

# **Inflation Hedging With South African Common Stocks: A JSE Sectoral Analysis.**

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## **ABSTRACT**

Inflation risk erodes purchasing power, redistributes wealth from lenders to borrowers and threatens investor's long-term objectives, which are often specified in real terms; financial market volatility presents an additional risk for investors and portfolio managers concerned with not only real returns but also absolute returns. Understanding key investment risks, of which inflation is one, is crucial for investment managers in order to design effective hedging strategies to preserve wealth over the long run. Empirical tests of the Fisher hypothesis in South Africa have shown that common stocks are a good hedge against inflation. However, empirical evidence from developed countries has also shown that the relationship between common stocks and inflation is heterogeneous across the sectors and industries. This paper analysed the sectoral differences in the hedging ability of South African common stocks to test for this heterogeneity.

The paper presents disaggregated sector models to test heterogeneity across the eight sectors of the JSE securities exchange. Understanding which of these sectors offers the best hedge against inflation is important to investors, allowing them to place money where the value will be best preserved during times of higher inflation. The disaggregated sectors tested included the Basic Materials price index, Industrials price index, Consumer Goods price index, Health Care price index, Consumer Services price index, Telecommunications price index, Financials price index, and Technology price index.

Johansen Cointegration techniques were employed to empirically test the Fisher hypothesis for the South African market. For the Fisher hypothesis to hold, this paper was required to find evidence of cointegration between the share indices and CPI, as well as a positive slope coefficient for the cointegrating regression.

The results of the cointegration test showed that the All Share index and each of disaggregated sector indices were cointegrated with CPI. This implied that a long run relationship exists between common stocks and inflation. Two techniques were used to estimate the cointegrating regressions for each model, a standard long-run cointegrating regression normalizing on the share index and a Vector error correction model (VECM). For all the models both techniques reveal a positive relationship between common stock and CPI with the coefficients for the long run cointegrating regression derived from the various models ranging between 1.41 – 3.62

while the coefficients from the VECM ranged from 1.42 - 4.85. The varying coefficients provide evidence of the heterogeneity of the hedging ability of common stocks. Overall the evidence from the long run cointegration regression suggests that in times of high inflation investors are most compensated for changes in inflation in common stocks relating to the Consumer Services and Health Care sectors, but that in general all sectors of the JSE provide some hedge for inflation. The results suggest that investors are compensated for changes in inflation if they invest in specific industries rather than in the All Share index, thus diversifying portfolios could provide a better hedge for inflation. Although positive coefficients were found the weak exogeneity test revealed only technology Index was caused by changes in CPI.

The Paper concluded that in the long run all sectors provided protection against inflation during the period of study, but the evidence only fully supports the Fisher hypothesis for the Technology index, due to the results of the weak exogeneity test that revealed that CPI is weakly exogenous only in the equation of the Technology index.

# DECLARATION

I Dennis Kawawa do hereby declare that except for references specifically indicated in the text and such help as I have acknowledged, this thesis is wholly my own work and has not been submitted at any other University or Technikon for any degree purposes.

Signed \_\_\_\_\_ by on this 7th day of December 2017

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# LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ALSI	All Share Index
BFH	Behavioural Finance Hypothesis
BRICS	Brazil, Russia, India, China and South Africa
CIS	Commonwealth of independent states
DF	Dickey-Fuller
DGP	Data generating process
ECM	Error correction model
FL	Flow through rates
G7	Group of seven
GDP	Gross Domestic Product
ICB	Industry Classification Benchmark
JB	Jacque Bera
JSE	Johannesburg Stock Exchange
KPSS	Kwiatkowski Phillip Schmidt and Shin
LCPI	Log of Consumer Price Index
LM	Lagrange Multiplier
LSE	London Stock Exchange
NASDAQ	National Association of Securities Dealers Automated Quotation
NSE	Nigerian Stock Exchange
NYSE	New York Stock Exchange
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
PP	Phillip Perron

SACF	Sample Auto-Correlation Function
SADC	Southern African Development Community
SARB	South African Reserve Bank
SAARC	South Asian Association for Regional Cooperation
SC	Schwarz Criterion
SECA	Stock Exchange Control Act
SETS	Stock Exchange Trading System
SME	Small to Medium Scale Enterprises
S&P 500	Standards and Poor Stock Index
SRI	Socially Responsible Investment Index
UDI	Unilateral Declaration of Independence
UK	United Kingdom
USA	United States of America
VAR	Vector Auto-Regressive Model
VECM	Vector Error Correction Model

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# CHAPTER 1

## Introduction

### 1.0 Background

Inflation is defined as the persistent rise in the average of all prices (Arnold and Auer, 2015). “Inflation risk erodes purchasing power, redistributes wealth from lenders to borrowers and threatens investors long-term objectives which are often specified in real terms” (Arnold and Auer, 2015:188), for these reasons it has been argued that there are few issues in finance as important as the impact of inflation on financial markets and the implications for investment policies (Ang *et al.*, 2012; Arnold and Auer, 2015). Due to this perceived importance to financial markets, the effect of inflation on various financial assets has been widely studied. One of the main areas of study has been the relationship between inflation and stocks, specifically the ability of common stocks to hedge against inflation (Luintel and Paudyal, 2006; Chinzara, 2011; Arnold and Auer, 2015; Tiwari *et al.*, 2015).

There are several possible definitions for inflation hedging, the most popular with empirical studies states that “an asset is an inflation hedge if its real return is independent of the rate of inflation, implying a positive correlation between the nominal return of the asset and inflation” (Arnold and Auer, 2015:189). If there is a correlation of 1 between the asset returns and inflation, the asset is called “a perfect hedge because price increases are perfectly compensated by corresponding asset returns” (Arnold and Auer, 2015:189). The theoretical framework for this definition is provided by the use of the Fisher hypothesis which predicts a positive relationship between common stocks and inflation. (Arnold and Auer, 2015)

Using the Fisher hypothesis studies have suggested that as the general price levels increase investors in the stock market are fully compensated by a corresponding increase in the nominal stock market returns and thus the real return remains independent and unaffected (Tiwari *et al.*, 2015).

The Fisher hypothesis asserts that the nominal interest rate consists of a real rate plus the expected inflation rate (Tiwari *et al.*, 2015). Fisher believed that the real and monetary sectors of the economy are for the most part unrelated. Fisher hypothesized that the expected real rate

of interest is determined by real factors in the economy such as the productivity of capital and is independent of the expected inflation rate (Tiwari *et al.*, 2015). This hypothesis was then generalized to all assets in efficient markets instead of just the real rate of interest (Arnold and Auer, 2015).

There have been a number of empirical studies testing the Fisher hypothesis in USA and European markets as well as some developing nations, for which the results have been mixed, with several studies finding a negative relationship between inflation and stock returns thus rejecting the Fisher hypothesis (Fama, 1981; Gultekin, 1983; Lothian and Simaan, 1998; Anari and Kolari, 2001; Tiwari *et al.*, 2015).

Although research in developed nations has been conducted, research on the effects of inflation on stock returns specifically testing the Fisher hypothesis seems to be limited in South Africa and Africa in general (Alagidede, 2009). The majority of studies that examine the effects of inflation on stock markets in South Africa take a broader approach and examine the general macroeconomic determinants of stock returns (of which inflation is one) and very little focus is placed on studying the Fisher hypothesis or hedging ability of common stocks (Adam and Tweneboah, 2008; Chinzara, 2011). A few studies have examined the ability of stocks to hedge inflation in African countries see for example Gavriilidis and Kgari (2016), and Alagidede (2009). Of these studies, the vast majority examine the overall hedging ability of the broad stock market index without specifically testing how the hedging ability of stocks vary across the individual sectors of the exchanges in question (Alagidede, 2009).

More recent literature suggests that the effect of inflation on stock prices is likely to be heterogeneous across various industries (Ang *et al.*, 2012). It is argued that although the overall stock market may be a poor hedge for inflation, certain sectors have characteristics that make them a better hedge than others (Ang *et al.*, 2012). Boudoukh *et al.* (1994) for example found that non-cyclical industries tend to have a positive relationship with inflation whereas the opposite was true for cyclical industries.

Luintel and Paudyal (2006) were the first to test the heterogeneity across industries using a cointegration framework. Luintel and Paudyal (2006) found, using both aggregated and disaggregated industry level UK stocks data, that in the long run UK stock are a hedge for inflation. They highlighted that the Consumer Goods industry provided the best hedge while the Mineral Extraction sector compensated investors the least for inflation (Luintel and

Paudyal, 2006). This had also been found earlier by Sadorsky (2001), whose research concluded that natural resources stocks are not good inflation hedgers contrary to intuition.

Overall, there are ambiguities for the relationship between stock return and inflation for both the developed countries and developing countries and specifically for African countries, there appears to be need for more research particularly analysing the relationship between inflation and individual sector stock returns. Furthermore, although fewer studies have been done in African countries, it is noted that inflation is generally higher in emerging markets than in developed nations, making the study of the relationship between stocks and inflation even more important in these markets (Phiri, 2017).

### **1.1 Problem statement**

Understanding inflation is crucial for investment managers in order to design effective hedging strategies to preserve wealth over the long run. Although empirical tests of the Fisher hypothesis in South Africa have shown that common stocks are a good hedge against inflation, empirical evidence from developed countries has also shown that the relationship between common stocks and inflation is heterogeneous across the sectors and industries which has not been empirically studied for South African common stocks.

### **1.2 Goal of the research**

The goal of this research is to analyse the sectoral hedging ability of common stocks in South Africa so as to examine and identify which sectors of the Johannesburg Stock exchange are the best hedges against inflation in South Africa. The Johannesburg Stock exchange is made up of 8 main sectors i.e. Basic Materials, Industrials, Consumer Goods, Health Care, Consumer Services, Telecommunications, Financials, and Technology. Understanding which of these sectors offers the best hedge against inflation is important to investors, allowing them to place money where the value will be best preserved during times of higher inflation (Amenc *et al.*, 2009).

The objectives are as follows:

1. To analyse the relationship between inflation and common stocks by testing if the Fisher hypothesis holds in South Africa.
2. To analyse how the hedging ability of common stocks differs from sector to sector; attempting to establish which industries provide the best hedge against inflation in South Africa.

3. To discuss the implication of the findings for portfolio management.

### **1.3 Methodology**

To achieve the objectives of the study cointegration testing will be used. One issue that has been noted in the past was that “stock returns and inflation rates exhibit special time-series properties. Inflation is a slow-moving and persistent process, with much lower variance than stock returns. This negatively influences correlation tests between the two variables because non-stationary variables introduce the problem of spurious regression, which is the detection of significant relationships even though none exist” (Arnold and Auer, 2015:196).

In line with more recent studies, this paper will search for cointegration between inflation and stock prices. If the two variables are found to be non-stationary but cointegrated, the equation  $\delta_t = \alpha_0 + \alpha_2 \pi_t + e_t$  can be interpreted as a long run cointegrating regression, reflecting an equilibrium relationship between stock prices and inflation. Therefore, finding cointegration combined with a value of  $\alpha_2$  not significantly different from one is supportive of a long-run Fisher relationship (Arnold and Auer, 2015).

Johansen (1988)’s cointegration procedure will be used to test for cointegration. The test for cointegration will initially be conducted on the JSE All Share index return and inflation to determine if common stocks, in general, are a good hedge for inflation in South Africa. The test will then be conducted on the returns of each of the nine sectors (indexes) of the JSE and inflation measured by the national consumer price index.

To compare the hedging ability of the sectors, the coefficient  $\alpha_2$  of each of the cointegrating regressions will be compared. The greater the value for  $\alpha_2$  the greater the elasticity of the stock returns with respect to inflation and thus theoretically the better hedge of inflation. After comparing the results, a brief discussion on the implications for Portfolio management will be conducted

### **1.4 Organization of the study**

The layout of this study is as follows: Chapter 2 will provide the theoretical and empirical review of the literature on the relationship between stock prices and inflation. Chapter 3 will provide a brief historical graphical analysis of inflation in South Africa and the performance of each of the indexes used in the study. Chapter 4 will provide the research methodology and a description of the data used in the cointegration analysis. Chapter 5 provides the empirical results. Chapter 6 offers a summary of the paper and the conclusions drawn from the findings

# CHAPTER 2

## Literature Review

### **2.0 Introduction**

The theoretical relationship between stock prices and inflation is based on the seminal work of Fisher. Fisher hypothesised a positive relationship between stocks and inflation, but several alternative hypotheses have been developed over time postulating a negative relationship (Nelson, 1976). This Chapter will discuss the theoretical framework of the study and the empirical literature. The Chapter will begin by discussing the Fisher hypothesis and various alternative theories linking stocks and inflation, namely the proxy hypothesis, inflation hypothesis, tax-effect hypothesis and the money illusion theory.

While the majority of studies examine the Fisher hypothesis with aggregated common stock data, the literature suggests that the relationship between common stocks and inflation varies across industries i.e. that the relationship is heterogenous across industries. Thus in order to give a full picture, after discussing the Fisher hypothesis the empirical literature on the heterogeneity will also be discussed. Another noteworthy aspect noted in the empirical literature is the asymmetric nature of the inflation and common stock relationship, with the relationship varying in times of high and low inflation. Therefore, a brief theoretical and empirical discussion on this asymmetry is discussed. The chapter will conclude with a summary of the empirical literature that has tested the Fisher hypothesis in both developed and developing countries with a particular focus on South African literature.

### **2.1 Economic Theory**

When studying the relationship between common stocks and inflation we can begin by examining the general relationship between macroeconomic variables and stocks. The theoretical foundation of the relationship between stocks and macroeconomic variables is based on models such as the Capital Asset Pricing Model, the Arbitrage Pricing theory, and the present value models such as the Gordon Growth theory (Kandir, 2008). Underlying all these models is the Efficient Market Hypothesis. Although these models give a general foundation as to how macroeconomic variables affect stock returns they do not directly explain the relationship of inflation to stock market returns but imply a relationship through the interaction of interest rates.

According to Ibrahim and Agbaje (2013), original studies analysing the relationship between inflation and stock returns focused on the Fisher hypothesis. Given that the empirical evidence at the time was suggestive of a positive relationship, the conclusion was therefore that stocks are a hedge against inflation (Nelson, 1976). However as more empirical studies were conducted some evidence was found supporting a negative relationship between stocks and inflation and several hypotheses were developed to explain this, namely the proxy hypothesis, the tax-effect hypothesis and inflation hypothesis (Ibrahim and Agbaje, 2013). Although it has been widely accepted that a relationship exists there has been no consensus on whether the relationship is a positive or negative (Eita 2012). The following section discusses the theoretical foundations underlying the relationship between stocks and inflation focusing on each of the aforementioned hypothesis.

## 2.2 Fisher Hypothesis

Early theoretical and empirical research accepted the conventional wisdom that stocks should be a hedge against inflation thus predicting a positive relationship between stocks and inflation. These early studies used simple regression analysis to test the relationship between stocks and inflation (Nelson, 1976). This positive relationship was explained through the use of the Fisher hypothesis. The theory put it forward that as general price levels increase investors in the stock market are fully compensated by a corresponding increase in the nominal stock market returns and thus the real return remains independent and unaffected (Tiwari *et al.*, 2015).

The Fisher hypothesis first was stated by Irvin Fisher to relate nominal interest rates and expected inflation. Fisher asserted that the nominal interest rate consisted of a real rate plus the expected inflation rate. Fisher believed that the real and monetary sectors of the economy are for the most part unrelated. Therefore, Fisher hypothesized that the expected real rate of interest is determined by real factors such as the productivity of capital and is independent of the expected inflation rate (Nelson, 1976).

General Fisher hypothesis is stated as:

$$i_t = r_t + \pi_t \dots \dots (2.1)$$

Where  $i$  is the nominal interest rate,  $r$  is the real interest and  $\pi$  is the inflation rate. This hypothesis was then generalized to all assets in efficient markets (Gultekin, 1983). The Fisher hypothesis has been generalised for all asset and for stock returns is specified as:

$$\delta_t = \alpha_0 + \alpha_2 \pi_t + e_t \dots \dots (2.2)$$

Where  $\delta_t$  is the stock returns,  $\pi$  is the actual inflation which is the combination of the unexpected and expected inflation. While  $e$  is the error term. The sign of  $\alpha_2$  determines if the specification is in line with the Fisher hypothesis. Thus, a significant and positive sign for  $\alpha_2$  suggests that stock hedges inflation while a negative sign suggests the contrary (Ibrahim and Agbaje, 2013).

The Fisher hypothesis was extended by Fama and Schwert (1997) to differentiate between expected and unexpected inflation. The Fisher hypothesis has been further expanded to consider the fact that investors are liable to pay taxes on returns (i.e. capital gains). This is the tax augmented Fisher hypothesis; according to this specification in order for investors to be fully compensated for inflation, the nominal return should include the effects of both taxes and inflation. Thus, proponents of the tax augmented hypothesis argue that unlike the traditional Fisher hypothesis that predicts a value of 1 for  $\alpha_2$ ,  $\alpha_2$  in equation 2 should exceed one (Luintel and Paudyal, 2006).

There have been a number of empirical studies testing the Fisher hypothesis in the US and European markets as well as some developing nations, for which the results have been mixed (Tiwari *et al.*, 2015). A number of studies (Anari and Kolari, 2001; Solnik and Solnik, 1997; Lothian and Simaan, 1998) have found a positive relationship between inflation and stocks but other studies have found that in many cases there was a negative relationship between inflation and stock returns. According to Arnold and Auer (2015), the first of these studies was Bodie's (1976) seminal study. Bodie (1976) used the New York stock exchange (NYSE) returns for the period 1953 – 1972 and found that short-run returns are negatively related to both expected and unexpected inflation. These results were later confirmed by Nelson (1976), Jaffe and Mandelker (1976), Fama and Schwert (1977) and Gultekin (1983). These papers were some of the earliest studies to reject the long-held belief that stocks provide a perfect hedge for inflation.

### **2.3 Explaining the negative relationship**

Many empirical Studies have developed various theoretical explanations regarding the negative relationship between stock prices and inflation, in the next section, we summarise some of these major theories.

### **1.3.1 Proxy hypothesis**

One of the earliest and most accepted explanations for the negative relationship was given by Fama (1981) and is referred to as the Proxy hypothesis. Fama (1981) examined the effect of both the expected and unexpected components of inflation on stock returns and hypothesised that the negative relationship was induced by the negative relationship between inflation and other real economic activity, which are in turn explained by a combination of money demand theory and the quantity theory of money. Fama (1981) explained that unexpected inflation impacts “negatively on saving ability of the citizens and as a result, low saving leads to a fall in the demand for stocks and equities. This decrease in demand causes the price of equities to fall thereby reducing returns on equities and stocks” (Tiwari *et al.*, 2015). Fama (1981) concluded that the effect of macroeconomic variables on stock returns is dependent on the relationship between future cash-flows and inflation, any economic variable that increases inflation will have a negative effect on stock returns.

As with the Fisher hypothesis the empirical evidence for the proxy hypothesis has been contradictory with several studies such as Kaul (1987), Barnes *et al.*, (1999) Gallagher and Taylor (2002) finding evidence in support of the hypothesis while others like McCarthy *et al.* (1990), Cochran and DeFina (1993), Caporale and Jung (1997) and Adrangi *et al.* (1999) finding no evidence in support of the proxy hypothesis, thus there has been no consensus on the validity of the proxy hypothesis (Erbaykal *et al.*, 2008).

### **1.3.2 Inflation hypothesis**

Another explanation for the negative relationship between inflation and stock prices was given by Geske and Roll (1983) their hypothesis is sometimes referred to as the inflation hypothesis. Geske and Roll (1983) addressed the connection between fiscal and monetary policies in explaining the relationship between stock return and inflation. The inflation hypothesis assumes that a fall in real economic activity has a negative effect on stock prices, but also results in a reduction in the revenue collected by the government. This reduction in revenue results in increased government fiscal deficits. A country’s central bank then in response to increased deficits monetizes a part of the deficit which results in an increase in money supply and increased money supply results in an increase in inflation.

Thus, as a result of reduced economic activity stock returns fall and the proceeding government interventions to boost the economy results in rising inflation. This results in the emergence of a negative correlation between stocks and inflation. Studies testing this theory have largely been negative with few studies supporting that the hypothesis holds in practice (Tiwari *et al.*, 2015)

### **1.3.3 Tax-effect hypothesis**

The third explanation is the Tax-effect hypothesis introduced by Feldstein (1980) who observed that for the US economy due to the valuation of depreciation and inventories, inflation generates artificial capital gains. Given that the capital gains are subjected to taxes, in an inflationary situation, the corporates face increased tax liabilities. The inflation induced tax liabilities reduce the real after-tax earnings. Given this situation, the rational investor will reduce common stock valuation to take into account the effect of inflation. Thus inflation causes a downward movement in stock prices. Although this explanation is theoretically plausible, it is contextual to the US tax regime, hence cannot be accepted universally for all countries. In addition to this, a Tobin-type effect could also result in a positive relationship between inflation and real stock prices, since higher inflation acts as a negative return on money, and savers substitute out of money into capital (Arnold and Auer, 2015). Tiwari *et al.*, (2015) and Hooks (1993) tested this theory but found no evidence to support it.

### **1.3.4 Money Illusion**

Apart from the standard economic explanations of the relationship between stocks and Inflation, they are a few explanations that are based on behavioural economics (Marx and Struweg, 2015).

Money illusion is a behavioural concept that is also used to explain the relationship between stock markets and inflation. The concept was introduced by Modigliani and Cohn (1979). The concept asserts that investors make two major errors in evaluating equities due to inflation. Modigliani and Cohn (1979) states “Firstly, in inflationary periods, investors capitalise equity earnings at a rate that parallels the nominal value, rather than the economically correct real value” – in other words, investors look at total returns in isolation of inflationary movements. However, the real economic value independent of inflation (less than the nominal value) is ignored thus assets are overpriced by investors. “Secondly, investors fail to allow for the gain

to shareholders accruing from depreciation in the real value of nominal corporate liabilities” (Modigliani and Cohn, 1979). Both these errors are as a result of investors ignoring the effect of inflation in the future on present values. These errors result in assets being overvalued and liabilities undervalued. Therefore real stock prices “tend to decline during periods of high inflation, although this is not valuation driven but rather as a result of the mispricing of inflation in discounting earnings” (Marx and Struweg, 2015).

Lee (2010) tested the money illusion hypothesis in the US and other developed countries, and the results were inconsistent with the hypothesis. While the Money illusion hypothesis suggests a negative relationship at all times, Lee (2010) found that the relationship was positive or negative depending on the inflation regime

Another explanation similar to the money illusion concept was proposed by Pindyck (1984). Pindyck (1984) argues that the reason that stock prices fall during periods of high inflation is due to higher perceived risk by investors amid uncertainty associated with high inflation.

Additionally, the Behavioural Finance Hypothesis (BFH), states that recent economic conditions and the direction of the market affects the way in which investors respond to new information. Veronesi (1999), theoretical equilibrium model states that “investors discount good (bad) news at a higher rate if it is announced during bad (good) times” (Diaz and Jareno, 2009). It is argued that in good economic times higher inflation changes will have a small effect on changes to stock prices.

### **1.3.5 Long run relationship models and Methodology**

Although the various hypothesis attempt at rationalising a negative relationship of stocks and inflation, another possible explanation to why the relationship between stock returns and inflation is so puzzling could also be linked to the properties of the analysed data and the econometric approaches that had been used for testing the relationship (Arnold and Auer, 2015).

In an analysis of the literature, Arnold and Auer (2015) find that early studies testing the Fisher hypothesis, which in its nature describes a long-run relationship between assets and inflation, used small samples which would not accurately capture this relationship. Thus, Arnold and Auer (2015) concluded that the negative relationship found between stocks and inflation in

some past research was the result of spurious regressions. More recent studies suggest that using longer time series or cumulative stock returns can increase confidence in the findings.

Boudoukh and Richardson (1993) who used a much longer time series than previous studies, collecting almost 200 years of data – from 1802 to 1990 – for the US and the UK, found that long-horizon nominal stock returns are positively related to forecasted and actual long-term inflation. Boudoukh and Richardson (1993) long run findings have been confirmed by Solnik and Solnik (1997) and Lothian and Simaan (1998) using panel data of eight and 23 advanced economies. These studies found that the Fisher model holds for stocks held for 1-year or more. Even for horizons of less than 12 months, the Fisher model is not rejected. Lothian and Simaan (1998) found that for the vast majority of the 23 OECD countries examined, average stock returns and inflation move together in the long run and that the two variables are also positively correlated across the countries.

In contrast to Boudoukh and Richardson (1993), Engsted and Tanggaard (2002) assessed the hedging properties of US and Danish stock, measuring multi-period expected returns and inflation from a VAR model involving only one-period variables. Their study found that Danish stock returns co-move with expected inflation in the long run but not at short horizons. For US stocks, however, the relationship between expected returns and inflation is quite weak at all horizons. Thus, the Fisher model does not perform better as the horizon increases in the US case; however, it does so for Danish stocks.

Lothian and McCarthy (2001) also extend the time-series dimension and cover data for the US and the UK from 1790 to 2000 and for 14 OECD countries (including the US and the UK) from 1945 until 1999. Using cointegration tests, OECD panel data and the long series for the US and the UK found that stock returns and inflation had a positive relationship. For the short run relationship, Lothian and McCarthy (2001) found a negative relationship between the two variables.

In the same year, Anari and Kolari, (2001) tested the long-run Fisher effect for six major economies (the US, Canada, the UK, France, Germany, and Japan) and found evidence supporting the Fisher hypothesis. Anari and Kolari, (2001) also conducted an impulse-response analysis and found that initially, the response of stock prices to a shock in goods prices is negative which turns positive over long horizons. This study helped to reconcile previous short-

run and long-run evidence concluding that stocks were a good inflation hedge over a long holding period.

Initially, Schotman and Schweitzer (2000) had been the first to formally test the sensitivity of the hedging property of stocks to time. They showed that stocks provide a hedge against inflation if the investor's investment horizon is 15 years or longer.

Apart from the length of the data used another problem with earlier studies that could have resulted in spurious regression was the problem of measurement errors in inflation. It is argued that these measurement errors introduced errors in variables causing problems in the standard OLS estimations of Fisher-type models which needed to be addressed by instrumental variable regression (Arnold and Auer, 2015).

Following from this, another issue noted in the studies are that stock returns and inflation rates exhibit special time-series properties. Inflation is a slow-moving and persistent process, with much lower variance than stock returns. This negatively influences correlation tests between the two variables because non-stationary variables introduce the problem of spurious regression where a significant relationship is detected even though none exists (Arnold and Auer, 2015). To avoid this problem, newer studies search for cointegration between inflation and stock returns. If the two variables are found to be non-stationary but cointegrated the equation  $\delta_t = \alpha_0 + \alpha_2\pi_t + e_t$  can be interpreted as a cointegrating regression, reflecting an equilibrium relationship between stock returns and inflation. Therefore, finding cointegration combined with a slope parameter not significantly different from one is supportive of a long-run Fisher relationship. Because cointegrating regressions only consider long-term dynamics, they are usually supplemented by error correction models (ECM).

Among the first authors to apply ECM in an inflation hedging context are Cochran and DeFina (1993). Cochran and DeFina (1993) used US data from 1947 to 1989 and found that for both expected and unexpected components real stock returns are not independent of inflation. Hence, the results of this study provided evidence that US stocks do not provide a hedge for inflation.

Ely and Robinson (1997) tested quarterly data from 1957 to 1992 for 16 industrialised countries using a vector error correction model (VECM), their results found that stocks maintain their

real value relative to goods prices and this conclusion generally does not depend on the source of the inflation shock (real or monetary sector).

### **2.3 Heterogeneity of stock**

The previously mentioned studies and issues have focused on examining the overall stock market, but it is argued that although the overall stock market may be a poor hedge for inflation, certain sectors have characteristics that make them a better hedge than others (Ang *et al.*, 2012). Thus the literature suggests that the effect of inflation on stock prices is likely to be heterogeneous across various industries (Ang *et al.*, 2012). The empirical literature on the heterogeneity is much sparser than the literature for the overall stock market. The following section gives a brief summary of the empirical literature examining the heterogeneity of stocks across industries highlighting the key arguments. The focus is also placed on examining some of the concepts explaining what renders some stocks more effective hedges against inflation than others. The concepts examined include the concept of Inflation flow through rates (IFR), Profit margins and Cyclicalities of stocks.

Estep and Hanson (1980) proposed the flow-through model. The model assumes that inflation would have no effect on stock prices because the effects can ‘flow through’ to customers. The model puts it that the greater the flow through rate, the smaller the effect of inflation on stocks.

Inflation flow through is an important characteristic for the determination of stocks that would be a good hedge and studies have shown that the flow through rate differs from industry to industry with certain industries more able to pass on price increases to customers than others. The difference in sectors flow-through rate was first studied by Asikoglu and Ercan (1992). Their research found that the negative effect of an increase in inflation was inversely related to the company’s ability to transmit changes in inflations to their prices (Cano *et al.* 2016).

More recently using data from the Spanish stock exchange, Diaz and Jareno (2009) analysed the effect of IFR and found that “the flow-through capability of companies helps to explain the significant different responses exhibited by sectoral returns to inflation announcements”. While testing 6 sectors, (Oil and Energy, Basic Materials and construction, Consumer Goods, Consumer Services, Financial and Real estate services, and technology and telecommunications), Diaz and Jareno (2006) found that on average the technology and

telecommunications sector had the greatest short-run response to inflation while Basic Materials had the smallest response.

Another characteristic that has been noted is a firm's profit margin. A profit margin can be defined as the "amount of profit a firm makes per unit of sales (output) and is computed as the ratio of profits to (net) sales" (Ertek, 2009). The higher a firm's profit margin the higher the prospective hedging ability. The profit margin explanation is linked to the inflation flow through theory in that the higher the profit margin the higher the inflation flow-through rate. This theory, however has seen very little testing in empirical studies (Ertek, 2009). Another factor closely related to the profit margin concept noted to affect the ability of stocks to hedge inflation is a firm's book-to-market ratio. While testing how stock markets react to unexpected inflation across the business cycle Wei (2009) found that firms with low book-to-market ratios more negatively correlated with unexpected inflation.

Cyclicalities has also been noted as having an effect on the heterogeneity of stocks. Cyclicalities can be defined as the degree to which a firm's/industry's performance is influenced by the general economic environment. This theory was tested by Boudoukh *et al.* (1994), who found that non-cyclical industries tend to have a positive relationship with inflation whereas the opposite was true for cyclical industries.

The earliest study examining the heterogeneity of stocks is Blanchard (1982) who found that the variability of goods prices early in the production chain (food, energy) is larger than those of intermediate goods sector. Wei and Wong (1992) examined the relationship between stock returns and inflation across 19 industries from the NYSE during the pre and post-world war periods, testing the proxy hypothesis. Their results found that the proxy hypothesis holds for natural resource industries finding a negative relationship, however, for the other sectors, the proxy hypothesis could not be fully supported (Wei and Wong, 1992).

Luintel and Paudyal (2006) were the first to test the heterogeneity across industries using a cointegration framework. Luintel and Paudyal (2006) found, using both aggregated and disaggregated industry level UK stocks data, that in the long run, UK stocks are a hedge for inflation. They highlighted that the Consumer Goods industry provided the best hedge while the mineral extraction sector compensated investors the least for inflation (Luintel and Paudyal, 2006). This had also been found earlier by Sadorsky (2001), whose research concluded that natural resources stocks are not good inflation hedgers contrary to intuition.

More recently Ciner (2015) found using industry level data that small firms are likely to hedge inflation better than larger firms due to smaller firm's ability to adjust prices more quickly in reaction to changes in inflation. Their research also found a positive relationship between inflation and stock returns for companies related to the commodity and technology industries.

Bampinas and Panagiotidis (2016) tested how the inflation hedging ability varies across portfolios sorted on long-run betas. Their research found that while the long run relationship between aggregate market and inflation was insignificant there was a substantial subset of individual stocks that had a positive and significant relationship with inflation. They found that the energy sector has the highest ability to hedge inflation followed by the materials and Consumer Goods sector.

## **2.4 Asymmetric nature**

Another notable feature of the stock and inflation relationship noted from the literature is the asymmetric nature of the relationship, meaning that the relationship between stocks and inflation changes in high and low inflation and varies across economies.

Ahmed and Cardinale (2005) examined data of different inflation regimes from 1919 to 2002 in the US, the UK, Germany and Japan. They found mixed results but conclude that stocks tend to be a partial inflation hedge. They also found stocks appear to react asymmetrically to high or low inflation. With the exception of Japan, they found that in the short run (one year), stock returns have been significantly higher at times of 'normal' inflation (up to three percent) but lower in case of deflation or very high inflation. This result led to the conclusion that stocks do not provide a sufficient hedge when inflation is high i.e. when it is most needed.

Kim and Ryoo (2011) also found similar results to Ahmed and Cardinale (2005) finding that short-term adjustments to the long-run equilibrium of stock returns and inflation differed depending on the levels of inflation. Kim and Ryoo (2011) examined US common stocks over a period of more than 200 years, their results showed that US stocks had provided a hedge for inflation since the early 1980s. During this time there was a decline in the volatility of US inflation and other macroeconomic fundamentals, the period of time referred to as the 'Great Moderation'. Kim and Ryoo (2011) concluded that "With more stable inflation rates it is more likely that inflation expectations become more accurate, potentially leading to a better hedging performance".

Li *et al.*, (2010) examined the relationship between inflation and stocks in the UK, at both an aggregated level and for 10 sectors for the short and midterm. In the short run they found that unexpected changes in inflation had a negative effect on stock returns while expected changes had very little impact, thus they concluded that in the short run UK stocks were not hedges for inflation. In the mid-term, their results were mixed finding “significantly positive for the expected inflation and significantly negative for the unexpected inflation”. They also concluded that the ability of stocks to hedge inflation is dependent on “the inflationary economies or different inflationary regimes”, meaning that the relationship changes in times of low and high inflation. (Li *et al.*, 2010)

Le Long *et al.* (2013) examined the inflation-hedging properties of stocks in Thailand and Vietnam. They tested the relationship of both ex-ante and ex-post inflation with stock returns. Overall, they found a negative but insignificant relationship between both ex-ante and ex-post inflation and stocks returns. They went on to test how the relationship varies over time and found that in periods where inflation is moderate, stocks could provide a hedge to inflation.

In contrast to the previous studies, Boamah (2017) tested the Fisher hypothesis in two groups of countries, the G7 and BRICS to test how the stock and inflation respond in relatively low inflation economies (G7 countries) and high inflation economies (BRICS countries) and found that there was no significant variation. The evidence showed that apart from France, Italy and South Africa, the results are consistent with the suggestion that stocks have a positive relationship and this does not depend on the country’s inflation rate (Boamah, 2017).

## **2.5 Developing nation evidence**

In this section, we highlight some notable studies in developing nations before discussing the literature in Africa and then South Africa.

Bhatti and Pak (2013) tested the Fisher hypothesis for 3 Commonwealth of independent states (CIS) countries, Kazakhstan, Russia and Ukraine. They tested the Fisher hypothesis in both the long run and short run. In the short run, they found that the one to one relationship assumed by the Fisher hypothesis held only for Kazakhstan, but there was still a positive relationship found in Russia and Ukraine for stocks and inflation. To test the long run relationship Bhatti and Pak (2013) used the Engle-Granger cointegration testing and were unable to confirm the existence

of a long run relationship between stocks and inflation and they concluded that CIS stock markets do not tend to provide a hedge for inflation in the long run.

Shah *et al.* (2012) tested the Fisher hypothesis for countries in the South Asian Association for Regional Cooperation (SAARC). Their study included Pakistan, Sri Lanka, Bangladesh and India. Shah *et al.* (2012) used the ADRL test model to test the long run relationship and a ECM test for the short run relationship. The results were mixed, finding a negative relationship for stocks and inflation in Pakistan, India and Bangladesh and a positive one in Sri Lanka.

### **African Research**

Research on the effects of stock returns on inflation seems to be limited in South Africa and Africa in general (Alagidede, 2009). The majority of studies that examine the effects of inflation on stock markets in South Africa take a broader approach and examine the general macroeconomic determinants of stock returns and very little focus is placed on isolating the impact of inflation. A few studies have examined the ability of stocks to hedge inflation in African countries, of these studies the vast majority examine the overall returns of stock markets using various all share indexes and not the individual sectors of the exchanges in question (Alagidede, 2009). Although fewer studies have been done in African countries it is noted that inflation acceleration in emerging markets is likely to be larger than in developed nations, making the study of the relationship between stocks and inflation more important in these markets.

As noted by Alagidede and Panagiotidis (2010) Two crucial questions that had not been addressed at the time in the literature is whether stock markets in African countries offer a shelter to investors in the face of rising inflation, and how do stocks perform under inflationary conditions. This is particularly important for sub-Saharan (SSA) countries, as they tend to have high inflation. It is also noted by Bekaert and Wang (2010) that there are higher inflation betas for emerging markets compared to developed markets.

Alagidede, (2009) examined the Fisher hypothesis for 6 African countries (Egypt, Kenya, Morocco, Nigeria, South Africa and Tunisia) using OLS estimations. Their study found that in the short run only Kenya and Nigeria stocks had a significant positive relationship with the inflation of the respective country. Furthermore, only Kenya had a one to one relationship as hypothesised by the Fisher hypothesis. When the horizon was extended to 5 years the evidence

showed that the stocks in Kenya, Nigeria and Tunisia were consistent with the Fisher hypothesis. Thus, they concluded that in these 3 markets stocks were a good hedge for inflation in the long run.

Alagidede, (2009) study was later updated by Alagidede and Panagiotidis (2010) who tested the same six countries this time testing for cointegration to test the long run relationship of the stock market index and inflation. In contrast to Alagidede, (2009), Alagidede and Panagiotidis (2010) found that all the stock markets showed a significant positive cointegrating relationship with their respective inflation with the exception of Kenya and Tunisia.

Udegbunam and Eriki (2001) used a simple stock price model to test the relationship between stocks and inflation in Nigeria for the period 1980-1997 using annual data. Their research found a negative relationship between the two variables and also noted a strong relationship between Nigerian stock prices and other economic indicators such as GDP.

Adam and Frimpong (2010) tested the Fisher hypothesis in Ghana using cointegration analysis and found evidence to support that stocks in Ghana provide a hedge for inflation. They concluded that “Ghana market is efficient in inflationary environments as investors are compensated in high stock returns when prices of goods are on the rise” (Adam and Frimpong, 2010).

Gavriilidis and Kgari (2016) tested the short run and long run Fisher hypothesis in Botswana and found that in the short run there was a positive but insignificant relationship and using cointegration testing found no evidence of a long run relationship between stocks and inflation.

## **South Africa**

Early empirical studies that did not use econometric techniques examining the relationship between inflation and stock market returns in South Africa had concluded that equities serve as a hedge against inflation over the long term. The earliest of these studies is most likely Bethlehem (1972). Bethlehem (1972) examined the returns of 20 randomly selected JSE stock returns for the period between 1951 and 1971. Bethlehem (1972) concluded that South African stocks provided a good hedge during the period of study. Bethlehem (1972) results were later supported by the findings of Roome (1986) who found stocks to be a good hedge. Further support of stocks as a hedge for inflation in South Africa was given by Firer and Mcleod (1999)

who examined the performance of stocks and cash against inflation between 1925 and 1998. Firer and Mcleod (1999) results found that stocks were a good hedge of inflation during the period of study. However, a study by Jorion and Goetzmann (1999) found that during the period between 1947 and 1996 stocks had a negative relationship with inflation.

More recently studies have used more advanced empirical techniques to examine the relationship between stocks and inflation. Phiri (2017) notes only 7 studies in total that have been conducted on stock returns in South Africa using econometric techniques, these are Geyser and Lowies (2001), Alagidede and Panagiotidis (2010), Arjoon *et al.* (2012), Eita (2012), Khumalo (2013), Tripathi and Kumar (2014) and Marx and Struweg (2015).

Geyser and Lowies (2001) is one of the earliest studies on the relationship between inflation and stock returns in South Africa. Their study examined the relationship of individual stocks on the South African and Namibian stock exchange, and inflation of the respective countries. The study picked the top 10 (in 2000) stocks from the JSE and Namibian stock exchange and using regression analysis examined if there was a negative correlation between inflation and share prices. Geyser and Lowies (2001) found varying results and they concluded that neither of the two selected countries offered a perfect hedge against inflation. From their results, it was also noticed that companies in the mining sector correlated negatively with inflation while for the companies in other sectors such as financial services, information technology and food and beverage sectors there was a slight positive correlation.

Arjoon *et al.* (2012) studied the long run relationship between inflation and real stock prices in South Africa using a structural bivariate vector autoregressive (VAR) methodology with quarterly data from 1980 to 2010. Their study found considerable evidence that in the long run real stock prices do not react to permanent changes in inflation. They concluded that at least in the long run, their findings imply that investment in stocks could provide a hedge against inflation.

Eita (2012) studied the relationship between stock market returns and inflation in South Africa using quarterly data from 1980 to 2008. Their study aimed to determine if the relationship between stocks and inflation was positive or negative, and the causal relationship. Using the All Share Index (ALSI) and gold index as proxies for stock market returns on the JSE, the study found the relationship was positive and the causality is unidirectional from inflation to stock market returns when the gold was used as the proxy. These results suggested when gold is the

proxy that the past and present values of inflation could help predict stock market returns. The results differed when the All Share Index was used as a proxy for stock market returns; it was found that the causality was bi-directional which suggests that the two variables cause each other. This implied that past and present values of inflation could be used to predict stock market returns. Similarly, past and present values of stock market returns can be used to predict inflation and that for the period 1980 to 2008 stocks in South Africa were a hedge against inflation.

Khumalo's (2013) study used an Auto-Regressive Distributed lag model (ARDL) to examine the interactions of inflation and stock prices over the long run using data covering the period 1980Q1 to 2010Q. They found that there is a strong negative relationship between stocks and inflation, implying that stock prices declined during the inflationary phase (Khumalo, 2013).

Tripathi and Kumar (2014) studied the relationship of inflation and stocks for the BRICS markets using quarterly data from 2000Q1 to 2013Q4, and their results found that only Brazilian stocks had a positive relationship with domestic inflation. For South Africa, a significant negative relationship was found in the short run. Their study also found unidirectional causality from stock returns to changes in inflation. Using cointegration analysis they found no long-run relationship between stocks and inflation.

Marx and Struweg (2015) examined if the relationship between inflation, growth, interest rates and stock market returns are affected by periods of stagflation. Marx and Struweg (2015) found that overall stock markets were a hedge against inflation but during stagflation, the strength of the relationship declined. Their results also found that "The market becomes cheaper as inflation rises and more expensive as inflation falls, suggesting that investors do not believe that the market is, in fact, a good inflation hedge" (Marx and Struweg, 2015).

## **2.6 Conclusion**

In this chapter, we discussed the theory behind the relationship between stocks and inflation highlighting the Fisher hypothesis. The review of the literature indicates that a number of studies have been conducted examining the relationship between stocks and inflation in both developed and developing nations testing the Fisher hypothesis, with the results being mixed. The mixed results have been explained through the use of several alternative hypotheses with the proxy hypothesis having the most prominence. Although the alternative hypotheses have

provided plausible theoretical explanations of the observed negative relationship, more recent papers argue that the negative relationship found in early studies can be ascribed to spurious results as a result of the use of inappropriate econometric approaches and small sample sizes (Arnold and Auer, 2015). The literature shows that research testing the Fisher hypothesis using a cointegration framework and larger sample sizes have had more success confirming the hypothesis. The literature also reveals that the relationship between stocks and inflation is heterogeneous across industries, with certain industries demonstrating characteristics that make them a better hedge for inflation than others do<sup>1</sup>.

The literature also suggests that the relationship between inflation and stocks is also dependent on the level of inflation in an economy. Several studies (Long *et al.*, 2013; Kim and Ryoo, 2011; Ahmed and Cardinale, 2005) show that in periods where inflation is moderate, then stocks could provide a better hedge of inflation as compared to periods when there is high inflation. (Le Long *et al.*, 2013). Overall, there are uncertainties regarding the relationship between stock returns and inflation for both the developed and developing countries and specifically for African countries there appears to be need for more research, particularly for individual sector stock returns. Having examined the theoretical and empirical literature, the next chapter will analyse the Inflation history and stock market performance over the period of study.

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<sup>1</sup> (Bampinas and Panagiotidis, 2016; Luintel and Paudyal, 2006)

## CHAPTER 3

# Graphical analysis of common stock prices and inflation

### 3.0 introduction

Inflation is the continual rise in the prices of general goods and services in a country and it is typically measured by defining a basket of goods and services used by the general public and then keeping track of the cost of the basket. The South African Reserve Bank (SARB) (2017) states that inflation can cause problems and distortions in the economy such as losses to savers, taxpayers and people with fixed incomes, confusing price signals to producers and can result in slower expansion of businesses, rampant speculation, crowding out production and many other economic problems. For these reasons, the SARB has used inflation targeting to help control and mitigate inflation. Literature suggests that the level of inflation and the inflation regime used in a particular country is a factor in determining the relationship between common stocks and inflation as well as the ability of common stocks to hedge inflation. Thus through the analysis of the inflation history *apriori* expectations can be determined (Kim and Ryoo 2011).

Chapter 3 will provide a brief historical graphical analysis of inflation and common stock prices in South Africa. The performance of each of the sub-indexes of the JSE used in the study will also be tracked. Correlation analysis is also conducted and this overall analysis will help in formulating the *apriori* expectations.

### 3.1 Inflation and Inflation Targeting History

Examining the inflation and inflation targeting history is important for establishing *apriori* expectations underlying the relationship between common stocks and inflation for two main reasons. Firstly, it has been noted in past studies that the inflation regime can affect the hedging ability of common stocks. Research shows that for example, in times of moderate inflation the hedging ability of common stocks should be greater (Ahmed and Cardinale, 2005). Secondly not only does actual inflation affect the hedging ability of common stocks, but inflation expectations also have an impact on the extent to which common stocks can hedge inflation (Kim and Ryoo, 2011). Studies like Kumo (2015) and Mishkin and Schmidt-Hebbel (2007)

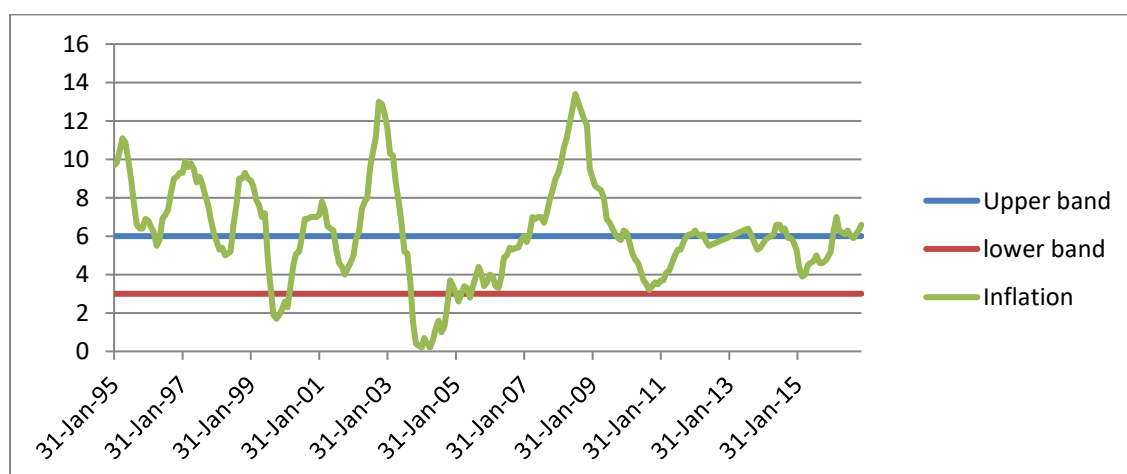
have shown that if the inflation targeting is successful it will serve to reduce inflation expectations, and this will presumably increase the hedging ability of common stocks (Kim and Ryoo 2011).

In this section, we provide a brief history of inflation targeting in South Africa from its commencement in February 2000 to the end of the study period in December 2016. In addition, we provide graphical analysis of the historical trend in inflation over the same period.

Inflation targeting is a form of monetary policy that involves the central bank making an explicit public commitment to control inflation as the primary policy objectives, by setting an explicit target for inflation and implementing a policy to achieve this target directly. As a response to the previous monetary policy regimes, such as controlling inflation through targeting monetary aggregates (M3, M2 or M1) failing, New Zealand was the first to adopt inflation targeting in 1990, following which several central banks have adopted the policy as the primary goal for monetary policy (Kumo, 2015). The empirical evidence on inflation targeting has shown that the policy regime has been mostly successful in reducing inflation with the IMF (2005) finding that countries using inflation targeting had a 4.8 percentage point reduction in average inflation when compared to other monetary policy regimes (Kumo, 2015).

The SARB introduced inflation targeting framework in February 2000 setting the target inflation rate range of 3% to 6%. Inflation targeting policy was intended to maintain the inflation rate within the target range and also reduce inflation volatility in order to promote growth (SARB, 2001).

**Figure 1: Trend Inflation before and after Inflation targeting**



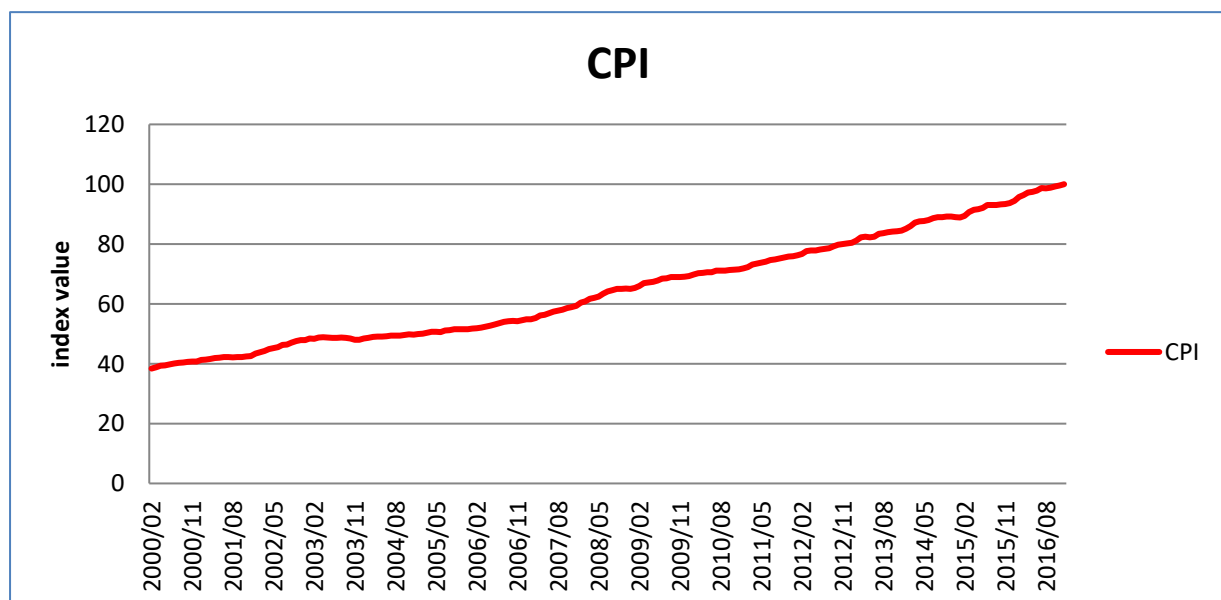
(McGregor BFA, 2017)

The above diagram illustrates the monthly year-on-year inflation rate both before and during the inflation targeting regime. During the 5 years before inflation targeting was adopted we can see that inflation was fairly volatile with inflation remaining above 6% for extended periods. After inflation targeting was introduced the volatility has been reduced with inflation rising seemingly more gradual (Kumo, 2015).

During the period of study, the inflation rate has breached the target range several times with the most major breaches occurring from February 2002 to June 2003, in which inflation peaked at 11% in August 2002, this was due to exogenous factors placing upward inflation pressures. A second spike was later experienced from April 2007 peaking at 13.4% in July 2008. This rise in inflation was driven by global inflationary pressures from rising global oil and food prices. Inflation began declining in late 2008 as global oil prices fell offsetting upward price pressures of a weaker rand exchange rate (SARB, 2017). Despite the above mentioned breaches of the inflation target the inflation targeting policy regime has been seen as a success in South Africa with inflation volatility being significantly lowered keeping inflation low for much of the period (Kumo 2015).

Despite the generally low monthly inflation, figure 2 shows how consumer prices have still more than doubled during the study period.

**Figure 2: Consumer Price Index (Base Dec 2016 = 100)**



(McGregor BFA, 2017)

### 3.2 Common Stock Performance History and Correlation

This section provides a graphical analysis comparing the performance of each of the stock markets price indices with CPI inflation. We begin with the correlation table of the various stock indices and CPI. This is followed by an analysis of the All Share Index (ALSI), comparing the performance of the index to the Consumer Price Index (CPI). This is followed by a graphical analysis of each of the individual industry indices comparing their performances to CPI.

The industries analysed in the study were determined by using the industry classifications as stated by the industry classification benchmark (ICB) adopted by the JSE (JSE, 2017). The ICB recognises 10 industries which are made up of various sectors, but our analysis will only be based on 8 instead of 10 industries as there are currently no stocks listed in the oil and gas industry and utilities industry and thus they will be excluded from the analysis. (FTSE, 2017).

#### 3.2.1 Correlation Table

As the graphical analysis may not clearly demonstrate the general relationship between the indices, Correlation coefficients were calculated to give a clearer picture of the relationships. Correlation coefficients represent the degree of the linear association between two variables with a coefficient of 1 representing a perfect association, the closer the value is to 1 the greater the linear association and a correlation coefficient of 0 representing no linear association (Taylor, 1990).

Indexes	CPI	All Share	Basic Materials	Consumer Goods	Consumer Services	Financials	Health Care	Industrials	Technology	Telecommunications
CPI	1	0.965482	0.626944	0.938214	0.924707	0.928621	0.92858	0.952203	0.684585	0.912154
All Share	0.965482	1	0.682264	0.947689	0.932166	0.979185	0.944883	0.990043	0.72627	0.946655
Basic Materials	0.626944	0.682264	1	0.425583	0.393372	0.573397	0.425677	0.719546	0.132982	0.757366
Consumer Goods	0.938214	0.947689	0.425583	1	0.985788	0.956598	0.983773	0.914691	0.828038	0.840473
Consumer Services	0.924707	0.932166	0.393372	0.985788	1	0.956816	0.978487	0.896229	0.826349	0.805383
Financials	0.928621	0.979185	0.573397	0.956598	0.956816	1	0.963362	0.968446	0.770671	0.9011
Healthcare	0.92858	0.944883	0.425677	0.983773	0.978487	0.963362	1	0.919458	0.818906	0.862684
Industrials	0.952203	0.990043	0.719546	0.914691	0.896229	0.968446	0.919458	1	0.684169	0.957121
Technology	0.684585	0.72627	0.132982	0.828038	0.826349	0.770671	0.818906	0.684169	1	0.644294
Telecommunications	0.912154	0.946655	0.757366	0.840473	0.805383	0.9011	0.862684	0.957121	0.644294	1

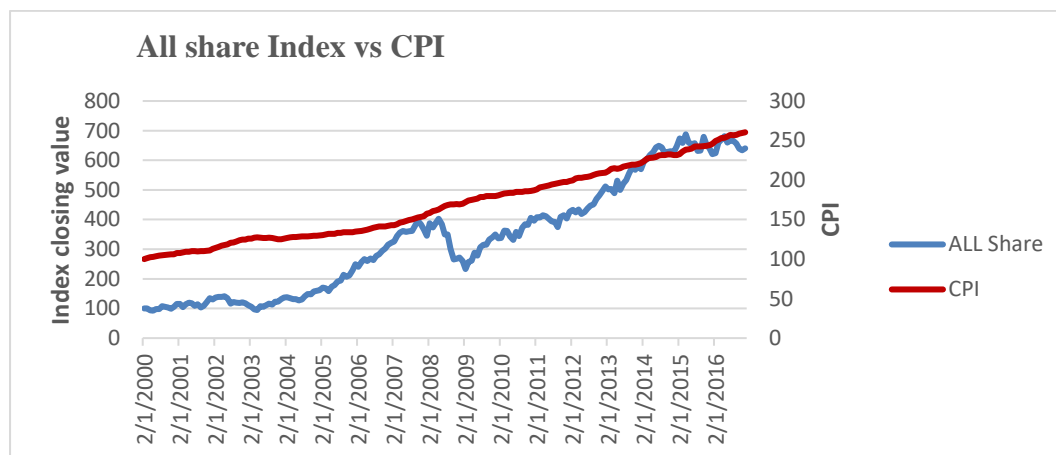
The above table displays the correlation coefficients between each of the stock indices and CPI. The table shows that each of the indices is highly correlated with CPI, with the ALSI being the

most correlated with CPI, while the Basic Materials index was the least correlated with CPI. A further analysis will be given below in the relevant sub sections of the indices.

### 3.2.2 Common Stock Performance History

In this section, we compare the performance history of each of the indices. Each graph displays the monthly closing values of the respective index rebased to equal 100 at the beginning of the study period to allow for a better comparison of performance with the CPI. Two scales are used on each graph with the primary scale displaying the closing sub-indices stock index value for the respective month, while the secondary axis shows the CPI value for the respective month

#### 3.2.2.1 Graphical analysis of the All Share Index and CPI



*\*All Share index closing value displayed on the primary axis. CPI displayed on the secondary axis (McGregor BFA, 2017)*

The FTSE/JSE All Share Index (ALSI) is a market capitalization-weighted index that is comprised of 99% of the total free float market capitalization of all listed companies on the JSE (JSE, 2017). Due to the ALSI comprising of the vast majority of the common stocks on the JSE, it is a good proxy for the general behaviour of common stocks in South Africa.

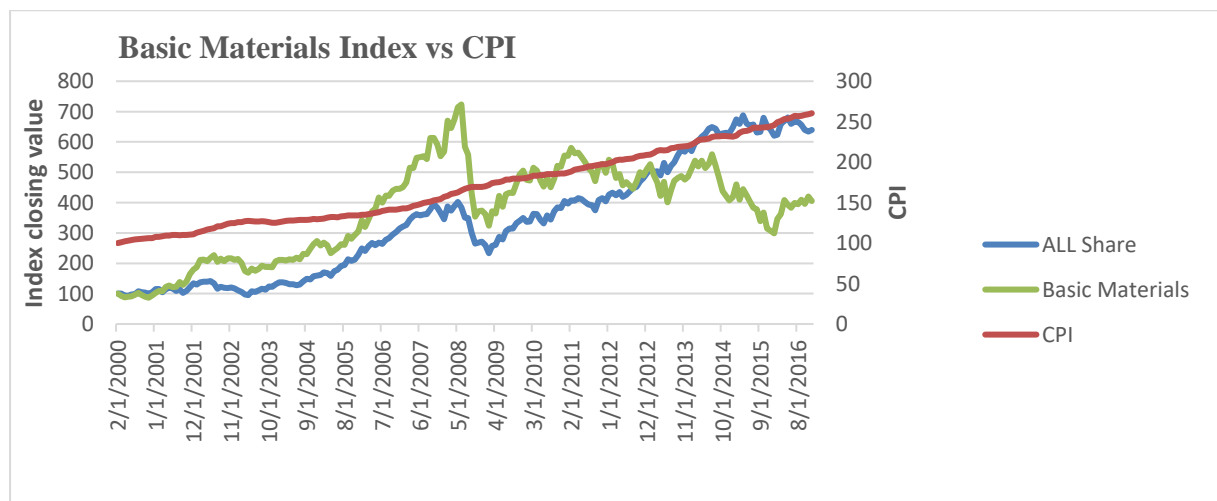
The growth of the ALSI price was relatively slow from 2000 to 2004 but experienced rapid growth from the end of 2004 till 2007 before experiencing a major decline between 2008 and 2009. This decline was largely a result of the global financial crises. Since the 2009 decline, there has been a rapid upward growth trend in the price index peaking in value in February 2015. This growth was driven by increased global investor appetite, higher global equity prices and favourable commodity prices (SARB, 2017).

The relationship between inflation and the All Share Index is not obvious from the above diagram. Although certain periods of the diagram such as the 2005- 2008 period do show some signs of correlation between increased inflation and common stock prices. During that period both indices grow rapidly and we observe that inflation slightly levels off as the ALSI experiences a decline.

We also observe that during this period the all share index price has grown at a much faster rate than inflation. The CPI index over the entire study period has increased by 160% with a compound annual inflation growth of 5.79%, while ALSI over the period has had overall growth of 540% and a compound annual growth rate of 11.54%.

From the correlation table, we observe that the ALSI is highly correlated with CPI with a correlation coefficient of 0.965482. Furthermore, the correlation between ALSI and CPI is the highest measured correlation among the JSE indices. The ALSI is also highly correlated with each of the industry indexes, the highest correlation being with the Industrials Index having a correlation coefficient of 0.990043. This high correlation could be explained by the fact that industrials make up a large proportion of the ALSI index.

### 3.2.2.2 Graphical analysis of the Basic Materials Index and CPI



*\*Basic Materials index closing value displayed on the primary axis. CPI displayed on the secondary axis*

(McGregor BFA, 2017)

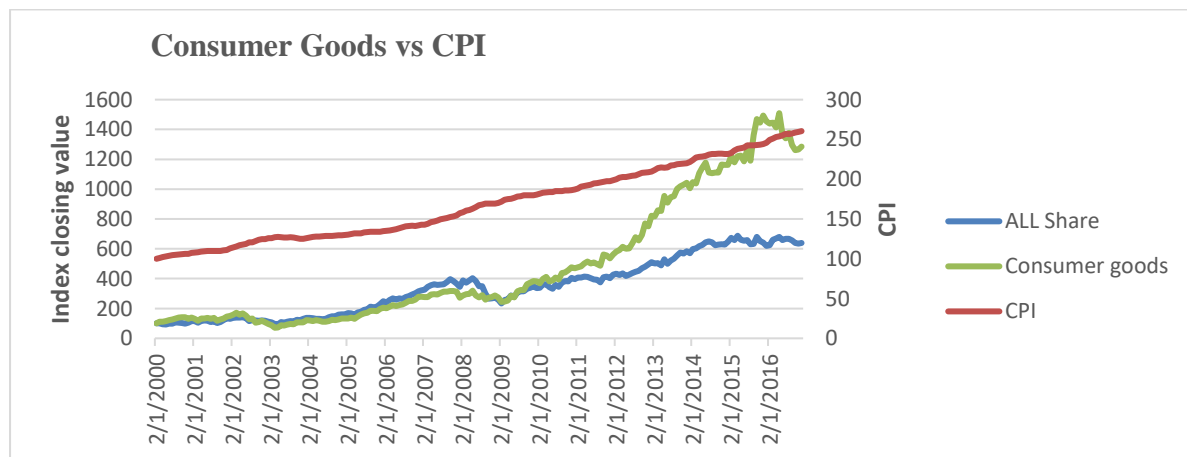
The FTSE/JSE Basic Materials index is a market capitalization-weighted index that is comprised of all the companies listed on JSE that belong to one of 4 sectors, these sectors are the chemical sector, forestry and paper sector, industrial metals and mining sector (FTSE, 2017).

At the beginning of the period of study the Basic Materials index moved closely with the ALSI having a general upward trend from Feb 2000 till Feb 2008 and declining at the onset of the global financial crises. After the financial crises, the Basic Materials index continued to move closely with the ALSI until 2011 when the Basic Materials index began to decline while the ALSI continued to grow. Unlike the ALSI the Basic Materials index has not been able to surpass its pre-crisis peak (SARB, 2017).

From the above diagram, the relationship between the Basic Materials index and the CPI is not easily observable. What we do observe is that during this period the Basic Materials index price has grown at a much faster rate than inflation, more than tripling during the course of the period with overall growth of 305% and a compound annual growth rate of 8.58%.

The correlation table shows that the Basic Material index, while correlated with CPI the correlation, is the weakest among the indices in the study with a correlation coefficient of 0.626944. The Basic Materials index is also correlated with the other indices in the study, but these correlations appear to generally be weaker than the other relationships, with correlation coefficients ranging from 0.757366 to 0.132982. The strongest correlation is with the telecommunications Index and the weakest is with the Technology index.

### 3.2.2.3 Graphical analysis of the Consumer Goods Index and CPI



\*Consumer Goods index closing value displayed on the primary axis. CPI displayed on the secondary axis (McGregor BFA, 2017)

The FTSE/JSE Consumer Goods index is a market capitalization-weighted index that is comprised of all the companies listed on JSE that belong to one of 6 sectors. The sectors are the automobiles and parts sectors, the beverages sector, the food producers sectors, the

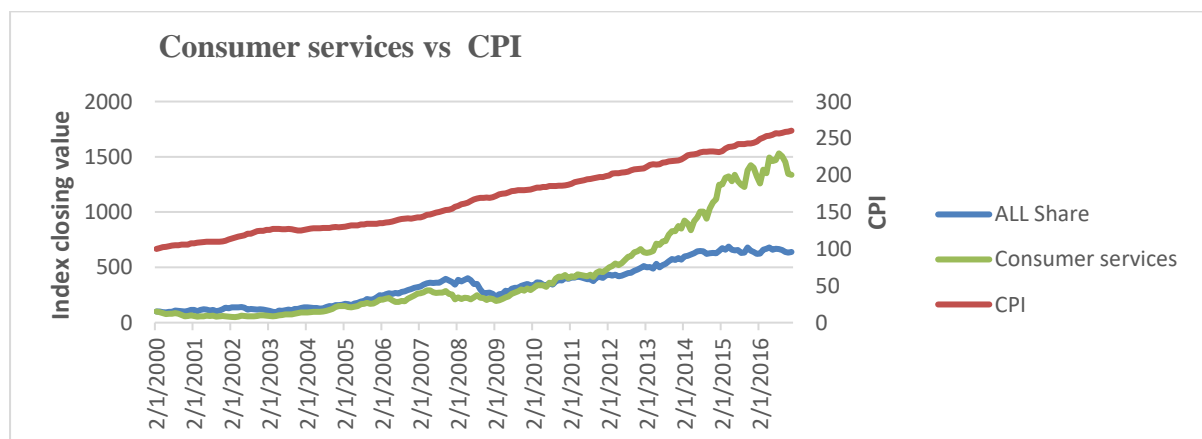
Household Goods & Home Construction sector, the Leisure Goods sector, the Personal Goods sector and the Tobacco sector (FTSE, 2017).

The Consumer Goods index has had a very strong upward trend during the study period growing by 12 times over the period. The period began with slow growth from 2000 to 2008; in 2008 there was a decline in the index price as a result of the global financial crises, but the Consumer Goods index was less affected by the financial crises than the ALSI. Following the financial crises, the Consumer Goods index experienced rapid growth with the Consumer Good index surpassing the ALSI in February 2012 and continuing to grow before peaking in December 2015. (SARB, 2017)

The relationship between inflation and the Consumer Goods index is not obvious from the above diagram, what we do observe is that during this period the Consumer Goods index price has grown at a much faster rate than inflation, with overall growth of 1185% and a compound annual growth rate of 16.20%.

The correlation table shows The Consumer Goods index and CPI are highly correlated with a correlation coefficient of 0.938214. The Consumer Goods index is also correlated with the other indices with correlation coefficients ranging from 0.983773 with the Healthcare to 0.425583 with the Basic Materials Index.

### 3.2.2.4 Graphical analysis of the Consumer Services Index and CPI



*\*Consumer Services index closing value displayed on the primary axis. CPI displayed on the secondary axis*

(McGregor BFA, 2017)

The FTSE/JSE Consumer Service index is a market capitalization-weighted index that is comprised of all the companies listed on JSE that belong to one of 4 sectors as per the ICB

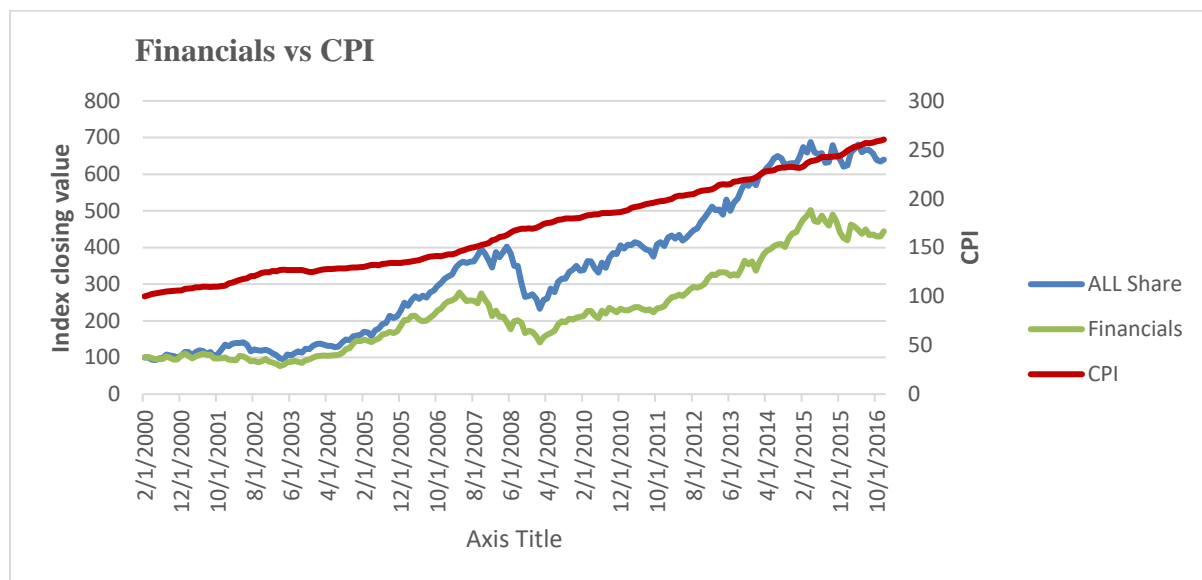
classification. These sectors include the Food & Drug Retailers, the General Retailers, the Media sectors and the Travel & Leisure sector (FTSE, 2017).

Over the study period, the Consumer Services index has had a strong upward trend growing by 13 times. Between 2000 and 2010 the growth appears to be gradual before growing rapidly from 2010 onwards. As with ALSI, the Consumer Service index was affected by the 2008 financial crises, decreasing somewhat in value during the period (SARB, 2017).

Just as with the other indices, the relationship between the Consumer Services index and the CPI is not obvious. What is observed is that both indices trend upwards and the Consumer Services index has grown by more than CPI during the period with overall growth of 1238% and compound annual growth of 16.48%.

The correlation table shows that the Consumer Services and CPI are highly correlated with a correlation coefficient of 0.924707. The Consumer Services index is also correlated with the other indices with correlation coefficients ranging from 0.978487 with the Healthcare to 0.393372 with the Basic Materials Index.

### 3.2.2.5 Graphical analysis of the Financials Index and CPI



*\*Financials index closing value displayed on the primary axis. CPI displayed on the secondary axis (McGregor BFA, 2017)*

The FTSE/JSE Financials Index is a market capitalization-weighted index that is comprised of all the companies listed on JSE that belong to one of 8 sectors according to ICB classification. The aforementioned sectors include the banks sector, non-life insurance sectors, the life

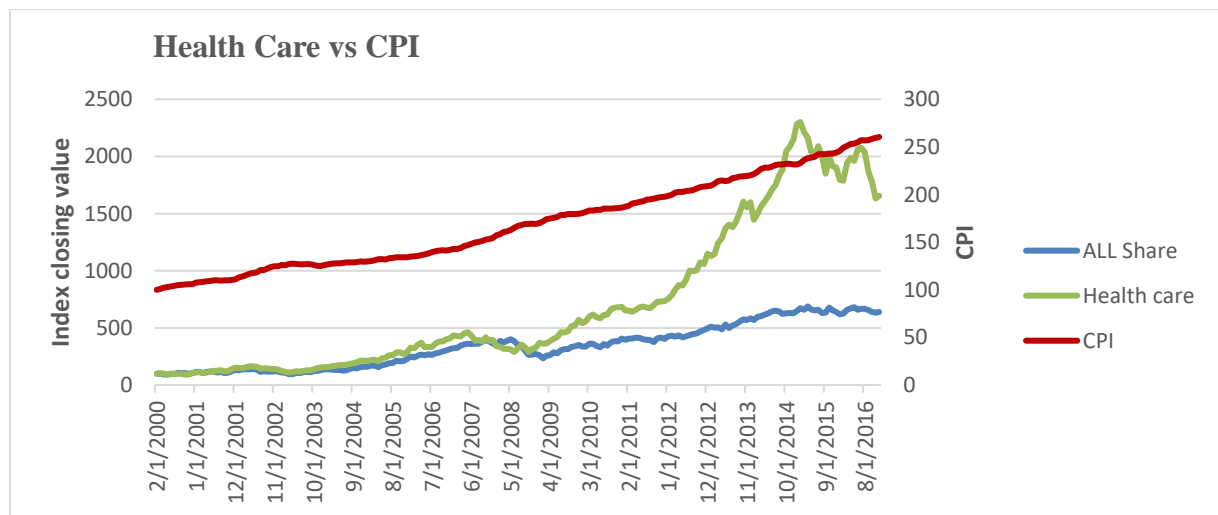
insurance sector the Real Estate Investment & Services sector, the Real Estate Investment Trusts sector, the Financial Services sector, the Equity Investment Instruments sector and Non-equity Investment Instruments sector (FTSE, 2017).

Over the study period, the Financials index has shown a general upward trend growing by 4 times during the period, with the only period showing negative growth being during the 2008 financial crisis. From the diagram it is observed that the financials index moves closely with the ALSI, this might be due to the fact that the financial stocks make up a large proportion of the ALSI (SARB, 2017).

The relationship between the CPI and The Financials index, on the other hand, is not as clear from the diagram. What is observed is that they both trend upwards and the Financials index has grown by more than CPI during the period with overall growth of 344% over the period. The compound annual growth rate of the Financials index was 9.17% during the period.

The correlation table shows the Financials and CPI are highly correlated with a correlation coefficient of 0.928621. The Financials index is also correlated with the other indices with correlation coefficients ranging from 0.979185 with the ALSI to 0.573397 with the Basic Materials Index.

### 3.2.2.6 Graphical analysis of the Health Care Index and CPI



\*Health Care index closing value displayed on the primary axis. CPI displayed on the secondary axis

(McGregor BFA, 2017)

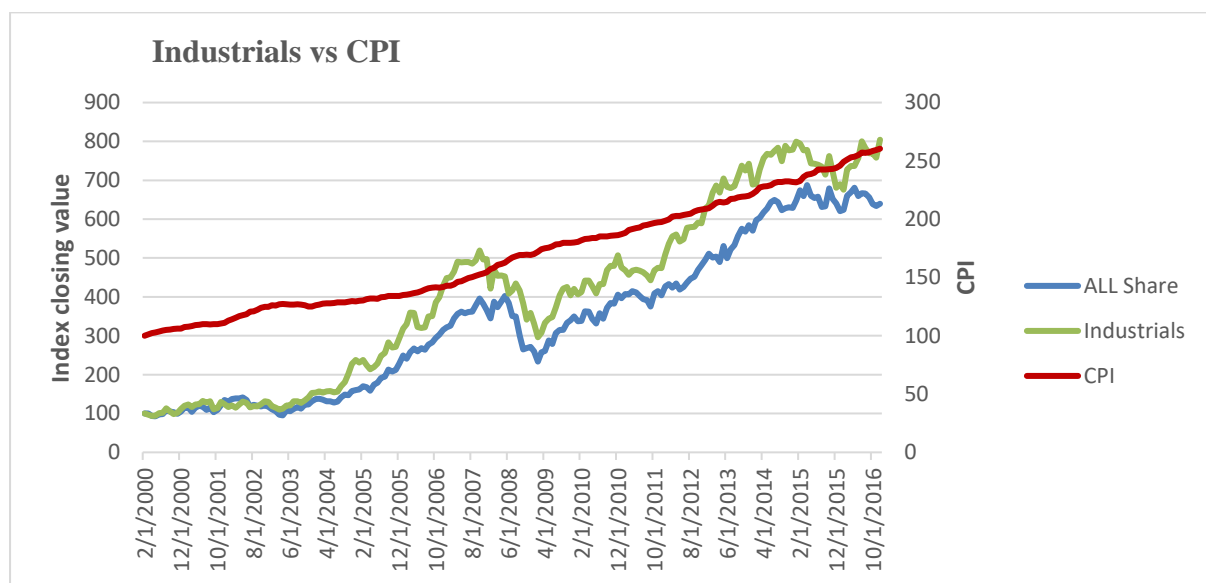
The FTSE/JSE Health Care index is a market capitalization-weighted index that is comprised of all the companies listed on JSE that belong to one of 2 sectors according to the ICB

classification, these sectors include the Health Care Equipment & Services sector and the Pharmaceuticals & Biotechnology sector (FTSE, 2017).

At the beginning of the period, the Health Care index had the lowest value of the indices in the study but has had the greatest overall percentage growth of 1556% and a compound annual growth 17.96%. This growth on the diagram is seen as gradual from 2000 to 2010 when growth becomes more rapid before peaking in 2015 and experiencing a slow decline to the end of 2016.

The relationship between inflation and the Healthcare index is not obvious from the diagram but the correlation table shows that the two indices are highly correlated with a correlation coefficient of 0.92858. The Health Care index is also correlated with the other indices with correlation coefficients ranging from 0.983773 with the Consumer Goods to 0.425677 with the Basic Materials Index.

### 3.2.2.7 Graphical analysis of the Industrials Index and CPI



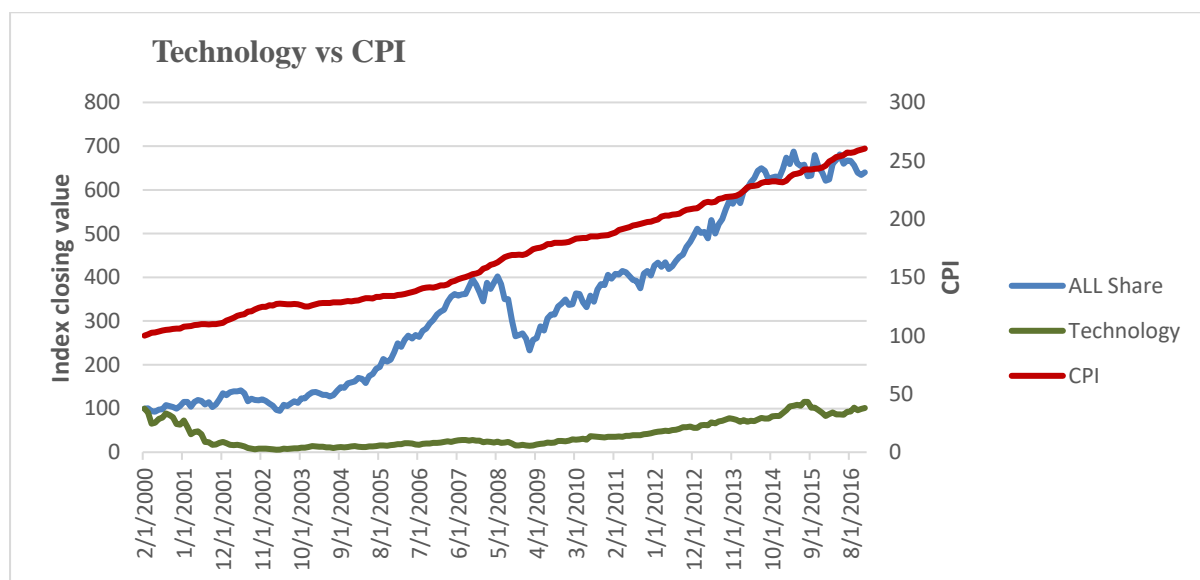
\*Industrials index closing value displayed on the primary axis. CPI displayed on the secondary axis (McGregor BFA, 2017)

The FTSE/JSE Industrials index is a market capitalization-weighted index that is comprised of all the companies listed on JSE that belong to one of 6 sectors as per the ICB classification, the sectors include the Construction & Materials sector, the Aerospace & Defence sector, the General Industrials, the Electronic & Electrical Equipment sector, the Industrial Engineering sector, and the Industrial Transportation sector. (FTSE, 2017)

Over the period the industrials index has moved closely with the ALSI, having a general upward trend with the only major decline observed during the global financial crises. The close movement is shown also in the high correlation coefficient of 0.990043; however, while the ALSI has grown by only 305% the Industrial index has grown by 704%. The compound annual growth of the Industrials index was 13.05%.

As with the ALSI, the relationship between inflation and the Industrials index cannot be easily observed on the diagram but the correlation table shows that the correlation coefficient is 0.952203. The Industrials index is also correlated with the other indices with correlation coefficients ranging from 0.990043 with the ALSI to 0.719546 with the Basic Materials Index.

### 3.2.2.8 Graphical analysis of the Technology Index and CPI



*\*Technology index closing value displayed on the primary axis. CPI displayed on the secondary axis (McGregor BFA, 2017)*

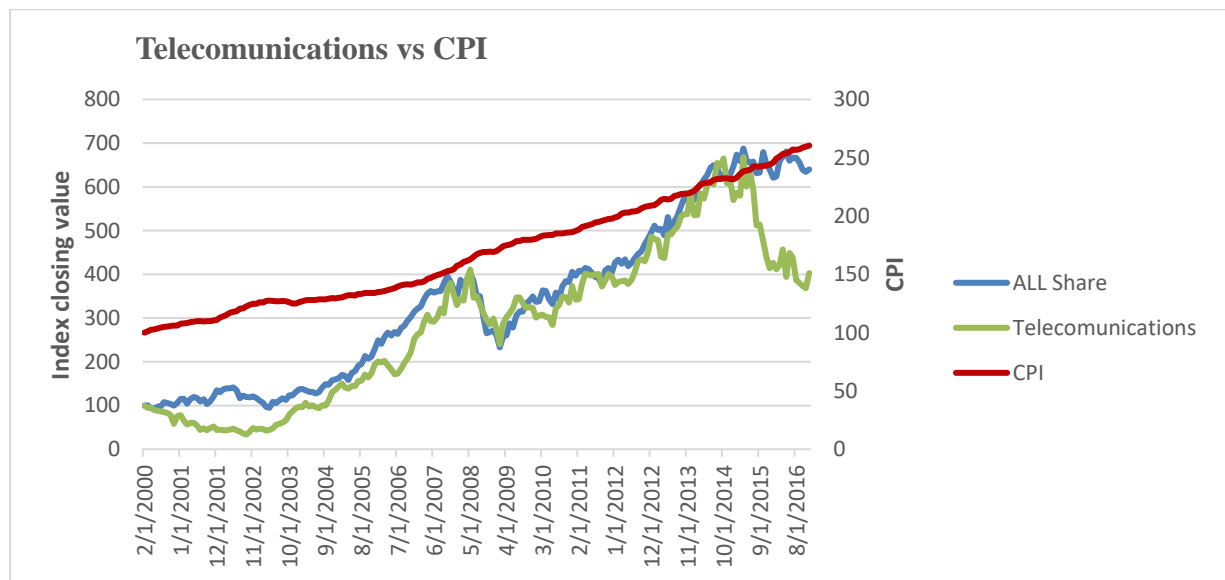
The FTSE/JSE Technology index is a market capitalization-weighted index that is comprised of all the companies listed on JSE that belong to one of 2 sectors as per the ICB classification, the sectors include the Software & Computer Services sector and the Technology Hardware & Equipment sector (FTSE, 2017).

The Technology index was in a state of decline at the beginning of the period from 2000 to 2003. The decline was a result of a global fall in information technology companies share price as a result of the collapse of the dot-com bubble (Kraay and Ventura, 2007). After 2003 the technology index has had a general upward trend with a slight decline during the 2008 financial crises but continuing to rise and peaking in July 2015. The index was in decline for the rest of

2015 and rebounded at the beginning of 2016 (SARB, 2017). Because of the decline at the beginning of the period of study, the growth over the period is very small with the change in value from February 2000 to December 2016 only amounting to only 1% overall. Thus, over the period, there has been compound annual growth of 0.08%.

Just as with the other indices the relationship between the Technology index and the CPI is not obvious. The correlation table reveals that the two indices are correlated with a correlation coefficient of 0.684585, this coefficient is the second lowest of the indices. The Technology Index is also correlated with the other indices with correlation coefficients ranging from 0.828038 with the Consumer Goods index to 0.132982 with the Basic Materials Index.

### 3.2.2.9 Graphical analysis of the Telecommunications and CPI



*\*Telecommunications index closing value displayed on the primary axis. CPI displayed on the secondary axis (McGregor BFA, 2017)*

The FTSE/JSE Telecommunications Index is a market capitalization-weighted index that is comprised of all the companies listed on JSE that belong to any one of 2 sectors as per the ICB classification. The sectors include the Fixed Line Telecommunications sector and the Mobile Telecommunications sector (FTSE, 2017).

Although beginning with a decline between 2000 and 2003, overall the telecommunications price index has had upward trend closely following the ALSI during the period with a minor drop during the financial crises and growth peaking in 2015 with a decline in 2016 (SARB, 2017). The telecommunications index has had a relatively slow growth compared to the ALSI with the overall growth of 303% and a compound annual growth rate of 8.54%.

As with the other indices, the relationship between the telecommunications index and the CPI is not obvious. What we do observe is that over the period they have both trended upwards with the telecommunications index growing faster than CPI.

The correlation table shows that the Telecommunications Index and CPI are correlated with a correlation coefficient of 0.912154. The Telecommunications Index is also highly correlated with the other indices with correlation coefficients ranging from 0.957121 with the ALSI to 0.644294 with Technology index.

### **3.3 Conclusion**

In this chapter, a graphical analysis has been conducted examining the inflation history of South Africa during the period that inflation targeting was introduced as the monetary policy goal. From the analysis, it is determined that despite some spikes in inflation, inflation has remained low and has experienced less volatility during the inflation targeting period than prior. The literature suggests that in these conditions common stocks will be a good hedge (Ahmed and Cardinale, 2005). The study also provides a graphical analysis of the performance of the common stock indexes to be used in the study. From our analysis, we find that the common stock indexes have experienced strong growth, which overall has tended to exceed the growth of CPI during the period of study. However, it should be noted that the relationship between stock market indexes and the CPI is not easily determined by the graphical analysis, thus correlation coefficients were calculated to give a better idea of the relationship. The correlation coefficients show that there is a strong correlation with each of the indices and CPI with the ALSI having the strongest correlation.

Thus, from the results of this preliminary graphical analysis, and supported with the literature we are in a position to formulate our *a priori* expectations. Our *a priori* expectations are that since common stocks and inflation move together and common stocks grow at a faster rate than inflation, this implies that stocks in South Africa are likely to hedge inflation during the period.

# CHAPTER 4

## Methodology

### 4.0 Introduction

In order to test the Fisher hypothesis for South African common stocks and examine the heterogeneity of the various industries, the study will make use of cointegration testing. One issue that was noted in previous studies is that stock returns and inflation rates exhibit special time-series properties such that they are often found to be non-stationary in level terms. Using non-stationary variables in standard OLS regression methods introduces the problem of spurious regression, which is the detection of significant relationships where none exists (Arnold and Auer, 2015).

To avoid the problem of spurious regressions in modern studies examining the Fisher hypothesis search for cointegration between inflation and common stock returns (Luintel and Paudyal, 2006; Alagidede and Panagiotidis, 2010). If the two variables are found to be non-stationary but cointegrated, a stable long-run relationship can be estimated reflecting an equilibrium relationship between common stock returns and inflation. Finding cointegration between the variables means that a Vector Error Correction model (VECM) can be estimated to study the long run and short-run dynamics. This study, therefore, uses the Johansen (1988) cointegration testing to test the Fisher hypothesis. This chapter will outline the specific methodological steps that will be followed to test for cointegration between common stock returns and inflation. The last section of this chapter will also outline the data to be used.

### 4.1 Stationarity Test

Following the Johansen cointegration procedure, the first step will involve testing the stationarity of the CPI and common stock indices.

A time series is considered stationary if the mean and variance are constant over time thus future predictions can be made from past data. In practice many economic time series are non-stationary meaning the mean and variance change over time, thus using OLS based estimations becomes inappropriate and leads to spurious estimations. Non-stationary variables can be transformed into stationary variables by differencing the time series. The number of times that a variable must be differenced to become stationary is referred to as the “order of integration”.

In order to be able to test for cointegration, the order of integration must be the same for each of the variables thus stationarity tests are used to determine the order of integration. There are various informal and formal methods for testing for stationarity, in this study, the Augmented Dickey-Fuller (ADF) Test and the Kwiatkowski Philips Schmidt Shin (KPSS) test will be used to test for stationarity and to determine the order of integration of the variables (Gujarati and Porter, 2009:496).

The ADF is the most common test for stationarity; The ADF tests the null hypothesis that the variable has a unit root and therefore is considered to be non-stationary. Although it is commonly used there are several limitations that have been documented on the ADF. The first of these limitations is that it is argued that the ADF test has a low power of tests, thus it tends to accept the null hypothesis of a unit root even when there is none and may not detect structural breaks in a time series. Furthermore, the problem of “low power” becomes worse when testing smaller sample sizes of 50 observations or less. The second limitation is that the ADF test is sensitive to outliers, particularly in small sample sizes, thus outliers can exert undue influence on the results of the test. The third limitation is that the ADF test cannot distinguish between a series with a unit root and series which contain a parameter shift. Due to the limitations of the ADF, the KPSS is employed to ensure the robustness of the test. The KPSS has a null hypothesis that the variable is stationary. KPSS has an advantage over ADF with time series that are serial correlated and have a structural break (Brooks, 2008).

#### **4.2 Tests for Cointegration**

If both variables are found to be non-stationary in level terms but integrated at the same level, the next step will be to conduct the test for cointegration (Luintel and Paudyal, 2006). Two variables are considered cointegrated if they are individually integrated of the same order and there is at least one linear combination of the variables that is stationary. There are several methods for testing for cointegration. The literature shows that modern tests of the Fisher hypothesis such as Luintel and Paudyal, (2006), Alagidede and Panagiotidis, (2010) and Adam and Frimpong, (2010) commonly employ the Johansen cointegration test. Following the convention in the literature, the Johansen Cointegration approach will be utilized in this study.

Before testing for cointegration the appropriate lag order must be determined, this is important as an inappropriate lag length may lead to serial correlation and empirical studies have shown the Johansen cointegration test are sensitive to the chosen lag length. The appropriate lag is determined using the Akaike (AIC) and Schwarz-Bayesian (SIC) information criterion.

Using the inflation and the common stock returns a two variable VAR model will be estimated. The above-mentioned VAR model will be used to find the appropriate optimal lag lengths using the AIC and SIC information criteria.

After establishing the appropriate lags, the Johansen cointegration test will be used. The Johansen cointegration test involves the use of a general VAR model as shown below.

The general VAR model with  $k$  lags is specified as:

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^k B_i X_{t-i} + \rho z_t + E_{kt} \dots\dots\dots(4.1)$$

Where:

$X_t = [S_t, \pi_t]$  is a  $2 \times 1$  vector of I(1) variables

$$\Pi = ab$$

Where  $a$  is a  $n \times r$  matrix that gives the amount of each cointegrating vector and is known as the adjustment parameter, the matrix contains the error correction terms and is used to demonstrate the short run impact. The Term  $b$  is a  $r \times n$  matrix of cointegrating vectors. The number of cointegrated vectors is determined by the rank of the  $\Pi$  matrix. The matrix  $\Pi$  is interpreted as the long run coefficient matrix. To determine the rank of the  $\Pi$  matrix the Johansen trace statistics and the maximum Eigenvalues are used (Luintel and Paudyal, 2006).

The Johansen trace statistics is given as,

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^g \ln(1 - \lambda_i) \dots\dots\dots(4.2)$$

Where  $r$  is the number of cointegrating vectors under the null hypothesis. The trace stats tests the null hypothesis that the number of cointegrating vectors is less than or equal to  $r$ , against the alternative hypotheses that they are more than  $r$  cointegrating vectors.

The maximum Eigenvalues is given as:

$$\lambda_{max}(r, r + 1) = -T \ln(1 - \lambda_{r+1}) \dots\dots\dots(4.3)$$

The maximum Eigenvalue test tests the null hypothesis that the number of cointegrating vectors is equal to  $r$  against the alternative hypothesis that the number of cointegrating vectors is  $r + 1$ .

There are several models of assumptions of the nature of the data that change the structure of the VAR model to be tested, the statistical package used (EViews) allows for 5 different models of assumptions to be used.

- Model 1: Assumes there is no deterministic trend in the data, and no intercept or trends included in the Cointegrating equation or VAR model.
- Model 2: Assumes there is no deterministic trend in the data and includes an intercept in the cointegrating equation but no trends and intercept in the test VAR model.
- Model 3: Assumes there is a linear deterministic trend in data and includes an intercept and no trend in the cointegrating equation and VAR model.
- Model 4: Assumes linear deterministic trend in data and includes an intercept and trend in the cointegrating equation but no intercept in the test VAR model.
- Model 5: Assumes for a quadratic deterministic trend in the data and includes an intercept and trends in the test VAR model.

The decision of which model to be used is determined by the nature of the data. As model 1 and 5 are considered unlikely and model 4 considers a linear trend in the model and as the Fisher hypothesis is interpreted as equilibrium relationship a linear trend in that relationship may not be viewed as plausible and therefore these models will not be used. Our analysis will use model 2 or 3 dependent on a determination made after examining the data and stationarity test (Asterious and Hall, 2007)

If Cointegration can't be found then no long-run relationship exists between common stocks and inflation, thus the Fisher hypothesis will be rejected. If cointegration is found, this implies an equilibrium relationship between common stock returns and inflation and a cointegration regression can be estimated to determine if the relationship is positive or negative (Luintel and Paudyal, 2006).

### **4.3 Long-run estimation (cointegration regression) And VECM**

If cointegration is found, we then estimate the following long-run equation by normalizing by the common stock returns with variables in log form to produce the following regression:

$$\delta_t = \alpha_0 + (d)\pi_t + e_t \dots\dots\dots(4)$$

$\delta_t$  represents the JSE all-share index return

$\pi_t$  represents the inflation rate

If the variables are in log terms, the coefficient  $d$  in this equation is the elasticity of common stock prices with respect to inflation, otherwise known as the Fisher coefficient. As stated above finding a positive value for  $d$  not significantly different from one can be considered confirmation of the Fisher hypothesis and thus it can be concluded that common stocks are a hedge for inflation. If the Value of  $d$  is  $1 > d > 0$  then common stocks provide a partial hedge for inflation, if  $d > 1$  then the common stock returns increase at a rate faster than inflation and thus common stocks can be considered a full (but not perfect) hedge for inflation (Luintel and Paudyal, 2006).

Having established the number of cointegrating vectors the study estimates a VECM. The VECM not only gives a cointegrating regression but will allow us to observe the short run relationships of the variables. The VECM provides information on how short-term adjustments take place to restore the long-run equilibrium in response to short-term shocks. From the VECM we will observe the Impulse response and Variance decomposition.

Impulse responses trace out the responsiveness of the endogenous variables in the VECM to shocks to each of the other variables in the model. "For each endogenous variable, a unit shock is applied to the error and the effects over time are then noted" (Gujarati and Porter, 2009). Variance decomposition gives insights into the relative contribution of the structural shocks in explaining volatilities in the variables examined. Variance decomposition separates out the proportion of a change in the variable that occurs through its own lags and that which occurs through lags of other variables in the system when a shock is applied to the error. (Gujarati and Porter, 2009).

#### **4.4 Diagnostic Tests**

Two types of Diagnostics test will be used on the residuals of the Cointegrating regression and VECM.

The Cointegrating regression and VECM will be tested to ensure residuals are uncorrelated using the Lagrange Multiplier (LM) test. Cointegrating regression equations with correlated residuals will tend to produce coefficient estimates that are inefficient, thereby causing wrong conclusions to be made with regard to whether an exogenous variable is or is not important in explaining the endogenous variable concerned (Luintel and Paudyal, 2006).

The Residuals will also be tested to determine if they are normally distributed. It is important that the residuals are normally distributed because T-test and F-test are evaluated on the

assumption that residuals are normally distributed. To test the normality of residuals the Jarque-Bera (JB) test is used. The JB test stat follows an  $\chi^2$  distribution with a null hypothesis that the distribution of the residuals is symmetric, if the model shows evidence of significant skewness or kurtosis then the null of normality is rejected (Gujarati and Porter, 2009).

Since financial data is being used finding a normal distribution is unlikely and it has been argued that for cointegration results having non-normally distributed residuals may not pose a serious threat (Islam and Ahmed, 1999). Therefore, in our diagnostics, we are more concerned with serial correlation of the residuals.

The cointegration test and diagnostic tests will be applied to tests of CPI and each of the 9 Indices<sup>2</sup>. To compare the hedging ability of the sectors, the Fisher coefficient “d” from each of these models (equation (4.4)) will be compared. The greater the value of the Fisher coefficient the greater the elasticity of the specific common stock index with respect to inflation and thus theoretically the more successful that index is as a hedge of inflation.

After comparing the results, a brief discussion of the implications of the findings for portfolio management will follow.

#### **4.5 Data**

The Data consists of monthly common stock returns from Feb 2000 to Dec 2016 this period is chosen as this is a period in which inflation targeting was used in South Africa (SARB, 2017). Thus, using this period allows us to examine the hedging ability under the current inflation regime as research has shown that inflation hedging ability is dependent on the inflation regime (Li *et al*, 2010). To capture the aggregated common stock returns for the overall market the JSE All Share index return is used. Testing the All Share index is used to determine if in general common stocks in South Africa are a good hedge for inflation. For the various disaggregated industries (sectors), we use the respective JSE sector index. The disaggregated data is used to examine the heterogeneity of the ability of the various industries to hedge inflation.

The indices used in this study include JSE/FTSE All-Share price index, JSE/FTSE Basic Materials price index, JSE/FTSE Industrials price index, JSE/FTSE Consumer Goods price index, JSE/FTSE Health Care price index, JSE/FTSE Consumer Services price index,

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<sup>2</sup> The All Share, Basic Materials, Industrials, Consumer Goods, Health Care, Consumer Services, Telecommunications, Financials, and Technology Index

JSE/FTSE Telecommunications price index, JSE/FTSE Financials price index, and JSE/FTSE Technology price index. In order to only capture the effect of inflation on prices the indices used are price indices and ignore the effects of dividends. We use monthly Consumer price index (base December 2016) as the proxy for Inflation. The data is collected from McGregor BFA (2017).

All data is converted to log form before conducting the analysis as done in Luintel and Paudyal, (2006) in order to interpret regression results as elasticity.

#### **4.6 Conclusion**

This section provided the empirical framework that will be used to test the Fisher hypothesis. The framework is based on past research that has shown that searching for cointegration is the most effective way of testing the Fisher hypothesis. The limitations of this technique have also been highlighted particularly the need to choose the appropriate lag, use of an inappropriate lag can negatively affect the cointegration test and lead to serial correlation in the VECM cointegration regression

The test for cointegration will initially be conducted on the JSE all-share index return and inflation to determine if common stocks, in general, are a good hedge for inflation in South Africa. The test will then be conducted on the returns of each of the industries/sectors of the JSE and inflation. This allows us to compare the industries to determine which would be the most attractive to hedge inflation. Having provided the framework the next section will provide the results from the models and tests that have been used.

# CHAPTER 5

## Empirical Estimation and Results Analysis

### 5.0 Introduction

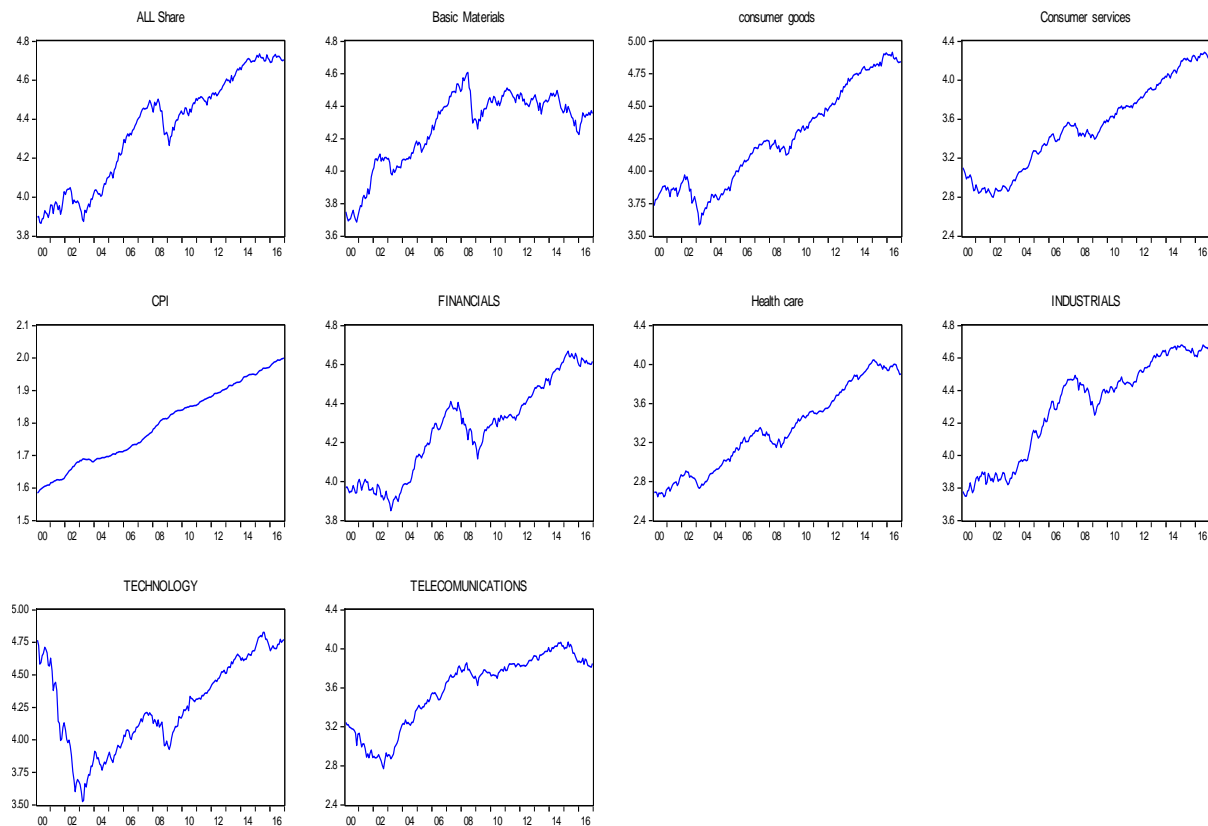
Chapter 5 will provide the results of the empirical study in testing the Fisher hypothesis. The chapter begins with a short graphical analysis and descriptive data of the time series to be used and then proceeds with the results of the formal ADF and KPPS test of stationarity. Once the integration level of the data is confirmed, the results of the cointegration test are reported. The test of cointegration is followed by the results of the long run regressions and The VECM as well as the results of the diagnostics test for each equation. The results of the cointegration test show that all the common stock indices have at least one cointegrating vector between them and inflation. Further, the long run cointegrating regressions and VECM all show that the relationships are all positive, providing supportive evidence of the Fisher hypothesis. The Fisher coefficients from the cointegrating regressions and VECM also provide evidence of the heterogeneity of common stocks with the coefficients varying in value from 1.3 – 4.6.

Further, From the VECM the impulse response and variance decomposition were also examined. The impulse response results showed that the short run relationship between common stocks and inflation varied with some common stocks demonstrating a positive short-run relationship with inflation and others demonstrating a negative relationship. The Variance decomposition, on the other hand, showed that with the exception of the technology index very little variance in common stocks was due to shocks in inflation.

Notably, the results indicate that the weak exogeneity test for the VECM shows that only the Technology index is truly endogenous, implying only the Technology index has movements caused by CPI. A further summary of the results and some of the key conclusions drawn from the results are presented in the final section of the chapter.

## 5.1 Preliminary Analysis

We begin the chapter by providing a graphical representation of the data in long term.



From the above graphs, all the indexes are observed trended upwards over the period. The upward trend of the data suggests that the data is likely to be non-stationary in level terms. A more detailed analysis of the movements of each of these variables has been given in Chapter 3.

**Table 5.1 Descriptive data**

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
CPI	1.796020	1.807535	2.000000	1.584331	0.120316	0.022897	1.724548
All Share	4.346099	4.427561	4.735922	3.865536	0.279298	-0.28413	1.694012
Basic Materials	4.267478	4.356539	4.608484	3.686837	0.229130	-0.95879	2.968836
Consumer Goods	4.251691	4.204538	4.914153	3.586272	0.383509	0.237637	1.772276
Consumer Services	3.517955	3.505050	4.285975	2.800758	0.448338	0.067940	1.880455
Financials	4.267051	4.295686	4.668776	3.850437	0.235569	-0.04846	1.847809
Health Care	3.330441	3.285006	4.048723	2.643739	0.429394	0.126483	1.787180
Industrials	4.301831	4.402783	4.683453	3.749982	0.300346	-0.47165	1.792228
Technology	4.258703	4.207766	4.827828	3.525743	0.343599	-0.06008	1.879581
Telecommunications	3.575623	3.732384	4.069721	2.770734	0.372255	-0.67268	2.094404

As the data is in log terms not much information is obtained from the descriptive data. What can be observed is that over the period the Consumer services index has been the most volatile with the highest standard deviation followed by the Health Care index. Over the Period Inflation has had the least volatility.

The next section reports the results of the formal test for stationarity required to proceed with the test for cointegration.

## 5.2 Unit root tests

**Table 5.2 Stationarity Test Intercept no trend**

Null Hypothesis: Variable	ADF Unit root in series T-Stat		KPSS Stationary LM-Stat		Order Of Integration
	level	First Difference	Level	First Difference	
<b>CPI</b>	-0.354645 (0.913)	-10.25096*** (0.000)	1.79568***	0.071529	I(1)
<b>All share Index</b>	-0.967582 (-0.7646)	-14.62378*** (0.000)	1.69592***	0.089928	I(1)
<b>Basic Materials Index</b>	-2.293288 (0.1752)	-14.57088*** (0.000)	1.23858***	0.311521***	I(1)
<b>Consumer Services Index</b>	0.627926 (0.9902)	-12.87357*** (0.000)	1.71439***	0.292233***	I(1)
<b>Consumer Goods index</b>	-0.194342 (0.9357)	-15.42106*** (0.000)	1.71203***	0.098211	I(1)
<b>Health Care Index</b>	-0.679059 (0.8483)	-13.48507*** (0.000)	1.73805***	0.099208	I(1)
<b>Financials Index</b>	-0.386666 (0.9078)	-13.48443*** (0.000)	1.60093***	0.094054	I(1)
<b>Industrials Index</b>	-1.213157 (0.6689)	-13.27572*** (0.000)	1.65565***	0.144283*	I(1)
<b>Technology Index</b>	-0.969384 (0.764)	-11.77773*** (0.000)	0.98686***	0.69923***	I(1)
<b>Telecommunications Index</b>	-0.734773 (0.8343)	-14.20295*** (0.000)	1.53686***	0.216288***	I(1)
Indicate reject null	<b>Test critical values:</b>		<b>Asymptotic critical values*:</b>		
1% level ***	-4.004132	-4.004365	0.216		
5% level **	-3.432226	-3.432339	0.146		
10% level *	-3.139858	-3.139924	0.119		

The ADF and KPSS results are inconsistent; all variables are non-stationary at level terms but stationary at first difference at the 5% level of significance in the ADF test. The KPSS test, on the other hand, indicated that all the variables are non-stationary at level terms. Furthermore, the results of the KPSS show that the Basic material index, Consumer goods, Technology index and Telecommunications Index are all non-stationary at first difference at 1%.

Basing our conclusion on the results of the ADF test we conclude that the Consumer price index and the 9 common stock market indices are integrated at the same level, I(1), thus the study proceeds with the cointegration test.

The study also tests the time series using the assumption that there is a trend in the data the results for this are shown in the table below.

**Table 5.3 stationarity test intercept and trend**

	ADF		KPSS		Order Of Integration
Null Hypothesis:	Unit root in series		Stationary		
	T-Stat		LM-Stat		
Variable	level	First Difference	Level	First Difference	
<b>CPI</b>	-1.931104 (0.6345)	-10.22704*** (0.000)	0.118383	0.06759	I(1)
<b>All share Index</b>	-1.79161 (0.7054)	-14.60883*** (0.000)	0.157148**	0.062396	I(1)
<b>Basic Materials Index</b>	-1.447259 (0.8441)	-14.80973*** (0.000)	0.38182***	0.031019	I(1)
<b>Consumer Goods Index</b>	-2.042167 (0.5743)	-15.40415*** (0.000)	0.213021**	0.075596	I(1)
<b>Consumer Services Index</b>	- 3.895455** (0.0139)	-12.93406*** (0.000)	0.102376	0.151067**	I(1)
<b>Financials Index</b>	-2.010729 (0.8483)	-13.45629*** (0.000)	0.086346	0.0872	I(1)
<b>Health Care Index</b>	-1.82555 (0.6888)	-13.46023*** (0.000)	0.103847	0.096837	I(1)
<b>Industrials Index</b>	-1.498702 (0.8272)	-13.29314*** (0.000)	0.248142***	0.067273	I(1)

<b>Technology Index</b>	- 3.664154** (0.0271)	- 12.14693*** (0.000)	0.256752***	0.200013**	I(1)
<b>Telecommunications Index</b>	-1.313882 (0.8816)	- 14.17402*** (0.000)	0.245406***	0.204837**	I(1)
• Indicate reject null	<b>Test critical values:</b>		<b>Asymptotic critical values*:</b>		
1% level ***	-4.004132	-4.004365	0.216		
5% level **	-3.432226	-3.432339	0.146		
10% level *	-3.139858	-3.139924	0.119		

Similar to the test for stationarity with only an intercept the results of the test with an intercept and trend are not uniform. For the ADF test, there is evidence that the Consumer Services index and Technology index is trend stationary in level terms at a 5% level. While the KPSS shows evidence that the CPI, All Share index, Consumer Goods index, Consumer Services index, Financials index and Health Care index are trend stationary at the 1% level. As the Data generating process (DGP) of stock indices are unlikely to have a trend in them (Rapach and Wohar, 2005) we conclude that the stock indices are I(1) and proceed with the cointegration test

### 5.3 Cointegration test

Having confirmed the level of integration of the variables, 2 variable VAR models were constructed each consisting of CPI and each of the sectoral indexes to test for the optimal lag order to be used in the cointegration test. The lag lengths chosen by the AIC and SIC are displayed in the table below. The AIC and SIC provided differing results in some cases, where the results differed the study opted to use the SIC as it fits closer with the assumption that any interaction of inflation and stocks would occur quickly (Luintel and Paudyal, 2006).

**Table 5.4 Lag selection**

Index	Selection criteria	
	AIC	SC
All Share Index	2	1
Basic Materials Index	3	1
Consumer Goods index	9	2
Consumer Services Index	2	2
Financials Index	3	2
Health Care Index	2	2

Index	Selection criteria	
	AIC	SC
Industrials Index	2	2
Technology Index	9	2
Telecommunications Index	2	2

After identifying the number of lags the Johansen approach is used to determine the number of cointegrating vectors. For the test, we use Model 2 from the EViews statistical package. Model 2 assumes there is no deterministic trend in the data and includes an intercept in the cointegrating equation which fits with our assumptions of the nature of the data being used.

**Table 5.5 Cointegration Test Johansen Trace Eigen value Test**

Index	H0:Rank<
	0
<b>All Share Index</b>	52.63583 (0.0000)
<b>Basic Materials Index</b>	58.12828 (0.0001)
<b>Consumer Goods Index</b>	52.61200 (0.000)
<b>Consumer Services Index</b>	57.94887 (0.000)
<b>Financial Index</b>	55.05448 (0.0000)
<b>Health Care Index</b>	56.39414 (0.0000)
<b>Industrials Index</b>	50.75015 (0.0000)
<b>Technology Index</b>	49.44875 (0.0000)
<b>Telecommunications Index</b>	43.69963 (0.0000))

Table 5.5 above shows results of the Johansen trace test. We test the Null hypothesis that there is no cointegrating relationship. The results suggest that there is at least one cointegrating vector between each pair of variables at the 1% level of significance with p-values less than 0.01.

**Table 5.6 Cointegration Test Johansen Maximum Eigen value Test**

	H0:rank =	
	0	1
<b>All share index</b>	48.97041 (0.0000)	3.665425 (0.4642)
<b>Basic Materials Index</b>	50.98705 (0.0000)	7.141237 (0.1191)
<b>Consumer Goods Index</b>	48.25338 (0.0000)	4.358624 (0.2305)
<b>Consumer Services Index</b>	49.75869 (0.0000)	8.190183 (0.0763)
<b>Financial Index</b>	55.05448 (0.0000)	3.745889 (0.4513)
<b>Health Care Index</b>	51.90797 (0.0001)	4.486175 (0.3445)
<b>Industrials Index</b>	46.96009 (0.0000)	3.790060 (0.4443)
<b>Technology Index</b>	38.03716 (0.0000)	11.41159 (0.0184)
<b>Telecommunications Index</b>	42.19737 (0.0000)	1.502265 (0.8730)

Table 5.6 Shows maximum Eigenvalue test results, which shows consistent results with the trace stat test. All common stock index models indicate at least one cointegrating vector with the exception of the Technology index that shows at most two cointegrating vectors. Maximum Eigenvalue tests the Null hypothesis of a maximum of zero cointegrating relationships between the common stock indices and CPI. The results show a rejection of the null for each of the indices at the 5% level of certainty with p-values less than 0.05. Against the null hypothesis that there is at most one cointegrating relationship, the results show a failure to reject the null at the 5% level of significance for all the indices with the exception of the Technology index and CPI which has a p-value of 0.0184. The results also show a failure to reject the null hypothesis of at least 1 cointegrating vector at the 10% level of significance for the Consumer Services index and CPI with a p-value of 0.0763.

#### **5.4 Cointegrating regression**

Having found evidence of cointegration between CPI and each common stock index we estimate the long-run cointegrating relationship. The results are shown in table 5.7

**Table 5.7 cointegration regression**

	Variable	Coefficient	Std. Error	t-Statistic	Prob.
<b>All Share Index</b>	CPI	2.215330	0.108680	20.38396	0.0000
	C	0.353064	0.195736	1.803776	0.0728
<b>Basic Materials Index</b>	CPI	1.417052	0.192577	7.358346	0.0000
	C	1.704628	0.346838	4.914774	0.0000
<b>Consumer Goods Index</b>	CPI	3.069518	0.139065	22.07247	0.0000
	C	-1.276011	0.250461	-5.094652	0.0000
<b>Consumer Services Index</b>	CPI	3.625513	0.145915	24.84670	0.0000
	C	-2.993978	0.262798	-11.39271	0.0000
<b>Financials Index</b>	CPI	1.811517	0.118484	15.28912	0.0000
	C	1.006245	0.213393	4.715452	0.0000
<b>Health Care Index</b>	CPI	3.482751	0.126963	27.43118	0.0000
	C	-2.928166	0.228664	-12.80551	0.0000
<b>Industrials Index</b>	CPI	2.332455	0.138787	16.80605	0.0000
	C	0.103591	0.249959	0.414431	0.6790
<b>Technology Index</b>	CPI	1.861650	0.333323	5.585129	0.0000
	C	0.900711	0.600324	1.500375	0.1351
<b>Telecommunications</b>	CPI	2.778137	0.217001	12.80242	0.0000
	C	-1.423208	0.390825	-3.641549	0.0003

Cointegration estimation was conducted with CPI as the dependent variable in each equation and the respective common stock index as the independent variable. The results of the cointegration estimation show that in the period between February 2000 and December 2016

all the JSE sector indices are found to have a positive and significant relationship with CPI. The All Share Index is found to have a positive relationship with CPI. The (Fisher) coefficient  $d$  shows that a 1% change in inflation results in a 2.22% change in the all share index. These results are similar to results found by Alagidede and Panagiotidis (2010) who found that a 1% change in inflation results in a 2.264% change in the All Share index and are also consistent with the tax augmented Fisher hypothesis, which postulates that the percentage change in common stock prices is expected to be greater than 1 to compensate investors for losses due to any taxes. The results suggest that generally common stocks in South Africa are a hedge for inflation thus during the period of study investors would be fully compensated for changes in inflation. This result suggests that for a given change in inflation investors can expect the All Share index to double over the long run

Examining the various disaggregated industry indices, the Consumer service index and the Health Care index have the greatest overall reaction to a change in inflation, with a 1% change in inflation resulting in a 3.62% and 3.48% change in the index returns respectively. Furthermore, the results suggest that common stocks related to the consumer-focused industries have the greatest elasticity with respect to changes in CPI, suggesting that investors expect an increase in consumer prices to translate to increased profitability in consumer related common stocks.

The telecommunications index and the industrial index also have a strong reaction to changes in inflation that is greater than the overall market as represented by the All Share index, with a 1% change in inflation resulting in a 2.78% and 2.33% change in the index respectively. On the other hand, the Technology, industrial and financial index all have a Fisher coefficient less than that of the All Share index.

The Basic Materials service index has the smallest overall reaction to changes in inflation, with a 1% change in inflation resulting in a 1.41 % change in returns. These results are consistent with Luintel and Paudyal (2006) study that found that for the UK the Consumer Goods sector common stocks offered the best hedge against inflation while Basic Material was the only index to actually have no long-run relationship with inflation. The low reaction could be attributed to other external factors such as international materials prices having a strong effect on the value and profits of common stocks in the Basic Materials indices, such firms that are highly correlated with international variables will be less affected by domestic price changes. It's noted that these results are in contradiction with the results of Ang *et al.* (2012) who when

testing individual stock inflation betas of stocks on the NYSE found that the highest betas were from stocks in the Basic Materials sector. Ang *et al.* (2012) also found when testing the S&P industry indices that the Basic Materials index was the only industry to have a positive beta with inflation. It can be argued that the reasons for the contradiction are related to the fact that Ang *et al.* (2012) examined the short-term relationship, whereas this study along with the UK study (Luintel and Paudyal, 2006) above focused on the long-term relationship. This suggests that common stocks in the Basic Materials industry may have a comparatively stronger reaction with inflation in the short run but over the long run the effects of inflation are smaller when compared to the other industries. In this study, the short run relationship will further be explored in the next section using the VECM impulse response.

Overall the evidence from the long run cointegration regression suggests that in times of high inflation investors are most compensated for changes in inflation in common stocks relating to the Consumer Services and Consumer Goods sectors, but that in general, all sectors of the JSE provide some hedge for inflation. The varying coefficients also provide evidence of the heterogeneity. That is investors are compensated for changes in inflation if they invest in specific industries rather than in the All Share index

To further examine the relationship between common stocks and CPI the next section will examine the VECM constructed from the data.

## **5.5 Vector Error correction model**

### **5.5.1 Exogeneity test**

One concern of the VECM is that it requires normalizing on the truly endogenous variable. In order to find the endogenous variable, a weak exogeneity test was performed on each common stock index with CPI. The results for the test are shown in the table below. As the focus is to determine if CPI has an effect on common stocks, in the long run, the main concern is whether common stock markets are endogenous in order to normalize on them.

**Table 5.8 Weak exogeneity Test**

Model	Price Index	CPI
All share	7.390361 (0.0604)	0.478701 (0.9235)
Basic Materials	2.233812 (0.3273)	7.431039 (0.0243)
Consumer Goods	1.228564 (0.541)	3.793326 (0.1501)
Consumer Services	3.01207 (0.2218)	3.983754 (0.1364)
Financials	5.842991 (0.0539)	9.848899 (0.0073)
Health Care	2.389028 (0.3029)	3.982563 (0.1365)
industrials	1.847635 (0.397)	3.591895 (0.166)
Technology	43.21885 (0.0000)	17.20558 (0.0456)
Telecommunications	1.582991 (0.4532)	4.820491 (0.0898)

The results show that for all the models with the exception of the Technology Index model the common stock indices are weakly exogenous at the 5% level of significance with p-values greater than 0.05. This result implies that the indices are not dependent on changes in CPI. The Technology index model shows evidence of being endogenous at the 1% level of significance. The Financials index and All Share show evidence of being endogenous at only the 10% level of significance.

Concerning the CPI several of the models show evidence that CPI is endogenous. The Basic Materials, Financials and Technology models show evidence that CPI is endogenous at the 5% level of significance with p-values less than 0.05 implying that the indices cause changes in CPI.

Thus, from the above test, the evidence suggests that the Fisher hypothesis only holds for the Technology index, since it is the only index found to be endogenous, implying it is the only common stock index that has movements caused by CPI. Despite the results of the exogeneity test we provide VECM cointegrating regressions normalized on all the common stock indices

The VECM is constructed using the same assumptions that are used in the Johannes cointegration test. Thus, in the VECM the assumption of an intercept and no trend in the data is used, and one cointegrating vector is assumed. The same lag structure used in the cointegration test is also used for the VECM. The VECM has both long run and short results

but as the long run estimates have already been discussed in the prior section of this study, the main purpose of analysing the VECM at this point in the study is to examine the short-term reactions of the common stock indices through examining the variance decomposition and impulse response. From the VECM the following long-run equations were derived shown in table 5.9.

**Table 5.9 VECM cointegration regression**

	<b>Variable</b>	<b>Coefficient</b>	<b>Std. Error</b>	<b>t-Statistic</b>
<b>All Share Index</b>	CPI	2.4149	0.231	[10.4165]
	C	-0.3576	-0.42203	[- 0.84741]
	Speed of Adjustment	0.012436	(0.00796)	[ 3.06031]
<b>Basic Materials Index</b>	CPI	1.42619	0.79492	[1.79414]
	C	0.73386	1.44053	[0.50943]
	Speed of Adjustment	0.00408	-0.0035	[ 1.15310]
<b>Consumer Goods Index</b>	CPI	3.06997	0.33366	[9.20098]
	C	-1.7748	0.60399	[- 2.93850]
	Speed of Adjustment	0.0092	-0.0035	[ 1.15310]
<b>Consumer services Index</b>	CPI	4.85438	1.97183	[2.46187]
	C	-2.1807	3.54957	[- 0.61435]
	Speed of Adjustment	-0.0033	-0.001	[-3.13361]
<b>Financials Index</b>	CPI	1.86779	0.43758	[4.26840]
	C	0.25376	0.79222	[0.32032]
	Speed of Adjustment	0.00835	-0.0037	[ 2.24122]

	<b>Variable</b>	<b>Coefficient</b>	<b>Std. Error</b>	<b>t-Statistic</b>
<b>Health Care Index</b>	CPI	3.79571	0.6442	[5.89216]
	C	-4.5022	1.16907	[-3.85108]
	Speed of Adjustment	0.00871	-0.0029	[3.03867]
<b>Industrials Index</b>	CPI	2.68843	0.46729	[5.75323]
	C	-1.1947	0.84913	[-1.40702]
	Speed of Adjustment	0.0064	-0.0029	[3.03867]
<b>Technology Index</b>	CPI	3.64504	0.46412	[7.85362]
	C	-1.8852	0.81378	[-2.31665]
	Speed of Adjustment	-0.0576	-0.0109	[-5.30318]
<b>Telecommunications</b>	CPI	3.22775	1.10665	[2.91669]
	C	-3.6792	2.00536	[-1.83468]
	Speed of Adjustment	0.00433	-0.0027	[1.59895]

The long-run equations derived from the VECM model are very similar to the results from the cointegrating equation with the only notable exception being the Consumer Services index and the Technology index. Both the Consumer Services index and the Technology index, VECM long-run regressions show a greater reaction to changes in inflation. The Technology index shows a 3.65% change in the VECM as compared to the 1.86% change in the standard cointegrating regression in response to a 1% change in inflation. The Consumer Services index also has a greater reaction with a 1% change in inflation resulting in 4.85% change in the VECM as compared to a 3.62% change in the cointegration regression.

The VECM also provides the speed of adjustment of common stocks to changes in CPI. In examining the speed of adjustment figure, we find that it is positive for most of the indices. For validity, the speeds of adjustment coefficients are required to be negative and significant. The speed of adjustment coefficient is found to be negative and significant only in the case of the Consumer Services and the Technology index thus we can conclude that there is a significant short-run relationship between these two indices and CPI. The speed of adjustment to the long run equilibrium for the Consumer Services index takes a substantially long time with only a 0.3% correction to the long run each month. While the Speed of adjustment for the technology index is much faster with 5% correction each month. The fast adjustment fits with evidence by Ang *et al.* (2012) who suggested that Technology common stocks are the fastest to adjust their pricing structure in reaction to changes in inflation. The results from the VECM strengthen the evidence that in the long-run the Fisher hypothesis holds but in the short run for the majority of the indices there is no significant relationship. The next section, reports the results of the impulse response.

### **5.5.1 Impulse response**

The graphical impulse response functions are provided in the appendix A. The majority of the indices report impulse response showing a negative reaction to a shock in CPI in the short run.

The impulse response shows that the All Share index has a negative response to a shock in the CPI. While the CPI initially reacts negatively to a shock in the All Share index, this reaction becomes positive after 4 months. Unlike the All Share index the Basic materials index demonstrates a positive reaction to a shock in the CPI. This positive reaction continues to expand as time goes but remains relatively small, this fits with Ang *et al.* (2012) research that found only the Basic materials has a positive response to changes in inflation in the short run. The Consumer Goods index demonstrates a small positive reaction to a shock in inflation, which slowly becomes negative in the 7<sup>th</sup> period. On the other hand, the Consumer Services index demonstrates an initial negative response to a shock in inflation that continues to decline over time. The Financials Index shows that in the 2<sup>nd</sup> period, there is a positive response to a shock in the CPI, but this response becomes negative in the 3<sup>rd</sup> period and continues to decline. The Health Care index shows a negative response to a shock in the CPI the shock is initially neutral in the first period but becomes negative and continues to decline over the period. The Industrials index is neutral in the 1<sup>st</sup> period and becomes positive in the 2<sup>nd</sup> period. During the rest of the periods, the reaction is neutral. The Technology index shows a largely negative

reaction to a shock in CPI that continues to decline throughout the period observed. The telecommunications index has a gradual negative reaction to a shock in the CPI.

### 5.5.2 Variance decomposition

**Table 5.10 All Share Variance Decomposition**

Variance Decomposition of ALL_SHARE:			
Period	S.E.	ALL_SHARE	CPI
1	0.020809	100.0000	0.000000
2	0.028602	99.99995	4.90E-05
3	0.035247	99.85394	0.146062
4	0.041844	98.44830	1.551699
5	0.047803	97.29921	2.700787
6	0.053291	96.36292	3.637081
7	0.058473	95.58427	4.415734
8	0.063354	94.96401	5.035990
9	0.067989	94.46183	5.538165
10	0.072426	94.04292	5.957082

Variance Decomposition of CPI:			
Period	S.E.	ALL_SHARE	CPI
1	0.001850	1.469369	98.53063
2	0.002933	1.313178	98.68682
3	0.003789	0.906803	99.09320
4	0.004514	0.668043	99.33196
5	0.005131	0.520260	99.47974
6	0.005663	0.496275	99.50373
7	0.006132	0.614695	99.38530
8	0.006553	0.895856	99.10414
9	0.006934	1.355931	98.64407
10	0.007285	2.005226	97.99477

The Variance decomposition shows how much variance in the dependent variable is attributed to shocks in the other variable. Table 5.10 above shows the variance decomposition for the All Share Index, the table shows that 100% of the variance originates from its own shocks in the first period and 0% from CPI. By the 10<sup>th</sup> period, the variance is only 5.95%.

The remaining variance decomposition table is provided in Appendix B. The Variance decomposition tables show that the common stock indices, with the exception of the technology index, have a very small reaction to shocks in the CPI. The variance decomposition of each of the common stock indices in the 1<sup>st</sup> period shows a 0% variance due to shocks in the CPI with 100% of the variance originating from its own shocks. Over time the variance slowly increases but still remains small with the variance in the common stock indices in the 10<sup>th</sup> period

originating from CPI shocks ranging from 0.04% and 2.51% with the exception of the technology index which demonstrates that 35% of the variance in the 10<sup>th</sup> periods is from shocks in CPI. As stated the high reaction is consistent with evidence from Ang *et al.* (2012) and the weak exogeneity test that shows that CPI has an effect on the technology index.

Examining the variance decomposition of CPI to the shocks of the various common stock indices we observe that an amount of variance in the CPI can be attributed to shocks in the common stocks. We observe that in the 10<sup>th</sup> period 11% of the variance in CPI is attributed to a shock in the Basic Materials index. The Consumer Goods index is also shown to cause significant variance in CPI particularly in the 2<sup>nd</sup> period when 8% of the variance in CPI is from shocks in the Consumer Goods index. The Consumer services index cause 11% of the variance in CPI in the 10<sup>th</sup> Period.

The evidence from the variance decomposition table shows that the various common stock indices have a very small reaction to short-term shocks in the CPI but on the other hand, the variance in CPI can be explained through shocks in the various indices.

## **5.6 Diagnostics**

For each of the models, 2 diagnostics test were conducted the serial correlation test and the normality test. The results of the diagnostics test are shown in the following sections.

### **5.6.1 Cointegrating regression**

#### **5.6.1.1 Serial correlation**

Appendix C shows correlograms of the various the Cointegration regression between the common stock Indices and CPI. All the correlograms show strong evidence of autocorrelation between the lagged residuals. The consequence of serial correlation is that the t stats from the regression are not accurate thus cannot be used to assess the model.

#### **5.6.1.2 Normality**

The table below shows the results of the normality test of the cointegrating regression between each of the indices and CPI.

**Table 5.11 JB normality Test cointegration regression**

	Jarque-Bera	Prob.
All share	11.89986	0.002606
Basic Materials	1.200808	0.54859
Consumer Goods	6.400558	0.040751
Consumer Services	1.724804	0.422147
Financials	2.387966	0.303012
Health Care	3.653856	0.160907
industrials	19.77562	0.000051
Technology	71.29204	0.00000
Telecommunications	13.54104	0.001147

using the Jarque-Bera test stat and a null that that residuals are multivariate normal the results show that 5 of the 9 models residuals are not normally distributed, these Models are the All Share, Consumer Goods, Industrials, Technology, Telecommunications regressions with CPI. The remaining four models show evidence that the model's residuals are normally distributed. What this means for the models found to be non-normally is that the F-test and t-tests of the coefficient might not be valid, but it has been argued that for cointegration results having non-normally distributed residuals may not pose a serious threat (Islam and Ahmed, 1999).

The diagnostics test for the Cointegration regression shows both evidence of autocorrelation and non-normally distributed residuals, this indicates that the model's t-test for the coefficients may not be valid and thus the estimations may not be appropriate for making inferences or forecasts from them.

## **5.6.2 VECM**

### **5.6.2.1 Serial correlation**

The LM stat tables are shown in Appendix D. The LM test has the null that there is no serial correlation. The p-values of the various models from the LM test shows that there is no evidence of serial correlation in the majority of the lag periods, with LM stats having p-values greater than 0.05 in each of the models, thus we fail to reject the null of no serial correlation.

### 5.6.2.2 Normality

**Table 5.12 JB normality Test VECM**

	Jarque-Bera	Prob.
All share	23.49795	0.0001
Basic Materials	24.01708	0.0001
Consumer Goods	48.85887	0
Consumer Services	16.96229	0.002
Financials	18.73423	0.0009
Health Care	18.7426	0.0009
industrials	27.35533	0
Technology	63.09364	0
Telecommunications	28.7869	0

Using the Jarque-Bera test stat and a null that residuals are multivariate normal the results show that none of the models' residuals are normally distributed at 1% level of significance with p-values less than 0.01 for each of the indices models. What this means for the models found to be non-normally is that the F-test and t-tests of the coefficient might not be valid, but it has been argued that for cointegration results having non-normally distributed residuals may not pose a serious threat (Islam and Ahmed, 1999)

### 5.7 Conclusion

In this chapter, we provided the results and findings for the test of the Fisher hypothesis using the Johansson cointegration test on sector common stock market indices of the JSE. Using Sector indices and the CPI data for the period February 2000 to December 2016 we find that all the pairs of common stock indexes and CPI are cointegrated thus implying a long run relationship between them.

The long-run cointegration regression and the VECM show that all common stock indexes have a positive relationship with inflation implying they would be able to hedge inflation. All the indices have Fisher coefficients greater than 1 implying the tax Augmented Fisher hypothesis holds in the long run for the various sectors of the economy. The cointegration regression also shows that indices relating to consumer industries had the highest reaction to changes in the CPI. This demonstrates the heterogeneity of the hedging ability of common stocks, with Consumer related industries demonstrating the best hedge for inflation.

From the VECM this study was also able to examine the short-run relationship between common stocks and inflation through examining the speed of adjustment, impulse response and variance decomposition. Examining the speed of adjustment coefficient, only the Technology index and the Consumer Services index showed evidence of short-run adjustment to the long run equilibrium with the Consumer Services showing 0.3% correction every month and the technology index showing 5% correction every month. The impulse response results also provided further evidence of the heterogeneity of the common stock inflation relationship with the short run response of the common stock indices to inflation shocks varying from positive to negative, while the Variance decomposition showed that with exception of the technology index very little variance in the common stock indices is as a result of shocks in inflation.

Overall the evidence suggests that there is protection from inflation by common stocks in the long run and the relationship is heterogeneous amongst industries, however, the results of the diagnostics test on the long run cointegration regression suggest that caution should be taken in producing conclusions from the regression as serial correlation was found in the lags.

# CHAPTER 6

## 6.0 Summary of the Study and Conclusion

This study analysed the relationship between inflation and common stock prices in South Africa. Chapter 1 contained the outline of the study providing the background literature and setting out the goals and methods to be used in the study. The goals of the research were to analyse the Fisher hypothesis for the various industry common stocks in South Africa to establish if common stocks in South Africa provide a hedge for inflation and if this relationship was heterogeneous across the various industries on the JSE.

The first step in the study was to examine the theoretical and empirical literature behind the relationship between stocks and inflation and this was done in chapter 2. The chapter began by discussing the Fisher hypothesis, the main theory underpinning the relationship between stocks and inflation. The Fisher hypothesis postulates that stocks should be a good hedge for inflation and that the relationship is positive. Within the discussion of the Fisher hypothesis the theories in opposition to the Fisher hypothesis were discussed, highlighting the proxy hypothesis, the tax effect hypothesis and the inflation hypothesis that postulates the stock and inflation relationship is negative and thus is not a good hedge for inflation. The Fisher hypothesis discussion also included evidence on the empirical literature addressing some of the findings and problems faced when testing the Fisher hypothesis.

Chapter 2 also discussed the literature relating to the heterogeneity of stocks. The literature suggested that stocks in different industries hedge inflation with varying degrees. The Chapter ended with a summary of the empirical literature regarding the relationship of stocks and inflation in developing nations and more specifically in South Africa. The literature showed that there was no consensus on the nature of the relationship between stocks and inflation. While most studies show that there is a significant relationship between stocks and inflation, whether that relationship is positive or negative seems to differ between economies and also is dependent on the inflation regime at the time of the study. Most studies suggest that stocks were a better hedge in times of low inflation and the hedging ability was reduced as inflation rose.

Having examined the empirical and theoretical literature, chapter 3 provided a brief historical graphical analysis of inflation and common stock prices in South Africa. Chapter 3 included

an analysis of the performance of each of the sub-indexes of the JSE used in the study. This analysis was used to help in determining the expected *a priori* relationship between common stocks and inflation. The conclusion drawn from the analysis is that although the relationship can't easily be observed graphically correlation test showed all the common stock indices with exception of the Basic Materials index where highly positively correlated with inflation. The *a priori* expectations drawn from the analysis is that common stocks and inflation move together and common stocks grow at a faster rate than inflation implying that common stocks in South Africa are likely to hedge inflation during the period of study.

Having given the preliminary findings, chapter 4 went on to outline the empirical methods to be used. In order to test the Fisher hypothesis, this study made use of cointegration testing specifically the Johansson cointegration methodology. The methodology requires each of the variables be integrated to the order I(1) so the first step outlined is stationarity testing using the ADF and KPSS tests. The next step involved finding the appropriate lag order for the VAR used to test for cointegration. Once the appropriate lag order is determined the Cointegration test is then performed to identify the number of cointegration vectors present in each model. If at least one cointegrating vector is found, then it can be concluded that a long run relationship exists between the common stock price and inflation. Once the cointegration test was conducted then a long run cointegration regression and VECM were estimated to establish if the possible relationship was positive or negative. The final step outlined was the running of diagnostics test on the models used, as well as outlining the data to be used.

Chapter 5 provided the results of the study. All the 9 indices and the CPI were found to be integrated at order I (1) thus we went forward to test for cointegration between CPI and each of the indices. The cointegration test showed that all the common stock indices were cointegrated with CPI suggesting a long run relationship, thus the cointegration regression and the VECM were then run.

The results of the cointegration estimation show that in the period between February 2000 and December 2016 all the JSE sector indices examined are found to have a positive and significant relationship with CPI, with varying Fisher coefficients all consistent with the tax augmented Fisher hypothesis. Having varying Fisher coefficients for the various disaggregated industry indices (models) provides support of the heterogeneity of common stocks as an inflation hedge. The results show that different common stocks, grouped by industry, provide greater protection against inflation than the overall market as represented by the All Share Index. The Consumer

Services, Consumer Goods, Health Care, Telecommunications and Industrials index all demonstrate Fisher coefficients greater than the All Share index. These results suggest that the above mentioned indices would perform better than the overall market in times of higher inflation. On the other hand, the Technology, Industrial, Financial and Basic Materials Index all have Fisher coefficients less than that of the All Share index, suggesting in times of high inflation these common stocks should be switched out for the other indices in the investors' portfolios.

From the indices examined the Consumer Service index, Consumer Good index and the Health Care index have the greatest overall reaction to changes in inflation. Having the Consumer Services and Consumer Goods react so highly to CPI suggest that common stocks related to consumer-focused industries have the greatest elasticity with respect to changes in CPI, suggesting that investors expect an increase in consumer prices to translate to increased profitability in consumer related common stocks.

The results are consistent with Luintel and Paudyal (2006) study that found that for the UK the Consumer Goods sector stocks offered the best hedge against inflation while Basic Material was the only index to actually have no long-run relationship with inflation. The low reaction could be attributed to other external factors such as international materials prices having a strong effect on the value and profits of common stocks in the Basic Materials indices, and thus such firms that are highly correlated with international variables will be less affected by domestic price changes. It is also noted that these results are in contradiction with the results of Ang *et al.* (2012) who when testing individual stock inflation betas of stocks on the NYSE found that the highest betas were from stocks in the Basic Materials sector. Ang *et al.* (2012) also found when testing the S&P industry indices that the Basic Materials index was the only industry to have a positive beta with inflation. It can be argued that the reasons for the contradiction are related to the fact that Ang *et al.* (2012) examined the short-term relationship, whereas this study along with the Luintel and Paudyal, (2006) study focused on the long-term relationship. This suggests that common stocks in the Basic Materials industry may have a comparatively stronger reaction with inflation in the short run but over the long run the effects of inflation are smaller when compared to the other industries.

Overall the evidence from the long run cointegration regression suggests that in times of high inflation investors are most compensated for changes in inflation in common stocks relating to the Consumer Services and Health Care indices but that in general, all sectors of the JSE

provide some hedge for inflation. The evidence suggests that if investors diversify their portfolios with common stocks from various industries rather than holding the All Share Index they will have a greater hedging performance in times of inflation.

After estimating the long run cointegration regression the VECM was estimated and analysed. The analysis began with a weak exogeneity test on each of the models to determine if the common stock indices were truly endogenous. The results of the weak exogeneity test revealed that only the Technology Index model had the common stock index as the endogenous variable. This suggested that only movements in the Technology Index were caused by changes in CPI. This implies that the Fisher hypothesis only truly holds in the long run for the Technology Index for South Africa. Finding only one common stock index to meet the assumptions of the Fisher hypothesis also further provides evidence that the Fisher hypothesis is indeed heterogeneous across industries.

The weak exogeneity test also revealed that in the Basic Materials, Financials and Technology models, CPI was the endogenous variable. CPI being the endogenous variable suggests that the Basic Materials, Financials and Technology indices can be used to predict inflation. Notably, while Eita (2012) found that the causality was bi-directional between the All Share index and inflation, this study finds that there is no causation between the All Share index and CPI. Despite the results of the weak exogeneity test the VECM models were still estimated normalizing on the respective common stock index.

The Fisher coefficients derived from the VECM model were very similar to those found in the long run cointegrating equation with the only notable exception being the Consumer Services Index and the Technology Index. Both the Consumer Services index's and the Technology Index's VECM long-run regression show a greater reaction to changes in inflation with the technology index having a 3.65% change in the VECM as compared to the 1.86% change in the standard cointegrating regression to a 1% change in inflation. The Consumer Services index also has a greater reaction with a 1% change in inflation resulting in 4.85% change in the VECM as compared to a 3.62% change in the cointegration regression. The results from the VECM regression help reinforce the hedging ability of common stocks and the heterogeneity of common stocks, with the Consumer Services Index showing the greatest hedging ability.

The VECM also allowed us to examine the short-term relationship between common stocks and inflation through examination of the speed of adjustment coefficient, impulse response and variance decomposition. The speed of adjustment coefficients showed only the Technology

index showed evidence of short-run adjustments to the long run. The impulse response analysis showed that the short-term response of common stocks to shocks in inflation varies between positive and negative amongst different industries. The All Share, Consumer Goods, Health Care, Technology and Telecommunications indices all have an initial negative response to inflation shocks. These results are in line with other studies that found that stocks react negatively to inflation shocks in the short run (Diaz and Jareno, 2009; Anari and Kolari, 2001). On the other hand, the Basic Materials, Consumer Goods, Industrials and Financials indices all show a positive reaction to shocks in inflation, further illustrating the heterogeneity of the relationship between common stocks and inflation. The variance decomposition then showed that for all the indices with the exception of the Technology Index, showed little variance as a result of shocks in inflation over a 10 month period.

Having used two regression techniques the final conclusion is that there is strong evidence of the Fisher hypothesis for the Technology Index, but for the rest of the indices, although having positive Fisher coefficients in the cointegrating regressions and the VECM, the results of the weak exogeneity test cast doubt on the exact nature of the relationship between common stocks and inflation. Although there is doubt with regards to the formal test results of the Fisher hypothesis in South Africa, the results outlined in chapter 5 suggest that common stocks provide some protection against inflation while the chapter 3 analysis also demonstrated how the rate at which common stocks grow is faster than the rate of inflation. This evidence shows that at least during the period of study stocks provided good protection from inflation in South Africa.

## **6.2 Areas of future study**

A possible area to expand the study could be to test the relationship between stocks and inflation using other proxies for inflation. For this study, the proxy used for inflation was the consumer price index of South Africa, while this is viewed as a suitable proxy, other proxies such as the producer price index PPI could be used to more fully examine the relationship and rising prices in South Africa.

Also to further expand the study other methodologies could be used. Apart from cointegration testing, some modern studies have used ADRL testing. Unlike cointegration testing, ADRL does not require that both time series being tested have the same order of integration, so it is argued that the relationship can be better tested (Shah *et al.*, 2012).

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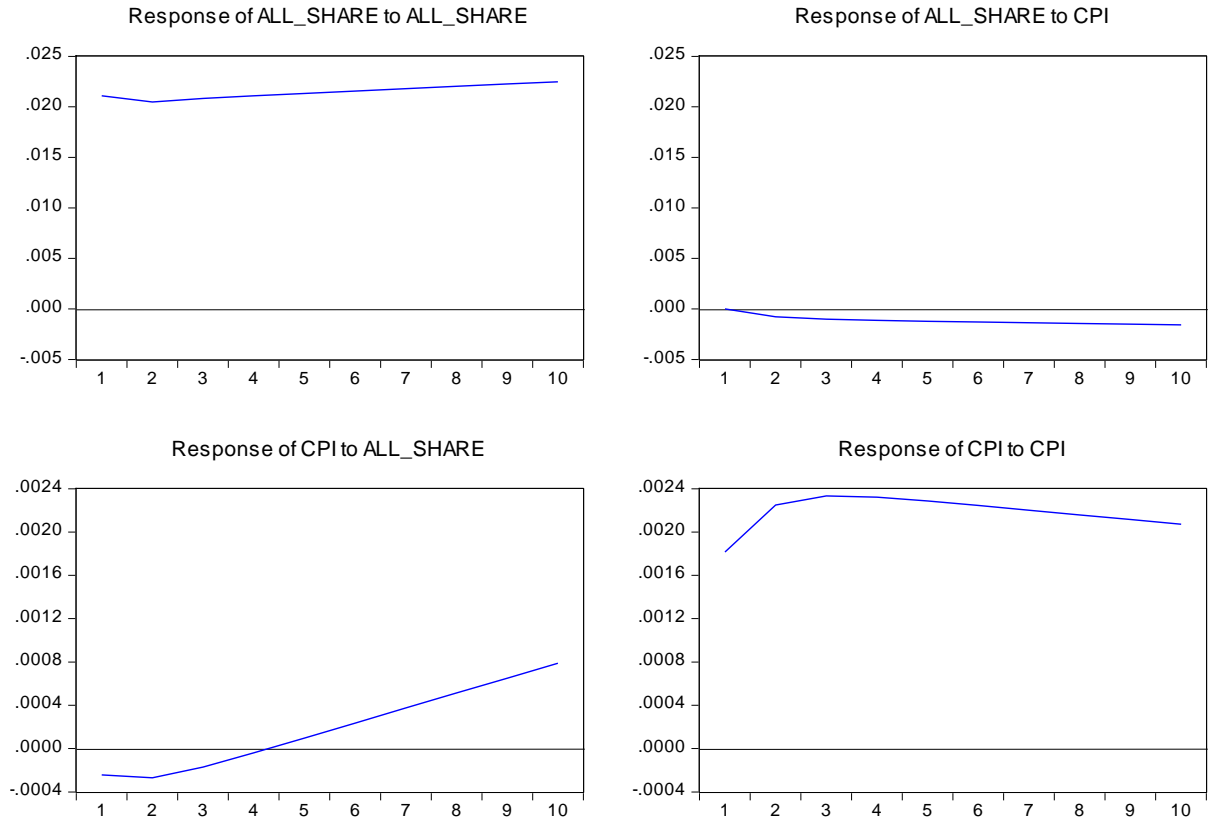
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# Appendix

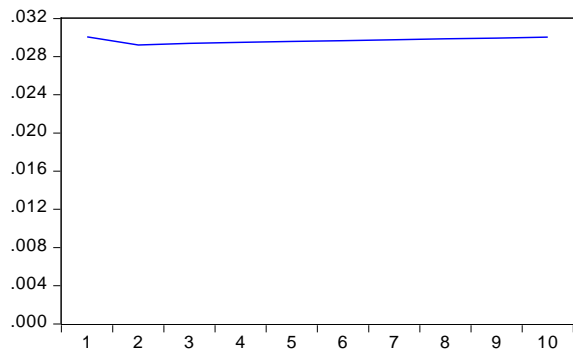
## Appendix A. Impulse response Graphs

Response to Cholesky One S.D. Innovations

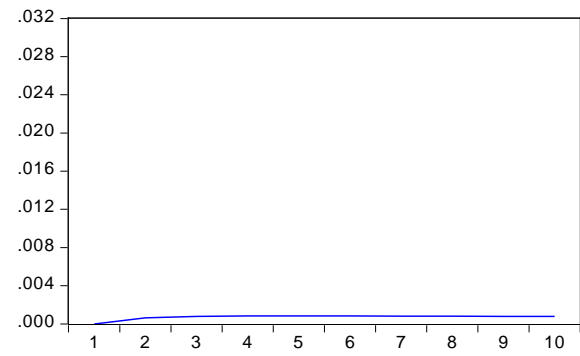


### Response to Cholesky One S.D. Innovations

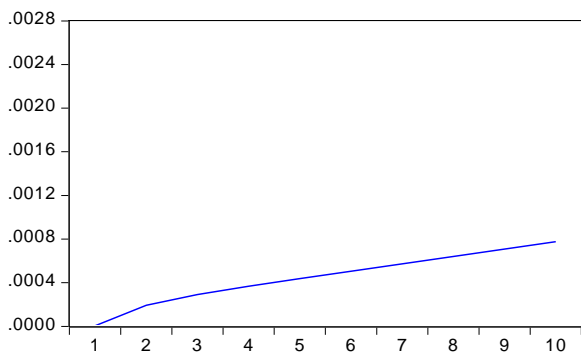
Response of BASIC\_MATERIALS to BASIC\_MATERIALS



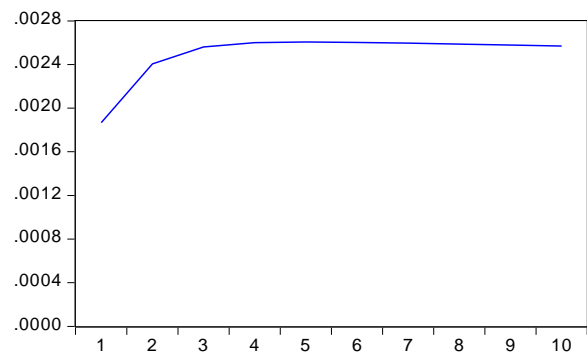
Response of BASIC\_MATERIALS to CPI



Response of CPI to BASIC\_MATERIALS

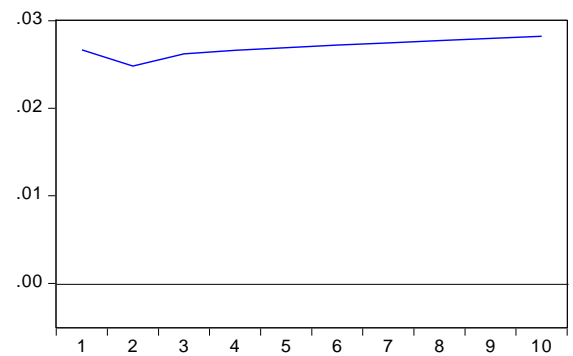


Response of CPI to CPI

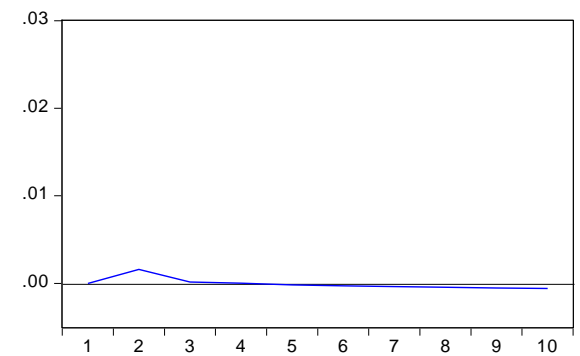


### Response to Cholesky One S.D. Innovations

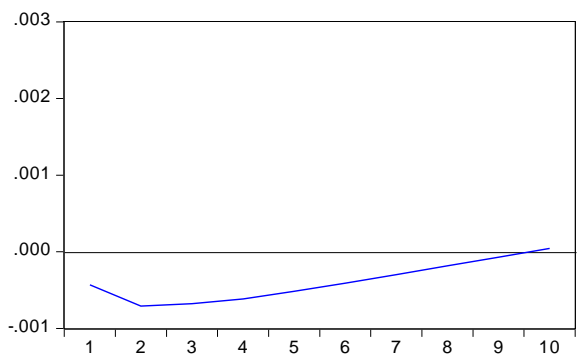
Response of CONSUMER\_GOODS to CONSUMER\_GOODS



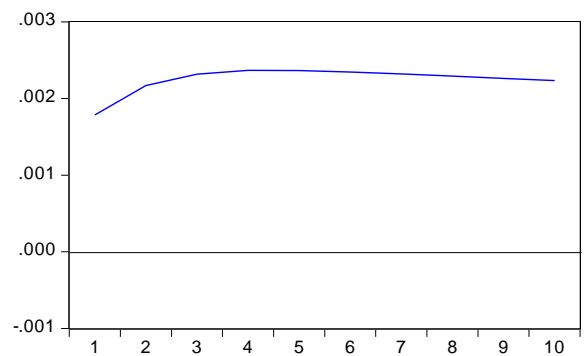
Response of CONSUMER\_GOODS to CPI



Response of CPI to CONSUMER\_GOODS

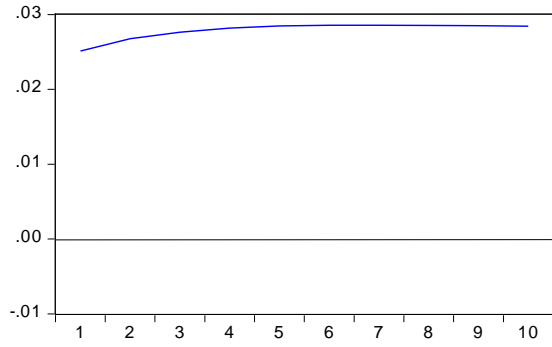


Response of CPI to CPI

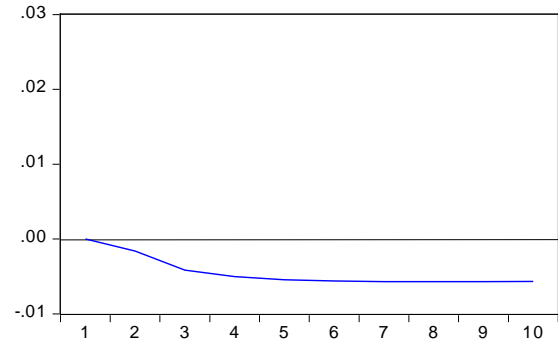


### Response to Cholesky One S.D. Innovations

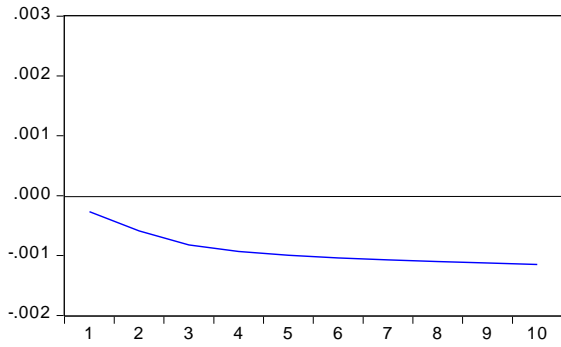
Response of CONSUMER\_SERVICES to CONSUMER\_SERVICES



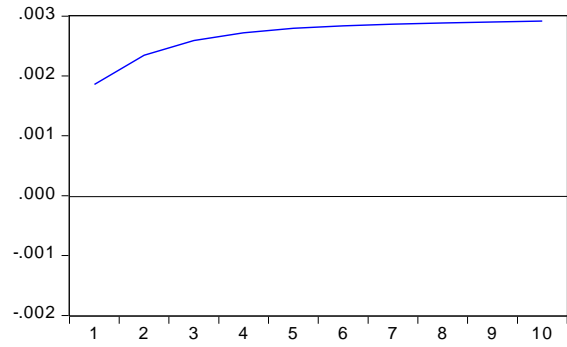
Response of CONSUMER\_SERVICES to CPI



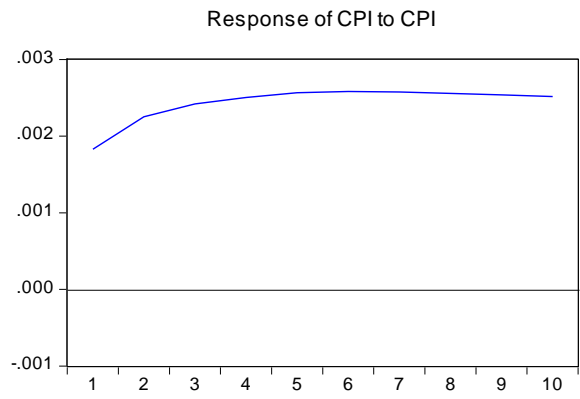
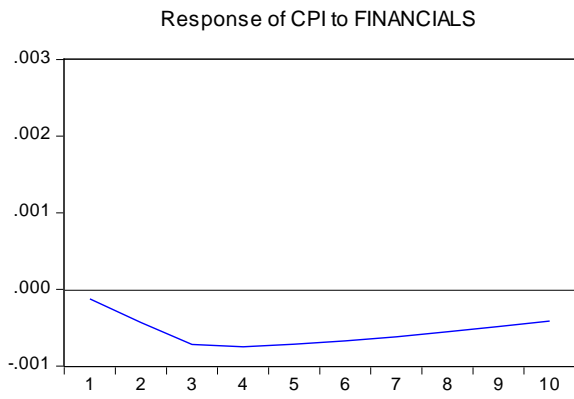
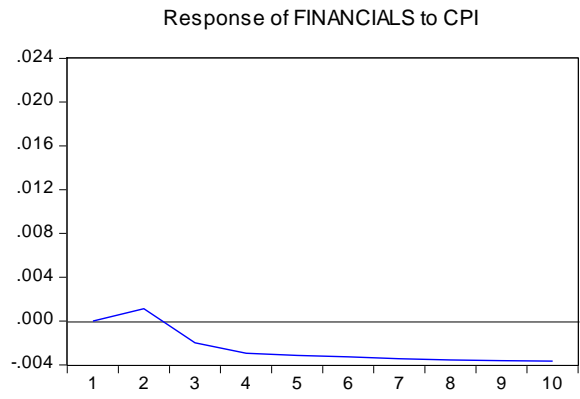
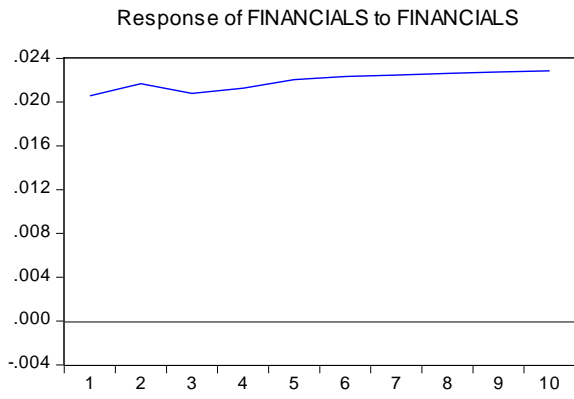
Response of CPI to CONSUMER\_SERVICES



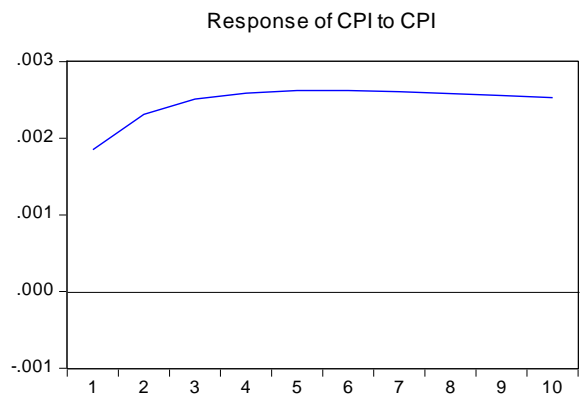
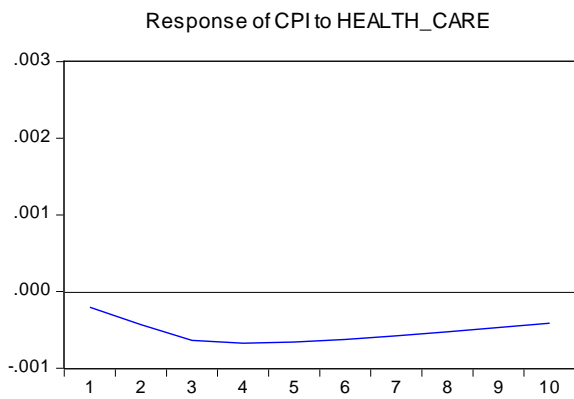
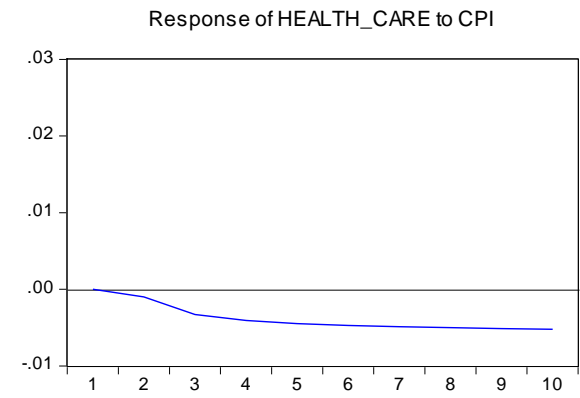
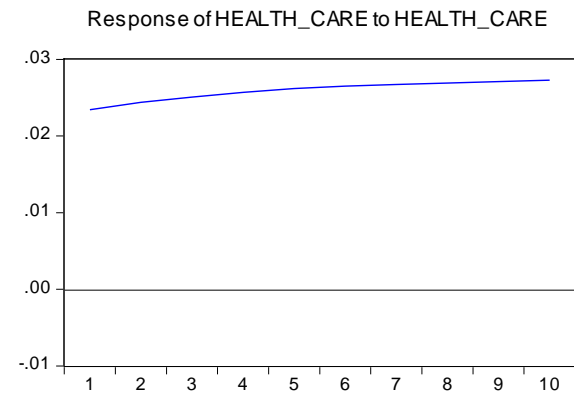
Response of CPI to CPI



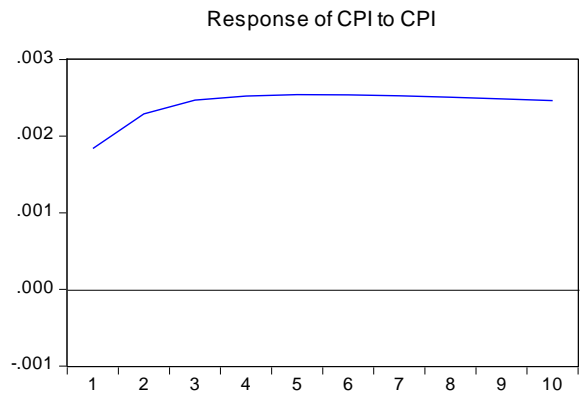
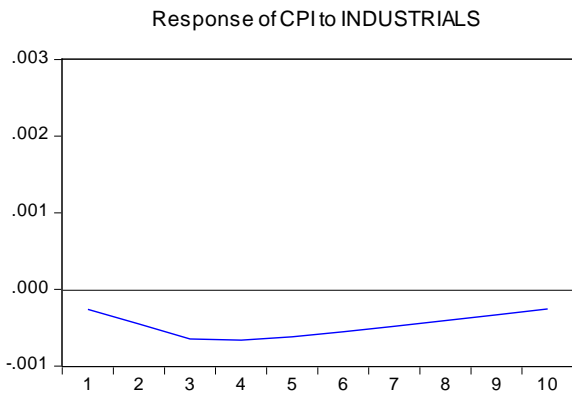
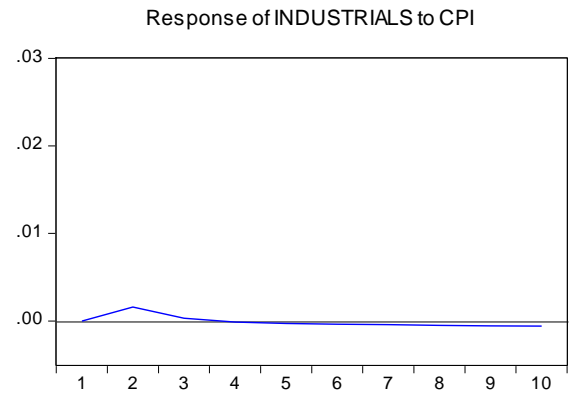
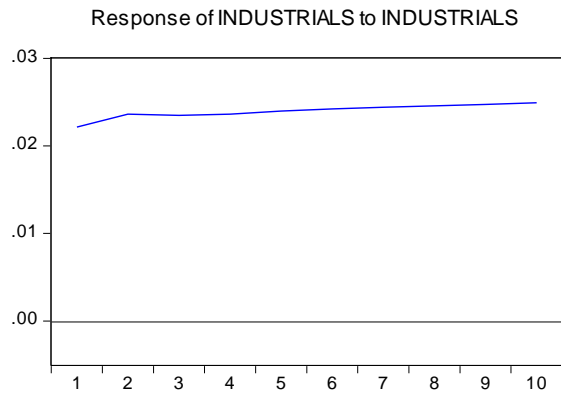
Response to Cholesky One S.D. Innovations



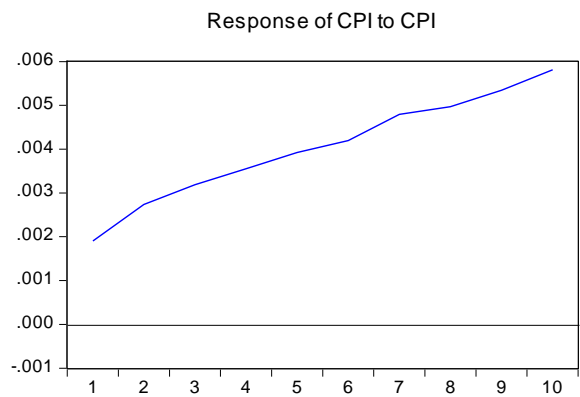
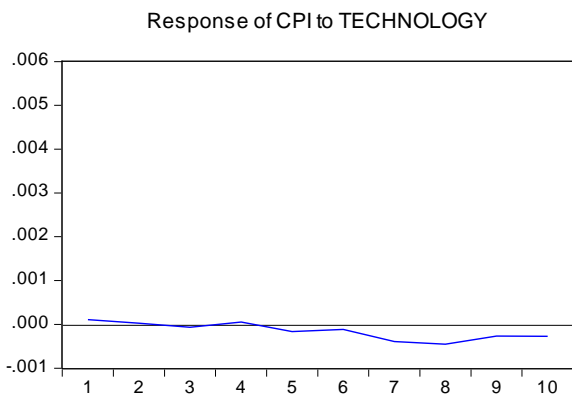
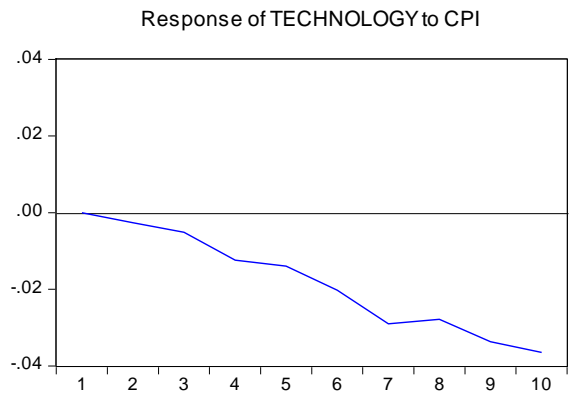
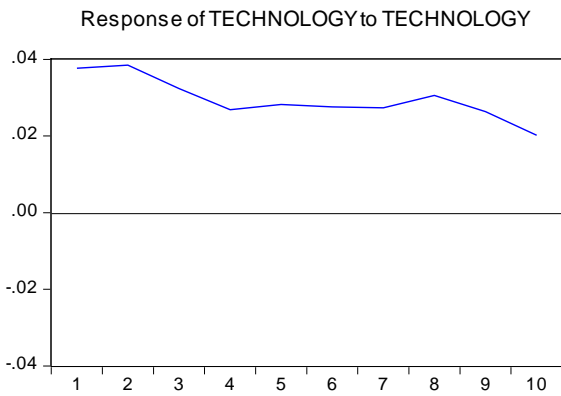
Response to Cholesky One S.D. Innovations



Response to Cholesky One S.D. Innovations

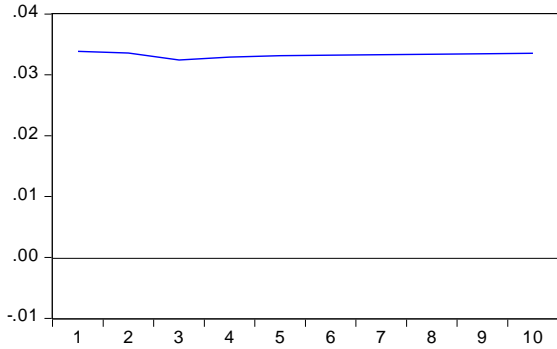


Response to Cholesky One S.D. Innovations

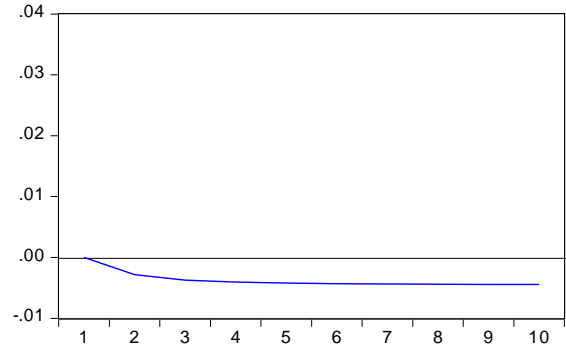


### Response to Cholesky One S.D. Innovations

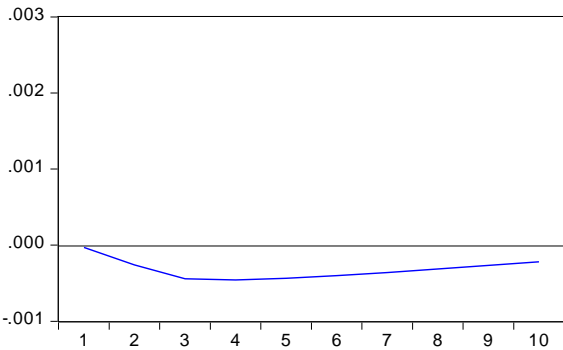
Response of TELECOMMUNICATIONS to TELECOMMUNICATIONS



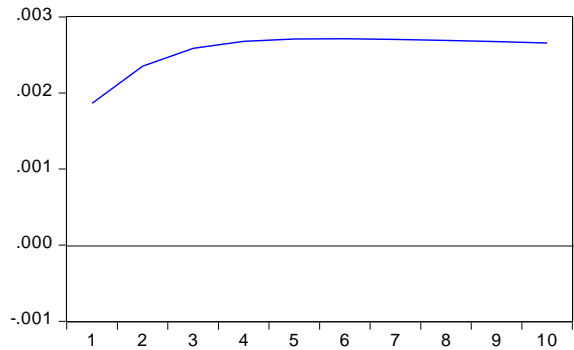
Response of TELECOMMUNICATIONS to CPI



Response of CPI to TELECOMMUNICATIONS



Response of CPI to CPI



## Appendix B Variance decomposition

Period	Variance Decomposition of ALL_SHARE:		
	S.E.	ALL_SHARE	CPI
1	0.020984	100.0000	0.000000
2	0.029194	99.99997	2.73E-05
3	0.036215	99.60240	0.397600
4	0.042300	99.26986	0.730139
5	0.047748	98.99825	1.001746
6	0.052752	98.78789	1.212115
7	0.057421	98.62195	1.378048
8	0.061830	98.48615	1.513852
9	0.066031	98.37123	1.628766
10	0.070063	98.27112	1.728879

Period	Variance Decomposition of CPI:		
	S.E.	ALL_SHARE	CPI
1	0.001835	1.466549	98.53345
2	0.002900	1.287254	98.71275
3	0.003745	0.866587	99.13341
4	0.004439	0.617088	99.38291
5	0.005025	0.558350	99.44165
6	0.005534	0.701785	99.29822
7	0.005989	1.056183	98.94382
8	0.006402	1.628492	98.37151
9	0.006785	2.423149	97.57685
10	0.007146	3.441833	96.55817

Variance Decomposition of BASIC_MATERIALS:			
Period	S.E.	BASIC_MATERIALS	CPI
1	0.029660	100.0000	0.000000
2	0.040994	99.91617	0.083834
3	0.052677	99.91842	0.081576
4	0.063050	99.45255	0.547455
5	0.072026	98.99717	1.002829
6	0.080027	98.49122	1.508777
7	0.087297	98.01893	1.981070
8	0.093954	97.62523	2.374768
9	0.100150	97.30145	2.698548
10	0.105981	97.03731	2.962685

Period	S.E.	BASIC_MATERIALS	CPI
1	0.001850	0.001667	99.99833
2	0.002968	0.457418	99.54258
3	0.003931	2.484442	97.51556
4	0.004813	4.085790	95.91421
5	0.005592	5.677023	94.32298
6	0.006279	7.180072	92.81993
7	0.006899	8.514969	91.48503
8	0.007465	9.725908	90.27409
9	0.007988	10.84292	89.15708
10	0.008478	11.88638	88.11362

Variance Decomposition of CONSUMER_GOODS:			
Period	S.E.	CONSUMER_GOODS	CPI
1	0.026664	100.0000	0.000000
2	0.036465	99.80955	0.190448
3	0.044908	99.87324	0.126760
4	0.052197	99.90616	0.093843
5	0.058728	99.92495	0.075054
6	0.064724	99.93626	0.063740
7	0.070311	99.94324	0.056761
8	0.075581	99.94745	0.052551
9	0.080595	99.94975	0.050250
10	0.085398	99.95064	0.049360

Variance Decomposition of CPI:			
Period	S.E.	CONSUMER_GOODS	CPI
1	0.001836	5.540105	94.45990
2	0.002928	8.034147	91.96585
3	0.003796	7.961508	92.03849
4	0.004516	7.480038	92.51996
5	0.005123	6.828495	93.17150
6	0.005650	6.139578	93.86042
7	0.006115	5.477311	94.52269
8	0.006533	4.878049	95.12195
9	0.006914	4.365502	95.63450
10	0.007266	3.956640	96.04336

Variance Decomposition of CONSUMER_SERVICES:			
Period	S.E.	CONSUMER_SERVICES	CPI
1	0.025131	100.0000	0.000000
2	0.036747	99.80622	0.193775
3	0.046174	99.06663	0.933369
4	0.054329	98.46918	1.530818
5	0.061578	98.02897	1.971029
6	0.068112	97.70900	2.291000
7	0.074082	97.47365	2.526351
8	0.079595	97.29808	2.701924
9	0.084733	97.16489	2.835110
10	0.089555	97.06226	2.937740

Variance Decomposition of CPI:			
Period	S.E.	CONSUMER_SERVICES	CPI
1	0.001879	1.994995	98.00501
2	0.003064	4.448169	95.55183
3	0.004097	6.517382	93.48262
4	0.005006	7.822124	92.17788
5	0.005819	8.714791	91.28521
6	0.006557	9.374557	90.62544
7	0.007236	9.893569	90.10643
8	0.007867	10.32273	89.67727
9	0.008461	10.69232	89.30768
10	0.009023	11.02098	88.97902

Variance Decomposition of FINANCIALS:			
Period	S.E.	FINANCIALS	CPI
1	0.020573	100.0000	0.000000
2	0.029906	99.85877	0.141227
3	0.036482	99.60768	0.392320
4	0.042334	99.22680	0.773197
5	0.047836	98.96413	1.035872
6	0.052894	98.76906	1.230939
7	0.057571	98.60251	1.397490
8	0.061953	98.46512	1.534876
9	0.066095	98.35328	1.646716
10	0.070034	98.26034	1.739659

Variance Decomposition of CPI:			
Period	S.E.	FINANCIALS	CPI
1	0.001834	0.457728	99.54227
2	0.002936	2.356917	97.64308
3	0.003873	4.799027	95.20097
4	0.004673	5.867662	94.13234
5	0.005379	6.197404	93.80260
6	0.006004	6.228603	93.77140
7	0.006562	6.105025	93.89498
8	0.007065	5.883149	94.11685
9	0.007523	5.604804	94.39520
10	0.007943	5.299151	94.70085

Variance Decomposition of HEALTH_CARE:			
Period	S.E.	HEALTH_CARE	CPI
1	0.023436	100.0000	0.000000
2	0.033840	99.91584	0.084159
3	0.042251	99.33494	0.665064
4	0.049614	98.84372	1.156277
5	0.056282	98.46877	1.531232
6	0.062382	98.18139	1.818606
7	0.068039	97.95477	2.045228
8	0.073341	97.77207	2.227927
9	0.078355	97.62088	2.379118
10	0.083128	97.49258	2.507423

Variance Decomposition of CPI:			
Period	S.E.	HEALTH_CARE	CPI
1	0.001862	1.225495	98.77451
2	0.003000	2.552028	97.44797
3	0.003962	4.062061	95.93794
4	0.004781	4.775642	95.22436
5	0.005492	5.063474	94.93653
6	0.006117	5.122437	94.87756
7	0.006674	5.051997	94.94800
8	0.007176	4.905249	95.09475
9	0.007632	4.714330	95.28567
10	0.008050	4.499373	95.50063

Variance Decomposition of INDUSTRIALS:			
Period	S.E.	INDUSTRIALS	CPI
1	0.022154	100.0000	0.000000
2	0.032413	99.75423	0.245767
3	0.040030	99.83215	0.167846
4	0.046480	99.87503	0.124974
5	0.052298	99.89847	0.101531
6	0.057630	99.91254	0.087456
7	0.062583	99.92117	0.078830
8	0.067236	99.92648	0.073524
9	0.071647	99.92960	0.070395
10	0.075857	99.93121	0.068794

Variance Decomposition of CPI:			
Period	S.E.	INDUSTRIALS	CPI
1	0.001858	1.963042	98.03696
2	0.002982	3.060140	96.93986
3	0.003926	4.491141	95.50886
4	0.004712	5.086013	94.91399
5	0.005389	5.201821	94.79818
6	0.005983	5.078723	94.92128
7	0.006512	4.838380	95.16162
8	0.006989	4.541396	95.45860
9	0.007425	4.223096	95.77690
10	0.007827	3.905667	96.09433

Period	Variance Decomposition of TECHNOLOGY:		CPI
	S.E.	TECHNOLOGY	
1	0.037657	100.0000	0.000000
2	0.053920	99.76092	0.239076
3	0.063095	99.17078	0.829216
4	0.069678	96.13798	3.862018
5	0.076466	93.46045	6.539550
6	0.083774	88.72150	11.27850
7	0.092773	81.01067	18.98933
8	0.101576	76.63678	23.36322
9	0.110206	70.80988	29.19012
10	0.117831	64.87918	35.12082

Period	Variance Decomposition of CPI:		CPI
	S.E.	TECHNOLOGY	
1	0.001905	0.306182	99.69382
2	0.003334	0.105861	99.89414
3	0.004612	0.076444	99.92356
4	0.005823	0.056379	99.94362
5	0.007024	0.092846	99.90715
6	0.008184	0.087935	99.91206
7	0.009493	0.239185	99.76081
8	0.010725	0.364787	99.63521
9	0.011986	0.341660	99.65834
10	0.013324	0.317880	99.68212

Period	Variance Decomposition of TELECOMMUNICATIONS:		CPI
	S.E.	TELECOMMUNICATIONS	
1	0.033872	100.0000	0.000000
2	0.047768	99.64606	0.353944
3	0.057853	99.33890	0.661097
4	0.066674	99.13407	0.865933
5	0.074571	98.98823	1.011766
6	0.081751	98.88031	1.119694
7	0.088384	98.79834	1.201657
8	0.094580	98.73412	1.265883
9	0.100421	98.68226	1.317738
10	0.105962	98.63929	1.360708

Period	Variance Decomposition of CPI:		CPI
	S.E.		
1	0.001864	0.027604	99.97240
2	0.003012	0.759485	99.24051
3	0.003994	1.656310	98.34369
4	0.004831	2.032179	97.96782
5	0.005557	2.153567	97.84643
6	0.006197	2.152302	97.84770
7	0.006770	2.085113	97.91489
8	0.007292	1.983097	98.01690
9	0.007771	1.864392	98.13561
10	0.008215	1.739924	98.26008

## Appendix C. autocorrelation

All Share

Date: 10/31/17 Time: 13:40  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.965	0.965	190.81	0.000
		2	0.930	-0.004	369.19	0.000
		3	0.893	-0.066	534.26	0.000
		4	0.850	-0.101	684.52	0.000
		5	0.803	-0.082	819.26	0.000
		6	0.757	0.002	939.79	0.000
		7	0.704	-0.134	1044.4	0.000
		8	0.651	-0.011	1134.5	0.000
		9	0.602	0.022	1211.8	0.000
		10	0.552	-0.027	1277.3	0.000
		11	0.501	-0.045	1331.4	0.000
		12	0.448	-0.075	1374.9	0.000

\*Probabilities may not be valid for this equation specification.

Basic Materials

Date: 11/30/17 Time: 23:26  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.969	0.969	192.45	0.000
		2	0.938	-0.005	373.89	0.000
		3	0.901	-0.122	542.16	0.000
		4	0.863	-0.043	697.25	0.000
		5	0.822	-0.064	838.50	0.000
		6	0.787	0.090	968.69	0.000
		7	0.747	-0.084	1086.7	0.000
		8	0.706	-0.072	1192.7	0.000
		9	0.669	0.045	1288.2	0.000
		10	0.629	-0.051	1373.1	0.000
		11	0.593	0.038	1449.0	0.000
		12	0.550	-0.149	1514.7	0.000

\*Probabilities may not be valid for this equation specification.

## Consumer Goods

Date: 11/30/17 Time: 23:29  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.961	0.961	189.37	0.000
		2	0.925	0.021	365.78	0.000
		3	0.885	-0.073	528.04	0.000
		4	0.830	-0.221	671.52	0.000
		5	0.784	0.074	800.13	0.000
		6	0.732	-0.083	912.66	0.000
		7	0.667	-0.182	1006.6	0.000
		8	0.605	-0.051	1084.2	0.000
		9	0.539	-0.030	1146.3	0.000
		10	0.476	0.026	1194.9	0.000
		11	0.421	0.046	1233.1	0.000
		12	0.368	0.029	1262.6	0.000

\*Probabilities may not be valid for this equation specification.

## Consumer Services

Date: 11/30/17 Time: 23:30  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.953	0.953	186.09	0.000
		2	0.903	-0.054	354.00	0.000
		3	0.855	-0.002	505.34	0.000
		4	0.810	0.004	641.87	0.000
		5	0.768	0.003	765.14	0.000
		6	0.712	-0.173	871.63	0.000
		7	0.655	-0.028	962.35	0.000
		8	0.605	0.036	1040.2	0.000
		9	0.566	0.080	1108.7	0.000
		10	0.525	-0.069	1167.9	0.000
		11	0.473	-0.115	1216.2	0.000
		12	0.425	0.018	1255.3	0.000

\*Probabilities may not be valid for this equation specification.

## Financials

Date: 11/30/17 Time: 23:31  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.972	0.972	193.50	0.000
		2	0.940	-0.074	375.43	0.000
		3	0.908	-0.009	546.17	0.000
		4	0.880	0.039	707.18	0.000
		5	0.844	-0.152	856.11	0.000
		6	0.801	-0.124	991.15	0.000
		7	0.753	-0.124	1110.9	0.000
		8	0.705	-0.016	1216.7	0.000
		9	0.654	-0.110	1307.9	0.000
		10	0.596	-0.140	1384.1	0.000
		11	0.537	-0.000	1446.3	0.000
		12	0.476	-0.098	1495.5	0.000

\*Probabilities may not be valid for this equation specification.

## Health Care

Date: 11/30/17 Time: 23:32  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.962	0.962	189.66	0.000
		2	0.917	-0.110	362.86	0.000
		3	0.871	-0.028	519.96	0.000
		4	0.826	-0.015	661.86	0.000
		5	0.776	-0.090	787.75	0.000
		6	0.715	-0.169	895.15	0.000
		7	0.644	-0.155	982.66	0.000
		8	0.577	0.033	1053.3	0.000
		9	0.509	-0.065	1108.7	0.000
		10	0.440	-0.072	1150.2	0.000
		11	0.366	-0.060	1179.2	0.000
		12	0.291	-0.065	1197.5	0.000

\*Probabilities may not be valid for this equation specification.

## Industrials

Date: 11/30/17 Time: 23:33  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.975	0.975	194.77	0.000
		2	0.944	-0.113	378.53	0.000
		3	0.913	-0.028	551.12	0.000
		4	0.883	0.019	713.44	0.000
		5	0.854	-0.010	865.98	0.000
		6	0.824	-0.035	1008.7	0.000
		7	0.787	-0.161	1139.5	0.000
		8	0.748	-0.027	1258.2	0.000
		9	0.710	0.013	1365.7	0.000
		10	0.673	-0.014	1463.0	0.000
		11	0.632	-0.135	1549.1	0.000
		12	0.592	0.040	1625.1	0.000

\*Probabilities may not be valid for this equation specification.

## Technology

Date: 11/30/17 Time: 23:34  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.958	0.958	188.18	0.000
		2	0.921	0.033	362.82	0.000
		3	0.882	-0.031	523.92	0.000
		4	0.839	-0.081	670.29	0.000
		5	0.792	-0.074	801.34	0.000
		6	0.739	-0.102	916.07	0.000
		7	0.683	-0.069	1014.7	0.000
		8	0.624	-0.075	1097.4	0.000
		9	0.571	0.039	1167.0	0.000
		10	0.519	0.003	1224.9	0.000
		11	0.462	-0.081	1270.9	0.000
		12	0.408	-0.018	1307.0	0.000

\*Probabilities may not be valid for this equation specification.

## Telecommunications

Date: 11/30/17 Time: 23:36  
 Sample: 2000M02 2016M12  
 Included observations: 202

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob*	
		1	0.968	0.968	192.02	0.000
		2	0.933	-0.063	371.23	0.000
		3	0.899	0.016	538.77	0.000
		4	0.863	-0.077	693.68	0.000
		5	0.825	-0.023	836.20	0.000
		6	0.788	-0.021	966.83	0.000
		7	0.750	-0.042	1085.6	0.000
		8	0.708	-0.070	1191.9	0.000
		9	0.670	0.052	1287.9	0.000
		10	0.628	-0.110	1372.6	0.000
		11	0.585	-0.017	1446.6	0.000
		12	0.545	0.001	1511.0	0.000

\*Probabilities may not be valid for this equation specification.

## Appendix D. VECM LM Test

The results of the LM test from VECM are given below.

All Share

VEC Residual Serial Correlation LM Tests  
 Null Hypothesis: no serial correlation at lag  
 order h  
 Date: 10/30/17 Time: 21:06  
 Sample: 2000M02 2016M12  
 Included observations: 200

Lags	LM-Stat	Prob
1	6.309548	0.1772
2	4.508328	0.3416
3	4.749727	0.3140
4	1.124525	0.8904
5	5.936015	0.2040
6	17.17885	0.0018
7	5.779057	0.2163
8	3.986797	0.4078
9	1.849200	0.7635
10	2.030310	0.7302
11	1.041966	0.9034
12	29.99482	0.0000

Probs from chi-square with 4 df.

The prob values from the LM test shows that there is no evidence of serial correlation in the majority of the lag periods, with LM stats having prob values greater than 0.05 with the exception of the 6<sup>th</sup> and 12<sup>th</sup> lags that both have a prob value less than 0.05

### Basic Materials

VEC Residual Serial Correlation LM Tests  
Null Hypothesis: no serial correlation at lag order h  
Date: 10/30/17 Time: 21:14  
Sample: 2000M02 2016M12  
Included observations: 199

Lags	LM-Stat	Prob
1	2.750772	0.6004
2	2.781493	0.5950
3	5.023515	0.2849
4	1.930745	0.7485
5	5.160680	0.2712
6	12.74596	0.0126
7	4.637354	0.3266
8	5.651820	0.2267
9	1.454626	0.8346
10	2.759698	0.5988
11	6.718780	0.1515
12	28.81046	0.0000

Probs from chi-square with 4 df.

The prob. values from the LM test shows that there is no evidence of serial correlation in the majority of the lag periods, with LM stats having p-values greater than 0.05 with the exception of the 6<sup>th</sup> and 12<sup>th</sup> lags that both have a p-value less than 0.05

### Consumer Goods

VEC Residual Serial Correlation LM Tests  
Null Hypothesis: no serial correlation at lag order h  
Date: 10/30/17 Time: 21:18  
Sample: 2000M02 2016M12  
Included observations: 200

Lags	LM-Stat	Prob
1	8.561854	0.0730
2	6.411499	0.1705
3	8.469664	0.0758
4	4.759114	0.3129
5	9.014887	0.0607
6	11.78084	0.0191
7	7.530656	0.1104
8	6.741839	0.1502
9	1.506677	0.8255
10	4.302347	0.3666

11	1.874905	0.7588
12	28.96532	0.0000

Probs from chi-square with 4 df.

The prob. values from the LM test shows that there is no evidence of serial correlation in the majority of the lag periods, with LM stats having p-values greater than 0.05 with the exception of the 6<sup>th</sup> and 12<sup>th</sup> lags that both have a p-value less than 0.05

#### Consumer services

VEC Residual Serial Correlation LM Tests  
Null Hypothesis: no serial correlation at lag order h  
Date: 10/30/17 Time: 21:19  
Sample: 2000M02 2016M12  
Included observations: 200

Lags	LM-Stat	Prob
1	2.633146	0.6210
2	1.633252	0.8028
3	4.579287	0.3332
4	4.137220	0.3878
5	7.978434	0.0924
6	7.439468	0.1144
7	5.452398	0.2439
8	5.857295	0.2101
9	0.625306	0.9602
10	2.803460	0.5912
11	4.411547	0.3532
12	26.03632	0.0000

Probs from chi-square with 4 df.

The prob. values from the LM test shows that there is no evidence of serial correlation in all of the lag periods with exception of the 12<sup>th</sup> period, that has a p-value less than 0.05.

#### Financials

VEC Residual Serial Correlation LM Tests  
Null Hypothesis: no serial correlation at lag order h  
Date: 10/30/17 Time: 21:20  
Sample: 2000M02 2016M12  
Included observations: 200

Lags	LM-Stat	Prob
1	2.430811	0.6571
2	1.480821	0.8300
3	4.454589	0.3480
4	4.951319	0.2923
5	6.365177	0.1735
6	6.162512	0.1873
7	7.896592	0.0954
8	1.676231	0.7950
9	1.431889	0.8386
10	1.986231	0.7383

11	4.261604	0.3718
12	27.11003	0.0000

Probs from chi-square with 4 df.

The prob. values from the LM test shows that there is no evidence of serial correlation in all of the lag periods with exception of the 12<sup>th</sup> period, that has a p-value less than 0.05.

Health Care

VEC Residual Serial Correlation LM Tests  
Null Hypothesis: no serial correlation at lag order h  
Date: 10/30/17 Time: 21:21  
Sample: 2000M02 2016M12  
Included observations: 200

Lags	LM-Stat	Prob
1	3.109278	0.5397
2	1.352710	0.8524
3	3.645828	0.4561
4	1.519162	0.8232
5	5.471387	0.2423
6	10.07557	0.0392
7	8.437324	0.0768
8	0.749531	0.9451
9	1.767390	0.7784
10	0.558259	0.9676
11	3.930427	0.4155
12	32.21280	0.0000

Probs from chi-square with 4 df.

The prob. values from the LM test shows that there is no evidence of serial correlation in all of the lag periods with exception of the 6<sup>th</sup> and 12<sup>th</sup> period both have a p-value less than 0.05.

Industrials

VEC Residual Serial Correlation LM Tests  
Null Hypothesis: no serial correlation at lag order h  
Date: 10/30/17 Time: 21:23  
Sample: 2000M02 2016M12  
Included observations: 200

Lags	LM-Stat	Prob
1	1.787844	0.7747
2	2.585476	0.6294
3	1.566337	0.8148
4	7.244392	0.1235
5	1.865152	0.7605
6	7.585914	0.1080
7	6.262960	0.1804
8	2.979123	0.5613
9	0.464823	0.9768
10	3.448598	0.4857
11	4.238788	0.3747
12	27.05737	0.0000

Probs from chi-square with 4 df.

The prob. values from the LM test shows that there is no evidence of serial correlation in all of the lag periods with exception of the 12<sup>th</sup> period, that has a prob. value less than 0.05.

## Technology

VEC Residual Serial Correlation LM Tests  
Null Hypothesis: no serial correlation at lag order h  
Date: 10/30/17 Time: 21:28  
Sample: 2000M02 2016M12  
Included observations: 193

Lags	LM-Stat	Prob
1	4.678765	0.3219
2	8.369889	0.0789
3	19.45602	0.0006
4	9.724382	0.0453
5	9.838086	0.0432
6	12.18827	0.0160
7	8.094062	0.0882
8	3.353849	0.5004
9	10.23247	0.0367
10	9.935134	0.0415
11	6.958671	0.1381
12	19.89810	0.0005

Probs from chi-square with 4 df.

The prob. values from the LM test shows that there is evidence of serial correlation in the 3<sup>rd</sup> to 6<sup>th</sup> lag periods and the 9<sup>th</sup>, 10<sup>th</sup> and 12<sup>th</sup> period all having a prob. value less than 0.05.

## Telecommunications

VEC Residual Serial Correlation LM Tests  
Null Hypothesis: no serial correlation at lag order h  
Date: 10/30/17 Time: 21:30  
Sample: 2000M02 2016M12  
Included observations: 200

Lags	LM-Stat	Prob
1	6.250270	0.1812
2	2.660665	0.6161
3	4.810874	0.3073
4	1.038221	0.9039
5	3.034170	0.5521
6	8.563024	0.0730
7	6.661104	0.1549
8	4.246776	0.3736
9	3.272815	0.5133
10	2.264713	0.6872
11	1.463683	0.8331

12	32.82694	0.0000
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Probs from chi-square with 4 df.

The prob. values from the LM test shows that there is no evidence of serial correlation in all of the lag periods with exception of the 12th period, that has a prob. value less than 0.05.

Apart from the VECM for the technology and CPI index, all other models show very little indications of serial correlation with the LM stats prob. values showing that there is no evidence of serial correlation in most lag periods.