EFFICIENT MARKET HYPOTHESIS IN SOUTH AFRICA : AN ANALYSIS USING THE FLEXIBLE FORM UNIT ROOT TEST

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EFFICIENT MARKET HYPOTHESIS IN SOUTH AFRICA : AN ANALYSIS USING THE FLEXIBLE FORM UNIT ROOT TEST

BY

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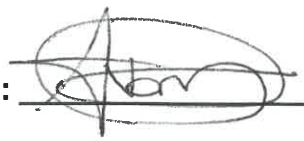
DECLARATION:

In accordance with Rule G5.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

SIGNATURE: 

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I. Abstract

An efficient stock market is characterised by prices that are reflective of all the information such that there are no opportunities for arbitrageurs. In an efficient market, it is impossible to beat the market, therefore it follows that stock prices in an efficient market should follow a random walk. This study investigates whether the Johannesburg Stock Exchange (JSE) is an efficient market using the JSE Top 40 listed stocks, thus the relevance of the EMH in the current South African market is analysed. A corerlation analysis is undertaken to find whether the individual stocks in the different sectors are correlated in their returns, or if there are any inter-sector correlations. This analysis showed that individual sector stocks are mostly correlated, however, the individual sector stocks do not show a relationship with common sectors.

The data used is monthly data of the individual stocks from 31 January 1999 to 30 June 2018. The study takes into consideration that the period is post the Asian Contagion and during the dot.com bubble. Also considered is the Global Financial crisis that occurred in 2007/2008. The study period thus allows enough time for market corerction. The study utilises the conventional unit root tests; the augmented Dickey-Fuller (ADF), Phillips- Perron (PP) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. Also utilised are modified unit root tests of Elliot, Rothenburg and Stock (ERS) (1996) as well as Ng and Perron (2001). Due to criticisms of the initially utilised unit roots, the nonlinear test of Kapetanois et al. (2003) and the Flexible Fourier form (FFF) is employed. Based on the empirical analysis, the study demonstrates that although the studies received conflicting evidence the FFF demonstrates the most “power” of the tests, thus is deemed to provide more accurate results. This test provided evidence of stationarity in the JSE market, thus implying inefficiency. The results were different for only two of the forty stocks, namely, Shoprite and Bidvest which implied efficiency.

The study thus found that the EMH is not relevant to the current South African market and other theories should be considered in analysing the market. This also provides a case for behavioural finance to be analysed, as the assumption that all investors are rational is questioned.

II. Acknowlegments

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III. List of Figures

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IV. LIST OF ABBREVIATIONS

ABG	Absa Group Ltd
ACF	Autocorrelation Function
ADF	Augmented Dickey Fuller
AFRIMA	Autoregressive Fractionally integrated moving average
AGL	Anglo American PLC
ANG	AngloGold Ashanti Ltd
APN	Aspen Pharmacare Holdings Ltd
AR	Autoregressive
ARMA	Autoregressive Moving Average
ASEA	African stock exchanges association
BESA	Bond Exchange of South Africa
BID	Bid Corp Ltd
BIL	BHP Billiton PLC
BSE	Bombay Stock exchange
BTI	British American Tobacco PLC
BVT	Bidvest Group Ltd/The
CAPM	Capital Asset pricing model
CFR	Cie Financiere Richemont SA
CLS	Clicks Group Ltd
CPI	Capitec Bank Holdings Ltd
DSY	Discovery Ltd
EMH	Efficient Market Hypothesis
ERS	Elliot, Rothenburg and Stock
ETF	Electronically Traded Fund
FFF	Flexible Fourier Function
FIBV	Federation International Bourses de Valeurs
FSR	FirstRand Ltd
FTSE	Financial Times stock exchange
GARCH	Generalised autoregressive conditional heteroscedasticity
GEAR	Growth, Employment and Redistribution
GFC	Global Financial crisis
GFI	Gold Fields Ltd

GRT	Growthpoint Properties Ltd
INL	Investec Ltd
INP	Investec PLC
IPO	Initial public offering
JET	Johannesburg Equities Trading
JSE	Johannesburg Stock Exchange
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LHC	Life Healthcare Group Holdings Ltd
MA	Moving Average
MEI	Mediclinic International PLC
MND	Mondi Ltd
MNP	Mondi PLC
MRP	Mr Price Group Ltd
MTN	MTN Group Ltd
MVR	Multiple Variance ratio
NED	Nedbank Group Ltd
NPN	Naspers Ltd
NRP	NEPI Rockcastle PLC
NTC	Netcare Ltd
NYSE	New York Stock exchange
OML	Old Mutual Ltd
P/E	Price earnings
PP	Phillips-Perron
RDF	Redefine Properties Ltd
REM	Remgro Ltd
RMH	RMB Holdings Ltd
RWH	Random walk hypothesis
SAB	South African Breweries
SAFEX	South African Futures Exchange
SAP	Sappi Ltd
SBK	Standard Bank Group Ltd
SECA	Stock Exchange Control Act
SENS	Securities Exchange News Services
SHP	Shoprite Holdings Ltd

SLM	Sanlam Ltd
SOL	Sasol Ltd
SPP	SPAR Group Ltd/The
SRI	Social Responsibility Index
Strate	Shares Transactions Totally Electronic
TBS	Tiger Brands Ltd
TFG	Foschini Group Ltd/The
TRU	Truworths International Ltd
VECM	Vector error correction model
VOD	Vodacom Group Ltd
WFE	World Federation of Exchanges
WHL	Woolworths Holdings Ltd/South Africa

1.1 Introduction and Background

The efficiency of emerging markets has been the centre of a contentious debate amongst economic and financial economists. Much research has examined the validity of the Efficient Market Hypothesis (EMH) theory which suggests that it is impossible to beat the market and to make a profit from any trading strategy or even to determine whether a stock is over or under valued. According to this hypothesis, investors are not able to predict the future performance of a stock and earn excess returns by having access to secret information, due to the assumption that all information is already incorporated in the stock price (Bruneau, et. al 2009). It is expected that the more efficient a market, the more random the sequence of its price movements, with the most efficient being the one in which prices are completely random and unpredictable (Fama, 1965; and Lo, 1997).

The EMH can be explained using three forms depending on the information that adjusts stock prices. The weak form EMH states that it is not possible to beat the market by analysing past prices as the current price fully incorporates the price history. The semi-strong form EMH suggests that the current price incorporates all publicly available information and is concerned with the speed and accuracy of the market's reaction to information as it becomes available. Since this information is publicly known the theory suggests that no one should receive excess profits from it. When both private and public information is fully reflected in prices this is known as a strong form EMH, implying that even if insider trading exists no above normal profits can be generated. This point according to Fama (1970) is ideal for the market as stock prices reflect the assets current performance as well as the company's future cash flows.

An efficient market is closely related to the random walk theory which states that stock prices cannot be predicted and should follow a random walk. If the random-walk theory is an accurate description of reality, then various other procedures such as the chartist procedure for predicting stock prices are irrelevant. The chartist technique attempts to employ knowledge of the past behaviour of a price series to predict the future behaviour, i.e. investors may seek to find a trend in historical price series to forecast future prices. The chartist technique would not work under an efficient capital market, even though research has shown that inefficiencies do occur in the market which allow for arbitrageurs to achieve above market returns.

For instance, Cornelis (1998) studied six Asian stock exchanges and discovered that only information from past prices reached these markets, a contradiction to EMH. This was a study

conducted for the year 1986 to 1996, pre-Asian financial crisis also called the "Asian contagion" which began in July 1997. This was a series of currency devaluations and other events that spread through many Asian markets. The currency markets first failed in Thailand following the government's decision to no longer peg the local currency to the US dollar. However, like all crises, this had started with a series of asset bubbles. This affected the South Asian countries and led to stock market declines, reduced import revenues and government upheaval throughout. Several East Asian currencies fell by as much as 38% with international stocks falling as much as 70% (Kuepper 2018). Also occurring during 1997 was the dot.com bubble also known as the Y2K which occurred till 2001. This was a period of extreme growth in the usage and adaption of the internet. This dot.com bubble led to several stocks declining sharply, losing their market capitalisation and others failing completely to a point of the companies shutting down.

More recently, the financial crisis of 2007 – 2008 was considered to be the worst since the global depression of 1929. What was a housing market crisis ended up affecting the economy and markets, leaving some companies out of business and stock values depreciating. Further, several companies and stocks have been under fire. In 2017, for example, Steinhoff went from being part of the JSE Top 40 index to being considered a penny stock in just a short period, the effect of this on the overall JSE market might be worth noting.

Groenewold and Ariff (1998) suggests that evidence for the EMH has been mostly gathered from developed markets such as the United States and Europe. However, with South Africa being an emerging market and housing the largest stock exchange in the continent, several studies relating to market efficiency with respect to African stock markets have been undertaken on the Johannesburg stock exchange (JSE) Biekpe and Mlambo (2007).

This study will analyse the efficiency of the JSE Top 40 individual stocks since 1999, which is post the Asian contagion, but during the dot com bubble period till June 2018 which provides enough time for market correction post the GFC. Given the possibility of both linear and nonlinear structures being associated with underlying data generating processes, this study formally tests the stationary properties of the time series by applying a battery of unit root tests comprising of a combination of linear and nonlinear testing procedures.

In particular, three conventional unit root tests will be undertaken, the augment Dickey-Fuller (ADF) unit root tests, Phillips-Perron (PP) and the Kwiatkowski, Phillips, Schmidt and Shin

(KPSS) test. The third (KPSS) test is a stationarity test that is used to confirm the results of the former. Modified unit root tests will also be employed, i.e. Dickey-Fuller (GLS) test of Elliot, Rothenburg and Stock (ERS) (1996) as well as the Ng and Perron (2001). Also, to be employed is the nonlinear Kapetanois et al. (2003) unit root testing procedure which is robust to asymmetries and the Flexible Fourier form (FFF) testing procedure described in Enders and Lee (2012) which is robust to asymmetries and unobserved structural breaks.

1.2 Problem statement and research questions

The study of market efficiency has grown in importance. A plethora of research papers have attempted to determine the best method to test the efficiency of the stock market, this including the South African stock market, the JSE. A number of methodologies have been used prior, however, this study will use the Flexible Fourier Function (FFF) which researchers have found to bring the most accuracy in results. Further, the use of indices has usually been used to reach a conclusion. The issue being that indices are a basket of stocks thus providing average and not actual figures. In testing individual stock returns over the period 1999-2018 and using actual data of the JSE's top 40 stocks, is the JSE top 40 efficient? Also, can the FFF provide accurate results with the stock prices?

The following questions were formulated to provide guidance on the overall execution of the research:

- Are the individual stocks of the JSE Top 40 efficient?
- Which individual stocks are the most market efficient?

1.3 Objectives of the study

The main objective of this study is to investigate the efficiency of the South African stock market. However, the specific objectives are:

- To analyse the relevance of the EMH in the current South African stock market.
- To find out if individual stocks grouped into sectors are correlated in their returns.
- To determine whether individual sector shares have common sectors they are correlated with.
- To find out whether individual investors can earn above normal profits in the market.
- To determine whether past prices can be an indication of future prices.

1.4 Research hypothesis and Methodology

The research hypotheses of this study are the tentative presumptions of the research problem, i.e. it gives a possible outcome. These possible outcomes are to be assumed for use in planning experiments intended to be given a direct experimental test. In this study, the focus is on the efficiency of individual stocks of the JSE top 40. The study employs a number of unit root tests to test the study's tentative presumptions. Conventional unit root tests are employed, i.e. the Augmented Dickey Fuller (ADF), Phillips-Perron and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS). These are by norm and historically the unit root tests utilised in the literature to study the efficiency of the market. These tests have since been modified, thus in addition to the unit root tests, the Dickey-Fuller (GLS) ERS as well as the Ng and Perron test will be used. Due to shortcomings explained later in the study, Nonlinear unit root tests are also employed, i.e. KSS and the Flexible Fourier function (FFF).

These tests are employed using monthly time series data received from Bloomberg. The monthly data series covers the period January 1999 to June 2018. The study is limited to the individual shares that are part of the JSE Top 40 index (J200) at the time the data was gathered.

The following Hypotheses are to be assumed:

$$H_o: \beta = 1 \ (The\ JSE\ Top\ 40\ is\ efficient) \quad (1)$$

$$H_1: \beta < 1 \ (The\ JSE\ Top\ 40\ is\ inefficient) \quad (2)$$

Ho is such that the process contains a unit root and is therefore efficient, against the alternative hypothesis H_1 that is, the process does not contain a unit root and is therefore stationary. H_1thus stating that the process is inefficient.

1.5 Significance of the study

This study focuses on the South African market which has received limited attention. There is a substantial amount of literature on market efficiency and stock return behaviour with researchers utilising different models and specifications. However, most of the research is concentrated in the developed markets, in particular, the United States and European markets. Thus, the need for more research in the emerging and less developed markets is well recognised.

In addition, previous studies that have been undertaken for South Africa tend to use either the JSE All share (J203) index data or other aggregated sectors series. This study is different in that the empirical analysis is performed using the returns of individual stock prices in the JSE Top 40 firms by market capitalisation. Another difference is that this current study takes into account unobserved structural breaks and asymmetries caused by financial crisis and other external shocks which cannot be properly accounted for under conventional unit root tests used in previous studies.

There are studies that have been undertaken that provide reasons why the stock market is likely to be efficient, theory also proposing that if markets are efficient then professional investment management is of little to no value. Whereas in an inefficient market, the opposite holds true. This study will thus either provide a case for or against the relevance of investment managers in the current stock market. In an efficient market, information-based trading is not profitable as all information is already captured in the price. This would imply that investors have no incentive to gather and analyse information as market prices are an unbiased estimate of the intrinsic worth of stocks. This would further imply that no investors should be able to consistently find undervalued or overvalued stocks that provide room for arbitrageurs to profit. This while investors pay significant amounts in management fees to active managers under the assumption that asset and investment managers are more sophisticated thus have better opportunities to achieve high returns for their capital.

The EMH has been widely accepted as valid, with the assumption that investors are rational. However, evidence against the theory has been mounting, with behavioural theorists challenging the assumptions of the EMH.

The degree to which the JSE is efficient affects all those who invest in it. At the time of writing over 50% of the companies listed on the JSE have offshore exposure, thus, the efficiency or lack thereof would be of interest to countries outside of SA due to their exposure and investable interests.

1.6 Organisation of the study

The remainder of the study will proceed as follows. Section 2 will provide an overview of the JSE, section 3 will provide an overview of market theories currently observed in the literature and a detailed review of previous literature conducted in the developing market, developed

markets and in South Africa. Section 4 will describe the data and research methodology used, section 5 will present the empirical results, followed by the conclusion and recommendations in section 6.

2 Overview of the JSE

The JSE is Africa's largest stock exchange by market capitalisation and it is commonly classified as an emerging market. Using Fama's measures, the JSE has been assessed to be semi-strong form efficient by Retief, Afflect-Graves and Hamman (1986). In contrast, Gilbertson found strong-form efficiency. Thompson and Ward (1995) showed that there are some share price dependencies but these are too small to be profitably exploited and therefore their study concluded that the JSE is "operationally efficient", meaning that a small group of investors are to outperform the market. This chapter looks at the JSE, the history and discusses the characteristics of this exchange.

2.1 History of the JSE

2.1.1 The developments of the JSE pre-1948

The Johannesburg Stock Exchange (JSE) was established in November 1887, fourteen months after the proclamation of the Witwatersrand goldfields known as the "gold rush". At inception, the JSE existed as an open outcry trading exchange which took place in a section divided by chains, hence the term "between the chains" Coetzee (2014). The exchange was founded by Benjamin Woollan who also became the first to list a company on the JSE, i.e. the Johannesburg Chambers and Company. This was followed by DRDGOLD Limited in 1895 which is the oldest company remaining listed to date. The primary objective of the stock exchange was to enable the new mines and their financiers to raise capital for the development of the industry and the subsequent formation of investment companies (Samkhange, 2010). In 1947 the first legislation covering financial markets and regulation of exchanges was promulgated, i.e. the Stock Exchange Control Act (SECA) (JSE, 2013).

2.1.2 The developments of the JSE 1948 - 1994

The JSE was admitted as a member of the of the World Federation of Exchanges (WFE) in 1963. Through its membership with the WFE, formerly the Federation International Bourses de Valeurs (FIBV), the JSE contributes to creating the best standards for the capital markets industry. This being done alongside other members from the Asia-Pacific region, Europe, the Middle East, the rest of Africa and America.

The exchange introduced property unit trusts in South Africa and listed two trusts on the JSE in 1969. Between 1978 and 1979 the SECA was amended to allow for broking firms to become incorporated, this was for companies with unlimited liability of director and shareholders (JSE, 2018). Twenty years after the property unit trusts, the SA bond market was formalised with SAB (South African Breweries) being the first corporate to issue a bond (JSE, 2018).

In 1993, the JSE became a founder member of the African Stock Exchanges Association (ASEA) thus becoming an active member of the African Stock exchange (Coetzee, 2014). The SA local exchange is now currently one of the 27 securities exchanges in Africa that are members of the ASEA which has the stated aim of developing member exchanges and to provide a platform for the exchange of information between them (ASEA, 2019).

2.1.3 The development of the JSE post 1994

Mabhunu (2004) indicates that from inception of the JSE all stockbrokers on the exchange were required to be South African citizens. This changed when in 1995 parliament approved the amendment of the SECA allowing for foreign investors to operate on the exchange. Further amendments included the introduction of corporate and qualified membership on the JSE and the introduction of regulations covering the protection of investors and members. The South African Institute of stockbrokers was also formed in 1995 in order to ensure the continuous development of stock brokers knowledge (JSE, 2018). During this period, the JSE breached the R1 trillion market capitalisation mark for the first time.

In 1996 the Johannesburg Equities Trading (JET) system was introduced to replace the old open-cry system. This meant that an order-driven automated trading system would now be used on the trading floor. Further to this, to ensure the availability of company information and market related news, the Securities Exchange News Service (SENS) was launched in 1997. Two years after, the STRATE (namely, Shares Transactions Totally Electronic) system was launched to dematerialise and electronically settle all transactions, this permitted the negotiating of brokerage fees which meant a shift from the old rigid ways (JSE, 2019).

In 2000 the JSE launched its first Electronically Traded Fund (ETF), the SATRIX 40 (JSE). This ETF tracks as closely as possible the value of the FTSE/JSE Top 40 index (J200). As at

the latest (i.e. June 2019) minimum disclosure document, this ETF has 69 257 investors with a market capitalisation of R 8 918 million.

In 2004 the Securities Services Act replaced the Stock Exchanges Control Act and the Financial Markets Control Act. In the same year, the Social Responsibility Index (SRI) was launched to measure the compliance of companies in relation to the three pillars of the triple bottom line, i.e. environmental, economic and social sustainability (JSE, 2018).

2.1.4 Demutualisation

Over a period of 100 years, before the 1990s, stock exchanges across the world were organised as mutual firms and as a member-owned co-operatives (Gribov, 2007). These members would be broker dealers with "seats" and voting rights on the exchange (JSE, 2018). The JSE was organised in such a manner until it was demutualised and registered through an initial public offering (IPO) in 2005. This changed the JSE from being a privately owned and privately funded non-proprietary voluntary association of members with statutory legal personality to the membership of the exchange being separate from ownership of the exchange. Thus, allowing for any person to purchase shares in the JSE with ownership of the JSE not being a requirement for membership. Aggarwal (2002) describes demutualisation as the method of converting a non-profit, mutually owned organization for profit, investor-owned corporation whereas Sibanda (2014) simply defines it as the process by which a member-owned exchange is reorganised as a shareholder-owned exchange, thereby essentially transforming its structure from private to public ownership.

2.1.4.1 Objective and benefits of demutualisation

Globally, stock exchanges have been transforming their corporate governance structures through demutualisation due to the competitive environment that is characteristic of the 21st century (Sibanda, 2014). It was after the very first stock exchange, Stockholm Stock Exchange, demutualised in 1993 (Sibanda, 2014) that had other stock exchanges initiating this process.

According to the JSE (2013) the primary reason behind the demutualisation that occurred in 2005 was to increase the efficiency of the exchange against the background of a global environment that had become more and more competitive. However, over and above that going

public meant the exchange had access to more capital and it provided a larger scope for moving towards globalization of the exchange. According to the JSE's 2008 annual report, foreign shareholders held 45% of the issued shares at the end of 2007, a great increase from the 18.9% recorded for 2016. Thus, showing that the process of demutualisation contributed to an increase in foreign investments.

The competitiveness the demutualisation provided allowed for better improved technologies and fee structures as the exchange became more commercially flexible and responsive to market needs. The process also offered the JSE additional capital raising opportunities (Sibanda, 2014). It was later listed as an exchange in 2006 which meant that the value of the stock exchange was improved.

2.1.5 Exchange markets

Sixteen years post the establishing of the JSE, the market saw the need for an alternative exchange that would be suitable for small and medium sized companies, thus the JSE launched AltX in 2003. This followed the failure of the Development Capital Market and the Venture Capital Market of the JSE that were launched in 1984. The main aim of these two markets was to provide listing for less mature companies that were unable to meet the stringent listing requirements of the JSE (Tchatchouang, 2017).

This was followed by YieldX for interest rate and currency instruments, the acquisition of South African Futures Exchange (SAFEX) in 2001 which provides a market for trading derivatives in South Africa (i.e. Futures, Exchange Traded CFD's, Options and other sophisticated Derivatives instruments) and of the Bond Exchange of South Africa (BESA) in 2009. The Exchange currently offers five financial markets namely equities and bonds as well as financial, commodity and interest rate derivatives (JSE, 2019).

2.2 Size of the JSE

The size of the market can be measured through the market capitalization (i.e. the number of shares outstanding multiplied by the current share price), turnover value, the number of listed companies and liquidity of the market. The market capitalisation, turnover value, the number of listed companies and the liquidity of the JSE from 1999 to 2008 appear in Table 1 below.

Table 1 is discussed through a breakdown based on the market capitalisation and turnover value (figure 1), the number of listed companies (figure 2) and the level of liquidity (figure 3).

Table 1: Size of the JSE

Year	Market capitalization R (bn)	Number of listed companies	Turnover value R (bn)	Liquidity (%)
1999	1616	668	448,38	34,6
2001	1771	542	606,14	38,5
2002	1584	472	808,66	39,1
2003	1741	443	752,25	35,8
2004	2493	389	1031,21	47,2
2005	3484	373	1278,69	48,9
2006	5015	389	2121,5	52,5
2007	5660	411	2980,11	30
2008	4514	411	3264,07	36,6
2009	5929	398	2796,08	32,8
2010	6698	397	2990,12	38,6
2011	6908	395	3286,83	31,8
2012	8383	387	3431,58	29,6
2013	10 626	375	3981,62	26,5
2014	11 505	380	4050,04	35,6
2015	11 727	382	5015,42	47,4
2016	13 580	376	5892,77	31,8
2017	15 461	366	5479,43	40,6
2018	15 208	364	5537,67	37,8

World Federation of Exchanges and JSE (2019)

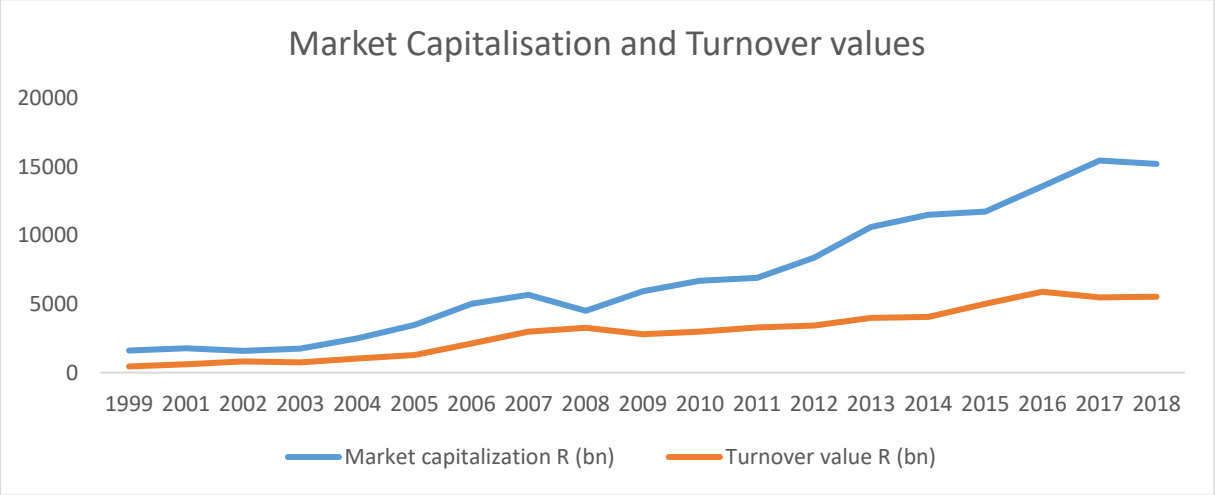
2.2.1 Market capitalisation and Turnover value

Figure 1 below shows an upward trend for both the market capitalisation of the JSE and the turnover value. This is an indication of the overall increase in these factors over the period of study. The JSE market capitalisation figures have had periods of significant increases with the exception of two drops, namely a 10.5% decrease between 2001 and 2002, and a heavy 20% decline between 2007 and 2008 which was during the GFC. According to the World Federation of Exchanges (2009) the JSE was ranked as the eighteenth largest stock market in the world in

terms of market capitalisation, one of the top five emerging markets and accounted for 75 per cent of the total capitalisation of African stock markets during this period.

By March 2011, the JSE was ranked 20th in the world and the value of the market capitalisation was R 6,908.5 billion at year end (JSE, 2011). Following that, the market has seen significant increases in its market capitalisation as can be witnessed in its 2018 reported numbers of R 15,208 billion.

Figure 1: Market capitalisation and turnover values



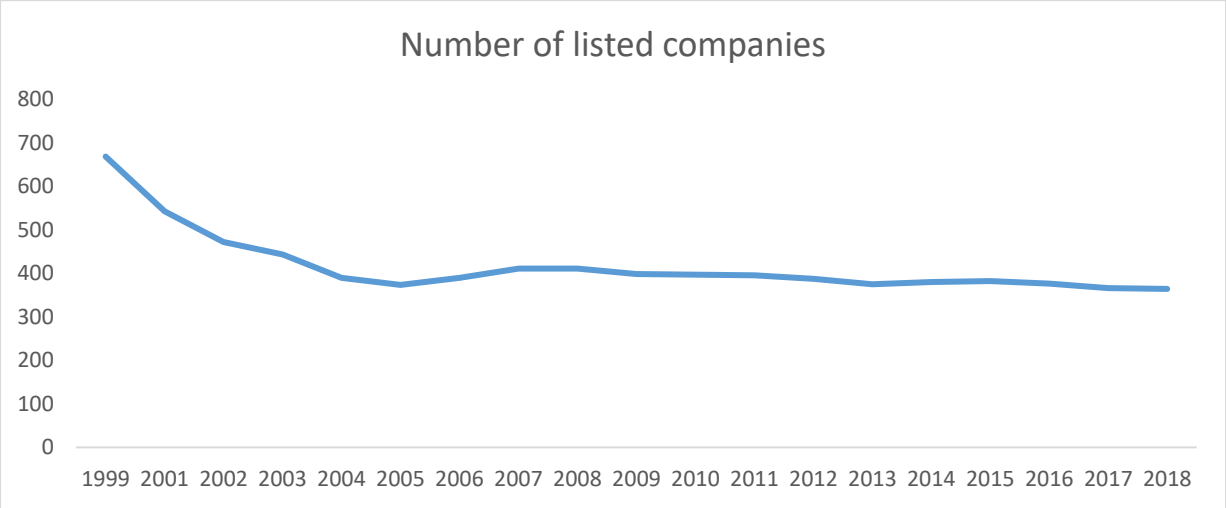
Source: World Federation of Exchanges and JSE (2019)

South Africa's market turnover value has been steadily increasing overtime reported at R448,38 billion in 1999, averaging R 2,934 billion for the period and closing at a high of R5,537,67 billion in 2018. The JSE has seen improvements in its trading systems which can be linked to these increases. Also, through the associations where the stock exchange holds memberships, a higher level of integration has been prevalent between the JSE and other markets. The country has also seen foreign participants boosting the South African financial market, with foreign listings proving to be increasing over time (Muzindutsi, 2011:92). In the same way, domestic participants are active in the market and through the improvements of technology and the process of globalisation the market has benefitted.

2.2.2 Number of listed companies

In analysing the period of study, figure 1 shows that by 1999, 668 companies were registered and listed on the JSE. This high figure could be linked to the process of privatisation that occurred during this period. Post-apartheid, the South African government had well over 300 state-owned enterprises and 50 percent of South African fixed capital assets were in state hands (Afeikhena,2004:6). Following the implementation of the Growth, Employment and Redistribution (GEAR) policy in 1996, a number of state-owned enterprise sales were initiated which provided a supply of new shares and a further boost to stock market development. Smith, Jefferis and Ryoo (2002:477) explain that privatisation programmes have involved the listing of shares in formerly nationalised firms. This would have meant a considerable increase in number of listed companies, however, the market saw a decline in numbers as the number of mergers and acquisitions increased.

Figure 2: Number of listed companies



Source: World Federation of Exchanges (2019)

The figure above shows a downward trend indicating a decrease in the number of listed companies. From 2001 to the end of 2005 the number of listed companies averaged 444 for the period and closed at 373 in 2005. This was following strict exchange controls that promoted domestic production and limited South African companies from exporting capital (Smith et al, 2002:477). The JSE also saw more stringent listing requirements that resulted in some companies delisting.

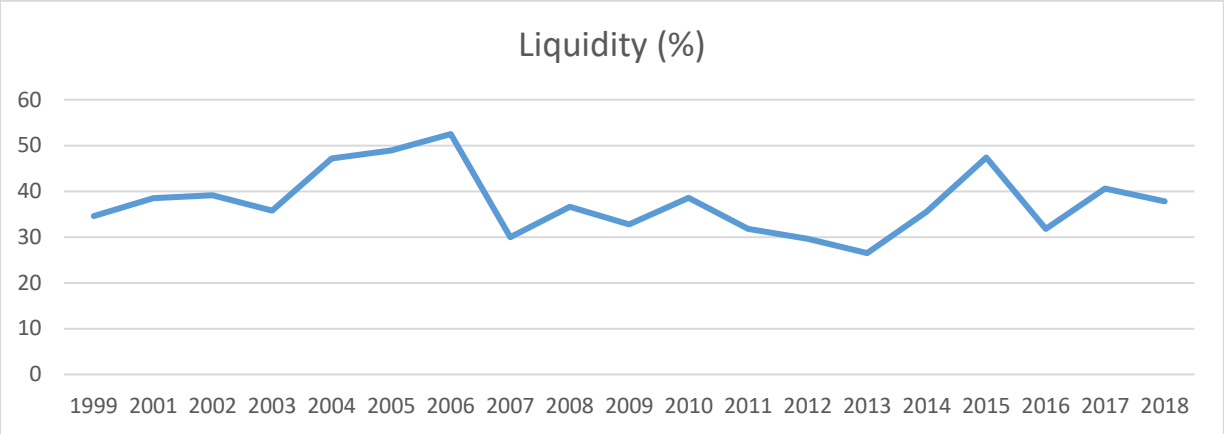
From 2006 the number of registered companies increased, reaching 411 companies by the end of 2008. This increase can be linked to the high level of economic growth in South Africa (Stats SA, 2010) during the period. The country had also attracted foreign direct investors that assisted in the growth of the exchange.

This was followed by a 3% decline in 2009 post the market crash and the numbers remaining almost flat for the three years post. Since then, the stock exchange has seen slight fluctuations in its numbers of listed having averaged 376 with no significant movements.

2.2.3 Liquidity

Liquidity has been an elusive topic for many years now since it is not only difficult to define, but it is also difficult to quantify. It was first introduced into literature by Keynes (1930: 67), who proposed that an asset is more liquid than another if it is more certainly realisable at short notice without loss. It has been suggested that liquidity has numerous dimensions (time, price and volume) and that Keynes 'definition takes account of only one of those dimensions, namely time. According to the JSE (2019) "liquidity refers to the transaction value a share sees every trading week." It is often calculated as an average for the day. Bodie, Kane and Marcus (2011) explain it as the cost and ease with which an asset can be sold. The general liquidity management test is to buy shares that have an average daily limit of at least ten times the value you wish to buy. According to Mlambo and Biekpe (2005) African stock markets are known to be illiquid in comparison to other regions markets. The JSE (2014) also indicates that African markets' liquidity is low compared to international norms, they indicate that this is due to a number of factors such as lack of counters listed on the exchanges, restrictive limits on short selling, the absence of retail investors from the markets, a lack of both product and documentation standardisation, the large and long term holdings of pension funds and high transaction costs.

Figure 3: Liquidity (%)



Source: World Federation of Exchanges and JSE (2019)

Figure 3 presents evidence of favour of the JSE (2014). They further indicate that liquidity could be improved by introducing a wider range of products, the standardisation of documentation which will help eliminate counterparty and settlement risk, active marketing by the exchanges as to the benefits of a company listing, attracting the retail investor into the market, facilitating securities lending by the long term investors, and lowering transaction costs. This will in turn boost investor confidence in the market. According to Chataika (2014) director at INVESCI "liquidity is the lifeblood of markets", he further states that there is no point in having a price if there is no liquidity in the market.

2.3 JSE Top 40 index

An index is a portfolio of shares designed to summarise the performance of the market that it represents into one number (Wugler, 2010). Originally, market indices "were developed as market benchmarks or performance measurement gauges" (Gastineau, 2002). However, as fund managers create more specialised funds, the use of indices that track the general stock market are no longer adequate (Sensoy, 2009). Hence this current study tests for market efficiency in the individual stocks of the JSE Top 40 index for a more rigorous analysis.

In South Africa, there are five indices that make up the Headline Category: The All Share Index (J203), the JSE Top 40 Index (J200), the Mid Cap Index (J201), the Small Cap Index (J202) and the Fledging Index (J204). These all comprise of instruments listed on the JSE Main Board and categorised by market capitalisation. The All Share index (ALSI) represents 99% of the

full market capitalisation of all eligible equities on the Main Board of the JSE. The ALSI is then split up into the JSE/FTSE Top 40 Index which represents the forty largest companies which are constituents of the J203, the Mid Cap Index which represents the next sixty largest companies from the J203 after the selection of the Top 40 Index (J200), the Small Capitalisation index which consists of the remaining companies after the Top 40 Index (J200) and the Mid Cap Index (J201) constituents and finally, the Fledgling Index which consists of all ordinary shares listed on the JSE Main Board, which are too small to be included in the J203 but comply with the eligibility criteria for index inclusion (JSE, 2018).

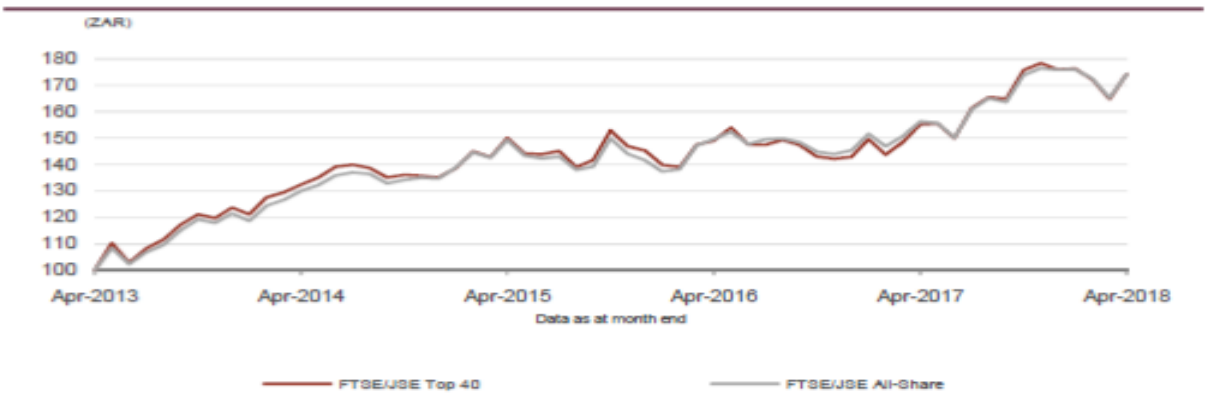
The Top 40 Index is a fair reflection of what happens to the South African market as a whole, because even though it contains only 40 of the shares listed on the JSE, it represents over 80% of the total market cap of all JSE listed companies. To illustrate this, figure 5 presents the total return performance for a five-year period post 2008 for the Top 40 Index (J200) and the All-share index (J203). The graph shows a close correlation between the performances, this being due to the highest performing shares in the market being constituents of both the indices. The illustration continues in figure 5 for the 5-year period post 2014.

Figure 4: Total Return Performance-JSE Top40 and JSE All-Share index (2008-2014)

Source: FTSE Russell

Figure 5 shows a relationship in the movement of the two indices and how they react to market forces. As per this figure, the total return (%) for the 5-year period was 74.3% for both the All Share as well as the Top 40 index, for the 3-year period the former returned 11.4% whilst the latter returned 12.3%. The return (%) for the year to date was -0.9 for both. The returns thus proving the close relationship between the two indices.

Figure 5: Total Return Performance-JSE Top40 and JSE All-Share index 2014 – 2019



Source: FTSE Russell

In analysing the volatility (%) differences between the two indices over a 5-year period, the Top 40 index shows a 1.2% higher volatility then the All Share, this difference is relatively close for the period, with the results closing at a 0.9% difference in the year to date in favour of the Top 40 index. The below figures illustrate the Top 10 listed companies that were the best and worst performers over a 5-year period.

Figure 6: Market best performers

Top 10	2013	2014	2015	2016	2017	2018	YTD
1	Mondi (+104%)	Capitec (+68%)	PSG Group (+77%)	Anglo's (183%)	Naspers (+72%)	Amplats (+55%)	Amplats (+38%)
2	Naspers (+103%)	Gold Fields (+60%)	Mondi (+66%)	Glencore (+122%)	Discovery (+65%)	Angogold (+42%)	BTI (+29%)
3	Aspen (+60%)	Aspen (+52%)	Capitec (+61%)	Bidvest (+83%)	Capitec (+61%)	Anglo's (+32%)	Anheuser-Busch (+27%)
4	Richemont (+59%)	PSG Group (+51%)	Sappi (+55%)	Anglogold (+44%)	Clicks (+60%)	BHP (+29%)	BHP (+23%)
5	Sasol (+48%)	Netcare (+50%)	BTI (+44%)	Amplats (+43%)	Mr Price (+60%)	Nedbank (+13%)	Anglo's (+22%)
6	PSG Group (+44%)	Mr Price (+47%)	Naspers (+40%)	Standard Bank (+41%)	Sanlam (+44%)	Netcare (+9%)	Capitec (+21%)
7	Discovery (+38%)	FirstRand (+47%)	Woolworths (+33%)	Sappi (+38%)	Glencore (+39%)	Clicks (+8%)	Naspers (+19%)
8	Netcare (+36%)	TFG (+45%)	Steinhoff (+32%)	TFG (+38%)	Anglo's (+35%)	Spar (+6%)	Bid Corp (+14%)
9	BTI (+36%)	Absa (+45%)	Vodacom (+26%)	Nedbank (+34%)	Amplats (+34%)	RMH (+4%)	Richemont (+12%)
10	Investec (+32%)	Tiger Brands (+42%)	Discovery (+24%)	Clicks (+33%)	FirstRand (+33%)	Mondi (+2%)	Glencore (+12%)

Source: Investec Wealth & Investment

The South African share market is relatively concentrated, as at April 2018 the top ten shares by market capitalisation represented 65.84% of the Top 40 index which are also the top constituents of the All Share index.

Figure 7: Market worst performers

Bottom 10	2013	2014	2015	2016	2017	2018	YTD
10	Spar (+4%)	Mondi (+8%)	Absa (-17%)	Mondi (-6%)	Redefine (+4%)	Richemont (-14 %)	Spar (-8%)
9	Clicks (-1%)	MTN (+7%)	Standard Bank (-18%)	BTI (-8%)	Investec (+3%)	Remgro (-15%)	Sanlam (-8%)
8	Anglo's (-9%)	Shoprite (+5%)	Goldfields (-19%)	Aspen (-8%)	Sappi (+1%)	Naspers (-16%)	Netcare (-8%)
7	Absa (-11%)	Vodacom (+3%)	BHP (-20%)	Steinhoff (-9%)	Vodacom (+1%)	Glencore (-17%)	Discovery (-14%)
6	Angloplats (-12%)	Richemont (+2%)	Nedbank (-21%)	Discovery (-13%)	Aspen (-1%)	Anheuser-Busch (-30%)	Woolworths (-14%)
5	Tiger Brands (-16%)	Anglo's (-3%)	Aspen (-23%)	Investec (-14%)	Woolworths (-3%)	MTN (-31%)	Vodacom (-16%)
4	Shoprite (-18%)	Sasol (-13%)	MTN (-36%)	Richemont (-16%)	Anheuser-Busch (-5%)	Tiger Brands (-39%)	Shoprite (-16%)
3	TFG (-28%)	Amplats (-13%)	Amplats (-46%)	Mr Price (-17%)	Anglogold (-15%)	BTI (-40%)	Sappi (-16%)
2	Anglogold (-53%)	Anglogold (-17%)	Glencore (-61%)	Anheuser-Busch (-26%)	Netcare (-18%)	Nepi (-44%)	Mr Price (-23%)
1	Goldfields (-63%)	BHP (-20%)	Anglo's (-66%)	Woolworths (-26%)	Steinhoff (-93%)	Aspen (-50%)	Aspen (-31%)

Source: Investec Wealth & Investment

Figure 6 and 7 prove that the major market movers are constituents of both indices. These results and the knowledge that the Top 40 index is the most monitored as an overall benchmark for the local JSE market are what assisted in the choice of using the Top 40 individual stocks for the study as the results will be a fair reflection of the JSE market.

2.4 Conclusion

This chapter gave a brief overview of the JSE market. Today the JSE is one of the most highly regulated exchanges and provides full electronic trading, clearing and settlement of equities, derivatives and other instruments. It is also the largest exchange in Africa and listed by the World Federation of Exchanges as among the top 20 exchanges in the world. Post the demutualisation, the JSE has attracted a significant number of foreign investors which has contributed to the growing South African economy. The next chapter discusses market theories and previous studies undertaken.

3. LITERATURE REVIEW

3.1 Introduction

In this chapter, both the theoretical and empirical literature of the stock market behaviour will be analysed. Section 3.2 will provide a theoretical review, 3.3 will be a discussion of a few of the theories that have been widely used in the financial markets. Section 3.4 will provide an empirical framework of previous studies conducted on developed and developing countries as well as the South African market respectively. Lastly, the chapter presents a brief assessment of the literature reviewed.

3.2 Theoretical framework

The theoretical framework presents the theories that have over the years surrounded the financial market particularly on the behaviour of share market prices. In the 1950s business cycle theorists believed that the economy's boom and bust periods could be predicted by tracing the evolution of several economic variables over time. The assumption was that if stock prices reflect the prospects of the firm, patterns of peaks and troughs in economic performance should show up in these prices (Bodie, et.al 2014). This section discusses the theories that have followed post that research.

3.2.1 Approaches of analysing markets

Two primary approaches of analysing markets are fundamental analysis and technical analysis. Fundamentalists focus on financial and economic theories as well as political developments to determine the forces of supply and demand. They are focused on measuring the intrinsic value of a stock whereas technical analysts instead use charts to identify patterns and trends to determine future movements. This is further divided into 2 major forms, i.e. Quantitative Analysis which uses various statistical properties to help assess the extent of an overbought or oversold stock and Chartism which uses lines and figures to identify trends and patterns.

a) Fundamental analysis

Fundamental analysis is according to Hassan, et.al. (2015) an analysis that is focused on obtaining the intrinsic value of shares using information of current and future earnings of a company to evaluate its fair value. Bodie et.al. (2015) agree with this, stating that fundamental analysts will usually start by analysing past earnings and examining the company's balance

sheets. This will be supplemented by further economic analysis, evaluating the quality of the firm's management, its performance relative to its peers in the industry and prospects of the industry. With this valuation they hope to attain insight into future performance of the firm that is not yet recognised by the market, thus enabling them to earn excess returns in future.

Fundamentalists attempt to determine the present discounted values of all payments a shareholder will receive from each share of a stock. In the case where the value exceeds that of a current stock price, this analysis recommends for that share be bought. If the fair value is not equal to the current stock price, fundamental analysts believe that the stock is either over or undervalued and that the market price will ultimately gravitate towards fair value (Fisher & Jordon 1995). This analysis uses earnings and dividend prospects of a firm, expectations of future interest rates and risk evaluation of the firm to determine the proper stock prices (Bodie, et.al 2014).

Fundamentalists believe that their analysis is good for long term investments and at spotting stocks that represent good value. Bodie, et.al. (2009) on the other hand suggests that the evaluation is not likely to be significantly more accurate than other analysts because your analysis would have to be better than everyone else's for it to be beneficial as the market price will already reflect all commonly recognised information.

b) Technical analysis

Technical analysis is according to (Fisher & Jordon 1995) the examination of past price movements to forecast future price movements. Although technicians recognise the value of information regarding future economic prospects of the firm, they believe that such information is not necessary for a successful trading strategy. This they suggest is because, whatever the fundamental reason for a change in stock price, if the stock responds slowly enough, the analyst will be able to identify a trend that can be exploited during the adjustment period (Bodie, et.al. 2009). Jack Schwager states: "One way of viewing it is that markets may witness extended periods of random fluctuation, interspersed with shorter periods of non-random behaviour. The goal is to identify these periods of major trends". Thus, agreeing that it is possible to identify a trend, however only during certain periods. It seems in order for the technical analysis to be successful stock prices need to have a sluggish response to fundamental supply and demand factors.

Further, the technical analysis is most commonly known for the notion of resistance levels or support levels. These are said to be price levels above or below which it is difficult for prices to pass. Chartists, as technicalists are mostly referred to, are focused more on what the prices are rather than why they are that way. They indicate that the "why" is simple, there are more buyers than sellers, i.e. greater demand than supply in the market. The "what" is found mostly by analysing past prices using charts.

The weakness of this analysis is that two technicians can look at a chart and draw different conclusions, this analysis is open to interpretation. It is also subjective and can be compromised by our personal biases. Technicians have also been criticized for being too late, by the time the trend is identified, a substantial portion of the move has already occurred. These analysts believe in a sell signal given when the neckline of a head and shoulders pattern is broken. They consider the market to be 80% psychological and 20% logical whereas fundamental analysts consider the market to be 20% psychological and 80% logical.

3.3 Market theories

3.3.1 Efficient market hypothesis (EMH)

Finance and investment literature have shown that prior the theory of efficient markets, little research was developed on stock prices. One of the pioneers was Fama (1970) who distinguished between the weak, semi-strong and strong efficiency hypothesis and integrated evidence from the random walk model. Researchers emphasized that previous prices cannot be an indication of future prices, i.e. P_{t+1} - Pt is independent of P_{t-1} where P_{t+1} is the future price, Pt is the current price and P_{t-1} is the price in previous periods. They emphasized that there should be no trends in price changes.

The argument was strengthened by the above-mentioned forms of market efficiency, i.e. weak form, semi-strong form and strong form. The weak form focuses on historical prices, where the semi-strong form discusses the effect of public information and this is finalised by a strong form efficiency which includes all information.

a) Weak form efficiency

The weak form efficiency describes the case where stock prices are said to reflect all information about historical share prices and trading volumes (Fama 1970). This form states

that current prices fully reflect historical information contained in the historical sequence of prices. As far as forecasting is concerned, there is no benefit in examining historical prices (Fisher & Jordon 1995) i.e. an investor may not enhance their ability to select stocks by knowledge of the history successive prices and realise excess profit from that as prices are believed to follow a random walk. Following the pioneering studies of Osborne (1962) and Fama (1965), weak-form efficiency in capital markets has been widely accepted as being a determining factor in supporting the evidence of efficient stock markets across the empirical literature.

b) Semi-strong form efficiency

Semi-strong form efficiency states that stock prices will reflect any publicly available information related to the stock. This includes price and trading data as well as firm specific data, such as the competency of management and forecasts of company performance (Bodie et al. 2010). Researchers of this variant assert that current stock prices fully reflect publicly available information. This includes, but is not limited to, publicly available annual reports, published brokerage reports, newspaper articles and all weak form information. This form claims that no excess returns can be received from the analyses of this information and that prices instantly change to reflect new public information.

c) Strong form efficiency

A third form of this hypothesis indicates that all information in a market, whether public or private is accounted and discounted for in the stock price. The strong form EMH asserts that prices instantly reflect even insider information, thus this information is not useful. They indicate that profits exceeding normal returns cannot be realised regardless of the amount of information or research an investor can access.

In such a market prices fully reflect all information and provide unbiased estimates of the underlying values. However, while there are a number of studies undertaken for the EMH, the validity is still questioned.

Further to this, Malkiel (2003) indicates that if a market is efficient and all available information is considered by share prices, then the occurrence of new information would cause share prices to follow a random walk. He states that this is because in an efficient market all new information and news are unpredictable, and the resulting price changes will be as well. If

this is the case, investors employing alternative strategies will not consistently be able to earn a return that is above the average buy-and-hold strategy without accepting above average risk (Malkiel 2003). This suggests that an uninformed investor could potentially achieve returns similar to investment professionals by investing in a portfolio of stocks.

3.3.2 Random walk hypothesis (RWH)

The random walk hypothesis (RWH) claims that market prices follow a random path without any influence from previous price movements (Bodie, 2014), thus suggesting that it is impossible to predict with any accuracy which direction the market will move at any point (Kendall, 1953; Fama, 1965; Samuelson, 1973; Milkin, 2010). This implies that future stock price movements cannot be determined from historical price information, especially in the short term, thus agreeing with the weak form efficiency.

As the essence of this argument is that stock prices should follow a random walk with prices being random and unpredictable, researchers of this theory emphasize that randomness in price changes should not be confused with irrationality in the level of prices. They state that if prices are determined rationally, then only new information will cause them to change. Therefore, a random walk would mean that prices reflect all current knowledge and that price changes in individual securities are independent.

This hypothesis assumes that the share markets are efficient, in which there are a large number of active participants competing to predict future prices, and where information is freely available to all. In such a market, the share price is considered to be a good estimate of its intrinsic worth. According to Keane (1983) pioneers of the RWH believe that it is impossible for investors to outperform the market without taking on additional risk, and that timing the market simply leads to underperformance. Bodie (2009) states that prices of securities depend on factors that affect expected return and expected risk. The information on these factors is released to the market at different intervals and investors react differently to the information. Prices therefore follow a random walk path and the direction and magnitude of their movement from past price series cannot be predicted accurately.

This RWH theory of Bachelier (1900) has been the subject of intense debate among academic professionals, investors and financial professionals. This was seen more recently during the global financial crisis where critics believed that the hypothesis caused financial leaders to

underestimate the dangers of asset bubbles and dismissed the hypothesis as being a useless way to examine how markets function in reality (Matothya, 2013). Researchers have also suggested that the theory presumes that information is freely and readily available and that there enough market participants with sufficient resources to take advantage of any profiting opportunity arising from systematic price movements of an individual stock, which is not always the case.

3.3.3 Price earnings ratio hypothesis

Researchers such as Basu (1977) believe that price earnings (i.e. P/E) ratio are indicators of future performance of a share. Advocates of this price-earnings ratio hypothesis suggest that stocks with a low P/E ratio will tend to outperform high yielding P/E stocks. They further suggest that returns of low P/E stocks tend to be greater than their underlying risks. This was found by Basu (1977) during the period 1957-1971 when he conducted a study analysing the NYSE. The study found that security price behaviour was not consistent with the EMH and that P/E ratio information was not fully reflected in security prices as suggested by the semi-strong form of the hypothesis. Disequilibria was found to exist in capital markets during the period. The study found over this 14-year period that low P/E portfolios earned superior returns on a risk-adjusted basis, the propositions of the price-ratio hypothesis on the relationship between investment performance of equity securities and their P/E ratios appeared to be valid. This is often referred to as efficient market anomaly.

In his study analysing the Swiss market, Gramespacher (2016) also found that during the period 2005-2015 the stocks with low P/E ratios earned higher results than those with higher P/E ratios. Further, the study found that low P/E portfolios were able to generate significant excess returns compared to the market. He concludes that P/E ratio information was not fully reflected in stock prices as suggested by the EMH.

3.3.4 Calendar day effect

A number of studies have found that January has been a very unusual month of stock market returns. Returns would tend to be unusually high during the first two weeks of the year, this was particularly evident for stocks with relatively small market capitalisations (Keim, 1983). This theory was documented in a book titled “The incredible January effect” by Haugen and Lakonishok (1988). There also appeared the day of the week effect which refers to the existence of a pattern on the part of stock returns, whereby these returns are linked to the particular day of the week. This relationship has mainly been verified in the USA than other emerging

countries. The last trading days of the week, being Friday, are quoted to have positive returns, while Monday, the first trading day of week, differs from other days, even producing negative returns (Cross, 1973; Lakonishok 1988; Rogalski 1984; Keim 1983). Coenen supports Cross (1973) who suggests that the average return on Fridays exceeds the average return on Mondays and that there is a difference in the patterns of price changes between those days. Coenen strengthens his argument by making an example of the 1929 stock market crash on Wall Street. He states that it started on Thursday 24th October with a loss of 11%. On Friday the 25th of October the market was stabilizing and the crash seemed as though it were just for a day. On Monday the 28th however, the market crashed again, losing almost 13% of the value. These events, according to him, show that the non-trading days of the weekend can have a large influence on how the stock market behaves on Mondays. This was an idea first documented by French (1980) and Gibbons and Hess (1981).

However, according to Connolly (1989) the evidence of a weekend anomaly is dependent on the estimation method and the sample period used. He states that after the mid-70's the existence of the weekend effect disappears. In 2000, Brusa, Liu and Schulman developed the "reverse" weekend effect, where they suggest that Monday returns are actually higher than the returns on other days. Evidence was found for the existence of multiple 'weekend effects' depending on firm size where small companies have smaller returns on Mondays and large companies have higher returns on Mondays. In addition, they found that during the period in which the reverse weekend effect was observed (i.e. 1988 – 1998), Monday returns for large firms would follow previous Friday returns when the Friday returns were positive, but they would not follow the previous Friday return when the returns were negative.

In a study by Cleary (2005), the author suggests that the Monday effect in the US and Canadian markets reversed during the period 1988 to 1998 and that there was a concentration of positive Monday returns during the first half of the month which was consistent with a study conducted by Wang, Li and Erikson (1997). Fortune (1998) found a negative Monday effect prior the 1987 crash, and that post the crash, the Monday effect switched from negative to positive. The author suggests that the cause of this switch has been investors ignorance of stock returns. Once investors are made aware of anomalies, they behave in ways to eliminate the anomaly. Concluding that post the 1987 crash, there is no support of the continuation of negative returns over the weekends.

3.3.5 Capital Asset pricing model

In finance, the essential question is how the risk in investment would affect the expected return. The capital asset pricing model (CAPM) has been marked as the birth of asset pricing theory as it is a way to demonstrate the relationship between the risk of a specific stock and the expected return to the investors in a reasonable equilibrium market. Harry Markowitz laid down the foundation in 1952 with his Markowitz model, years later the CAPM was published in articles by Jack Treynor (1962), William Sharpe (1964), John Litner (1965) and Jan Mossim (1966). It has three main assumptions, the first of which is that investors can borrow and lend at risk free interest rates and can buy and sell shares at market price with no taxes or costs. Secondly, investors only invest in efficient portfolios, i.e. portfolios with maximum return for a certain volatility. Thirdly, that all investors have a homogenous prediction for the volatilities and expected return of stocks as well as the correlation between them.

In summary, this model assumes that all investors will invest in the same portfolio of stocks as their expectations are equal. The CAPM builds on the Markowitz model, also known as the mean-variance model developed by Harry Markowitz (1952). This model is based on the expected returns (mean) and standard deviation (variance) of different portfolios as it assumes investors are risk averse and, when choosing among portfolios care only about the mean and variance of their one-period investment return, i.e. investors choose mean-variance efficient portfolios (Bailey, 2005).

The CAPM turns the Markowitz model into a testable prediction by identifying the risk-return relationship on assets and providing a benchmark rate of return for evaluating possible investments. The model also assists in estimating the cost of capital for firms and evaluating the performance of managed portfolios (Samkhange, 2010). Additionally, the model helps in making an educated guess as to the expected return on assets that have not yet been traded in the marketplace (Bodie, 2003). Following the development of this model, theorists have extended and adapted the approach to incorporate a number of different phenomena. Linters (1969) focused on returns in real terms, Brennan (1970) dealt with taxation, Black (1972) looked into instances where there is no riskless asset, Merton (1973) incorporated investor concerns with future investment opportunities, Rubinstein (1974) looked at a more general class of utility functions, Kraus and Litzenberger (1976) took into account the third moment of the return distribution, Levy (1978) incorporated transaction costs, Breeden (1979) focused on investors preferences for consumption, Merton (1987) dealt with market segmentation and

Markowitz (1990) considered restrictions on short sales. Decades later and after all the amendments, the CAPM is still used to estimate the cost of capital and evaluate the performance of stocks and portfolios.

3.4 Empirical review

Succeeding studies received conflicting evidence and varied findings for research undertaken for developed and emerging economies globally. Time series data were formally tested during different periods for dependencies in stock price movements with most studies using the runs test, serial correlation, Generalised autoregressive conditional heteroscedastic (GARCH), auto regression analysis, variance ratio tests, Dickey Fuller test (DF), and the Box Pierce test (Bonga-Bonga 2012; Jefferis and Smith 2004; Hadassin 1976). This section provides studies undertaken in developed and developing countries as well as in South Africa to determine the efficiency of the markets.

3.4.1 Empirical Review of Developed Countries

The general conclusion from most studies in developed countries has been that weak form market efficiency holds and that no exploitable patterns in past trading records exist as can be seen with a study undertaken by Groenewold and Kang (1993) who conducted weak and semi-strong efficiency tests of Australian stock market by using aggregate share price indexes and found the data consistent with the weak form efficiency. More recently, however, a number of studies have raised questions about the degree of prevailing market efficiency and have pointed to some market inefficiencies based on observations such as autocorrelation, the small-firm effect, the January-effect and the weekend-effect (Aga and Kocaman, 2008).

Konak and Seker (2014) aimed to identify whether the Financial Times Stock Exchange 100 (FTSE 100) prices are stationary during the period 2001 to 2009. The ADF and PP unit root tests were used, which showed that the market is non-stationary and therefore follows a random walk. The GARCH model was also employed, which found that the prices follow a random walk, supporting the weak form market efficiency hypothesis.

Starcevic and Rodgers (2011) undertook a study of the German stock market using the serial correlation tests, runs test and day of the week effect tests covering the period 2005 to 2007. They also did month of the year effects for the period 2001 to 2007. The serial correlation test found that the prices do not follow a random walk and the runs test returned similar results.

The study also found that Mondays produce higher returns for one index, i.e. DAX and Friday produced higher returns for two indices, MDAX and SDAX. They also found Tuesday to produce the lowest results, comparable to a study by Shiguang (2004) of the Chinese markets. The study found only limited evidence of statistically significant calendar anomaly effects which added credence to the findings of the serial correlations and runs test. The researchers however indicated that simulated trading tests based on a month-of-the-year calendar strategy appears to suggest that in some circumstances trading strategies based on month-of the-year effects might be profitable.

3.4.2 Empirical Review of Developing Countries

In earlier writings of developing markets, Ekechi (1989) analysed the Nigerian stock market using the serial correlation test and the runs test and concluded that the market is a weak form efficiency. Dickinson and Muragu (1994) in their study of the Nairobi Stock Exchange (NSE) found that the market provides empirical results consistent with weak-form efficiency. Poshakwale (1996) presented evidence concentrating on the weak form efficiency and on the day of week effect in the Bombay Stock Exchange (BSE) for the period 1987 – 1994. The study found that the BSE supports the validity of day of the week effect as returns achieved on Fridays were significantly higher compared to the rest of the days of the week. Also, due to the non-random nature of the series, a violation of the weak form efficiency in the BSE was found. Zychowicz et al. (1995) concluded that on the Istanbul Stock Exchange, daily and weekly returns diverge from a random walk, while monthly returns are consistent with weak form market efficiency.

Post the second millennium, Worthington and Higgs (2003) analyzed the markets of Latin America with the objective to detect whether these markets follow the theory of random walk or are weak form efficient. The researchers studied the daily returns of seven Latin American countries i.e. Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela through various techniques like correlation coefficient analysis, runs test, Augmented Dickey Fuller (ADF) test, Phillips-Perron (PP) test, Kwiatkowski, Phillips, Schmidt and Shin (KPSS) and Multiple Variance Ratio (MVR) tests. They found that significant correlation existed between returns and therefore the presence of randomness in the daily returns was rejected in these seven emerging markets and hence were not weak-form efficient. A year following that Phan and Zhou (2004) published evidence regarding the Vietnamese stock markets. They tested the efficiency using the random walk method for weekly stock market returns employing the

autocorrelation test, variance ratio test and the runs test for period July 2000 to July 2013. It was concluded that the Vietnamese stock market is not efficient and that prices are predictable due to psychological factors that strongly influence investors. The research found that investors usually act similarly making transaction prices predictable. They also state that investors in the stock market are not yet professional, hence psychological factors strongly influence their investment decisions. The study rejected the random walk hypothesis and found that the weak form efficient hypothesis does not hold for the Vietnamese stock market. In analysing the Thai stock exchange, Clark et.al. (2007) used the runs test and autocorrelation function tests (ACF). The runs test found the market to be inefficient and correlation on prices was found particularly during the post-crisis period. Implying that there was a strong chance that investors could use historical data to earn extraordinary gains by purchasing and selling stocks. In the same year, Dorina and Simina (2007) investigated a set of eight emerging markets for weak-form efficiency. This study included developing countries of Poland, Slovenia, Hungary, Lithuania, Turkey, Romania, Slovakia, and Czech Republic. When testing interdependencies between the stock prices the study employed Ljung-Box test, serial correlation LM test, runs test and BDS tests (applied on residuals generated by ARMA models) for both linear and nonlinear dependencies of the prices. These tests revealed that there are linear and non-linear dependencies in most of the series. This implied that set of these emerging markets are mostly weak-form inefficient and investors can generate abnormal returns.

In India, Gupta (2011) used three-unit root tests, ADF, PP and KPSS for the period 2007 to 2011 using quarterly data to test the efficiency of the market and results supported the weak form efficiency. However, the study found conflicting results for prior periods whilst daily and weekly data rejected the weak form during all sample periods. Bhay et al. (2014) also analysed the Indian and added the Pakistan markets for the period 2003 – 2013 using ADF tests, Auto-correlation and runs test. The results rejected the hypothesis that the stock markets are weak-form efficient.

3.4.3 Empirical Review for previous South African Studies

In analysing studies undertaken in the South African market, most studies both pre and post the Global Financial Crisis (GFC) found the JSE to be a weak form efficient. Amidst those were Jefferis and Smith (2004) as well as Bonga-Bonga (2012) who applied a GARCH model. On the other hand, Samkhange (2010) employed the ADF and PP unit root tests as well as multivariate co-integration, Granger causality, vector error correction model (VECM), impulse

response function analysis and variance decomposition analysis and supported that the JSE prices only reflect historical information.

Conversely, Hadassin (1976) used Von Neumann serial correlation and runs tests during the period 1971 to 1973 and found correlation between historical and future price changes. The study found that the JSE is not efficient and does not support the random walk model. More recently, Morris et al (2009) analysed the JSE during the period 2005Q1 to 2007Q2 using the Autoregressive fractionally integrated moving average (ARFIMA) and wavelet analyses and suggested that share prices have a long-term memory and price changes are correlated over time, providing evidence that the JSE is not efficient, even in its weak form. However, the studies may be subject to time period bias as the analysis were both conducted on short term time series. Noakes and Rajaratnam (2014) used the overlapping serial test adopted by Doyle and Chen (2013) and suggested that market efficiency may be dependent on the type or groups of specific stocks with similar attributes on the JSE. Thus, generalising about the efficiency of a stock exchange as a whole would not bring accurate results. Interestingly, Njanike (2010) found the JSE to be an efficient market which has the ability to correct itself in the event of an under/overvaluation.

Lim (2007) had an issue with most previously undertaken studies, implying that many provided evidence in favour of the EMH tests for linear dependencies in stock returns, therefore overlooking the possibility of non-linear dependencies. Post those raised concerns, Kruger et al. (2012) conducted their study on the JSE testing for nonlinear serial dependence in stock price changes. The literature found evidence of linear and nonlinear dependence in stock returns although this dependence was not consistent over time. Thus, the study found the JSE for the most part an efficient market with brief periods of inefficiency (Kruger et al. 2012). Prior to that, Mangani (2007) found that stock returns on the JSE were non-linearly dependent and could be predicted over time, thus providing evidence of the weak form. However, an observation made by Kruger et al. (2012) was that Mangani (2007) only made use of one of the many available nonlinear dependency tests, and the test suffered from a time period bias as it had a fairly small sample size which was the period 1973 – 2002. However, Kemp and Reid (1971) advise for smaller intervals to be used as they suggest results will be more accurate.

3.5 Conclusion

This chapter in its analysis of the different theories has produced conflicting evidence of studies undertaken in developed, developing and South African markets. Most studies who found evidence of the EMH found the market to be a weak form efficient one with evidence of the random walk theory. However, researchers also found evidence of other theories in the studies such as calendar effects which necessitates the undergoing of further studies on this subject.

4 Research Methodology

4.1 Introduction

This chapter provides the analytical frameworks used in addressing the objectives of this study as highlighted in chapter one. The chapter advances on some of the foundations laid in the literature reviewed and tests the stated hypothesis. The EMH, which is the primary theory being tested in this study, is associated with the random walk hypothesis according to the earlier analysis by Fama (1970). As indicated in the preceding chapter, the random walk argument is that prices should be random and unpredictable; further, there should be no trend in historical prices over time. Stock prices are efficient when they are stationary and do not have a unit root, to be specific, they should have a white noise process i.e. a process with no discernible structure with a constant mean, variance and zero auto-covariance, except at lag zero (Brooks, 2008). This chapter describes the empirical tests that will be utilised in investigating market efficiency for the Top 40 companies under the JSE.

4.2 Research design

The topic of market efficiency has been investigated by numerous academics using a number of research techniques and models in different markets. The volume of research has led to several advances, however, the topic still remains empirically undefined. In efforts to provide more accurate results, a highly structured process is necessary.

This study sets out specifically to investigate the weak form efficiency in the South African stock market. A correlation analysis is employed to test the relationship between the individual stocks and between the different sectors in the JSE. This was to meet the objective of determining firstly whether the individual stocks in a sector are correlated in their returns and secondly whether there are any inter-sector correlations.

In efforts to meet the rest of the objectives of the study, a number of unit root tests are employed. Firstly, the conventional unit root tests are used, i.e. the Augmented Dickey Fuller (ADF), Phillips-Perron and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS). As previously noted, these are by norm and historically the unit root tests utilised in the literature to study the efficiency of the market.

These tests have since been modified, thus in addition to the traditional unit root tests, the Dickey-Fuller (GLS) ERS as well as the Ng and Perron test will be used. Due to shortcomings of these tests that have been established, Nonlinear unit root tests are also employed, i.e. KSS and the Flexible Fourier function (FFF).

These tests are employed using monthly time series data received from Bloomberg. Saunders et al (2007:47) provides the distinction between primary and secondary data. They further indicate that where limited appropriate secondary data are available, researchers have to rely on primary data, i.e. data they collect themselves. However, in the secondary data category, the data is obtained from other sources, including but not limited to data sourced from Blomberg and the JSE as done in this study. The monthly data series covers the period January 1999 to June 2018. The study is limited to the individual shares that are part of the JSE Top 40 index (J200) at the time the data was gathered. Whilst indices offer an easy way to determine the overall performance and return of the stock market, this study chose to not employ index prices as these provide an average return and do not provide an accurate reflection of returns. The average of a basket could be significantly different to the actual return of some of the underlying shares and/or sectors, hence employing individual share returns in the tests that will follow will provide a more accurate indication.

4.3 Unit root tests

This study sets out to test the efficiency of the JSE. This section outlines the specific unit root testing procedures that will be employed to confirm whether or not the stock returns series confirms to the random Walk Hypothesis (RWH). Unit root tests are applied to detect the pattern of the trend in a stock price series. If the tests find no unit root in the time series of stock prices or if there is a deterministic trend in stock prices, it means that it has a constant mean, variance and covariance. This is turn means there is no stochastic trend in the stock prices and future movement pattern of stock price series and future movement pattern of stock prices can be identified based on past behaviour patterns (Chitenduru, 2013). The alternative being that the series follows a stationary process. To capture for robustness of the conclusions made about the efficiency of the JSE, the individual stock prices are tested for efficiency using a wide variety of unit root tests which will be explained in the following sections.

4.3.1 Conventional Unit root tests

4.3.1.1 Augmented Dickey Fuller (ADF) test

One way to test the efficiency of the market is to examine whether a historical sequence of stock prices is independent of one another or whether they contain a unit root. To test this, the study could have employed the Dickey- Fuller (DF) test, however, the test is only valid if the error terms are not auto-correlated, in the instance when the errors are correlated the test would be oversized. Thus, the Augmented Dickey Fuller (ADF) unit root test will be used in this study. The ADF test has three possible models of a data generating process as:

Model 1: with drift

$$\Delta pt = \mu t + \varphi p_{t-1} + \sum_{i=1}^{p} \alpha i \Delta p_{t-1} + \varepsilon t \quad (3)$$

Model 2: with drift and deterministic trend

$$\Delta pt = \mu t + \varphi p_{t-1} + \lambda_t \sum_{i=1}^{p} \alpha i \Delta p_{t-1} + \varepsilon t \quad (4)$$

Model 3: without drift or deterministic trend

$$\Delta pt = \varphi p_{t-1} + \sum_{i=1}^{p} \alpha i \Delta p_{t-1} + \varepsilon t \quad (5)$$

Where μt is the drift term, *t* is time, *p* is price of stock, λ is the coefficient on a deterministic trend, εt is the error term and the lags of Δpt ensure that εt is not correlated. The null hypothesis is that the series follows a unit root process against the alternative hypothesis of a stationary process. The hypothesis can be formally expressed as follows:

$$Ho : \varphi = 0 \quad (6)$$

$$H1: \varphi < 1 \quad (7)$$

The critical values are tested against the following test statistic:

$$\text{Test statistic} = \frac{\varphi}{SE\ (\varphi)} \quad (8)$$

The test statistic is compared against the critical values, of which when the test statistic is greater than the tabulated critical value, the unit root null hypothesis cannot be rejected whilst

when the statistic is of a lower value than the critical value, then the unit root hypothesis is rejected. However, the ADF unit root test has come under considerable criticisms owing to the determination of the number of lags included within the test. If one includes too few lags the test will not remove all of the autocorrelations and this would lead to biased results. However, including too may lags increases the coefficient standard errors because the increased number of parameters uses up degrees of freedom and therefore widens the standard errors. The ADF test has also been criticized as it conceals the case of heteroscedasticity which according to Brooks (2008) exists when errors do not have a constant variance, and neither does it consider non-normality in variables. The test only accounts for the autoregressive (AR) component and not the moving-average factor (MA). Lastly, the ADF cannot distinguish between a unit root and near unit root process i.e. whether $\emptyset = 1$ or $\emptyset = 0.95$, especially with small samples.

4.3.1.2 Phillips-Perron (PP) test

Following the development of the ADF test, Phillips and Perron (1988) developed a more generalised form of ADF testing procedure. Although similar to the ADF test, the PP test differs from the ADF tests mainly in how they deal with serial correlation and heteroscedasticity in the errors. In particular, where the ADF tests use a parametric autoregression to approximate the ARMA structure of the errors in the test regression, the PP tests ignore any serial correlation in the test regression (Samkhange, 2010). Consequently, the PP test is generally more robust in the presence of heteroskedasticity than the ADF test. Enders' (1995) suggest using both types of unit roots tests, since if they reinforce each other, one can have confidence in the results.

Like the ADF test, the PP test can be performed following three possible models as identified above, i.e. with the drift and deterministic trend and with drift and without drift and deterministic trend.

The test regression for the PP test can be specified as an autoregressive process of order one:

$$\Delta p_{t-1} = \mu t + \varphi p_{t-1} + \varepsilon t \qquad (9)$$

Where Δp_{t-1} is the change in past value of stock returns μt is the drift term, *t* is time, *p* is price of stock, εt is the error term and may be heteroskedastic. The null hypothesis in the PP test follows the same direction rule as in the case of the ADF test. While both the ADF and PP tests are commonly used in the literature for testing the presence of unit roots, both have been

criticised for exerting low testing power when distinguishing between unit root and near unit root process. The power of these tests is also reduced as deterministic terms are added to the test equations. That is, a model that includes a drift term and deterministic terms has less power than a model that includes only the drift term (Brooks, 2008). Schwert (1989) also found that if Δyt has an ARMA representation with a large and negative MA component, then the ADF and PP tests are severely size distorted, thus the null hypothesis gets rejected too often when it is true. The PP test is more size distorted than the ADF. In efforts to overcome some of these weaknesses, a confirmatory test has been proposed and the testing procedure is outlined below.

4.3.1.3 Kwiatkowski, Phillips, Schmidt and Shin

Following the criticisms of the two above mentioned tests, stationary tests was developed in the literature in efforts to combat the criticisms mentioned, thus to complement these tests. It has been deemed good practice to combine unit root tests with stationarity tests. The most commonly used stationarity test, the KPSS test, is due to Kwiatkowski, Phillips, Schmidt and Shin (1992) which has the following regression:

$$p_t = \mu t D_t + \beta t + \varepsilon t \tag{10}$$

$$\beta t = \beta_{t-1} + \varepsilon_t \tag{11}$$

Where D_t contains deterministic components (drift or drift plus deterministic trend), μt is I (0) as may be heteroskedastic and βt is a pure random walk with variance σ_ε^2. The null hypothesis is that p_t is I (0) which implies stationarity, this is formulated as follows:

$$H_0: \sigma_\varepsilon^2 = 0 \tag{12}$$

While the alternative hypothesis that implies stationarity is as follows:

$$H_1: \sigma_\varepsilon^2 > 0 \tag{13}$$

It is often suggested that KPSS, in which the null is that of stationarity, can be used to confirm results from the ADF and PP. However, as MK (1998) indicates, the KPSS also has the same poor power properties of the ADF. Thus, not only are all three of the above traditional tests sensitive to the issue of lag length and presence of large negative MA terms, they are also characterized by problems of poor power and size. Finally, it is worth noting that two data

generating processes will be utilized in the study -model with drift and deterministic trend (Model 1) and model with drift and deterministic trend (Model 2) for all three tests.

4.3.2 Modified Unit root tests

There have been developments in the literature that have modified the conventional unit root tests. In this study, the discussion of the modifications of tests over time have been restricted to the ADF and PP tests. Despite the problems and criticisms they face, they are still the most widely used and have been accepted in the literature as primary tests for unit roots. Further developments are being centered on them ((Phillips and Xiao (1998), Xiao and Phillips (1997), MK (1998), NP (2001)).

4.3.2.1 Dickey Fuller (GLS) ERS

Even though there is still no consensus on any one "most powerful" test, in their 1996 Econometrica article, Elliot, Rothenburg and Stock (ERS) proposed an efficient test modifying the conventional Dickey-Fuller test statistic using a generalized least square (GLS) rationale. They find that powers of the ADF tests are lower than those of the limiting power functions when deterministic components (mean or trend) are included in the data generating process. Elliot et al. (1996), hereafter ERS, proceed by first detrending the series as:

$$p_t^d = p_t - \hat{\beta}_0 - \hat{\beta}_1 t \tag{14}$$

$\hat{\beta}_0$ and $\hat{\beta}_1$ are obtained by regressing $\bar{p}$ on $\bar{z}$

$$\bar{p} = [p_1, (1-\propto L)p_2, \dots., (1-\propto L)p_t] \tag{15}$$

$$\bar{z} = [z_1, (1-\propto L)z_2, \dots.,((1-\propto L)z_t] \tag{16}$$

Where p_t is the original time series (i.e. stock prices) and z_t is [1,t], $\propto = 1 + (\bar{c}/T)$. ERS recommended that $\bar{c}$ takes the value of -7 or -13.5 depending on whether the series contains a drift or a drift and trend.

After the series has been suitably detrended the DF-GLS proceeds on similar lines as the traditional ADF test with the null hypothesis of a unit root being tested in:

$$\Delta p_t^d = \beta t + \varphi^d{}_{t-1} + \sum_{i=1}^{p-1} \alpha i \Delta p_{t-1}^d + \varepsilon t \tag{17}$$

Where φ^d represents the quasi-differenced data obtained from the GLS regression.

The results presented in ERS suggest that GLS local detrending yields substantial power gains over the standard ADF unit root test. However, in the presence of large negative moving average root in the residuals, the majority of unit root tests display significant size distortions resulting in over-rejections of the unit root null hypothesis (Schwert, 1989, Perron and Ng, 1996).

4.3.2.2 NG-Perron

Ng and Perron (2001) build on Elliot et al. (1996) and some of their own work (Perron and Ng, 1996) by using the detrended time series from the DF-GLS test and create efficient versions of the ADF and PP tests. This was following the development that the ERS test has poor size properties.

Ng and Perron (2001) use the GLS detrending procedure of ERS to create efficient versions of the modified PP tests of Perron and Ng (1996). These efficient modified PP tests do not exhibit the severe size distortions of the PP tests for errors with large negative MA or AR roots, and they can have substantially higher power. The test constructs four test statistics, namely MZ, MZt, MSB and MPT which are computed as:

$$\overline{MZ}_{\propto} = (T^{-1}\hat{y}_T^2 - \lambda^2)(2T^{-2}\sum_{i=1}^{T} y_{i-1}^{d})^2 \quad (18)$$

$$\overline{MSB} = (T^{-2}\sum_{i=1}^{T} y_{i-1}^{d} \,/\, \lambda^2)^{0.5} \quad (19)$$

$$\overline{MZ_t} = \overline{MZ_a}\; x\; \overline{MSB} \quad (20)$$

$$\overline{MPT} = \{(\bar{C}^2\left(2T^{-2}\sum_{i=1}^{T} y_{i-1}^{d}\right)^2 - \bar{c}T^{-1}\hat{y}_T^2)/\lambda^2, \qquad \text{if } if\ x_t = \{1\} \quad (21)$$

Where λ^2 is an estimate of the residual spectral density at the zero frequency. $\overline{MZ_t}$ and $\overline{MZ}_{\propto}$ are efficient versions of the Phillips (1987) and Phillips-Perron (1988) tests. Perron and Ng (1996) showed that the M tests have dramatically smaller size distortions in the presence of negative moving average errors.

The NP test in contrast to many of the other tests that have been developed over the years have caught on as a preferred alternative to the traditional ADF and PP tests. The time series in this test is demeaned or detrended by applying a GLS estimator, this improves the power of the

tests when there is a large negative MA root in differenced series. The second feature of the NP is a modified lag selection criteria. The standard lag selection procedures used in specifying the ADF regression (or for calculating the long run variance for the PP statistic) tend to underfit, i.e. they choose too small a lag length, where there is a large negative MA root. This creates additional size distortion in unit root tests. The modified lag selection criteria accounts for this tendency.

4.3.3 Non-linear tests

Failure to reject non-stationarity may be the result of lack of power of linear unit root tests. In the final stage of the empirical analysis, the non-linear tests are undertaken.

4.3.3.1 KSS nonlinear unit root test

The study begins the analysis following the framework of Kapetanois et.al. (2003) and considers the following model:

$$\Delta y_t = \beta_1 y_{t-1} + \propto_1 y_{t-1}[1 - \exp(-\beta y_{t-d}^2)] + \varepsilon_t \quad (22)$$

Where $e_t \sim iid(0, \sigma^2)$ and β is a smoothness parameter. Following Kapetanois et.al. (2003) the study assumes that the series is non-stationary if β_1=0 and d=1 and -2 < β_1< 0. However, since the unknown threshold parameters are not identified under the null (i.e. Davies (1987) problem) the null hypothesis cannot be evaluated directly. To circumvent this problem, a first order Taylor series approximation to equation (15) around $\beta = 0$ resulting in the following:

$$\Delta y_t = \delta_i y_{t-i}^3 + \varepsilon_t \quad (23)$$

In augmenting (16) with lags for correction of serial correlation in the disturbance term, the following is obtained:

$$\Delta y_t = \delta_i y^3{}_{t-1} + \sum_{j=1}^{p} \rho_i \Delta y_{t-1} + e_t \quad (24)$$

The null hypothesis of a linear unit is now tested as:

$$H_0: \beta_I = 0 \quad (25)$$

Against the alternative of stationary ESTAR process:

$$H_1: \beta_I = 0 \tag{26}$$

The test statistic evaluating these hypotheses is defined as:

$$t_{KSS} = \frac{\widehat{\beta}}{\sqrt{var}(\widehat{\beta})} \tag{27}$$

4.3.3.2 Flexible Fourier function

A major criticism with the testing procedure of Kapetanois et al. (2003) surrounds its failure to appropriately capture structural breaks in the testing procedure. After Becker et. Al (2006), the flexible Fourier transformation is used more in the literature in modelling structural breaks in recent years. The main advantage of this approach is that it eliminates the need to determine the number and type of structural breaks.

Enders and Granger (1998) demonstrate that the standard tests for unit root and cointegration all have lower power in the presence of misspecified dynamics. In the light of this information, it is important to determine not only the structural break but also the type of model of the nonlinear structure. There have been significant developments in nonlinear unit root tests in recent years and various significant tests that make use of various types of models have been developed (Kapetanious et al. (2003) (KSS), (Sollis (2004, 2009), Kruse (2011)).

The seminal papers of Becker et. al. (2006), Christopoulos and Leon-Ledesma (2010), Rodriguez and Taylor (2012) and Enders and Lee (2012) develop unit root testing procedures which uses selected frequency component of a Fourier function to estimate the deterministic components of the series. Christopoulos and Leon-Ledesma (2010) contribution proposed procedures that combine Fourier transformation and nonlinearity. This procedure is based upon the Fourier form in the first stage and the KSS test in the second stage, which in turn allow for modelling both nonlinearity and structural break.

Structural break tests were first introduced to literature by Perron (1989), Zivot and Andrews (1992) and Lee and Strazicich (2003,2004). Over the years in the literature these were developed to define the number of structural breaks and Prodan (2008) demonstrated that when the breaks are of opposite sign, it can be difficult to estimate the number and magnitude of multiple breaks. Becker et al. (2004, 2006) propose to use a Fourier series expansion to approximate the unknown number of breaks. In 2012 Enders and Lee suggested a unit root test with a Fourier function in the deterministic term in a Dickey Fuller type regression framework.

The Fourier approximation is as follows:

$$\alpha(t) = \alpha_i \sum_{k=1}^{n}(\sin 2\pi K_t /T) + b_i \sum_{k=}^{n} cos\,(2\pi Kt/T) + \epsilon_t \quad n < \frac{T}{2} \tag{28}$$

Whereas ϵ_t is a sequence of standard normal errors, k* is the frequency selected for the approximation, T is the sample size and n denotes the number of frequencies which as suggested by Becker et al. (2006) and Enders and Lee (2012) should be kept to a single frequency component (i.e. n=1). This is deemed sufficient to capture a series of smooth structural breaks as well as to overcome the problem of over-fitting and loss of regression power. The power properties are investigated are investigated using the following model:

$$\alpha(t) = \alpha_0 + \alpha_i(\sin 2\pi K_t /T) + b_i \cos(2\pi Kt/T) + \epsilon_t \tag{29}$$

The empirical procedure is practically carried out in the following four steps:

1. A two-dimensional grid search will be performed for combination of k bounded between $1 \leq k \leq 5$ and lag lengths bounded between $0 \leq j \leq 20$. The optimal values of [k*,j*] are those associated with the regression that yields the lowest sum of squared residuals (SSR).
2. Evaluate the estimated regression for serial correlation using the traditional Durbin Watson (DW) statistic.
3. Compare the test statistic against the critical values.

If the null hypothesis of a unit root is rejected, then:

$$H_0: \alpha_1 = \alpha_2 = 0 \tag{30}$$

Against the alternative hypothesis:

$$H_1: \alpha_1 = \alpha_2 \neq 0 \tag{31}$$

If the null hypothesis is rejected the study can conclude that the variable is stationary around a breaking deterministic function. The critical values are stipulated by Enders and Lee (2012).

4.4 Conclusion

This chapter set to outline the analytical frameworks that will be used to investigate the efficiency of the JSE Top40 individual stocks. The choice of empirical frameworks in this study is motivated by the evidence in the literature. The chapter also explained the reasons for adopting each of the analytical frameworks that will be used in this study.

This chapter outlined the conventional unit root tests that will be used (i.e. ADF, PP and KPSS). Due to criticisms of these tests (outlined in this chapter), modified unit root tests (DF (GLS) ERS and Ng-Perron) were discussed with their benefits and how they improve the conventional tests. In efforts to take non-linear behavior into consideration, the KSS unit root test was discussed which unfortunately does not account for structural breaks, thus, the Flexible fourier form is the last test that was discussed and that will be undertaken in the next chapter.

The findings of this research and the interpretation thereof are presented in the next chapter. A discussion of the results is also provided, however, the conclusions are done on the last chapter.

5 Data and Empirical results

5.1 Introduction

This chapter presents results from the applied empirical framework in order to address the objectives set out in the first chapter of the study. The chapter also looked at the nature of the data to be used and provides justifications for the choice in data. Section 5.2 presents the data used in the study. Section 5.3 presents descriptive statistics from the date. Section 5.4 presents conventional, the KSS and the FFF unit root tests. Section 5.5 of this chapter provides a conclusion and summary of the results.

5.2 Data description and sources

Monthly closing share prices for the period 01 January 1999 to 30 June 2018 are used to calculate the returns used in this analysis. In deciding on the period of study, the considerations that were taken are that, firstly, the market has experienced the Dot.com bubble (2000) as well as the Global financial crisis (2007/2008). The time period should thus not be too short for the results to not be biased by crises that occurred. The South African market specifically, has seen changes in the economy in the past 25 years, of that, the JSE has seen flat returns at least for the past 5 years with the exception of only a few outperformers in the market. The period could have been limited to 20 years or less, however because this study is analysing individual listed companies on the JSE, the date of listing also played a role.

The datasets used in this study consists of all stocks that are listed on the JSE Top 40 index. At the time of study, this index had 42 constituents the list of which is provided in Appendix 1. It is important to note that companies continuously move in and out of the Top40 index according to market capitalization. The raw data on the share prices is not included in the appendix because it is too voluminous.

Shares listed on the JSE are grouped according to economic sectors. The sectors which include, but not limited to, Basic materials, Consumer services, Financial services, Real-Estate, Healthcare, Pharmaceuticals, Industrials and Telecommunications. Some of these sectors are further grouped into sub sectors. All listed shares listed on the JSE are also grouped according to size (i.e. market capitalization) into either the the JSE Top 40 Index (J200), the Mid Cap Index (J201), the Small Cap Index (J202) or the Fledging Index (J204).

Most studies that undertook to test the efficiency of the South African market have tended to use either the All Share Index (J203) data or indices. Index returns are an average of many returns, they therefore tend to average out correlations that might exist in the individual stock returns Mabhunu (2004). He also indicates that in a number of developing markets, South Africa (i.e. JSE) included, trades are concentrated on stocks that normally have the highest weighting on the index. Thus, testing the J203 would not always yield accurate results. Though indices may provide a much needed summary of the market, for tests such as that undertaken by this study, an analysis of individual stocks is likely to yield more accurate results.

The data on share prices was received from Bloomberg, additional data on market size were received from the JSE as well as the World Federation of Exchanges (WFE). The statistical application, EViews 9, was used for all econometric analysis.

5.3 Descriptive statistics and correlation analysis

5.3.1 Descriptive statistics

Tables 2 to 8 presents the summary statistics of the JSE Top 40 individual stocks. The statistics were estimated as one common sample, however, the results are reflected on the below tables according to sector for ease of reference. The tables present the mean, median, maximum and minimum values, standard deviation kurtosis and Jarque-Bera statistics.

In the basic materials sector, Anglo American PLC (AGL) had the highest mean returns over the period of study whereas AngloGold Ashanti (ANG) has the lowest mean return. AGL also has the highest maximum return, and ANG with the lowest minimum return. ANG returns show the highest volatility risk as measured by the standard deviation of 7.93.

Skewness measures the asymmetry of the distribution of a series around its mean. The returns have skewness values that range between -1.05 and 0.62 with 62.5% of the distributions returning negative values. This implies that the distributions are more likely to be negative than positive and distributions are skewed to the left. ANG is more leptokurtic with a kurtosis value of 3.63. The kurtosis of any univariate normal distribution is 3, kurtosis values greater than 3 mean that the returns distributions have more outliers than normal distribution. The other distributions are less than 3 meaning that the distributions produce fewer and less extreme

outliers than does a normal distribution, these are called platykurtic. The Jarque-Bera statistics also indicate that the share returns for basic materials are not normally distributed.

Table 2: Descriptive statistics for Basic materials

	SOL	SAP	MND	MNP	GFI	BIL	ANG	AGL
Mean	2.44	0.62	1.36	1.34	-0.51	2.81	-1.49	3.64
Median	-0.25	2.69	1.88	2.31	-2.34	3.01	-0.15	2.11
Maximum	10.88	9.47	7.29	7.52	9.05	12.27	9.13	12.50
Minimum	-3.45	-10.81	-6.37	-6.34	-10.51	-7.65	-19.67	-4.74
Std. Dev.	5.44	6.00	4.80	4.76	6.62	5.82	7.93	5.58
Skewness	0.62	-0.64	-0.19	-0.16	0.12	-0.16	-1.05	0.16
Kurtosis	1.78	2.60	1.63	1.75	1.72	2.22	3.63	1.98
Jarque-Bera	1.39	0.83	0.92	0.75	0.76	0.32	2.24	0.52

Std. Dev. Denotes standard deviation

Table 3 presents the summary statistics of consumer services sector. Mr Price (MRP) had the highest mean returns followed by Clicks (CLS) with a difference of 0.05 and Tiger Brands Limited (TBS) has the lowest mean return followed by The Foschini Group (TFG) with a 0.04 higher mean difference than CLS. TFG had the highest maximum return in the sector and Truworths (TRU) had the lowest minimum returns for the period of study. TFG show the highest volatility risk as measured by the standard deviation of 11.25. The skewness results vary between -0.6 and 0.6, the distribution is more likely to be positively skewed. There is no distribution that returns kurtosis of 3. The skewness, kurtosis and Jarque-Bera values all indicate that the returns are not normally distributed.

Table 3: Descriptive statistics for Consumer Services

	WHL	SPP	TBS	TFG	TRU	SHP	SAP	MRP	NPN	CLS	BID	BTI	CFR
Mean	-0.73	1.38	-1.44	1.40	0.63	1.02	0.62	2.71	1.66	2.66	-1.09	-1.19	0.52
Median	-1.76	0.81	0.87	-0.18	3.29	-2.10	2.69	-0.66	-0.45	0.25	1.74	-1.34	1.84
Maximum	11.87	13.18	9.70	22.22	16.60	11.86	9.47	17.60	16.53	15.98	10.60	7.78	10.79
Minimum	-9.64	-9.25	-14.67	-15.43	-19.80	-7.08	-10.81	-8.76	-12.32	-5.62	-12.65	-14.12	-10.78
Std. Dev.	6.70	6.72	8.17	11.25	10.04	7.37	6.00	9.79	8.56	6.54	7.64	6.28	6.76
Skewness	0.44	0.08	-0.39	0.34	-0.43	0.51	-0.64	0.54	0.31	0.60	-0.13	-0.33	-0.26
Kurtosis	2.10	2.32	1.96	2.39	2.79	1.64	2.60	1.86	2.40	2.52	1.95	2.91	2.14
Jarque-Bera	0.72	0.21	0.76	0.38	0.36	1.33	0.83	1.14	0.34	0.77	0.53	0.20	0.46

Notes: Std.Dev. represents standard deviation.

Table 4 shows that the share returns in the financial services sector all had positive mean returns except for Investec Ltd (INL), with Standard Bank Group Ltd (SBK) holding the highest for the period. First Rand Ltd (FSR) had the highest maximum return and Capitec Bank Holdings Ltd (CPI) had the lowest minimum value for the period of study. CPI also had the highest volatility with a standard deviation of 11.49. The Skewness, Kurtosis and Jarque-Bera all reveal that the returns are not normally distributed.

Table 4: Descriptive statistics for Financial Services

	SBK	SLM	RMH	INP	NED	OML	DSY	FSR	CPI	ABG	INL
Mean	1.88	0.82	2.04	0.00	1.66	1.23	0.56	2.30	0.23	1.51	-0.03
Median	2.23	1.36	1.58	-0.83	2.30	1.97	1.60	1.12	3.90	-0.30	-1.08
Maximum	12.30	10.58	16.81	10.11	10.92	8.59	12.15	17.68	10.87	14.27	9.82
Minimum	-7.78	-8.18	-10.05	-11.04	-9.18	-7.18	-11.68	-10.97	-31.58	-12.38	-10.50
Std. Dev.	5.63	6.94	7.78	6.14	7.10	4.99	8.38	8.78	11.49	7.79	5.84
Skewness	0.13	0.14	0.19	-0.03	-0.22	-0.52	-0.02	0.08	-2.07	0.15	-0.07
Kurtosis	2.59	1.53	2.52	2.41	1.80	2.24	1.64	2.08	6.60	2.43	2.43
Jarque-Bera	0.11	1.02	0.17	0.16	0.75	0.76	0.84	0.39	13.85	0.19	0.15

Std. dev. denotes standard deviation

Table 5 presents the descriptive statistics for the real-estate sector. Redefine Properties Ltd (RDF) and Growthpoint Properties Ltd (GRT) had positive mean returns while Nepi Rockcastle PLC (NRP) had negative mean returns. NRP had the highest maximum and the lowest minimum return during this period of study which illustrate large deviations from its average returns. NRP also shows the highest volatility risk as measured by the standard deviation of 14.85. The results on the skewness implies that the distributions are more likely to be negatively distributed. GRT kurtosis results are greater than three implying that the returns are leptokurtic while RDF and NRP are below 3. The Jarque-Bera results also indicate that the returns are not normally distributed.

Table 5: Descriptive statistics for Real-Estate

	RDF	GRT	NRP
Mean	0.56	1.34	-2.80
Median	0.28	0.86	-0.46
Maximum	5.57	10.11	17.93
Minimum	-4.60	-6.75	-29.97
Std. Dev.	3.30	4.26	14.85
Skewness	-0.14	0.28	-0.79
Kurtosis	2.15	3.61	2.68
Jarque-Bera	0.36	0.31	1.21

Std. dev. denotes standard deviation

Table 6 presents the healthcare and pharmaceuticals sector's summary statistics. Mediclinic International PLC (MEI) had the lowest mean return while Netcare Ltd (NTC) had the highest mean return for the period of study. MEI had the highest maximum return as well as the lowest minimum return. MEI's mean return is the furthest return from its median of the other shares in the sector, it also shows the highest volatility as illustrated by the standard deviation. NTC has a skewness value of 0 with MEI showing a value close to 1(i.e. 0.96), LHC and APN show negative values. The Skewness, Kurtosis and Jarque-Bera results imply that the results are not normally distributed as a group sample, with the distributions being skewed to the right.

Table 6: Descriptive statistics for Healthcare & Pharmaceuticals

	LHC	MEI	NTC	APN
Mean	0.13	-2.56	1.27	-0.52
Median	-0.02	-6.34	-1.29	-0.22
Maximum	10.02	14.45	11.13	6.03
Minimum	-12.10	-12.12	-10.09	-9.61
Std. Dev.	6.88	7.72	7.28	5.39
Skewness	-0.52	0.96	-0.00	-0.32
Kurtosis	2.40	3.10	1.68	1.72
Jarque-Bera	0.66	1.71	0.78	0.93

Std. dev denotes standard deviation

Table 7 presents the summary statistics for the industrial sector. Bidvest Group Ltd (BVT) had the highest mean return, the highest mean return and the lowest minimum return. The share also proved to be the most volatile. The distributions are not normally distributed.

Table 7: Descriptive statistics for Industrials

	BVT	REM
Mean	1.71	-0.19
Median	2.21	1.45
Maximum	13.65	9.78
Minimum	-19.35	-9.66
Std. Dev.	10.13	5.68
Skewness	-0.69	-0.26
Kurtosis	2.77	2.51
Jarque-Bera	0.91	0.23

Std. dev denotes standard deviation

Table 8 presents the summary statistics for the telecommunications sector. Both MTN and Vodacom (Vod) had negative mean returns. Vod had the highest maximum as well as the

lowest return during the period of study. Vod also proved to be the most volatile, with a standard deviation of 6.96. The skewness values are between 0 and 1, however none are zero. The skewness, kurtosis and Jarwue-Bera results imply that the share returns are not normally distributed.

Table 8: Descriptive statistics for Telecommunications

	VOD	MTN
Mean	-2.82	-0.31
Median	-2.99	-2.23
Maximum	11.54	10.70
Minimum	-12.26	-8.96
Std. Dev.	6.96	6.02
Skewness	0.44	0.43
Kurtosis	2.79	2.06
Jarque-Bera	0.37	0.74

Std. dev denotes standard deviation

The JSE Top 40 shares analysed as a group show that Anglo American PLC in the basic materials-mining sector had the highest mean return of 3.64% during the period of study. This result is supported by the fact that South Africa's economy is a primary minerals-intensive economy, with approximately one-fifth of the economy dependent on the mining sector. Nepi-Rockcastle (NRP) which is a property investment and development group had the highest maximum return of 17.93% as well as the lowest minimum return of -29.97% during the period of study. NRP also showed the highest volatility risk as measured by the standard deviation of 14.85. This risk can be noted in Nepi's numbers as it closed in 2018 with a negative 44% in its share price. A report was issued by short sellers in November 2018, claiming that NRP had "numerous inconsistencies" in the group's financial reporting which could have contributed to the share's poor performance. However, the company was cleared by the regulators.

5.3.2 Correlation analysis

To further examine the behaviour of stock returns of the JSE Top 40 individual shares, the correlation analysis is carried out. The correlation coefficients provide some useful insights regarding the relationship between the individual stocks. Appendix A1 provides the correlation coefficients of the Top 40 stocks across the period of study.

The Big 4 commercial banks (Absa, FirstRand Limited, Nedbank and Standard Bank) are seen to have high correlation in their results. They are also seen to have similarities in the sectors they have the highest correlation with. For instance, all four banks have high correlation results with the retail sector except for Bidvest (BID) and Clicks (CLS) as well as with the food and beverages (Tiger Brands). There is also a high correlation between these four banks and REITs (Growthpoint and Redefine) as well as the insurance sector (Discovery, Sanlam and Old Mutual) with Old Mutual and FirstRand yielding the lowest correlation results.

However, Capitec banks (CPI) results do not show high correlation between itself and other banks or financial services, nor with any one particular sector. The bank shows the highest correlation with individual companies, Discovery (DSY) and Nepi Rockcastle (NRP). Investec (INP and INL) and Capitec have different target market groups, with the former focusing on the niche high earning group and the latter the opposite to middle income earners. This can be seen even in their negative correlation results. Both Investec Ltd and PLC have the highest correlation with Old Mutual (OML).

British American Tobacco (BTI) is highly correlated with Aspen in the pharmaceutical sector and the companies in the basic materials sector excluding Mondi. The company is also correlated with luxury good holding company Cie Financiere Richemont SA (CFR), media house Naspers (NPN) as well as Nepi-Rockcastle (NRP).

The basic materials sector shows conflicting results. Chemical company Sasol (SOL) shows high correlation with the BHP Group (BIL), Naspers (NPN), Nepi-Rockcastle (NRP) as well as paper company Sappi (SAP). The gold companies (GFI and ANG) are correlated to Nepi Rockcastle. Paper companies do not show high correlation with each other nor do they have similar companies they are correlated with. Sappi (SAP) shows the highest correlation with Anglo Gold Ashanti (ANG) and British American Tobacco (BTI) whereas Mondi shows the highest correlation with the BHP Group (BIL).

The Health sector individual companies (Netcare, Life Healthcare and Mediclinic) show correlation with Growthpoint (GRT). Life Health Care (LHC) and Mediclinic (MEI) show further correlation with MTN, Nedbank (NED), Old Mutual (OML) and Redefine properties (RDF). MEI shows high correlation with CLS and Woolworths (WHL), whereas the other two show results that are not as significant. LHC shows correlation with Discovery, investment

holding company Remgro (REM), Standard bank (SBK), Sanlam (SLM) and Vodacom (VOD) whereas the other two show results that are not as significant. Pharmaceutical company, Aspen, shows no correlation with the healthcare companies and instead the results prove correlation with NPN and BTI.

The analysis over this period shows that most individual stocks in each sector are correlated with each other, however, a study comparing different sectors would not yield accurate results as the individual companies in the sectors do not all correlate with the same sectors.

5.4 Unit root tests

This section examines the order of integration of the JSE Top40 index share price returns. The study employs unit root tests to test the efficiency of the market. In order to determine if variables are stationary or nonstationary, the null hypothesis is such that if the test statistic is greater than the critical value, then the study does not reject the null hypothesis and concludes that the series is nonstationary. If the test statistic is less than the critical value then the study rejects the null hypothesis and concludes that the series is stationary.

5.4.1 Conventional Unit root tests

In starting off the studies empirical test, Table 10 presents the results from the three commonly used conventional unit root tests Augmented Dickey-Fuller (ADF) test, Phillips Perron (PP) test and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test. The tests are all undertaken using two empirical settings, namely, with an intercept and with an intercept and trend (i.e. with a drift as well as drift and trend). The optimal lag length of the tests are determined by a minimisation of the Schwartz criterion.

The first unit root test that the study undertakes is the ADF test. The null hypothesis is rejected at all levels of significance for majority of the results. This excludes NRP which failed to reject the null hypothesis at all levels of significance regardless of whether the tests are performed at intercept or intercept and trend level. MEI on the other hand rejected the null hypothesis when the test was performed at intercept level and accepted the null hypothesis when tests were performed at intercept and trend level.

The ADF test has been criticised because it ignores hetereoskedasticity and non-normality in the time series and it cannot differentiate between a unit root and near unit root process. As Enders (1995) suggested to use more than one type of unit root test, the PP test is also employed. The results from the PP indicate that share returns data exhibit stationarity regardless of whether tests are performed with drift or with drift and trend. Only NRP unanimously failed to reject the stationary null hypothesis at all levels.

Apart from criticisms of the PP test that are similar to those of the ADF test such as it having poor size properties, Anyikwa (2018) also indicates that the power of this test is reduced as

deterministic terms are added to the test equations. That is, a model that includes a drift term and deterministic term has less power than a model that includes only the drift term (Brooks, 2008). To overcome some of these weaknesses, in the literature, the KPSS test has often been used to confirm results of the ADF and PP unit root tests.

The study employs the third conventional unit root test, the KPSS, to confirm the results of the first two tests undertaken. The series provided conflicting results. Majority failed to reject the null hypothesis regardless of whether the test is performed with a drift or with a drift and trend. This is with a few exceptions, BHP Group, Remgro, Capitec and Life Healthcare failed to reject the null hypothesis only at the drift level and rejected the null hypothesis at drift and trend. On the other hand, British American Tobacco, Shoprite, Bidvest, Woolworths, Sappi, Mondi Ltd and Nepi-Rockcastle all accepted the null hypothesis at drift and trend, however, rejected it at drift level. The results show that Vodacom is the only share that unanimously rejected the null hypothesis both at drift and with drift and trend.

Table 9: Conventional Unit root tests

Variables	ADF		PP		KPSS	
	Intercept	Intercept + Trend	Intercept	Intercept + Trend	Intercept	Intercept + Trend
NPN	-14.13***[0]	-14.12***[0]	-14.11***[11]	-14.09***[11]	0.08	0.05
BIL	-16.78***[0]	-16.97***[0]	-16.71***[4]	-16.71***[3]	0.36*[4]	0.05
CFR	-17.62***[0]	-17.59***[0]	-17.47***[3]	-17.44***[3]	0.08	0.08
AGL	-14.52***[0]	-14.55***[0]	-14.58***[0]	-14.60***[4]	0.17	0.06
SOL	-16.72***[0]	-16.97***[0]	-16.65***[4]	-16.91***[4]	0.43*[4]	0.05
SBK	-16.55***[0]	-16.56***[0]	-16.87***[8]	-16.92***[8]	0.11	0.04
FSR	-17.18***[0]	-17.15***[0]	-17.32***[3]	-17.30***[3]	0.09	0.04
MTN	-13.23***[0]	-13.33***[0]	-13.34***[5]	-13.41***[5]	0.23	0.05
BTI	-12.12***[0]	-12.16***[0]	-12.13***[8]	-12.22***[9]	0.23	0.18**[10]
OML	-14.44***[0]	-14.42***[0]	-14.51***[5]	-14.48***[5]	0.07	0.06
MNP	-11.95***[0]	-12.05***[0]	-11.96***[5]	12.04***[5]	0.20	0.13
SLM	-15.85***[0]	-15.83***[0]	-15.89***[4]	-15.88***[4]	0.05	0.05
ABG	-15.72*** [0]	-15.72*** [0]	-15.82***[0]	-15.83***[0]	0.12	0.07
REM	-17.18***[0]	-17.41***[0]	-17.31***[5]	-17.51***[8]	0.50**[6]	0.11
SHP	-16.48***[0]	-16.45***[0]	-16.72***[11]	-16.69***[11]	0.24	0.24***[12]
APN	-14.15***[0]	-14.13***[0]	-14.17***[0]	-14.15***[0]	0.17	0.08
BID	-6.97***[0]	-6.81***[0]	-6.80***[2]	-6.65***[2]	0.16	0.15**
GRT	-15.44***[0]	-15.64***[0]	-15.44***[1]	-15.64***[0]	0.34	0.02
VOD	-11.68***[0]	-11.95***[0]	-11.92***[10]	-13.36***[17]	0.52**[14]	0.13*[24]
INP	-13.69***[0]	-13.68***[0]	-13.71***[5]	-13.71***[5]	0.09	0.07
BVT	-15.35***[0]	-15.39***[0]	-15.44***[10]	-15.60***[12]	0.17	0.05
RDF	-13.99***[0]	-14.08***[0]	-14.02***[10]	-14.24***[11]	0.24	0.04
NED	-14.65***[0]	-14.66***[0]	-14.64***[6]	-14.66***[7]	0.14	0.05
MRP	-14.93***[0]	-14.90***[0]	-14.93***[2]	-14.90***[2]	0.07	0.06
TBS	-15.58***[0]	-15.59***[0]	-15.65***[6]	-15.67***[6]	0.13	0.07
WHL	-16.12***[0]	-16.12***[0]	-16.13***[2]	-16.13***[2]	0.19	0.13*[4]
DSY	-16.40***[0]	-16.40***[0]	-16.32***[5]	-16.34***[4]	0.09	0.07
SAP	-14.34***[0]	-14.33***[0]	-14.34***[6]	-14.33***[6]	0.18	0.17**[6]
RMH	-15.99***[0]	-15.97***[0]	-16.14***[4]	-16.11***[4]	0.10	0.06
CPI	-15.63***[0]	-16.11***[0]	-15.53***[5]	-16.08***[3]	0.52**[5]	0.10
ANG	-16.03***[0]	-16.13***[0]	-16.02***[2]	-16.16***[3]	0.2	0.02
CLS	-14.80***[0]	-14.91***[0]	-14.84***[10]	-15.08***[12]	0.29	0.07
MND	-12.24***[0]	-12.34***[0]	-12.21***[0]	-12.33***[0]	0.23	0.14*[2]
NRP	-2.55	0.85	-2.17	-1.72	0.13	0.14*[3]
NTC	-15.25***[0]	-15.38***[0]	-15.28***[6]	-15.39***[6]	0.27	0.04
GFI	-15.66***[0]	-15.76***[0]	-15.65***[3]	'-15.75***[2]	0.20	0.04
TFG	-14.56***[0]	-14.53***[0]	-14.59***[4]	-14.56***[4]	0.07	0.05
SPP	-14.15***[0]	-14.35***[0]	-14.16***[3]	-14.44***[5]	0.31	0.03
MEI	-3.75**[6]	-3.12	-4.83***[3]	-4.79***[3]	0.06	0.06
LHC	-10.27***[0]	-11.32***[0]	-10.27***[2]	-11.64***[9]	0.88***[4]	0.08
TRU	-15.30***[0]	-15.29***[0]	-15.37***[5]	-15.38***[6]	0.20	0.10
INL	-14.29***[0]	-14.28***[0]	-14.26***[3]	-14.25***[0]	0.10	0.07

Notes: ***, ** and * denote the1%, 5% and 1% significance levels respectively. The lag length for ADF test is based on Schwarz information criterion, while the bandwidth for PP and KPSS test is based on the Newey-West.

5.4.2 Modified unit root tests

In recognition of the criticisms of conventional tests, there have been a barrage of studies attempting to construct more efficient unit roots (Campbell and Perron (19991), Maddala and Kim (1998) henceforth MK and Phillips and Xiao (1998)). Although the KPSS test has often been used to confirm results of the ADF and PP unit root tests, this test has also been found to have the same poor power and size properties as the traditional ADF and PP tests. Even though there is still no consensus on any one "most powerful" test, Elliot, Rothenburg and Stock (1996) (ERS hereafter) proposed an efficient test modifying the conventional Dickey-Fuller test statistic using a generalized least square (GLS) rationale. They demonstrated that this modified test has the best overall performance and that the DF-GLS (ERS) test "has substantially improved power when an unknown mean or trend is present" (1996).

Table 11 presents conflicting evidence of the DF-GLS (ERS) unit root test. A majority (67%) of the reported evidence rejects the unit root null hypothesis and points to a stationary process in the share returns. However, a number of stock returns failed to reject the null hypothesis at the drift level, however, rejected the null hypothesis at drift and trend level. Those are the BHP Group, Standard Bank, FirstRand, Sanlam, Remgro, Shoprite, Mr Price, Discovery, RMB Holdings, Clicks, TFG, and Truworths. On the other hand, Bidvest, Mondi Ltd and Nepi-Rockcastle fail to reject the null hypothesis at drift and trend level, whilst rejecting the null hypothesis at drift level. Only Aspen and Capitec unanimously failed to reject the null hypothesis at all levels.

Due to the conflicting evidence provided by the DF-GLS (ERS) test, the study further applies the Ng-Perron test which is an extension of the DF-GLS (ERS). Ng and Perron (2001) developed the M-tests (MZa, MZb, MSb and MPt) which were deemed to have the best adjusted power properties. As can be observed from table 8, the N-P test provides divergent results. The results show that at least one share from each JSE sector failed to reject the null hypothesis both when the tests are performed with a drift or with drift and trend. Only British American Tobacco and Absa rejected the null hypothesis at all M-tests undertaken both at drift and with drift and trend. Nepi-Rockcastle on the other hand rejected the null hypothesis for MZa, MSb, MPt (at drift and with drift and trend) and for MZt at drift then failed to reject the null hypothesis for the MZt test performed at drift and trend.

Table 90: Modified Unit Roots

Variables	Dickey Fuller GLS (ERS)		NG- PERRON							
	Intercept	Intercept + Trend	Mza		MZt		MSb		MPt	
			Intercept	Intercept + Trend	Intercept	Intercept + Trend	Intercept	Intercept + Trend	Intercept	Intercept + Trend
NPN	-13.93***[0]	-14.00***[0]	-115.19***[0]	-115.24***[0]	-7.56***[0]	-7.58***[0]	0.06	0.06	0.25	0.82
BIL	-1.41	-5.10***[2]	-3.34	-32.08***[2]	-1.27	-3.98***[2]	0.38***[6]	0.12	7.32***[6]	3.00
CFR	-3.44***[2]	-5.26***[2]	-15.86***[2]	-28.56***[2]	-2.81***[2]	-3.77***[2]	0.18***[2]	0.13	1.58	3.24
AGL	-4.53***[2]	-8.13***[1]	-29.87***[2]	-77.48***[1]	-3.85***[2]	-6.22***[1]	0.13	0.08	0.85	1.19
SOL	-2.52**[3]	-5.83***[2]	-9.53**[3]	-33.06***[2]	-2.18**[3]	-4.02***[2]	0.22***[3]	0.12	2.57***[3]	2.99
SBK	-1.17	-7.81***[1]	-1.62	-74.57***[1]	-0.89	-6.07***[1]	0.55***[8]	0.08	15.00***[8]	1.37
FSR	-1.54	-3.96***[3]	-4.56	-20.13**[3]	-1.40	-3.17**[3]	0.30***[4]	0.15***[3]	5.58***[4]	4.52***[3]
MTN	-4.18***[3]	-12.69***[0]	-25.87***[3]	-112.31***[0]	-3.55***[3]	-7.49***[0]	0.13	0.06	1.10	0.81
BTI	-3.36***[2]	-5.80***[1]	-13.41**[2]	-37.13***[1]	-2.48**[2]	-4.29***[1]	0.18***[2]	0.12***[1]	2.25***[2]	2.52
OML	-14.32***[0]	-14.22***[0]	-112.78***[0]	-112.69***[0]	-7.48***[0]	-7.49***[0]	0.06	0.06	0.25	0.84
MNP	-2.05**[4]	-9.90***[0]	-4.65	-63.75***[0]	-1.51	-5.64***[0]	0.32**[4]	0.08	5.27***[4]	1.46
SLM	-1.56	2.79*[5]	-2.22	-4.82	-1.05	-1.41	0.47***[5]	0.29***[5]	11.00***[5]	18.15***[5]
ABG	-2.32**[4]	-3.93***[4]	-6.8*[4]	-16.46*[4]	-1.82*[4]	-2.85*[4]	0.27***[4]	0.17**[4]	3.68***[4]	5.63**[4]
REM	-1.26	-3.44**[5]	-2.60	-7.66	-1.06	-1.95	0.40***[5]	0.25	9.06***[5]	11.89***[5]
SHP	-1.57	-12.81***[0]	-1.28	-112.66***[0]	-0.60	-7.50***[0]	0.46***[7]	0.06	13.75***[7]	0.81
APN	-0.86	-2.45	-0.58	-2.97	-0.41	-1.16	0.71***[5]	0.39***[5]	27.80***[5]	29.18***[5]
BID	-2.87***[1]	-2.79	-4.73	-5.74	-1.39	-1.65	0.29***[1]	0.28***[1]	5.46***[1]	15.76***[1]
GRT	-11.44***[0]	-12.86***[0]	-115.85***[0]	-115.85***[0]	7.61***[0]	-7.61***[0]	0.06	0.07	0.21	0.79
VOD	-2.18**[2]	-9.64***[0]	-6.99*[2]	-53.74***[0]	-1.54	-5.14***[0]	0.22***[2]	0.09	4.57***[2]	1.88
INP	-1.70*[3]	-3.02**[3]	-4.59	-12.17	1.42	-2.46	0.31***[3]	0.20***[3]	5.51***[3]	7.49***[3]
BVT	-15.13***[0]	-15.13***[0]	-115.99***[0]	-115.99***[0]	-7.61***[0]	-7.61***[0]	0.07	0.07	0.23***[0]	0.80
RDF	-11.44***[0]	-12.86***[0]	-102.70***[0]	-107.49***[0]	-7.16***[0]	-7.31***[0]	0.06	0.06	0.24	0.90
NED	-14.27***[0]	-14.07***[0]	-115.62***[0]	-7.57***[0]	-7.56***[0]	-7.57***[0]	0.07	0.06	0.28***[0]	0.86
MRP	-1.17	-3.26**[3]	-2.79	-13.67	-1.02	-2.62*[3]	0.36***[4]	0.19***[3]	8.29***[4]	6.66***[3]
TBS	-3.13***[4]	-13.16***[0]	-13.24**[4]	-113.64***[0]	-2.56**[4]	-7.53***[0]	0.19***[4]	0.06	1.88***[4]	0.81
WHL	-1.87*[4]	-3.68***[4]	-5.10	-13.62	-1.48	-2.60	0.29***[4]	0.19***[4]	5.09***[4]	6.69***[4]
DSY	-0.87	-2.29*[4]	-1.73	-6.59	-0.76	-1.81	0.44***[4]	0.27***[4]	11.84***[4]	13.83***[4]
SAP	-14.05***[0]	-14.08***[0]	-115.32***[0]	-115.34***[0]	-7.57***[0]	-7.58***[0]	0.06	0.06	0.23	0.81
RMH	-1.24	-2.42***[5]	-1.97	-6.55	0.87	-1.80	0.44***[5]	0.27	11.19***[5]	13.89***[5]
CPI	-1.20	-2.20	-1.00	-2.69	-0.64	-1.11	0.64	0.41***[5]	21.14***[5]	32.35***[5]
ANG	-14.66***[0]	-15.35***[0]	-115.85***[0]	-115.99***[0]	-7.60***[0]	-7.61***[0]	0.07	0.07	0.22***[0]	0.79
CLS	-1.42	-3.07**[5]	-2.40	-9.36	-0.98	-2.16	0.41***[6]	0.23***[5]	9.53***[6]	9.73***[5]
MND	-1.67*[4]	-2.51	-3.06	-5.53	-1.22	-1.64	0.40***[4]	0.29***[4]	7.99***[4]	16.39***[4]
NRP	-2.73**[1]	-2.79	-8.35**[1]	-13.67*[1]	-1.97*[1]	-2.61	0.23***[1]	0.19***[1]	3.14***[1]	6.66***[1]
NTC	-15.28***[0]	-15.28***[0]	-115.99***[0]	-115.99***[0]	-7.59***[0]	-7.60***[0]	0.06	0.06	0.24	0.81
GFI	-1.81*[5]	-4.19***[3]	-4.77	-23.97***[3]	-1.44	-3.46***[3]	0.30***[5]	0.14***[3]	5.37***[5]	3.81
TFG	0.73	-3.27**[3]	-0.52	-12.94	-0.32	-2.54	0.61***[7]	0.19***[3]	22.83***[7]	7.04***[3]
SPP	-14.16***[0]	-14.36***[0]	-80.53***[0]	-80.30***[0]	-6.33***[0]	-6.33***[0]	0.07	0.07	0.32	1.15
MEI	-4.82***[0]	-4.86***[0]	-13.35**[0]	-13.38	-2.56**[0]	-2.58	0.19***[0]	0.19***[0]	1.90***[0]	6.84***[0]
LHC	-8.70***[0]	-9.89***[0]	-25.24***[1]	-47.34***[0]	-3.45***[1]	-4.79***[0]	0.13	0.10	1.30	2.29
TRU	-1.02	-2.80*[5]	-1.26	-6.58	-0.59	-1.81	0.46***[5]	0.27***[5]	13.79***[5]	13.83***[5]
INL	-1.95**[5]	-3.82***[4]	-5.22	-16.19*[4]	-1.60	-2.83*[4]	0.31***[5]	0.17***[4]	4.72***[5]	5.73***[4]

Notes: ***, ** and * denote the1%, 5% and 1% significance levels respectively. The lag length selections for DF GLS (ERS) and NG-Perron tests are based on Schwarz information criterion

5.4.3 Non-linear KSS unit root test

Apart from the inconclusive results, the previous tests do not take into consideration possible non-linear behaviour in the JSE Top 40 index stocks. Lim (2011) noted that the assumption of linearity implies that the level of market efficiency remains unchanged throughout the estimation period. As argued by Kapetanois et al. (2003), transactions costs and other frictions in financial assets are likely to lead to nonlinear equilibrium adjustments which linear unit root tests would exert low power in differentiating from unit root processes. Thus, given the possibility of a nonlinear structure being associated with underlying data generating processes of stock returns, we formally test the stationary properties by applying the KSS test.

The results from the series as reported in Table 12 shows that the test statistics estimated from majority of the series fail to reject the unit root null hypothesis at all levels of significance with the exception of Sasol, Vodacom and Netcare.

5.4.4 Non-linear with structural breaks

One major shortcoming with the KSS unit root test is its inability to directly account for structural breaks in the regression. Of recent, there has been growing consensus that a flexible Fourier form (FFF) approximation of unit roots has good size and power properties in detecting a series of unknown structural breaks (Enders and Lee (2012) and Taylor (2012)).

Thus, in the final stage of the empirical analysis, the FFF unit root test is carried out for the top 40 market returns. As indicated in the previous chapter, this testing procedure is undertaken in three phases. The first stage is to search for the optimal combinations of the length of Fourier function frequencies, k*, and the lag length, j*. The optimal combinations of k* and j* are obtained as those which simultaneously minimise the SRR. These are reported in table 13.

Secondly, to ensure that the optimal lag length removes all possible serial correlation, the Durbin Watson (DW) statistic is estimated and the obtained statistics are recorded. Note that no lags were included for SPP and BID as there was no evidence of serial correlation present. Thirdly, the regressions are tested for linearity and the test statistics are recorded in the table 13 below. Critical values were adopted at T=234. In performing the tests, all Top 40 individual

JSE listed stocks, with the exception of Shoprite and Bidvest, reject the null hypothesis at different significant levels, with the majority rejecting at the 1% level.

Table 11: Non- linear KSS

Variables	KSS			
	T Statistic	AIC	DW	Lag
NPN	-1.50	7.68	2.00	2
BIL	1.52	7.21	1.99	2
CFR	0.76	6.89	2.02	2
AGL	0.31	7.58	2.00	4
SOL	2.03*	6.95	1.89	3
SBK	-0.76	6.63	1.99	2
FSR	-0.36	6.78	1.99	5
MTN	-0.08	7.35	1.99	2
BTI	-1.72	6.25	1.99	4
OML	0.53	6.83	1.99	2
MNP	0.53	7.37	2.00	2
SLM	-0.74	6.61	1.99	3
ABG	-0,90	6.86	2.01	2
REM	-0.89	6.06	1.98	3
SHP	-1.26	6.91	1.98	2
APN	-1.85	7.04	2.03	3
BID	0.89	6.63	1.99	2
GRT	-1.37	6.48	2.03	2
VOD	-2.15*	6.33	1.99	4
INP	-0.04	6.89	1.98	2
BVT	-0.56	6.57	2.00	2
RDF	-0.73	6.37	1.98	2
NED	-0.88	6.66	1.99	2
MRP	0.90	7.47	2.00	2
TBS	-0.07	6.60	1.99	2
WHL	0.23	7.02	2.00	2
DSY	0.44	7.03	1.99	3
SAP	-1.63	7.38	2.02	5
RMH	-0.73	6.74	1.99	2
CPI	-0.47	7.31	1.99	3
ANG	0.63	7.84	1.99	2
CLS	-1.28	6.83	2.00	2
MND	0.06	7.22	1.99	2
NRP	-1.78	8.63	2.02	0
NTC	2.4*	6.99	1.98	4
GFI	1.17	7.79	1.99	2
TFG	1.21	7.25	1.99	2
SPP	0.07	6.36	1.99	2
MEI	0.03	7.37	2.05	3
LHC	1.65	6.37	1.96	4
TRU	-0.6	7.13	1.99	2
INL	-1.22	7.01	2.00	2

Note: ***, ** and * represent the 1%, 5% and 10% significance levels respectively. The critical values associated with KSS tests are -2.82(1%), -2.22(5%) and -1.92(10%) and the optimal lag lengths for the tests are based on minimisation of AIC and SC criterion. Optimal frequency approximation, K, is selected via a minimisation of the SSR.

Table 10: Non-linear with structural breaks

	FFF			
Variables	t statistic	K	DW	S.S.R
NPN	-14.10***[1]	1	1.96	29310.29
BIL	-16.92***[1]	1	1.98	17935.33
CFR	-17.64***[1]	1	1.98	12978.88
AGL	-14.62***[1]	1	1.98	26845.98
SOL	-16.83***[1]	1	1.98	15576.78
SBK	-16.58***[1]	1	2.00	9999.89
FSR	-17.11***[1]	1	2.01	12130.02
MTN	-13.27***[1]	1	1.99	20588.31
BTI	-12.79***[1]	1	1.99	3173.02
OML	-14.44***[1]	1	1.99	11951.86
MNP	-12.43***[1]	1	1.98	10972.21
SLM	2.47**[3]	3	1.92	9884.159
ABG	-15.70***[1]	1	1.98	12593.75
REM	-17.45***[1]	1	1.98	5236.88
SHP	-0.87	2	2.01	13388.28
APN	-14.23***[1]	1	2.02	18580.51
BID	0.31	5	1.88	787.93
GRT	-15.47***[3]	3	1.96	8819.060
VOD	-12.07***[1]	1	2.01	3225.67
INP	-13.65***[1]	1	1.98	10592.94
BVT	-15.31***[1]	1	1.99	9463.31
RDF	-14.05***[1]	1	1.99	7219.32
NED	-14.68***[1]	1	1.98	10436.80
MRP	-14.98***[1]	1	2.01	23308.04
TBS	-15.63***[1]	1	1.99	9637.68
WHL	-16.28***[1]	1	1.98	15445.54
DSY	-16.44***[1]	1	2.01	9461.84
SAP	-14.64***[1]	1	1.98	24345.47
RMH	-15.95***[1]	1	2.02	11371.93
CPI	-15.95***[1]	1	1.68	19703.93
ANG	-16.06***[1]	1	1.99	33534.41
CLS	-14.91***[1]	1	2.00	12253.95
MND	-12.75***[1]	1	2.01	9401.28
NRP	-2.08*[1]	1	1.79	1752.03
NTC	-15.53***[2]	2	1.96	15491.84
GFI	-15.77***[1]	1	1.98	31917.41
TFG	-14.58***[1]	1	2.02	18756.65
SPP	-14.24***[1]	1	1.99	5262.98
MEI	-4.64***[1]	1	1.98	1810.25
LHC	-11.35***[1]	1	1.94	2784.98
TRU	-15.29***[2]	2	2.01	16580.34
INL	-14.27***[1]	1	1.98	14710.14

Notes: "***", "**", "*" denote the 1%, 5% and 10% critical levels. Critical values are derived from Kapetanosis et. al. (2003) as follows: 2.82(1%), 2.2(5%) and 1.92(1%). Optimal lag frequency approximation, K, is selected at a minimisation of the SSR.

5.5 Conclusion

This chapter empirically examined the efficiency of the JSE analysing the stocks that are constituents of the Top40 index. The chapter began with the presentation of preliminary results by analysing the descriptive statistical properties and correlation of the individual stocks of the market considered. This was followed by the analysis of the unit root/stationarity of the stock price series using three conventional tests (ADF, PP and KPSS), modified tests (DF GLS (ERS) and NG-Perron), Non-linear KSS and Non-linear with structural breaks (FFF).

The analysis of the preliminary results revealed that the share with both the lowest and highest return for the period of study was Nepi-Rockcastle, this share thus showed the highest volatility risk for the period of study. As a sector, the consumer services industry showed the highest average volatility as measured by the standard deviation. The market has seen top performing shares such as Naspers with minimum share price of R11 and maximum price of R3,687 and Capitec with minimum share price of R 0.50 and maximum price of R 1,050 for this period. However, the share prices were transformed into returns (%) and the series was estimated on the dates where all data is available, thus the descriptive statistics utilised a total of 11 observations.

The correlation analysis assisted in showing that individual sector stocks are mostly correlated, however, the individual stocks do not show a relationship with common sectors. The evidence from the conventional ADF and PP unit root test presented the conclusion that the null hypothesis is rejected on the "majority rule" thus implying that the JSE is not a unit root process and is a stationary process. Due to criticisms of the two tests in the literature, the KPSS test was employed to confirm these results. This test presented conflicting results with majority failing to reject the null hypothesis with some exceptions to the rule. Upon employing modified unit root tests, though the results provided opposing contentions, majority of the reported evidence rejected the unit root in favour of a stationary process for the DF (GLS) ERS. The Ng-Perron test proved that the JSE market does not have a "one size fits all" model that can be employed as the individual stocks provide conflicting evidence, even for the stocks in the same sector. Only British American Tobacco and Absa managed to reject the null hypothesis at all M-tests undertaken for the Ng-Perron test.

In employing the non-linear tests, the KSS results are inconclusive, however they are deemed as biased as they do not take into consideration structural breaks. The study concludes that the FFF test is more accurate with it presenting evidence of stationarity, thus nonefficiency, with Shoprite and Bidvest the only two stocks failing to reject the null hypothesis. The last chapter provides an overall conclusion of the study undertaken.

6. Conclusion, policy implications and recommendations

6.1 Introduction

This chapter presents the general conclusion and summary of the findings of the study in section 6.2. The main findings which respond to the research questions and objectives set out in the first chapter of this study are presented in section 6.3. Finally, section 6.4 presents the recommendations for further study and policy recommendations.

6.2 Summary

The study aimed to investigate the efficient market hypothesis using the Top 40 individual stocks of the Johannesburg stock exchange (JSE) for the period 01 January 1999 to 30 June 2018. The study also set out to determine whether there was any correlation between the individual companies in a sector as well as to note of any correlation in sectors that may be present in evidence of individual stock returns.

The market has witnessed significant growth periods as seen in market capitalisation numbers as well as steady turnover values over this period. This can be partially linked to the developments that the JSE has seen overtime, such as moving from having a concentrated risk in gold mining at inception to its current structure which is well diversified into a number of sectors. It has been of great benefit for the market and its individual companies to move from the old open cry system to the current electronic trading system used as it reduced friction in the trading process. Through its memberships and change in certain regulations and legislations, the JSE has seen growth in the number of foreign investors who were historically not able to operate on the exchange. Thus, a higher level of integration between the JSE and other markets has been prevalent. The introduction of SENS which was implemented to ensure early, wide dissemination of price sensitive information has provided the market with information at a much faster rate, in efforts to remove informational inefficiency in the market.

On the other hand, the number of listed companies has not been growing and African stock markets are still known to be illiquid in comparison to other markets. If the market is liquid, then all perceived inefficiencies could be readily arbitraged, making the market efficient.

According to chartists, an astute chart reader can actively compete to profit from any dependence in the return series, fundamental analysts indicate that they can interpret economic and political events and 'accurately' evaluate the eventual effects of such information on share prices. Researchers and investors have found a number of theories on how to "beat the market" such as the P/E ratio where they suggest that stocks with low P/E ratio will tend to outperform high-yielding P/E stocks. Others have found that the first two weeks of the year tends to yield high returns as well as the last trading day of the week, Friday. However, if prices are efficient, they cannot earn any excess profits from reading charts, or interpreting events.

In practice, there still exists conflicting evidence between the conclusion that markets are efficient and other theories which suggest that sophisticated investors can earn excess profits. Previous literature analysed on the JSE, however, obtained conflicting results. Most found the JSE to be a weak form efficient market, indicating that information about historical prices and trading volumes is already reflected.

In addition to the conventional ADF, PP and KPSS tests, the study further employed modified and asymmetric unit root testing procedures proposed by Elliot, Rothenburg and Stock (ERS), Ng and Perron (1996,2001) , Kapetanious et al.(2003) and Enders and Lee (2012).

6.3 Main findings

The empirical results obtained bridge conflicting results. When the linear unit root tests are employed, the results rejected the null hypothesis of a unit root. Suggesting that stock market series does not follow a unit root process. The KPSS test that was employed as a confirmatory test presented conflicting results with majority of the stocks failing to reject the null hypothesis.

In employing the modified tests, majority of the DF (GLS) ERS rejected the null hypothesis whereas the results for the Ng-Perron only showed British American Tobacco and Absa managed to reject the null at all M-tests, all other stocks provided conflicting results. In analysing the nonlinear test results, the KSS was deemed inconclusive because the test does not take into consideration structural breaks. Thus, the study concludes that the FFF test is more accurate. With the exception of two stocks, this test rejects the null hypothesis of a unit root and concludes that the Top 40 index, thus the All Share index, is not a unit root process and is a stationary process. This implies that the JSE is not efficient as the EMH indicates. The

implication is that sophisticated investors can use technical analysis skills to earn above normal returns.

Traditional finance is built on a number of key pillars, including that of efficient markets which got the peak of its success in academic and professional settings in the 1970s. This study provides proof against this theory, thus provides a case for a new line of research: Behavioural finance. This theory criticizes the EMH for the assumption that investors are all rational and suggests that the influence of psychology on the behaviour of investors should be considered and the subsequent effect that this has on the market.

6.4 Policy implications

Given the main findings of the study, further research is required on what drives market prices as they have been proved inefficient. The JSE should consider the psychology of investors and shareholders in line with the theory of behavioural finance.

The benefits of listing should be actively communicated as the market has not been seen to list, rather delist in the JSE.

Regulatory authorities should intensify efforts to ensure compliance to insider trading laws by market participants. Following the news in 2017 of seventeen banks being accused of colluding and price fixing, more stringent processes should be followed. The commission had found that from atleast 2007, these banks had a general agreement to collude on prices for bids, offers and bid-offer spreads. This not only would have had an effect on the currency but also on the local market, especially for companies that export/import.

6.5 Possible area of further research

The EMH has faced great criticisms as the behavioural finance theory indicated that investors are not always rational and sometimes behave irrationally and are influenced by emotion during times of increased uncertainty. This is consistent with research findings by Phan and Zhou (2004) that found that investors usually act similarly making transaction prices predictable. This they found was due to the stock market investors not being sophisticated, hence, psychological factors influenced their investment decisions. The results of the current study provide a case for behavioural finance, thus a study worth looking into would be what drives

share price movement, an analysis into the individual stocks of the Top 40 index so to analyse whether South African investors are rational.

Lastly, an analysis of sophisticated investors utilising chartist procedures and whether or not they earn above normal returns could also be a study worth considering.

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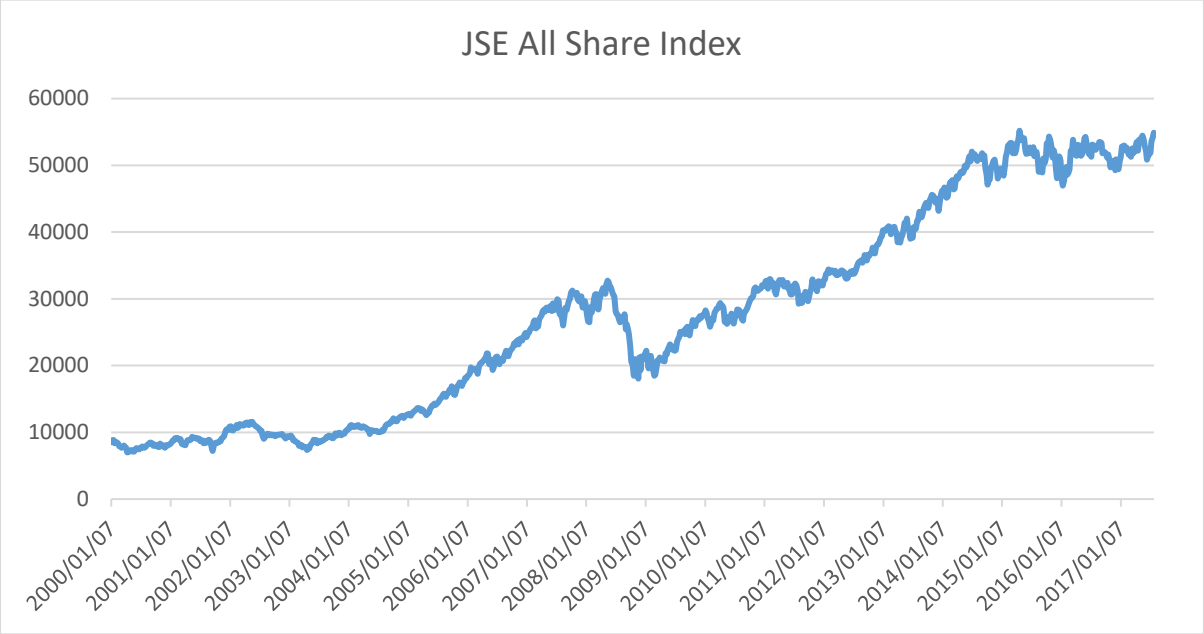
APPENDIX A1: Correlation matrix for top 40 JSE companies

	INL	ABG	AGL	ANG	APN	BID	BIL	BTI	BVT	CFR	CLS	CPI	DSY	FSR	GFI	GRT	INP	LHC	MEI	MND	MNP	MRP	MTN	NED	NPN	NRP	NTC	OML	RDF	REM	RMH	SAP	SBK	SHP	SLM	SOL	SPP	TBS	TFG	TRU	VOD	WHL
INL	1.00																																									
ABG	0.33	1.00																																								
AGL	0.37	-0.21	1.00																																							
ANG	-0.36	-0.28	-0.01	1.00																																						
APN	0.46	-0.18	0.50	0.15	1.00																																					
BID	0.41	0.24	-0.13	-0.15	0.47	1.00																																				
BIL	0.01	-0.52	0.53	0.37	0.22	0.12	1.00																																			
BTI	-0.21	-0.35	0.24	0.64	0.55	0.33	0.47	1.00																																		
BVT	0.09	0.51	0.17	0.36	-0.03	0.12	0.02	0.20	1.00																																	
CFR	-0.00	-0.56	0.60	0.26	0.62	0.30	0.63	0.62	0.15	1.00																																
CLS	-0.02	0.26	-0.31	0.23	0.10	0.53	-0.01	0.06	0.50	0.25	1.00																															
CPI	-0.21	0.35	-0.45	-0.18	0.03	0.47	-0.16	-0.03	-0.19	-0.18	0.39	1.00																														
DSY	0.16	0.89	-0.19	-0.16	-0.04	0.28	-0.36	-0.24	0.39	-0.41	0.38	0.66	1.00																													
FSR	0.42	0.93	-0.08	-0.32	-0.12	0.28	-0.32	-0.27	0.40	-0.53	0.06	0.36	0.84	1.00																												
GFI	-0.28	-0.26	-0.14	0.63	0.34	0.05	0.09	0.56	0.05	0.21	0.15	0.12	-0.08	-0.17	1.00																											
GRT	0.31	0.88	-0.06	-0.50	-0.14	0.37	-0.44	-0.35	0.53	-0.27	0.34	0.32	0.76	0.80	-0.40	1.00																										
INP	1.00	0.31	0.35	-0.37	0.44	0.44	0.04	-0.20	0.09	0.02	0.00	-0.22	0.13	0.39	-0.32	0.31	1.00																									
LHC	-0.07	0.33	0.31	-0.05	-0.06	-0.04	0.16	-0.19	0.31	0.11	0.27	0.34	0.55	0.26	-0.37	0.43	-0.08	1.00																								
MEI	0.17	0.29	0.04	-0.14	0.01	0.49	0.18	-0.15	0.45	0.29	0.69	0.31	0.37	0.27	-0.05	0.54	0.18	0.51	1.00																							
MND	-0.10	-0.64	0.02	0.10	0.05	0.07	0.49	0.11	-0.30	0.41	0.08	-0.08	-0.53	-0.48	0.46	-0.51	-0.09	-0.35	0.27	1.00																						
MNP	-0.07	-0.66	0.01	0.05	0.05	0.10	0.49	0.08	-0.34	0.40	0.07	-0.10	-0.57	-0.49	0.39	-0.52	-0.05	-0.38	0.25	1.00	1.00																					
MRP	-0.08	0.67	-0.03	0.10	-0.47	-0.36	-0.37	-0.26	0.76	-0.39	0.14	-0.20	0.48	0.52	-0.18	0.57	-0.10	0.30	0.11	-0.55	-0.58	1.00																				
MTN	0.16	0.64	0.17	0.02	0.12	0.14	-0.07	-0.13	0.58	-0.02	0.48	0.39	0.80	0.61	0.16	0.60	0.12	0.57	0.56	-0.16	-0.23	0.51	1.00																			
NED	0.27	0.83	-0.09	-0.22	-0.25	0.08	-0.37	-0.52	0.56	-0.38	0.44	0.22	0.77	0.65	-0.48	0.80	0.26	0.64	0.47	-0.61	-0.62	0.69	0.64	1.00																		
NPN	0.36	-0.00	0.26	0.38	0.60	0.38	0.45	0.57	-0.02	0.18	-0.05	0.13	0.13	0.13	0.18	-0.23	0.37	-0.03	-0.26	-0.18	-0.18	-0.31	0.03	-0.15	1.00																	
NRP	-0.26	0.03	-0.08	0.50	0.30	0.45	0.39	0.51	0.29	0.40	0.67	0.59	0.37	0.02	0.52	-0.00	-0.26	0.29	0.40	0.21	0.16	-0.10	0.52	0.03	0.38	1.00																
NTC	-0.15	0.02	0.28	-0.14	-0.11	0.19	0.25	0.02	0.41	0.47	0.34	0.01	0.03	-0.04	-0.35	0.41	-0.12	0.61	0.70	0.02	0.02	0.17	0.17	0.30	-0.40	0.11	1.00															
OML	0.55	0.58	0.32	-0.34	0.20	0.30	-0.16	-0.31	0.56	0.14	0.49	-0.01	0.50	0.42	-0.48	0.73	0.56	0.50	0.55	-0.39	-0.38	0.43	0.59	0.77	-0.07	0.04	0.42	1.00														
RDF	0.21	0.62	-0.09	-0.50	-0.22	0.26	-0.42	-0.49	0.47	-0.10	0.48	0.16	0.49	0.44	-0.53	0.86	0.22	0.49	0.67	-0.35	-0.34	0.48	0.41	0.79	-0.51	-0.11	0.65	0.78	1.00													
REM	0.46	0.82	0.24	-0.24	0.06	0.37	-0.02	-0.07	0.54	-0.18	0.14	0.27	0.78	0.89	-0.33	0.80	0.45	0.51	0.38	-0.54	-0.55	0.49	0.64	0.69	0.29	0.15	0.25	0.61	0.49	1.00												
RMH	0.48	0.90	-0.02	-0.43	-0.14	0.30	-0.26	-0.32	0.36	-0.49	0.04	0.32	0.79	0.98	-0.32	0.81	0.46	0.26	0.27	-0.47	-0.48	0.48	0.57	0.66	0.14	-0.02	-0.01	0.49	0.46	0.91	1.00											
SAP	-0.14	-0.59	0.03	0.70	0.44	0.21	0.59	0.75	-0.10	0.48	0.13	-0.06	-0.42	-0.49	0.64	-0.72	-0.13	-0.42	-0.24	0.46	0.46	-0.50	-0.23	-0.65	0.60	0.54	-0.36	-0.48	-0.76	-0.42	-0.52	1.00										
SBK	0.07	0.80	-0.06	-0.45	-0.40	-0.09	-0.46	-0.58	0.37	-0.47	0.14	0.28	0.74	0.67	-0.60	0.83	0.06	0.67	0.32	-0.67	-0.68	0.68	0.54	0.89	-0.32	-0.15	0.36	0.62	0.77	0.68	0.69	-0.85	1.00									
SHP	0.30	0.46	0.23	0.13	-0.02	-0.48	-0.31	-0.39	0.40	-0.36	-0.06	-0.28	0.39	0.38	-0.00	0.24	0.24	0.30	-0.01	-0.37	-0.42	0.63	0.53	0.56	-0.06	-0.21	-0.19	0.39	0.19	0.30	0.30	-0.37	0.44	1.00								
SLM	0.07	0.78	0.09	-0.17	-0.25	-0.25	-0.33	-0.38	0.40	-0.49	-0.01	0.26	0.81	0.72	-0.29	0.62	0.03	0.58	0.05	-0.67	-0.71	0.73	0.70	0.75	0.01	0.04	-0.02	0.46	0.37	0.71	0.72	-0.56	0.83	0.64	1.00							
SOL	0.23	-0.09	0.17	0.42	0.37	0.48	0.69	0.48	0.04	0.28	0.19	0.21	0.09	0.04	0.07	-0.21	0.26	0.21	0.13	0.04	0.04	-0.36	0.01	-0.05	0.83	0.51	-0.02	-0.06	-0.33	0.27	0.06	0.57	-0.27	-0.22	-0.13	1.00						
SPP	0.45	0.92	-0.11	-0.16	-0.09	0.21	-0.37	-0.35	0.59	-0.44	0.38	0.21	0.82	0.83	-0.25	0.77	0.44	0.30	0.28	-0.57	-0.58	0.67	0.70	0.85	0.12	0.12	-0.07	0.70	0.54	0.78	0.83	-0.41	0.69	0.55	0.76	0.02	1.00					
TBS	0.33	0.70	0.23	0.19	0.06	0.27	0.16	0.15	0.78	-0.06	0.32	0.10	0.67	0.73	-0.07	0.58	0.32	0.39	0.32	-0.43	-0.46	0.61	0.69	0.61	0.41	0.38	0.13	0.54	0.28	0.86	0.73	-0.06	0.46	0.37	0.64	0.39	0.79	1.00				
TFG	0.03	0.91	-0.33	-0.19	-0.43	0.04	-0.53	-0.42	0.51	-0.62	0.24	0.35	0.82	0.81	-0.26	0.82	0.01	0.46	0.35	-0.60	-0.63	0.74	0.56	0.84	-0.25	-0.02	0.21	0.42	0.67	0.69	0.75	-0.69	0.86	0.45	0.75	-0.18	0.76	0.56	1.00			
TRU	-0.06	0.74	-0.07	-0.10	-0.22	-0.04	-0.51	-0.22	0.65	-0.27	0.26	0.18	0.67	0.63	-0.02	0.78	-0.09	0.46	0.44	-0.45	-0.50	0.77	0.65	0.69	-0.42	0.03	0.39	0.47	0.69	0.56	0.54	-0.65	0.74	0.51	0.65	-0.41	0.58	0.47	0.85	1.00		
VOD	0.34	0.34	0.54	-0.10	-0.15	-0.35	0.06	-0.42	0.53	-0.02	-0.02	-0.43	0.22	0.30	-0.43	0.40	0.33	0.57	0.36	-0.25	-0.27	0.61	0.44	0.62	-0.24	-0.29	0.43	0.62	0.50	0.45	0.32	-0.55	0.56	0.72	0.51	-0.14	0.42	0.43	0.40	0.50	1.00	
WHL	0.32	0.68	-0.15	-0.35	-0.19	0.47	-0.21	-0.26	0.61	-0.10	0.58	0.15	0.51	0.57	-0.38	0.80	0.35	0.16	0.53	-0.26	-0.24	0.51	0.46	0.66	-0.17	0.14	0.33	0.74	0.74	0.60	0.64	-0.37	0.55	0.02	0.36	-0.09	0.74	0.60	0.54	0.45	0.26	1.00

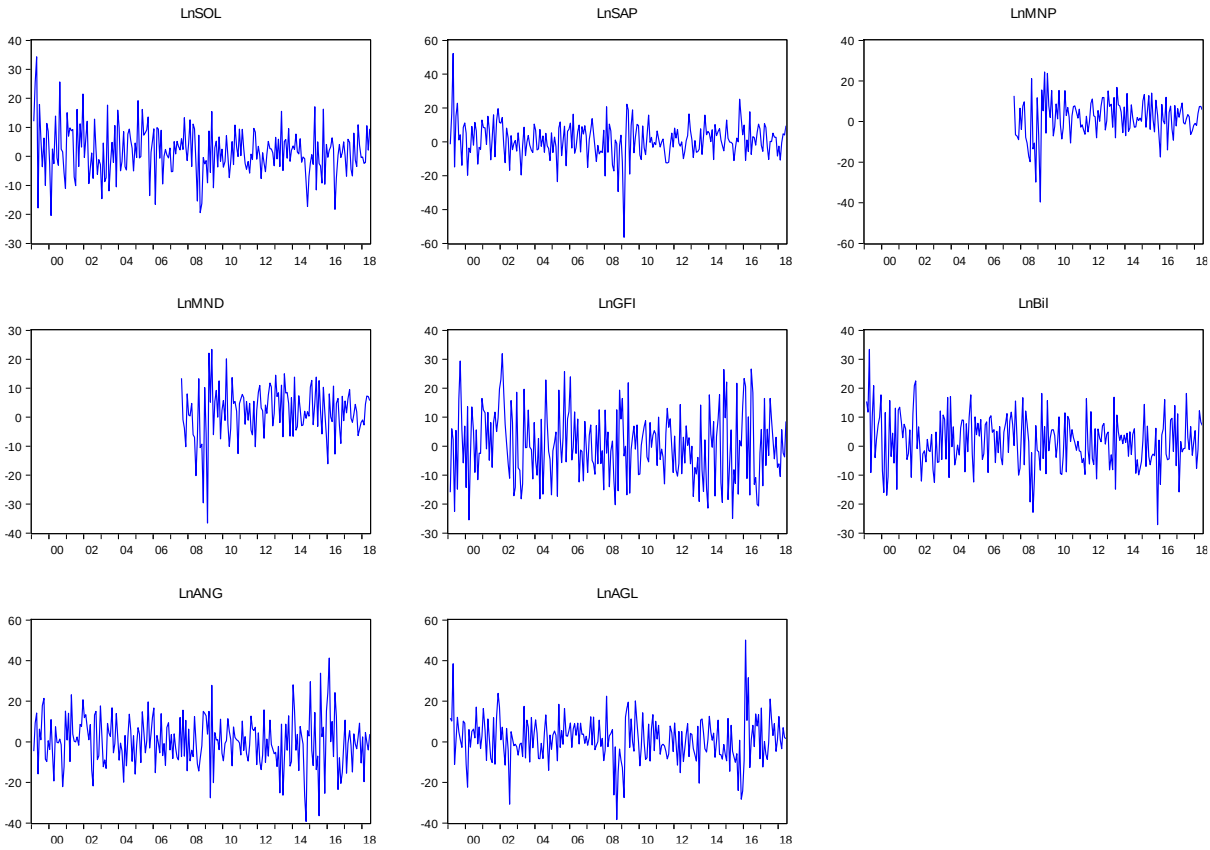
APPENDIX A2: JSE ALL SHARE TOP40 STOCKS

Share	Short code
Naspers Ltd	NPN
BHP Billiton PLC	BIL
Cie Financiere Richemont SA	CFR
Anglo American PLC	AGL
Sasol Ltd	SOL
Standard Bank Group Ltd	SBK
FirstRand Ltd	FSR
MTN Group Ltd	MTN
British American Tobacco PLC	BTI
Old Mutual Ltd	OML
Mondi PLC	MNP
Sanlam Ltd	SLM
Absa Group Ltd	ABG
Remgro Ltd	REM
Shoprite Holdings Ltd	SHP
Aspen Pharmacare Holdings Ltd	APN
Bid Corp Ltd	BID
Growthpoint Properties Ltd	GRT
Vodacom Group Ltd	VOD
Investec PLC	INP
Bidvest Group Ltd/The	BVT
Redefine Properties Ltd	RDF
Nedbank Group Ltd	NED
Mr Price Group Ltd	MRP
Tiger Brands Ltd	TBS
Woolworths Holdings Ltd/South Africa	WHL
Discovery Ltd	DSY
Sappi Ltd	SAP
RMB Holdings Ltd	RMH
Capitec Bank Holdings Ltd	CPI
AngloGold Ashanti Ltd	ANG
Clicks Group Ltd	CLS
Mondi Ltd	MND
NEPI Rockcastle PLC	NRP
Netcare Ltd	NTC
Gold Fields Ltd	GFI
Foschini Group Ltd/The	TFG
SPAR Group Ltd/The	SPP
Mediclinic International PLC	MEI
Life Healthcare Group Holdings Ltd	LHC
Truworths International Ltd	TRU
Investec Ltd	INL

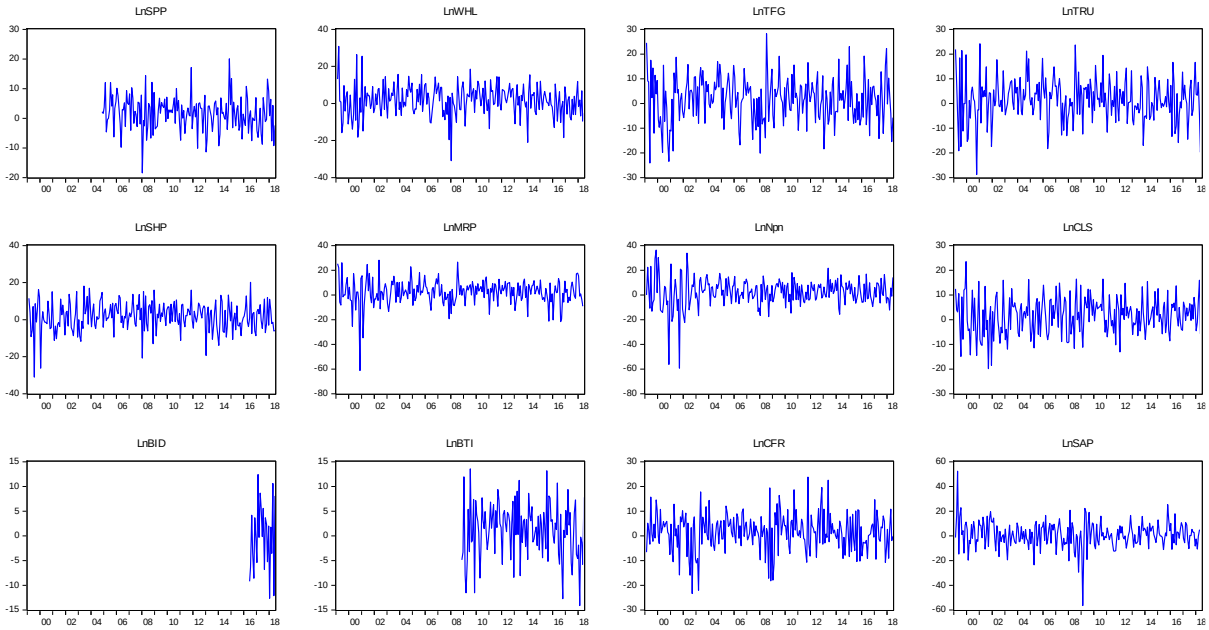
A3: JSE ALL SHARE INDEX



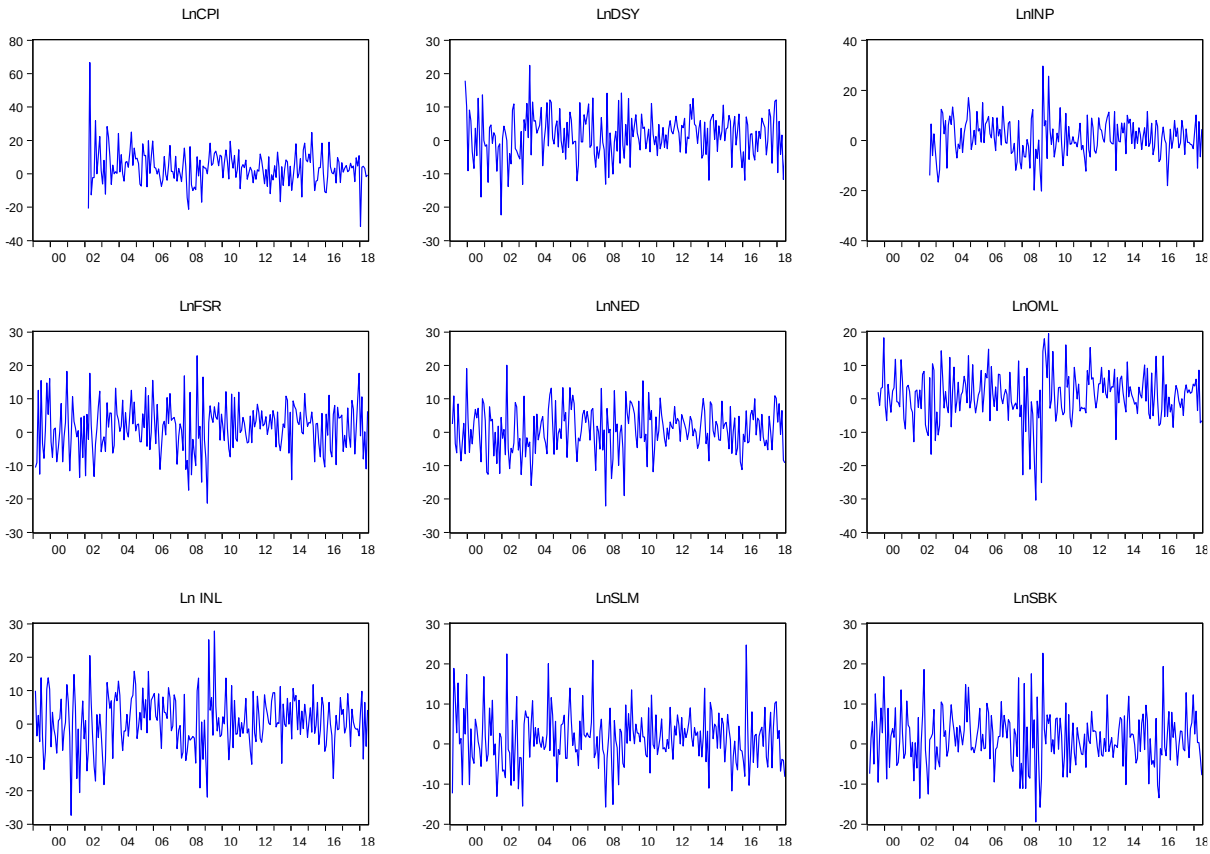
A4: Basic Materials



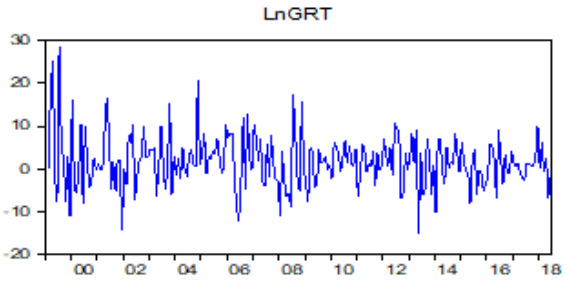
A5: Consumer services

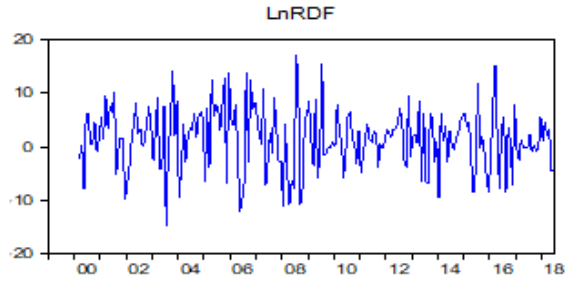


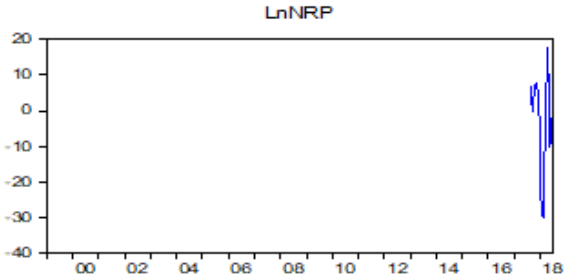
A6: Financial services



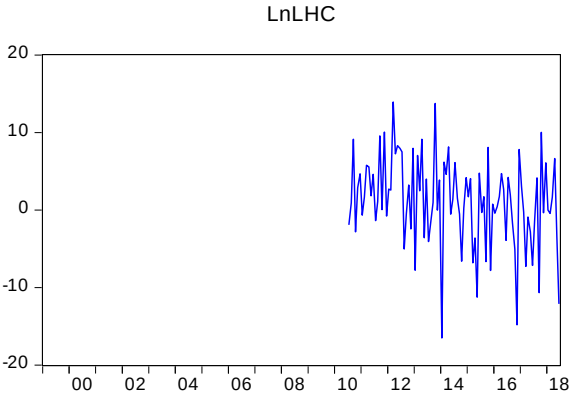
A7: Real Estate

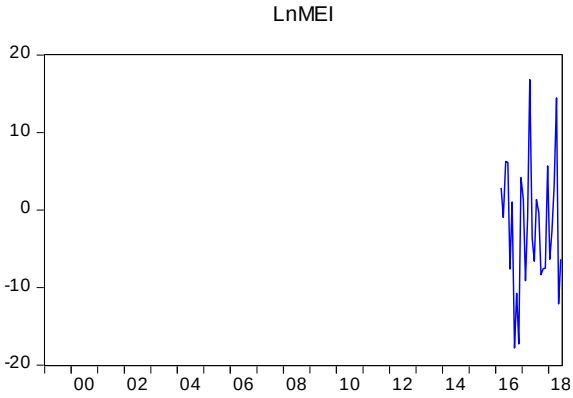


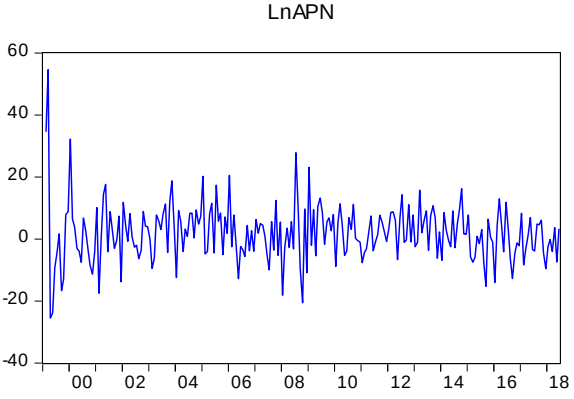


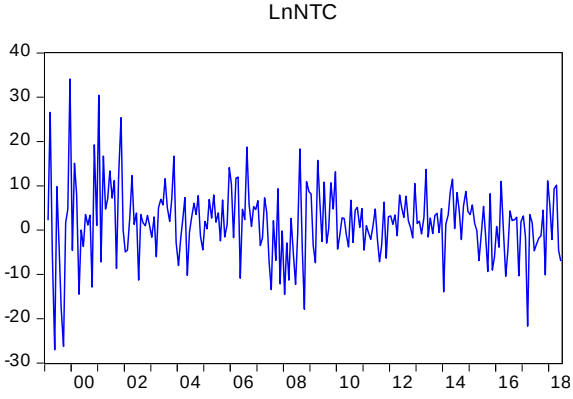


A8: Healthcare & Pharmaceuticals

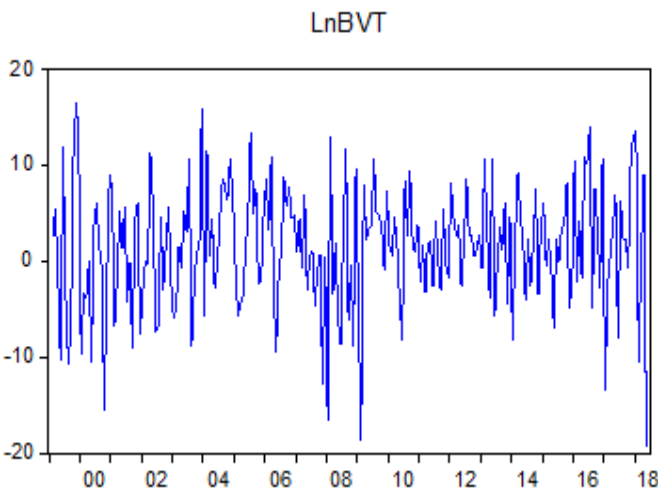


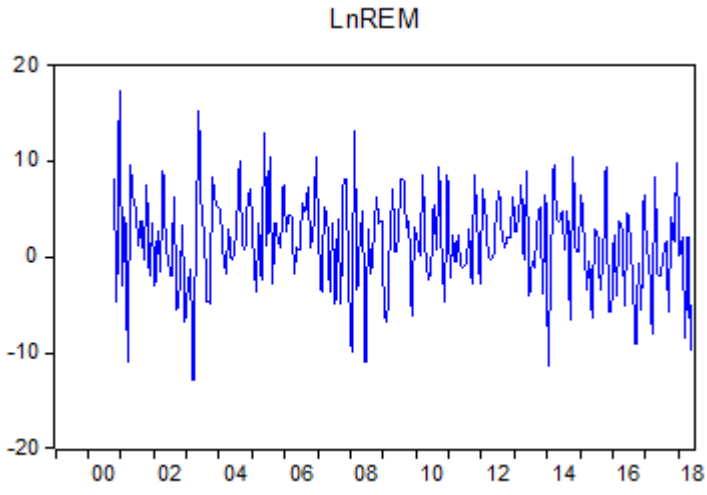






A8: Industrials





A9: Telecommunication