited (NPN) have higher total observed runs than expected runs. Due to this, the Z-statistic for all the time series other than Naspers (NPN) is positive, and this indicates an existence of negative correlation which implies that the time series follow a random walk.

The monthly results on the other hand show that all the time series other than that for British American Tobacco PLC (BTI) have higher total observed runs than expected runs. Due to this, the Z-statistic for all the time series other than British American Tobacco PLC (BTI) is positive, and this indicates an existence of negative correlation which implies that the time series follow a random walk.

In conclusion, based on the analysis of both the weekly and monthly data of the indices of the JSE (RESI 10, FINI 15, INDI 25), it is concluded that the JSE is a weak-form efficient market. Further analysis of both weekly and monthly data of the top individual companies under the respective indices is carried out and provides mixed results. The results of some companies show the existence of positive dependence while others show the existence of negative dependence. It is

seen as some companies provide mixed results with the different data sets used i.e., they exhibit positive dependence when their weekly time series are analysed and negative dependence when their monthly time series are analysed. From this, one can conclude that the JSE does not perfectly exhibit weak-form efficiency and that pricing irregularities, as well as predictable patterns, can appear over time which may persist for short periods. Therefore, an investor can earn an abnormal return during certain periods of weak-form inefficiency because it is possible to predict the future price of a stock and during certain periods of weak-form efficiency.

4.5 AR (1)-GARCH (1,1)-Model

4.5.1 Post Diagnostic Tests

Two post-diagnostic tests were conducted after applying the GARCH (1,1) model and the residuals were analysed to discover whether serial correlation and an arch effect exist. This was done to confirm whether the GARCH (1,1) model was fit to provide reliable results on the weak-form efficiency of the JSE. Serial correlation is used to measure the relationship between the value of a variable over different periods. An arch effect on the other hand establishes volatility clustering or mean reversion, time-varying conditional volatility. The Ljung box test was used to test for serial correlation of the residual and the arch effect was tested using the Heteroskedasticity test. The Ljung box test employs several lags that examine the overall randomness of data. It is commonly used in testing the presence of serial correlation in residuals of different models for example the GARCH (1,1) model. The Heteroskedasticity test on the other hand is a statistical test used to examine if residuals of a regression model have changing variance and this helps to analyse the volatility in time series to forecast future volatility. These two post-diagnostic tests were conducted for all the different indices (RESI 10, FINI 15, INDI 25) as well as the different companies under these indices for the different data sets (weekly, monthly). The results are presented below in the following sections.

4.5.1.1 Post Diagnostic Test: Serial Correlation Test- Ljung Box Test

The good GARCH (1,1) model requires the absence of serial correlation, and this was examined using this test. The absence of serial correlation would deem the GARCH (1,1) model fit to provide reliable results on the weak-form efficiency of the JSE. The serial correlation was tested using 4 lags as in the study by Bonga-Bonga (2012). The weekly and monthly results of the serial correlation test (Ljung box test) for the JSE indices are shown in Table 25 below.

Table 25. Weekly and Monthly Ljung Box Test Results of the JSE Indices

Observations	Lags	Q-Stat (Weekly)	Probability (Weekly)	Q-Stat (Monthly)	Probability (Monthly)
RESI 10	1	0.9311	0.335	0.8460	0.358
	2	1.3224	0.516	2.6197	0.270
	3	2.7428	0.433	3.2752	0.351
	4	3.5479	0.471	3.5572	0.469
FINI 15	1	0.0183	0.892	0.1881	0.664
	2	0.0343	0.983	0.1962	0.907
	3	0.0612	0.996	1.2056	0.752
	4	2.8860	0.577	1.7528	0.781
INDI 25	1	0.0057	0.940	0.5890	0.443
	2	0.1634	0.922	0.7415	0.690
	3	0.2014	0.977	2.3094	0.511
	4	0.6923	0.952	2.3105	0.679

The weekly and monthly results of the serial correlation test (Ljung box test) for the JSE indices displayed in Table 25 above show that all the lags of the different data sets are greater than alpha (0.05). This means that the test is statistically insignificant at the 5% level which implies that the residuals are not correlated. This implies that the GARCH (1,1) model is a good/fit model and can provide reliable results about the weak-form efficiency of the JSE

The weekly and monthly results of the serial correlation test (Ljung box test) for the companies under the RESI 10 index are shown in Table 26 below.

Table 26. Weekly and Monthly Ljung Box Test Results of the companies under the RESI 10 Index

Observations	Lags	Q-Stat (Weekly)	Probability (Weekly)	Q-Stat (Monthly)	Probability (Monthly)
AMS	1	1.3736	0.241	0.0171	0.896
	2	1.4670	0.480	2.4694	0.291
	3	1.4670	0.690	2.4775	0.479
	4	1.4684	0.832	2.5018	0.644
ANG	1	0.4876	0.485	0.0863	0.769
	2	3.0804	0.214	0.0905	0.956
	3	4.2915	0.232	0.3310	0.954
	4	8.4893	0.075	0.3416	0.987
BHP	1	2.5085	0.113	1.2539	0.263
	2	2.8989	0.235	3.2589	0.196
	3	3.9229	0.270	3.3093	0.346
	4	4.0852	0.395	3.6120	0.461
GFI	1	0.0591	0.808	0.0942	0.759
	2	0.5976	0.742	0.2284	0.892
	3	0.9773	0.807	1.0477	0.790
	4	1.004	0.910	3.5408	0.472

The weekly and monthly results of the serial correlation test (Ljung box test) for the different companies under the RESI 10 index reveal that all the lags of the different data sets for the different companies under these indices are greater than alpha (0.05) as shown in Table 26 above. This means that the test is statistically insignificant at the 5% level which implies that serial correlation is absent. This means that the GARCH (1,1) model is a good/fit model and can provide reliable results about the weak-form efficiency of the JSE.

The weekly and monthly results of the serial correlation test (Ljung box test) for the companies under the FINI 15 index are shown in Table 27 below.

Table 27. Weekly and Monthly Ljung Box Test Results of the companies under the FINI 15 Index

Observations	Lags	Q-Stat (Weekly)	Probability (Weekly)	Q-Stat (Monthly)	Probability (Monthly)
ABG	1	0.5489	0.459	0.0130	0.909
	2	1.0847	0.581	1.5229	0.467
	3	1.1083	0.775	1.7034	0.636
	4	1.6859	0.793	3.0977	0.542
FSR	1	0.1177	0.732	0.7141	0.398
	2	0.1709	0.918	0.9530	0.621
	3	0.1744	0.982	2.5363	0.469
	4	0.3746	0.985	3.6881	0.450
SML	1	0.0765	0.782	0.0144	0.904
	2	0.0784	0.962	0.1372	0.934
	3	0.3435	0.952	1.2804	0.734
	4	7.5376	0.110	1.3026	0.861
SBK	1	0.8390	0.360	1.5426	0.214
	2	2.5983	0.273	1.6407	0.440
	3	3.0222	0.388	3.2234	0.358
	4	8.4949	0.075	4.5154	0.341

The weekly and monthly results of the serial correlation test (Ljung box test) for the different companies under the FINI 15 index reveal that all the lags of the different data sets for the different companies under these indices are greater than alpha (0.05) as shown in Table 27 above. This means that the test is statistically insignificant at the 5% level which implies that serial correlation is absent. This means that the GARCH (1,1) model is a good/fit model and can provide reliable results about the weak-form efficiency of the JSE.

The weekly and monthly results of the serial correlation test (Ljung box test) for the companies under the INDI 25 index are shown in Table 28 below.

Table 28. Weekly and Monthly Ljung Box Test Results of the companies under the INDI 25 Index

Observations	Lags	Q-Stat (Weekly)	Probability (Weekly)	Q-Stat (Monthly)	Probability (Monthly)
BTI	1	0.3235	0.570	0.0002	0.989
	2	0.5614	0.755	0.2264	0.893
	3	0.8064	0.848	0.3685	0.947
	4	1.2486	0.870	0.4703	0.976
CFR	1	1.1095	0.292	0.2505	0.617
	2	1.1465	0.564	0.8837	0.643
	3	1.1561	0.764	1.7041	0.636
	4	2.9361	0.569	2.8637	0.581
MTN	1	0.1991	0.655	0.0562	0.813
	2	1.0775	0.583	0.1544	0.926
	3	7.2423	0.065	0.7197	0.869
	4	7.5823	0.108	0.8948	0.925
NPN	1	4.E-05	0.995	1.3036	0.254
	2	0.1157	0.944	1.5298	0.465
	3	2.3192	0.509	2.3975	0.494
	4	2.5753	0.631	2.8139	0.589

The weekly and monthly results of the serial correlation test (Ljung box test) for the different companies under the INDI 25 index reveal that all the lags of the different data sets for the different companies under these indices are greater than alpha (0.05) as shown in Table 28 above. This means that the test is statistically insignificant at the 5% level which implies that serial correlation is absent. This means that the GARCH (1,1) model is a good/fit model and can provide reliable results about the weak-form efficiency of the JSE.

5.5.1.2 Post Diagnostic Test: Heteroskedasticity Test: ARCH Test

The presence of an arch effect would deem the GARCH (1,1) model unfit and unable to provide reliable results on the weak-form efficiency of the JSE hence the need to employ the heteroskedasticity test.

The weekly and monthly results of the heteroskedasticity test for the JSE indices are displayed in Table 29 below.

Table 29. Weekly and Monthly Heteroskedasticity Test- ARCH Test Results of the JSE Indices

Observations	F-Statistic	Obs R-Squared	Prob. F	Prob. Chi-Square
RESI 10 (Weekly)	0.876704	3.516973	0.4776	0.4753
FINI 15 (Weekly)	0.709509	2.849951	0.5857	0.5832
INDI 25 (Weekly)	0.183288	0.739255	0.9471	0.9464
RESI 10 (Monthly)	0.839839	3.407550	0.5028	0.4921
FINI 15 (Monthly)	0.532923	2.185740	0.7118	0.7016
INDI 25 (Monthly)	0.608799	2.490257	0.6571	0.6464

Based on the weekly and monthly results of the arch test (Heteroskedasticity test) of the JSE indices shown in Table 29 above, the P-values of the F-statistic and the Chi-Square of the JSE indices, are greater than alpha (0.05), and this means the test is statistically insignificant at the 5% level which implies an absence of an arch effect.

The weekly and monthly results of the arch test (heteroskedasticity test) for the companies under the RESI 10 index are shown in Table 30 below.

Table 30. Weekly and Monthly Heteroskedasticity Test- ARCH Test Results of the companies under the RESI 10 Index

Observations	Prob. F (Weekly)	Prob. Chi-Square (Weekly)	Prob. F (Monthly)	Prob. Chi-Square (Monthly)
AMS	0.8013	0.7995	0.5591	0.5480
ANG	0.0940	0.0940	0.9871	0.9862
BHP	0.4199	0.4177	0.4980	0.4873
GFI	0.9178	0.9168	0.5245	0.5136

The weekly and monthly results of the arch test (heteroskedasticity test) shown in Table 30 above reveal that the P-values of the F-statistic and the Chi-Square of all the companies under the RESI 10 index are greater than alpha (0.05) which means that the test is statistically insignificant at the 5% level, and this implies that there is no arch effect. This, therefore, confirms the fitness of the GARCH (1,1) model.

The weekly and monthly results of the arch test (heteroskedasticity test) for the companies under the RESI 10 index are shown in Table 31 below.

Table 31. Weekly and Monthly Heteroskedasticity Test- ARCH Test Results of the companies under the FINI 15 Index

Observations	Prob. F (Weekly)	Prob. Chi-Square (Weekly)	Prob. F (Monthly)	Prob. Chi-Square (Monthly)
ABG	0.7810	0.7791	0.6139	0.6029
FSR	0.9809	0.9806	0.4749	0.4644
SML	0.1186	0.1184	0.8799	0.8739
SBK	0.0799	0.0800	0.2474	0.2419

The weekly and monthly results of the arch test (heteroskedasticity test) shown in Table 31 above reveal that the P-values of the F-statistic and the Chi-Square of all the companies under the FINI 15 index are greater than alpha (0.05) which means that the test is statistically insignificant at the 5% level, and this implies that there is no arch effect. This, therefore, confirms the fitness of the GARCH (1,1) model.

The weekly and monthly results of the arch test (heteroskedasticity test) for the companies under the INDI 25 index are shown in Table 32 below.

Table 32. Weekly and Monthly Heteroskedasticity Test- ARCH Test Results of the companies under the INDI 25 Index

Observations	Prob. F (Weekly)	Prob. Chi-Square (Weekly)	Prob. F (Monthly)	Prob. Chi-Square (Monthly)
BTI	0.8738	0.8725	0.8951	0.8897
CFR	0.5701	0.5676	0.5078	0.4970
MTN	0.0960	0.0959	0.9231	0.9189
NPN	0.6427	0.6403	0.6098	0.5987

The weekly and monthly results of the arch test (heteroskedasticity test) shown in Table 32 above reveal that the P-values of the F-statistic and the Chi-Square of all the companies under the INDI 25 index are greater than alpha (0.05) which means

that the test is statistically insignificant at the 5% level, and this implies that there is no arch effect. This, therefore, confirms the fitness of the GARCH (1,1) model.

4.5.2 AR (1)- (GARCH (1,1) Model Results

The AR (1)- (GARCH (1,1) Model was conducted for the different data sets (weekly, monthly) for the different indices (RESI 10, FINI 15, INDI 25) to test for the efficiency of the JSE for the study period 30th January 2009 to 30th January 2019. Furthermore, the individual companies under the RESI 10, FINI 15 and INDI 25 indices were examined to give a clearer picture of the weak-form efficiency of the JSE. The GARCH (1,1) model was used to investigate the relationship between past and current returns i.e., whether they exhibit a random walk. Furthermore, this model was used to investigate the presence of volatility clustering which determines the market's response to new shocks on stock returns.

4.5.2.1 Analysis of Weekly and Monthly Results of the JSE Indices

The weekly and monthly results of the GARCH (1,1) model for the different JSE indices (RESI 10, FINI 15, INDI 25) are displayed in Table 33 below.

Table 33. Weekly and Monthly AR (1) -(GARCH (1,1) Model Results of the JSE Indices.

Observations	Variable	Coefficient (Weekly)	Probability (Weekly)	Coefficient (Monthly)	Probability (Monthly)
RESI 10	**Variance Equation**				
	RESID (-1) ^2 (a)	0.150000	0.3469	0.239241	0.3068
	GARCH (-1) (β)	0.600000	0.1332	0.552445	0.0823
	$a_1 + \beta_1$	0.750000		0.791686	
FINI 15	**Variance Equation**				
	RESID (-1) ^2 (a)	0.103005	0.0000	0.156778	0.3160
	GARCH (-1) (β)	0.784316	0.0000	0.570148	0.0217
	$a_1 + \beta_1$	0.887321		0.726926	
INDI 25	**Variance Equation**				
	RESID (-1) ^2 (a)	0.122000	0.0046	0.023768	0.7037
	GARCH (-1) (β)	0.735627	0.0000	0.684962	0.0075
	$a_1 + \beta_1$	0.857627		0.70873	

Based on the weekly and monthly results of the various indices (RESI 10, FINI 15, INDI 25), the summation of a_1 and β_1 (under the variance equation of table 33 above) for all these indices is close to one which indicates persistent volatility clustering. High volatility clustering means that the market responds to shocks persistently i.e., the effects of a new shock on stock returns will last for a longer period in these markets as old information is of high importance. This suggests that the JSE is weak-form inefficient, and an investor has a chance of exploiting opportunities to earn an abnormal return. The weekly results of the summation of a_1 and β_1 of the RESI 10, FINI 15 and INDI 25 indices are 0.750, 0.887321, 0.857627 respectively. The monthly results of the summation of a_1 and β_1 of the RESI 10, FINI 15 and INDI 25 indices are 0.791686, 0.726926, 0.70873 respectively.

4.5.2.2 Analysis of Weekly and Monthly Results of the Companies Under the RESI 10 Index

The weekly and monthly results of the GARCH (1,1) model for the individual companies under the RESI 10 index are displayed in Table 34 below.

Table 34. Weekly and Monthly AR (1) -(GARCH (1,1) Model Results of the Companies Under the RESI 10 Index

Observations	Variable	Coefficient (Weekly)	Probability (Weekly)	Coefficient (Monthly)	Probability (Monthly)
AMS	**Variance Equation**				
	RESID (-1) ^2 (a)	0.080168	0.0051	0.166248	0.0713
	GARCH (-1) (β)	0.875042	0.0000	0.772799	0.0000
	$a_1 + \beta_1$	0.955210		0.939047	
ANG	**Variance Equation**				
	RESID (-1) ^2 (a)	0.070160	0.0020	0.196202	0.0343
	GARCH (-1) (β)	0.919122	0.0000	0.724012	0.0000
	$a_1 + \beta_1$	0.989282		0.920214	
BHP	**Variance Equation**				
	RESID (-1) ^2 (a)	0.035348	0.0081	0.069927	0.6125
	GARCH (-1) (β)	0.942306	0.0000	0.664421	0.3079
	$a_1 + \beta_1$	0.977654		0.734348	
GFI	**Variance Equation**				
	RESID (-1) ^2 (a)	0.026291	0.0000	0.087570	0.3957
	GARCH (-1) (β)	0.966858	0.0000	0.835555	0.0001
	a1 + β1	0.993149		0.923125	

Based on the weekly and monthly results of the companies under the RESI 10 index, the summation of a_1 and β_1 (under the variance equation of table 34 above) for all the individual companies under the RESI 10 index is close to one which indicates persistent volatility clustering. This indicates that the market responds to shocks persistently i.e., the effects of a new shock on stock returns will last for an extended period in these markets as old information is of high importance. This suggests that the JSE is weak-form inefficient, and an investor has a chance of exploiting these opportunities to earn an abnormal return. The companies under the RESI 10 Index include Anglo American Platinum Limited, Anglo Gold Ashanti Limited, BHP Group PLC and Gold Fields Limited whose weekly results of the summation of a_1 and β_1 are 0.955210, 0.989282, 0.977654, 0.993149 respectively. The monthly results of the summation of a_1 and β_1 of these same companies are 0.939047, 0.920214, 0.734348, 0.923125 respectively.

4.5.2.3 Analysis of Weekly and Monthly Results of the Companies Under the FINI 15 Index

The weekly and monthly results of the GARCH (1,1) model for the individual companies under the FINI 15 index are displayed in Table 35 below.

Table 35. Weekly and Monthly AR (1) -(GARCH (1,1) Model Results of the Companies Under the FINI 15 Index

Observations	Variable	Coefficient (Weekly)	Probability (Weekly)	Coefficient (Monthly)	Probability (Monthly)
ABG	**Variance Equation**				
	RESID (-1) ^2 (a)	0.079156	0.0001	-0.102734	0.2382
	GARCH (-1) (β)	0.815574	0.0000	1.093960	0.0000
	$a_1 + \beta_1$	0.894730		0.991226	
FSR	**Variance Equation**				
	RESID (-1) ^2 (a)	0.090806	0.0000	0.170853	0.2609
	GARCH (-1) (β)	0.774840	0.0000	0.678849	0.0539
	$a_1 + \beta_1$	0.865646		0.849702	
SML	**Variance Equation**				
	RESID (-1) ^2 (a)	0.091907	0.0000	0.212069	0.0785
	GARCH (-1) (β)	0.867628	0.0000	0.481920	0.1725
	$a_1 + \beta_1$	0.959535		0.693989	
SBK	**Variance Equation**				
	RESID (-1) ^2 (a)	0.079200	0.0000	0.088590	0.4883
	GARCH (-1) (β)	0.846112	0.0000	0.634242	0.1425
	a1 + β1	0.925312		0.722832	

Based on the weekly and monthly data of the companies under the FINI 15 index, the summation of a_1 and β_1 (under the variance equation of table 35 above) for all the individual companies under the FINI 15 index is close to one which indicates persistent volatility clustering. This indicates that the market responds to shocks persistently i.e., the effects of a new shock on stock returns will last for a longer period in these markets as old information is of high importance. This suggests that the JSE is weak-form inefficient, and an investor has a chance of exploiting these opportunities to earn an abnormal return. The companies under the FINI 15 Index include Absa Group Limited, First Rand Limited, Sanlam Limited and Standard Bank Group whose weekly results of the summation of a_1 and β_1 are 0.894730,

0.865646, 0.959535, 0.925312 respectively. The monthly results of the summation of a_1 and β_1 of these same companies are 0.991226, 0.849702, 0.693989, 0.722832 respectively.

4.5.2.4 Analysis of Weekly and Monthly Results of the Companies Under the INDI 25 Index

The weekly and monthly results of the GARCH (1,1) model for the individual companies under the INDI 25 index are displayed in Table 36 below.

Table 36. Weekly and Monthly AR (1) -(GARCH (1,1) Model Results of the Companies Under the INDI 25 Index

Observations	Variable	Coefficient (Weekly)	Probability (Weekly)	Coefficient (Monthly)	Probability (Monthly)
BTI	**Variance Equation**				
	RESID (-1) ^2 (a)	0.035637	0.0000	-0.048126	0.3098
	GARCH (-1) (β)	0.967785	0.0000	0.640176	0.1635
	$a_1 + \beta_1$	1.003422		0.592050	
CFR	**Variance Equation**				
	RESID (-1) ^2 (a)	0.039991	0.0526	0.132019	0.2858
	GARCH (-1) (β)	0.885546	0.0000	0.238959	0.8114
	$a_1 + \beta_1$	0.925537		0.370978	
MTN	**Variance Equation**				
	RESID (-1) ^2 (a)	0.098254	0.0000	0.042834	0.6983
	GARCH (-1) (β)	0.830400	0.0000	0.586674	0.3930
	$a_1 + \beta_1$	0.928654		0.629508	
NPN	**Variance Equation**				
	RESID (-1) ^2 (a)	0.107431	0.0085	-0.102390	0.0230
	GARCH (-1) (β)	0.775723	0.0000	0.980399	0.0000
	a1 + β1	0.883154		0.878009	

Based on the weekly data of the companies under the INDI 25 index, the summation of a_1 and β_1 (under the variance equation of table 36 above) for all the individual companies under the INDI 25 index is close to one which indicates persistent volatility clustering. This indicates that the market responds to shocks persistently i.e., the effects of a new shock on stock returns will last for a longer period in these markets as old information appears to be of high importance. This suggests that the JSE is weak-form inefficient an investor has a chance of exploiting these

opportunities to earn an abnormal return. The companies under the INDI 25 Index include British American Tobacco PLC, Compagnie Financière Richemont SA, MTN Group and Naspers Limited whose weekly summation of a_1 and β_1 are 1.003422, 0.925537, 0.928654, 0.883154 respectively.

However, based on the monthly data of the companies under the INDI 25 index, the summation of a_1 and β_1 (under table 36) for all the individual companies under the INDI 25 index other than Naspers Limited is not close to one. This indicates low and volatility clustering for all the companies except Naspers Limited that exhibits persistence and volatility clustering. Low volatility clustering implies that the effects of a new shock return will last for a shorter period in these markets as old information appears to be of low importance and this implies weak-form efficiency of the market. The companies under the INDI 25 Index include British American Tobacco PLC, Compagnie Financière Richemont SA, MTN Group and Naspers Limited whose monthly summation of a_1 and β_1 are 0.592050, 0.370978, 0.629508, 0.878009 respectively. However, since most of the companies under the INDI 25 index exhibit low volatility clustering, it is concluded that the JSE is weak-form efficient, and an investor cannot predict the future stock price to earn an abnormal return.

In conclusion, from the weekly results of the different companies under the RESI 10, FINI 15 and INDI 25 indices, it can be concluded that based on weekly data, the JSE does not follow the random walk and is weak-form inefficient during the period of 30th January 2009 to 30th January 2019. This means that an investor can earn an abnormal return because of the possibility to predict the future stock price.

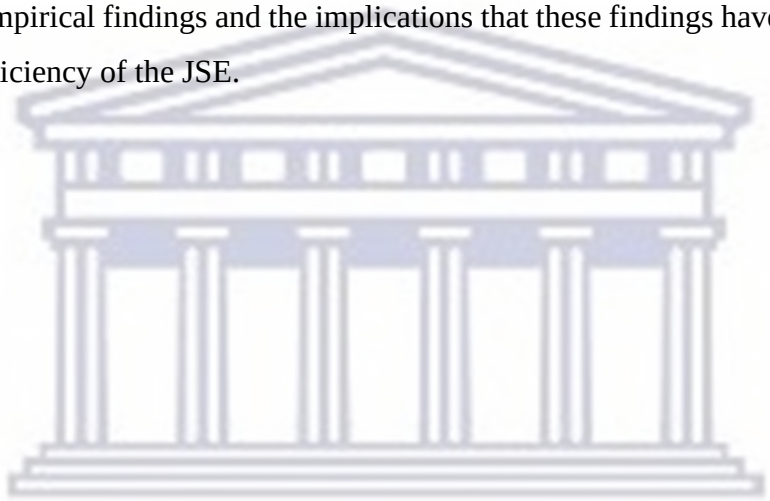
However, the monthly data of the different companies under the RESI 10, FINI 15 and INDI 25 indices provides mixed results as some companies exhibit weak-form efficiency and others exhibit weak-form inefficiency during the period of 30th January 2009 to 30th January 2019. This shows that some parts of the JSE exhibit weak-form efficiency and others exhibit weak-form inefficiency which implies that an investor can earn an abnormal return from some investing in some parts of the market because he can predict the future stock price since stock prices do not follow the random walk. However, since most of the companies exhibit weak-form

inefficiency, we can conclude that based on monthly data, the JSE is found to be weak-form inefficient during the period under study.

4.6 Conclusion

This chapter aimed at presenting an empirical analysis of the weak-form efficiency of the JSE. To achieve this, the chapter analysed both the weekly and monthly historical prices of the different indices of the JSE as well as the top-performing companies under these indices to compare the different parts of the market.

In the proceeding chapter, the research is brought to a conclusion with a discussion of the empirical findings and the implications that these findings have on the weak-form efficiency of the JSE.



Chapter 5: Summary and Conclusions

5.1 Introduction

The final chapter of this dissertation looks at the purpose of the study, analysis of the study's results in relation to the hypotheses tested, a summary of findings in relation to other authors/researchers, recommendations, and areas of further research. The findings have been presented against the problem statement and hypotheses as discussed in chapter one.

5.2 Conclusions and Recommendations to the Research

Capitalizing on market inefficiencies has always been the objective of each professional investor since the inception of stock markets. Over the past couple of years, various research has been conducted to examine the weak-form efficiency of stock markets with the use of various statistical analysis tests. Research papers have mainly focused on the weak-form of the EMH due to the availability of data to test this hypothesis. This study focused on the weak-form of the EMH using weekly and monthly data of the major three indices of the JSE (RESI 10, FINI 15, INDI 25) as well as the companies that fall under these respective indices. This research was carried out to explore the empirical evidence of the weak-form efficiency of the JSE. To achieve this, four different statistical tests were applied (Unit root tests, variance ratio test, runs test and GARCH (1,1) model) to the different indices of the JSE as well as on the individual companies under the JSE indices for the period 30th January 2009 to 30th January 2019. This study tested a number of different hypotheses, and they are stated along with a discussion of their results in the next sub-section.

5.2.1 Findings as they Apply to the Research Hypotheses

Hypothesis 1: The RESI 10 index is weak-form efficient when all the different methods are analysed.

The weak-form efficiency of the RESI 10 index was investigated using the unit root tests, variance ratio test, runs test and the GARCH (1,1) model. Both weekly and monthly data were used to run these tests and they revealed the following results.

The unit root tests, that is the ADF test, and the PP test indicated that both weekly and monthly data of the RESI 10 index have p-values that are less than 5% and due to this, the null hypothesis was rejected. P-values of less than 5% imply that the time series of these companies exhibit stationarity, have no unit root and do not behave randomly. This confirmed the weak-form inefficiency of the RESI 10 index for the period studied.

The variance ratio test was conducted, and it gave two results, namely the individual tests and joint tests. The individual test results relate to the individual test periods stated while the joint test results provide the tests of the joint null hypothesis for all test periods. The variance ratio test was used because it is more robust compared to the other tests conducted. The weekly data results for both the joint and individual tests of the RESI 10 index rejected the null hypothesis and this implies that the weekly return series of this index are not random, hence it is weak-form inefficient. Similarly, the monthly data for the joint tests of the RESI 10 index reject the null hypothesis and this implies that the monthly return series of this index are not random, hence it is weak-form inefficient. However, the monthly individual tests of the RESI 10 index fail to reject the null hypothesis for most periods which implies that that the RESI 10 index is weak-form efficient and moves from periods of efficiency to periods of relative predictability.

The runs test indicated that both the weekly and monthly results of the RESI 10 index confirm weak-form efficiency as they all have an actual number of runs that are greater than the expected number of runs leading to a positive Z-value and negative serial correlation.

Based on the AR GARCH (1,1) model, both weekly and monthly data for the RESI 10 index revealed that the summation of a_1 and β_1 is close to one which indicates persistent volatility clustering. This implies that the RESI 10 index is weak-form inefficient, and an investor can exploit opportunities to earn an abnormal return.

Hypothesis 2: The FINI 15 index is weak-form efficient when all the different methods are analysed.

The weak-form efficiency of the FINI 15 index was investigated using the unit root tests, variance ratio test, runs test and the GARCH (1,1) model. Both weekly and monthly data were used to run these tests and they revealed the following results.

The unit root tests, that is the ADF test, and the PP test indicated that both weekly and monthly data of the FINI 15 index have p-values that are less than 5% and due to this, the null hypothesis was rejected. P-values of less than 5% imply that the time series of these companies exhibit stationarity, have no unit root and do not behave randomly. This confirms the weak-form inefficiency of the FINI 15 index for the period studied.

The variance ratio test revealed that the weekly data results for both the joint and individual tests of the FINI 15 index reject the null hypothesis and this implies that the weekly return series of this index are not random hence it is weak-form inefficient. Similarly, the monthly data for the joint tests of the FINI 15 index reject the null hypothesis and this implies that the weekly return series of this index are not random, hence it is weak-form inefficient. However, the monthly individual tests of the FINI 15 index fail to reject the null hypothesis for half the periods and reject the null hypothesis for half of the periods which implies that that the FINI 15 index is weak-form efficient and moves from periods of efficiency to periods of relative predictability.

The runs test indicated that both the weekly and monthly results of the FINI 15 index confirm weak-form efficiency as they all have an actual number of runs that are greater than the expected number of runs leading to a positive Z-value and negative serial correlation.

Based on the AR GARCH (1,1) model, both weekly and monthly data for the FINI 15 index revealed that the summation of a_1 and β_1 is close to one which indicates persistent volatility clustering. This implies that the FINI 15 index is weak-form inefficient, and an investor can exploit opportunities to earn an abnormal return.

Hypothesis 3: The INDI 25 index is weak-form efficient when all the different methods are analysed.

The weak-form efficiency of the INDI 25 index was investigated using the unit root tests, variance ratio test, runs test and the GARCH (1,1) model. Both weekly and monthly data were used to run these tests and they revealed the following results.

The unit root tests, that is the ADF test, and the PP test indicated that both weekly and monthly data of the INDI 25 index have p-values that are less than 5% and due to this, the null hypothesis was rejected. P-values of less than 5% imply that the time series of these companies exhibit stationarity, have no unit root and do not behave randomly. This confirms the weak-form inefficiency of the INDI 25 index for the period studied.

The variance ratio test revealed that the weekly data results for both the joint and individual tests of the INDI 25 index reject the null hypothesis, and this implies that the weekly return series of this index are not random, hence it is weak-form inefficient. Similarly, the monthly data for the joint tests of the INDI 25 index reject the null hypothesis and this implies that the weekly return series of this index are not random hence it is weak-form inefficient. However, the monthly individual tests of the INDI 25 index fail to reject the null hypothesis for half the periods and reject the null hypothesis for half of the periods which implies that that the INDI 25 index is weak-form efficient and moves from periods of efficiency to periods of relative predictability.

The runs test indicated that both the weekly and monthly results of the INDI 25 index confirm weak-form efficiency as they all have an actual number of runs that are greater than the expected number of runs leading to a positive Z-value and negative serial correlation.

Based on the AR GARCH (1,1) model, both weekly and monthly data for the INDI 25 index revealed that the summation of a_1 and β_1 is close to one which indicates persistent volatility clustering. This implies that the INDI 25 index is weak-form inefficient, and an investor can exploit opportunities to earn an abnormal return.

Hypothesis 4: The individual companies under the respective JSE indices (RESI 10, FINI 15, INDI 25) are weak-form efficient when all the different methods are analysed.

The weak-form efficiency of the individual companies under the respective JSE indices (RESI 10, FINI 15, INDI 25) was investigated using the unit root tests, variance ratio test, runs test and the GARCH (1,1) model. Both weekly and monthly data were used to run these tests and they revealed the following results.

The unit root tests, that is the ADF test, and the PP test indicated that both weekly and monthly data for all the time series i.e., the individual companies under the RESI 10, FINI 15 and INDI 25 indices have p-values that are less than 5% and due to this, the null hypothesis is rejected. P-values of less than 5% imply that the time series of these companies exhibit stationarity and have no unit root and do not behave randomly. This confirms the weak-form inefficiency of all the individual companies under these indices for the period studied.

The variance ratio test revealed that the weekly data results for both the joint and individual tests of all the individual companies under the JSE indices reject the null hypothesis, and this implies that the weekly return series of these companies are not random hence weak-form inefficient. However, the monthly results for both the joint tests and individual tests of these companies revealed mixed results. The joint tests revealed that some companies (Anglo American Platinum Limited, Gold Fields Limited, Absa Group Limited, First Rand Limited, Compagnie Financière Richemont SA, Naspers Limited) fail to reject the null hypothesis, and this implies that their return series are random hence weak-form efficient. On the other hand, the joint tests also revealed that other companies (Anglo Gold Ashanti Limited, BHP Group PLC, Sanlam Limited, Standard Bank Group, British American Tobacco PLC, MTN Group) reject the null hypothesis, and this implies that their return series are not random hence weak-form inefficient. Individual tests are conducted to investigate the efficiency of these companies during different periods. These tests reveal that all the companies under the JSE indices follow a random walk during some periods and exhibit predictability during other periods. This

implies that they experience weak-form efficiency during some periods and weak-form inefficiency during other periods.

The weekly runs test results revealed that all the companies under the JSE indices except those under the RESI 10 index and Naspers Limited under the INDI 25 index have a greater actual number of runs than the expected number of runs leading to a positive Z-value and negative serial correlation. This implies that when weekly data is used, only the companies under the RESI 10 index and Naspers Limited under the INDI 25 index do not follow the random walk hence are weak-form inefficient, while the companies under the FINI 15 and INDI 25 indices follow the random walk hence are weak-form efficient. On the other hand, the use of monthly data reveals that all the companies under the JSE indices except British American Tobacco PLC under the INDI 25 index have the actual number of runs greater than the expected number of runs leading to a positive Z-value and negative serial correlation. This implies that all the companies under the JSE indices except British American Tobacco PLC follow the random walk hence are weak-form efficient.

Based on the AR GARCH (1,1) model, the weekly and monthly data of the respective companies under these indices provide mixed results. The weekly results show that the summation of a_1 and β_1 for all the companies under the RESI 10, FINI 15 and INDI 25 indices is close to one which indicates persistent volatility clustering. This implies that these companies are weak-form inefficient, and an investor can exploit opportunities to earn an abnormal return. On the other hand, the monthly results show that the summation of a_1 and β_1 for all companies under the RESI 10 and FINI 15 indices is close to one which indicates persistent volatility clustering, hence the companies under the RESI 10 and FINI 15 indices are weak-form inefficient, and an investor can exploit opportunities to earn an abnormal return. However, the summation of a_1 and β_1 for all the companies under the INDI 25 index except Naspers is not close to one, which indicates low volatility clustering. This implies that all the companies except Naspers are weak-form efficient, and an investor cannot exploit opportunities to earn an abnormal return.

From the tests carried out, it is concluded that the JSE is not purely weak-form efficient or weak-form inefficient after the global financial crisis. The results show

that it undergoes different cycles i.e., moves from periods of weak-form efficiency to periods of relative predictability. This is shown as some indices as well as different companies are found to be weak-form efficient and others weak-form inefficient which implies that some parts of the market are weak-form efficient, and others are weak-form inefficient.

5.2.2 Discussion on Findings

In this section, a discussion of the findings of this study in relation to other research or studies that have been conducted on financial markets is presented. This is done to understand if the results of this study support, refute or add to these other studies.

The findings of this study agree with the findings of Heymans and Santana (2018) who confirmed in their study that the JSE is weak-form efficient and moves from periods of efficiency to periods of predictability which is in line with the results of this study.

This study as well agrees with the findings of Phiri (2015) who investigated the weak-form efficiency of the JSE. The results of his study revealed mixed results with the linear root tests accepting the weak-form efficiency of the JSE while the non-linear root tests rejected the weak-form efficiency of the JSE. Therefore, the results of the study conducted by Phiri (2015) agree with the results of this study as the different tests as well provided mixed results on the weak-form efficiency of the JSE.

However, the findings of this study disagree with the findings of Abakah et al. (2018) and Kiran et al. (2019) who investigated the weak-form efficiency of the JSE. Both studies find the JSE to follow the random walk which concludes its weak-form efficiency. This study showed that the JSE is not perfectly weak-form efficient as it moves from periods of efficiency to periods of relative predictability. The existence of varying results implies that the JSE has weakened from being an informationally efficient market to a market that provides opportunities for investors to exploit opportunities based on information, hence making an abnormal return. Therefore, it can be said that the strategies implemented to improve the weak-from efficiency of the JSE have not entirely produced positive results.

The findings of this study are as well compared to the various findings of recent research that has been conducted on different developed and emerging markets. These are presented below.

Neifar (2020) investigated the weak-form efficiency of the Islamic and conventional markets in Canada using monthly data of two different indices, i.e., the Conventional Canadian Stock Index (CCSI) and the Dow Jones Islamic Canadian Price Index (DJICPI) to apply both linear and nonlinear unit root tests. The results of their study disagree with this study as both indices bear characteristics of a random walk which implies weak-form efficiency of the stock markets.

Showalter and Gropp (2019) investigated the weak-form efficiency of the United States stock market by using daily returns of 100 securities on the S&P 500 to apply the ADF tests, variance ratio tests as well as five machine learning algorithms. The findings of their study agree with the findings of this study as the different tests revealed mixed results. The statistical tests found potential stationarity which implies weak-form inefficiency of the United States stock market while the algorithmic trading results found little predictive power which implies weak-form efficiency of the United States stock market.

Sarkar (2019) investigated the weak-form efficiency of two stock exchanges in India (Bombay stock exchange and National stock exchange) with the use of the Kolmogorov-Smirnov Goodness of Fit, runs test, ADF and PP tests of stationarity. The findings of this study found the two stock exchanges to be weak-form inefficient meaning an investor can be able to predict future price movements. These findings disagree with the findings of this study conducted on the JSE which revealed mixed results.

Emenike and Kirabo (2018) explored the weak-form efficiency of the Uganda Securities Exchange (USE) using daily data to apply both linear serial dependence tests (autocorrelation function and Ljung-box Q tests) and nonlinear tests (autoregressive conditional heteroscedasticity Lagrange multiplier). The results of their study revealed mixed results with the linear models approving weak-form efficiency and the non-linear models disproving weak-form efficiency of the USE.

These results agree with the results of this study conducted on the weak-form efficiency of the JSE as both studies revealed mixed results.

Hawaldar et al. (2017) applied the Kolmogorov-Smirnov Goodness of fit test, runs test and autocorrelation test to examine the weak-form efficiency of individual stocks listed on the Bahrain Bourse. The results of this study revealed mixed results with the Kolmogorov-Smirnov Goodness of fit test concluding that the stock market follows a random walk, the runs test revealing that the share prices of seven companies do not follow the random walk and the autocorrelation test revealing that share prices generally exhibit low to moderate correlation. These results agree with the results of this study conducted on the weak-form efficiency of the JSE as both studies revealed mixed results.

Njuguna (2016) applied the variance ratio test, runs test, unit root tests, and the serial correlation test to investigate the weak-form efficiency of the Nairobi Securities Exchange (NSE). The results of this study revealed mixed results with the serial correlation test, unit root tests and runs test finding the NSE weak-form inefficient while the variance ratio test found it weak-form efficient. These findings agree with the results of this study conducted on the weak-form efficiency of the JSE as both studies revealed mixed results.

From the research above conducted on the JSE (Kiran et al. (2019), Heymans and Santana (2018), Abakah et al. (2018), Phiri (2015)) as well as the different developed (Neifar (2020), Showalter and Gropp (2019)) and emerging markets (Sarkar (2019), Emenike and Kirabo (2018) Hawaldar et al. (2017), Njuguna (2016)), it is seen that the findings of some studies refute the findings of this study and others agree with the findings of this study. Note should be taken that this study as well differs and adds to prior literature because it used three indices (RESI 10, FINI 15, INDI 25) and further looked at the companies under these indices. Previous studies like Heyman and Santana (2018) have only looked at indices to explore the weak-form efficiency of the JSE. In addition, this study used both weekly and monthly data while previous studies, for example, Abakah et al. (2018) have used either daily, weekly, or monthly data individually.

Smith et al. (2002) highlight two main reasons as to why some financial markets may not be efficient. The first factor is the size of the market, and this is seen as more developed markets have higher market capitalization which makes it impossible to acquire above-market returns, hence making them efficient compared to their emerging counterparts. Secondly, the liquidity of a market is a contributing factor, and this is the main consideration in African markets. Markets that have low levels of turnover relative to their size, make it difficult for the market to have a high number of trading transactions done which contribute to it following a random walk and being efficient. This is because low levels of turnover relative to the size of the market result in some stocks not being traded during certain periods which prevents price change of the stock.

For one to be able to obtain above-market returns, two conditions should be in place i.e., the market should be inefficient and transaction costs including slippage should be kept low to allow exploitation of the market inefficiencies. Note should be taken that although this research focused on the efficiency of the JSE and detected inefficient properties in the JSE, further research that includes transactional costs should be carried out to confirm whether one exploit these inefficiencies.

Employing active or passive portfolio management usually depends on the efficiency of a financial market. Active portfolio management is more suitable for an inefficient market while passive portfolio management is more suitable for an efficient market. Therefore, accounting for the results obtained in this study, one can conclude that active portfolio management is more suitable for the JSE. It can be concluded that an investor can use technical analysis to make above-market returns through the exploitation of existing arbitrage opportunities that allow excess returns without excess risk.

5.2.3 Recommendations

The research provides recommendations to various stakeholders of the JSE such as academics, investors, regulatory authorities as well as managers. From the results of this study, it is suggested that the JSE commission should develop techniques to disseminate official information to market participants to enable stock prices to reflect this information at the right time. Furthermore, there is a need for

policymakers to inform potential investors of the opportunities available in the stock market to arouse their interest in capital market activities hence increasing the breadth and depth of the capital market.

This study reveals to other stakeholders and investors that trading strategies like technical analysis can be generated and used to earn an abnormal return. Since the JSE moves from periods of weak-from efficiency to periods of weak-form inefficiency, stock prices may not always fully reflect all available information, hence investors can use this information to forecast share prices, making an abnormal return.

To academics, this research discloses the behaviour of stock prices on the JSE by looking at weekly and monthly data for both different indices as well as companies under these indices using statistical approaches. This provides a foundation for other researchers to investigate more about stock price behaviour on the JSE using different methods or techniques like trading strategies as well as explore the behaviour of stock prices in different emerging markets.

5.3Areas of Further Research

There are further areas of possible research that this study did not conduct. This study used statistical methods in examining the weak-form efficiency of the JSE, however, technical analysts highlight that the methods they apply when investing in financial markets are so different that their significance cannot be determined by statistical tests. Therefore, it is important to directly examine the significance of various techniques like trading strategies, econometric modelling and theories that are popular in today's finance world (Behavioural Finance Theory and Adaptive Market Hypothesis theory) and compare their performance with each other.

Furthermore, since this study was focused on the stock market of South Africa, this same research topic can be applied to other asset classes including derivate instruments and bond markets. In addition, further research can be conducted to examine the rate at which semi-strong information is incorporated into the share price, once disseminated.

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