THE INFLATION HEDGING PROPERTIES OF SOUTH AFRICAN ASSET CLASSES

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investors with an inflation hedge. This is important for local investors to be aware of when deciding to invest in foreign asset classes with the goal of hedging against inflation. Utilising the Engle-Granger Cointegration test, the findings of this study suggest that both domestic and foreign asset classes do not display a long-term relationship with inflation. This suggests that both domestic and foreign asset classes are anti-inflation hedges, since neither covary positively with inflation in the long-run. One major implication of these findings is that investment firms, whose benchmarks' contain consumer price indices (CPI), rely on the fact that the average returns of various asset classes exceed the average inflation rate in the long run, rather than being good inflation hedges (viz. co-movement with inflation).

Abstract

Inflation poses a serious threat to the purchasing power of assets over time. This study examines the short and long-term inflation hedging capabilities of South African equities, bonds, listed property and cash - and compares them to foreign substitutes. The aim of this study is to investigate the inflation hedging capabilities of four primary asset classes in both domestic and foreign contexts: equities, bonds, listed real estate and cash. More specifically, this study evaluates how well each asset class performs with respect to South African inflation, and through a comparative analysis of the results, identifies which asset class may be regarded as the superior inflation hedge. Moreover, the inflation hedging capabilities of domestic assets are compared to foreign asset classes in an attempt to provide investors with valuable insights as to whether domestic and/or foreign asset classes offer better protection against the harmful effects of inflation. Finally, the study demonstrates how well these asset classes perform with respect to inflation over short and long-run horizons.

The data used in this study comprises total return indices which portray a more accurate picture of an investor's return. The period 1999-2015 forms the range within which data for all domestic and foreign asset classes are available, and thus constitutes the sample period used in this study's comparative analysis. Excluding domestic bonds on the basis of data availability, the comparative analysis of domestic asset classes, dates back to 1965. This study makes use of the following tests: Pearson correlations, Augmented Dickey-Fuller, Phillips-Perron, Granger causality, OLS regression, VAR and Impulse Response Functions, and Cointegration.

This study finds evidence in support of a negative contemporaneous and lagged relationship between domestic and foreign equities, and South African inflation in the short-run (also widely recognised as the "inverted Fisher effect"). Domestic bonds, property and cash were found to provide a partial inflation hedge in the short-run. Cash was found to exhibit the strongest hedging properties. On the other hand, foreign bonds, property and cash were found to be anti-inflation hedges with contemporaneous and lagged inflation. However, although foreign asset classes do not offer protection against contemporaneously or lagged inflation, they do provide a leading return prior to inflation manifesting. Consequently, if profits are taken early enough it can provide

Declaration

I, Donovan Stefan, hereby declare that the work contained herein is my own work (apart from where acknowledgements and references specify otherwise). Neither the whole nor part of this study are being or have been submitted for another degree at this or any other university. The University of Cape Town is hereby empowered to reproduce this study, either wholly or partially, for research purposes in any manner whatsoever.

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1. Introduction

Inflation poses a serious threat to the purchasing power of assets over time. Lintner (1975: 259) argues that: “few matters are of more serious concern to students of finance and to members of the financial community than the impacts of inflation on our financial institutions and markets and its implications for investment policy”.

1.1 Background to this study

More specifically, inflation presents a significant threat to developing economies since they are more likely than developed economies to be exposed to inflationary shocks, both irregular and persistent (Brière & Signori, 2013). This is noteworthy since it means that developing countries cannot be reliably compared with their more developed counterparts. More specifically, developing countries are exposed to more frequent and significantly larger inflation shocks, often triggered by crises affecting their currency (e.g. a depreciation that results in pass-through in the direction of local inflation) and/or government debt. Furthermore, investors in developing countries usually have a thinner array of local assets to select from than investors in developed countries (Brière & Signori, 2013). Additionally, increasing inflation in developing markets is likely to be greater and faster due to their steeper overall growth rates (Amenc, Martellini, & Ziemann, 2009). Consequently, given these observed trends of inflation growth in developing economies, and the knowledge with respect to the historical effects of inflation on their economies, inflation hedging has become a significant priority not only for private investors - who perceive inflation as a direct danger to their purchasing power - but also for pension funds, the aim of which is to provide real returns to its investors (Arnold & Auer, 2015). The effects of inflation, which depreciates the value of investments over time in real terms, can be managed if an investor is able to completely capture the rate of inflation in the return of their investment (Huang & Hudson-Wilson, 2007). Briefly, for an asset to be an inflation hedge its nominal return must have a positive correlation of one or close to one with inflation, and its real returns must be independent of inflation (Fama and Schwert, 1977).

Previously, numerous scientific studies have documented the relationship between asset returns and inflation rates in an attempt to discover which assets can shield investors from inflation (see, for example, Roll, 1972; Nelson, 1976; Fama & Schwert, 1977; Brière & Signori (2012); Spierdijk, & Umar, 2015). However, despite the abundance of literature on this topic, there is as yet no general consensus on whether assets, such as equities, bonds, property and cash, can provide investors with inflation hedging benefits. Previous research on this topic has investigated various empirical hypotheses: Are these asset classes able to protect against both expected and unexpected elements of inflation? Do these asset classes act as an inflation hedge in the short and long-term? Is the hedging capability of these asset classes durable both over time and amid changing economic conditions, or is this durability simply a function of the particular sample under investigation?

As previously mentioned, there is no academic consensus regarding whether these assets can provide an effect hedge against inflation. One possible reason for the conflicting findings so far is perhaps attributable to *methodological* concerns; for instance, the use of different data sources, sample periods, frequency of data, country and econometric methodology (Arnold & Auer, 2015). In addition to these concerns, and with particular relevance to this study, the existing research (on the inflation hedging capabilities of the aforementioned asset classes) has also tended to focus primarily *on developed countries*. As such, the literature on this topic focusing on developing countries is limited, particularly African developing countries. Since mitigating the effects of inflation on the market value of investments is a central concern for the financial sector, it follows that research investigating the relationship between the hedging capability of certain asset classes and inflation is especially urgent within the economic climate of developing countries. Indeed, from a historical perspective, the majority of African countries – subsequent to the economic restructuring in the 1980s - have implemented stringent monetary and fiscal policies. Yet despite these attempts, inflation in African nations has tended toward a general rising trend. High inflation levels can have considerable negative consequences for the financial sectors of African countries, especially in the situation of fixed nominal rates, the selection of asset classes and the composition of assets **(**Alagidede & Panagiotidis, 2010).

South Africa represents a particularly important domain for current research into the inflation hedging capabilities of assets in African countries. Although South Africa is generally considered an African country with highly developed financial markets and a thriving financial industry, it has nonetheless been vulnerable to macroeconomic instability (e.g. inflation shocks) caused by significant political turmoil, exchange rate depreciation and drought; this, despite implementing important macroeconomic stabilisation policies, such as inflation targeting, in which the central bank's objective is to maintain inflation within a 3%-6% band (South African Reserve Bank, 2016). Moreover, South Africa has historically suffered from high inflation which has had the deleterious effect of eroding an individual's purchasing power. From the middle of the 1970s South Africa frequently suffered from double digit to high single digit inflation, with inflation peaking at over 20% in the 1980s (see appendix B14).

1.2 Contribution

This study will supplement the existing literature on the inflation hedging properties of asset classes in the following ways. Firstly, it will provide a comprehensive investigation into the inflation hedging capabilities of four primary asset classes (equities, bonds, real estate and cash). Both the South African domestic and the foreign counterparts of the above aforementioned four asset classes are investigated in order to identify how well each asset performs as an inflation hedge with respect to South African inflation. Despite the fact that South Africa has the largest stock exchange in Africa, no study has yet investigated the hedging abilities of these South African assets. The existing literature having focused primarily on the hedging capabilities of only the equity asset class within the context of Africa. Secondly, through a comparative analysis of the results, this study will attempt to identify which of the selected asset classes may be regarded as the superior inflation hedge for an investor. Furthermore, the inflation hedging abilities of domestic assets will be compared to foreign asset classes in order to provide investors with valuable insights into the most effective methods of protection against the deleterious effects of South African inflation. Lastly, this study will investigate how well these asset classes perform with respect to inflation over short and long-run horizons.

As such, this research is geared towards delivering valuable insights for local investors who participate in the South African market. This information could also prove useful for foreign investors who have investments in South Africa that are just as economically vulnerable to the deleterious effects of domestic inflation which reduces an investor purchasing power. It is hoped that such valuable information may be gleaned from answers to the following questions - of which it is the purpose of this study to provide: 1) Which asset class provides the superior inflation hedging capacity? 2) Do domestic assets, as opposed to foreign ones, provide a better hedge against inflation in South Africa? 3) Which asset classes protect investors against inflation in both the short and/or long-term? In summary therefore, *this study aims to investigate the empirical relationship between the effects of inflation and the returns on the four aforementioned primary asset classes*. This analysis should allow for the identification of those domestic asset classes with the highest durability against inflation, as well as a comparison of their respective hedging capacities relative to their foreign asset counterparts.

1.3 Organisation of the remainder of the study

The remainder of the study is organised as follows: Section 2 comprises a discussion of the theory behind inflation hedging. Section 3 then reviews the literature related to the topic, which is followed by a description of the data in section 4. Subsequently, section 5 describes the methodologies applied, followed by the results in section 6. Finally, section 7 contains this study's concluding remarks, while section 8 ends by suggesting some avenues for supplementary research.

2. Inflation hedging theory

This section outlines Fisher's influential theory of interest rates, which has established itself as the explanatory bedrock for most empirical studies investigating the relationship between asset class returns and inflation.

According to Irving Fisher's (1930) theory of interest rates, "nominal interest rate can be expressed as the sum of an expected real return and an expected inflation rate" (Fama & Schwert, 1977: 115). A seminal study conducted by Fama and Schwert (1977) on the relationship between asset returns and inflation indicated that the proposition that expected nominal returns include market assessments of expected inflation rates could be applied to all assets. Therefore, if the information available at time t-1 is processed efficiently then the market "will set the price of any asset 'j' so that the expected nominal return on the asset from t-1 to t is the sum of the appropriate equilibrium expected real return and the best possible assessment of the expected inflation rate from t-1 to t" (Fama & Schwert, 1977:115). Formally, this means:

$$\mathbf{E}\{\boldsymbol{R_{jt}}|\boldsymbol{\Omega_{t-1}}\} = \mathbf{E}\{\boldsymbol{I_{jt}}|\boldsymbol{\Omega_{t-1}}\} + \mathbf{E}\{\boldsymbol{\pi_t}|\boldsymbol{\Omega_{t-1}}\} \quad \textbf{(1)}$$

Where:

$\mathbf{E\{R_{jt}|\Omega_{t-1}\}}$ **:** Expected nominal return on asset j from t-1 to t based on the available information at Ω_{t-1}**.**

$\mathbf{E\{I_{jt}|\Omega_{t-1}\}}$ **:** The appropriate equilibrium expected real return on asset j implied by the information set (Ω) available at t-1.

$\mathbf{E\{\pi_t|\Omega_{t-1}\}}$ **:** The best possible assessment of the expected value of the inflation rate (π_t) that can be made on the basis of Ω_{t-1}.

Equation (1) above expresses that the market uses the information set available at t-1 (Ω_{t-1}) to accurately assess the expected inflation rate and to determine the suitable equilibrium expected real return on asset j, that may include a risk adjustment which distinguishes the expected return on asset j from that on other assets. Subsequently, the market will set the price of the asset so that the expected nominal return is the sum of the equilibrium expected real return and the appropriately assessed expected inflation rate.

Fisher, as a quantity theorist, believed that the real and monetary segments of the economy are mostly independent (Fama & Schwert, 1977). He therefore theorised that real factors would determine the expected real return in **equation (1)**; for example, the efficiency of capital, investor time preferences, and appetites for risk. As a result, he suggested that the expected real return and expected inflation rates are independent. This notion is useful for our study as it permits us to examine the relationship between asset returns and inflation without being required to introduce a complete general equilibrium model for the expected real returns.

In order to test the combined hypotheses that the market is efficient, and that the expected real return and expected inflation rate vary independently, one requires a method to measure expected inflation. In prior academic studies there have been a few methods with which one has been able to obtain an estimate of the expected inflation rate. For example, through survey measures (used to obtain consensus-inflation forecasts), time series models, inflation swaps and inflation linked bonds, and through the use of realised inflation as a rational forecast for future inflation (see Lintner, 1975; Rödel, 2012).

Accordingly, provided that there is some appropriate measure of the expected inflation rate, one is able to test the joint hypothesis stated above from estimates generated by the OLS regression model:

$$\mathbf{R_{jt} = \alpha_j + \beta_j E\{\pi_t | \Omega_{t-1}\} + \varepsilon_{jt}} \quad \textbf{(2)}$$

OLS regression approximates "the conditional expected value of the dependent variable as a function of the independent variable" (Arnold & Auer, 2015: 194). Therefore, an estimate of βj that is not statistically and significantly dissimilar from one is consistent with the hypothesis that the expected nominal return of asset j fluctuates with a one-to-one correlation with the expected inflation rate. It thus acts as a perfect inflation hedge. **Equation (1)**, which if rearranged implies that the expected real return is equal to the expected nominal return less the expected inflation rate, suggests that a βj which is not significantly different from one is also consistent with the postulation that the expected real return on the asset and expected inflation rate are unrelated (Fama & Schwert, 1977). This implies that investors will on average be fully compensated for the erosion caused by inflation in their purchasing power.

Furthermore, while Fisher (1930) accounts for only expected inflation, Fama and Schwert (1977) augment **equation (2)** by also considering unexpected inflation, which results in the following regression equation:

$$\mathbf{R_{jt} = \alpha_j + \beta_j E\{\pi_t | \Omega_{t-1}\} + \gamma_j [\pi_t - E\{\pi_t | \Omega_{t-1}\}] + \eta_{jt}} \quad \textbf{(3)}$$

In the above regression model an asset j is a perfect hedge against expected inflation if βj is not statistically and significantly dissimilar from one. This means that the expected nominal return on the asset fluctuates in a one-to-one relationship with the expected inflation rate and the expected real return on the asset is uncorrelated with the expected inflation rate. In addition, asset j is a perfect hedge against unexpected inflation if γ_j is not significantly different from one. Any significant parameter (β_j, γ_j) values between zero and one will imply that the asset provides a partial inflation hedge. In contrast negative parameter (β_j, γ_j) values indicate that the asset behaves as an anti-inflation hedge. Consequently, if this situation arises the asset can only be an inflation hedge if it is shorted. Thus, if after estimating the above regression equation we obtain that both parameters, β_j and γ_j are equal to one, then asset j is said to be a complete hedge against inflation (both expected and unexpected). In other words, the nominal return on asset j co-moves in a one-to-one relationship with both the expected and unexpected constituents of inflation and the ex post real return on the asset is uncorrelated with the ex post inflation rate (Fama & Schwert, 1977).

3. Literature review

This section reviews the empirical literature concerning the relationship between equities, bonds, property and cash with inflation, and focuses on seminal historical studies in addition to more recent studies.

3.1 Equities as an inflation hedge

Some insight can be inferred from the present value model of security valuation with respect to the relationship expected between equity returns and inflation:

$$\mathbf{P_{it}} = \sum_{\mathbf{n=1}}^{\infty} \frac{\mathbf{E[D_{it+n}]}}{\mathbf{[1 + k_i]^n}}$$

$\mathbf{P_{it}}$ = The price of asset i in period t.

$\mathbf{E}[\mathbf{D}_{\mathbf{it+n}}] =$ Expected dividend receipt in period t+n**.**

$\mathbf{k_i} =$ The required rate of return on asset i.

The primary objective of most central banks is to achieve and maintain price stability by controlling the inflation rate within a country. More specifically, ensuring price stability by controlling inflation is very important within developing economies that tend to suffer from erratic and high inflation rates. Safeguarding price stability is fundamental to sustainable and balanced economic development and growth (South African Reserve Bank, 2016). Price stability reduces uncertainty in the economy, and consequently offers a positive atmosphere for growth and employment creation. Moreover, controlling inflation rates provides protection to the purchasing power of people's incomes and wealth. In an effort to control inflation, the South African Reserve Bank (SARB) has adopted an inflation targeting policy since February 2000. Inflation targeting is a monetary policy according to which the central bank announces an inflation target band, to which it then commits keeping the inflation rate within by adjusting the repo rate (South African Reserve Bank, 2016).

From the denominator of the above expression, it is evident that equity prices are likely to be inversely related to changes in the interest rate (Van Rensburg, 1999). Given this insight in the context of the SARB's inflation targeting policy, the following intuition can be inferred: as inflation tends toward the upper end of the target range, or breaches it, the reserve bank will respond by increasing the repo rate, which will result in a rise in the short-term interest rate. This explains how, by raising the short-term interest rate via the repo rate, the reserve bank accomplishes two primary objectives. The first is to reduce inflation until it is within its target range again, while the second is to defend the local currency from depreciation. Accomplishing the above two objectives protects individuals' purchasing power in both local and foreign contexts. However, this suggests that equities tend to be a poor hedge against inflation; since, if inflation rises to levels near to or above the upper end of the target range, the SARB will respond by raising the short-term interest rates, which - as the value model of security valuation shows - is negatively related to equity prices (Van Rensburg, 1999).

3.1.1 Consensus regarding the inflation hedging properties of equities prior to 1970

According to Arnold and Auer (2015), research conducted prior to 1970 utilised either anecdotal evidence or simple regression analysis to examine the relationship between equity returns and inflation. These studies agreed with the notion that the returns of equities tend to co-move with inflation in a one-to-one relation as predicted by the Fisher model (Roll, 1972; Nelson, 1976). Consequently, before 1970, the consensus amongst academics and non-academic financial professionals of the stock market was that returns on equities co-move in a one-to-one relation with the rate of inflation. This observed relationship is simply an extension of Fisher's (1930) well-known hypothesis on the theory of nominal interest rates, here applied to rates of return on equities. However, acceptance of this extension has lost substantial traction in more recent years as a consequence of the contradictory evidence found in empirical studies post-1970 (Arnold & Auer, 2015).

There appears to be a disagreement between theory and empirical evidence in the literature with regards to the hedging capabilities of equities. Conventional finance theory postulates that equities should be a useful inflation hedge for two main reasons. Firstly, equities are said to be a real security - in the sense that they represent claims on real, productive assets of firms (Bodie, 1976; Fama & Schwert, 1977; Spyrou, 2004; Ang, 2014). Consequently, the real rate of return on equities should be unaffected by changes in consumer prices (Spyrou, 2004). Secondly, since most firms leverage their capital and are net debtors, and because the firm's long-term obligations to pay fixed nominal amounts decline in real value (this is known as the debtor-creditor hypothesis), investors should tend to profit from unexpected inflation (Lintner, 1975). However, as will be demonstrated below, more recent empirical evidence (post-1970) is at odds with theoretical expectations, since the majority of this literature tends to observe a negative – rather than a positive - association between equity returns and inflation. In other words, more recent evidence implies that equities are in fact bad inflation hedges (Bodie, 1976; Jaffer & Mandelker, 1976; Nelson, 1976; Fama, 1981; Solnik, 1983; Marshall, 1992).

3.1.2 Consensus regarding the inflation hedging properties of equities between 1970-1990

Academic studies post-1970 that conduct an empirical analysis on the ability of equities to shield investors from inflation losses in purchasing power have attracted substantial attention in academia, owing to the significantly higher inflation rates affecting countries on a global scale (Arnold & Auer, 2015). Bodie's (1976) influential academic study regarding equities and inflation hedging attempted to determine to what extent equities are an inflation hedge. This study made use of the New York Stock Exchange (NYSE) equity returns and the consumer price index obtained from the US Bureau of Labor Statistics for 1953-1972. With holding periods of one month, three months and one year, the regression results indicated that, in contrast to what economists commonly thought to be true, the real return on equity was not positively, but *negatively* related to both expected and unexpected short-term inflation. The proxy for the unexpected change inflation is defined as $\mathrm{D(t)} - \overline{\mathrm{D}}\mathrm{(t)}$, Where $\mathrm{D(t)}$ represents the index of purchasing power, which is the value of the consumer price index (CPI) at the beginning of the holding period divided by its value at the end$\left(\frac{\mathrm{P_{(t)}}}{\mathrm{P_{(t+1)}}}\right)$ and $\overline{\mathrm{D}}\mathrm{(t)}$ is the mean. However, $\overline{D}(t)$ the expected value of the index of purchasing power is not observable. Bodie (1976) deals with this by assuming that $\overline{D}$ evolves according to the model of "adaptive expectations". Adaptive expectations say that $\overline{\mathrm{D}}\mathrm{(t)} = \overline{\mathrm{D}}\mathrm{(t-1)} + \theta[\mathrm{D(t-1)} - \overline{\mathrm{D}}\mathrm{(t-1)}]$, which makes the current $\overline{\mathrm{D}}$ a function of past realized values of $\overline{\mathrm{D}}\mathrm{(t)}$. The negative correlation observed between the returns and inflation leads to a somewhat surprising conclusion that equities seem to be a poor inflation hedge in the short-run and that in order for equities to be an inflation hedge they must be sold short. This unexpected result is by no means a remote finding.

Academic studies conducted by Nelson (1976), Jaffe and Mandelker (1976), Fama and Schwert (1977) and Gultekin (1983) all verify the negative relationship between equity returns and inflation in the short-run. A study by Jaffe and Mandelker (1976) used a comprehensive sample spanning from 1876 to 1971, in order to investigate the relationship between consumer and wholesale prices (indexed as a proxy for inflation) and the Lawrence Fisher index (as a proxy for US equity returns). Jaffe and Mandelker (1976) conclude that equity returns appear to be independent of inflation over the long period. However, they also state that these results should be interpreted with a degree of caution since they may be skewed due to flawed data collection methods (viz. the CPI published by the Bureau of Labour statistics needed substantial upgrading with respect to its sampling procedures prior to 1953). As a consequence, the majority of their study focused on monthly data from January 1953 to December 1971. Nevertheless, this analysis also supported the hypothesis that equity returns are significantly negatively related to inflation.

A later study conducted by Gultekin (1983) demonstrated that, for the majority of the twenty-six countries analysed, a consistent absence of positive relationships (i.e. either no or a negative relationship) obtained between equity returns and inflation. Most of the twenty-six countries analysed were developed. Interestingly, these findings were consistent irrespective of the three distinct proxies used for expected inflation viz. 1) contemporaneous inflation 2) short-term interest rates and 3) expected and unexpected components of inflation decomposed by ARIMA models. Lastly, a study conducted by Fama and Schwert (1977) also found a negative relation between equity returns and expected inflation for the period of 1953-1971 in the USA. Based on the above literature and empirical findings, it is quite evident that contrary to established theory prior to 1970, equities appear to be poor hedges against inflation.

3.1.3 Attempts to explain the negative relationship between equities and inflation

Subsequently, there has been a number of theories that have emerged in the literature that attempt to explain the negative relationship between equities and inflation. Some of these theories include tax effects, inflation illusion, equity risk premium and the well-known proxy hypothesis which is explained below and has been the subject of many academic studies[1]. Additionally, the properties of the data and econometric methodology applied has also been suggested reasons for the negative relationship.

[1] See Feldstein and Summers (1979) and Summers (1980) for tax effect hypothesis, Modigliani and Cohn (1979) for the inflation illusion hypothesis and Malkiel (1979) and Pindyck (1984) who initially outlined the equity risk premium hypothesis.

Proxy hypothesis

Fama (1981) hypothesised that the negative relationship between equity returns and inflation observed after 1953 is a consequence of proxy effects. The proxy hypothesis proposes that the negative relationship observed between equities and inflation is spurious, and results from inflation acting as a proxy for both real drivers of equity returns as well as expectations of future real economic activity (Attie and Roache, 2009). The proxy hypothesis is perhaps best explained by insights from money demand theory and quantity theory of money, both of which suggest that measures of real activity should dominate measures of inflation. More specifically, when measures of real activity and inflation are used as explanatory variables in real equity return regressions (for monthly, quarterly, and/or annual data) the negative relations between real equity returns and expected inflation rates are eliminated. In other words, as Arnold and Auer (2015: 195) suggest, while equities "benefit from higher expected economic activity…increasing inflation leads to lower economic activity due to the short-term non-neutrality of money." That is, since equity returns are positively related to real activity and real activity is negatively related to changes in inflation, equity returns are therefore negatively related to inflation. Thus changes in inflation will indicate changes in economic activity. As a result, the negative relationship observed between equity returns and inflation turns out to be spurious.

Building on this explanation Geske and Roll (1983) propose that one of the reasons behind the spurious (in the economic sense) relationship between inflation and equity returns, for the USA, is debt monetisation by the central bank. However, this opinion is later rejected by Ely and Robinson (1992). In a related argument, Kaul (1987) suggested that the anomaly may be due to a deficit-induced and counter-cyclical monetary policy that interacts with money demand. The proxy effect is supported by numerous studies which propose that changes in inflation in fact proxy for more fundamental determinants of equity prices (e.g. expected future output; uncertainty about relative prices) (Geske & Roll, 1983; Kaul, 1987; Kaul & Seyhun, 1990).

However, prior tests conducted by studies have empirical shortcomings. Firstly, the one period ahead actual output has been utilised to measure expected output and secondly, the dispersion of individual prices about their mean has been utilised to gauge relative price uncertainty. With this methodology many academic studies have found support for the proxy hypothesis (Cochran &

Defina, 1993). Both these measures have shortcomings with dispersion about the mean being very different from price uncertainty (Cuckierman, 1979,1893). Moreover, Lahiri, Teigland and Zaporowski (1998) also provides empirical evidence that measures of dispersion are not good measures of uncertainty. Cochran and Defina (1993) found that inflation has a consistently negative and significant impact on real stock prices irrespective of which variables are incorporated in the model. This implies that inflation does not simply proxy for other variables such as future changes in real output and price uncertainty, but is rather an important determinant of real stock prices. In summary, it is evident from the above mentioned literature that the proxy hypothesis has been supported and rejected by several studies.

Data properties and econometric methodology

An additional account for the contradictory relationship between equity returns and inflation suggests a link between the properties of time series data and the econometric methodologies used to investigate the hedging effectiveness. Firstly, the Fisher effect more accurately describes real world relationships over long periods of time, but most of the earlier studies are conducted on small samples over short periods. Consequently, more modern studies suggest that using longer data sets can increase sureness in the results e.g. Solnik and Solnik (1997) find a positive relationship between inflation and equity returns.

Secondly, measurement error in the inflation variable introduces the classical errors in variable problem in the OLS estimations of Fisher type models, which can be corrected for by an instrumental variable regression (Boudoukh & Richardson, 1993). Thirdly, equity returns and inflation rates display unique time series properties. Inflation is a gradual but persistent process, with a significantly lower variance than stock returns (Schotman & Schweitzer, 2000). Consequently, this impacts the validity of the correlation results between the two variables (Madsen, 2007). This arises because non-stationary variables introduce the problem of spurious regression, which is when significant relationships are found even though they don't exist (Granger, Hyung, & Jeon, 2001). To prevent the problem of obtaining spurious results, more recent academic studies look for co-integration between equity returns and inflation. If the two variables are non-stationary but co-integrated, then the regression can be interpreted as a co-integrating regression and reflective of an equilibrium relationship between the level of the index for the respective asset class and the consumer price index. However, because co-integrating regressions only consider long-term dynamics, they are usually supplemented by error correction models (ECM). This methodology, suggested by Granger (1983) and Engle and Granger (1987), captures both the short and long-run effects that one time series may have on another. Thus, an ECM allows one to capture short-run transitory changes as deviations from the long-run relationship. Alternatively, one could use the first differences as regression variables which could potentially solve the problem of spurious regression, however this eliminates long-run information that is crucial to measuring the Fisher effect (Hendry, 1986).

3.1.4 Consensus regarding the inflation hedging properties of equities post-1990

Literature investigating the relationship between equity returns and inflation subsequent to the 1990s has addressed these methodological issues, providing a broader picture than those of the previous two decades (Arnold & Auer, 2015). For example, a study by Boudoukh and Richardson (1993) utilised a long time series spanning nearly 200 years of data from 1802-1990 for the United states (US) and the United Kingdom(UK). They make use of an instrumental variable regression, with instruments such as past inflation rates and short and long-term interest rates. In both cases nominal stock returns over long-time horizons are positively related to both the ex-ante and ex-post inflation. Results from the OLS regression demonstrate an ex post Fisher coefficient of 0.52 over the sample period and similar coefficients for the two sub period from 1870-1990 and 1914 to 1990. Thus, Boudoukh and Richardson (1993) find that the relationship between equity returns and inflation in the US and UK in the short-run (1 year) are uncorrelated or slightly negatively correlated. However, over the long-run (5 years or more), they are positively correlated.

Results indicating a positive relationship, over the long run, between equity returns and inflation have been confirmed by multiple other academic studies (Solnik & Solnik, (1997); Lothian & Simaan, 1998). Solnik and Solnik (1997) tested the Fisher model using an instrumental variable approach. The instruments used were the 3-month treasury bill rate, long-term bond rate, past 3-month and 1-year inflation rates. However, they use a much shorter period of only 38 years which may result in sample bias and reduced testing power. This was econometrically compensated for by using a cross-section of 8 major countries. Solnik and Solnik (1997) found that the Fisher model holds for time horizons spanning 1-12 months (short-term), but the magnitude of the slope coefficient provides stronger support at longer horizons. These findings on the one hand support Boudoukh and Richardson's (1993) results regarding the positive relationship between equity returns and inflation over the long-run. On the other hand, they oppose this same study with respect to the Fisher model's applicability at short horizons. Additionally, Lothian and Simaan (1998) found that average equity returns kept pace with inflation in the long-run for almost all 23 OECD countries investigated. Moreover, across countries there was a positive correlation between equity returns and inflation.

Another academic study conducted by Lothian and McCarthy (2001) also make use of an extended time series data set. It covers data for both the US and the UK from 1790-2000 and for 14 OECD countries from 1945-1999. With the use of co-integration tests, a long time series for the US, UK and OECD panel data Lothian and McCarthy (2001) provide evidence that equity prices keep pace with movements in the overall price level. However, equities are only an inflation hedge over very long periods. For shorter horizons they found a negative relationship- making equities an unsuitable inflation hedge. Furthermore, an academic study by Anari and Kolari (2001) tested the long-run Fisher effect for 6 developed economies for 1953- 1998 (the US, Canada, the UK, France, Germany and Japan). They utilised monthly equity indices, price indexes and co-integration methods. Anari and Kolari (2001) found that the long-run elasticity of equity prices, with regards to inflation, ranges from 1.04-1.65; supporting the Fisher effect. Additionally, through impulse response analysis they found that the response of equity prices to fluctuations in consumer prices displayed an initial negative reaction, but stabilised and became positive over longer horizons. These findings suggest that investors should expect equities to be strong inflation hedges over long time periods.

This relationship was further explored by Schotman and Schweitzer (2000) who examined the sensitivity of the inflation hedging abilities of equities over different time horizons. They found that equities "provide a hedge against inflation if the investor's horizon is 15 years or longer" (Schotman & Schweitzer, 2000: 311). This is further evidence that equities tend to be a poor hedge in the short-run. Cochran and Defina (1993) are among the earliest authors to apply the ECM in an inflation hedging setting. They make use of US data from 1947-1989 and find evidence that real equity returns are not independent of inflation and in fact inflation, both actual or unexpected depress real equity returns. Therefore, US equities tend not to provide a long-term hedge. Both expected and unexpected constituents of the inflation rate have a negative effect on real equity returns. In contrast, Ely and Robinson (1997), using quarterly data from 1957-1992 for 16 developed economies, found that - with a few exceptions - equities generally maintain their real value relative to goods prices.

Another study conducted by Engsted and Tanggaard (2002) investigate the inflation hedging capabilities of US and Danish Equities from 1922-1997 with annual data. They improve upon Boudoukh and Richard's (1993) instrumental variable approach by making use of a VAR approach which involves no time overlapping variables which is said to cause significant issues. They measure multi-period expected returns and inflation from a VAR model involving one period variables. Their findings suggest that the relationship between expected returns and inflation strengthens as the time horizon increases for Danish stocks which confirms the Fisher hypothesis. However, contrary to the findings by Boudoukh and Richard's (1993) for US stocks they find that the Fisher model does not perform better as the horizon increases. They found that the relationship between expected inflation and expected returns weakens as the horizon increase from 1 to 5 to 10 years. Finally, in neither country do they find evidence that equities offer a good hedge against unexpected inflation not even in the long-run.

Ahmed and Cardinale (2005) examine the relationship between equity returns and inflation for different inflation regimes from 1919- 2002. Their study analyses 4 large and developed countries (US, the UK, Germany and Japan). They found that in the short-run equities appear to respond differently during periods of low or inflation. This implies that equites do not offer protection when it is most needed during periods of high inflation in the short-run. Kim and Ryoo (2011) further confirm this finding, and conclude that equity returns and inflation display asymmetric adjustments to the long-run equilibrium, which are themselves contingent on the inflation regime. Furthermore, they find compelling evidence that US equities have been a hedge against inflation in the long-run from the early 1950s, which coincides with the decline in the volatility of US inflation. The reason for the better hedging ability may well be attributed to more stable inflation rates, which increase the probability that inflation expectations become more accurate. This result offers further empirical validation with respect to the Fisher relationship between equity returns and inflation.

The literature to date on the relationship between equities and inflation within an African context has been scant. There is only one study conducted by Alagidede and Panagiotidis, (2010) that investigates this relationship for 6 African countries (Egypt, Kenya, Morocco, Nigeria, South Africa and Tunisia). They used both parametric and nonparametric co-integration procedures as well as monthly data for equity price indices and consumer price indices from 1980-2007. They illustrate that the point estimates for the elasticities of equity prices with respect to inflation ranges from 0.015 for Tunisia to 2.264 for South Africa. Moreover, these elasticities are positive and statistically significant with the exception of Tunisia and Kenya, which is indicative of a positive long- run relationship. This means that for every 1% increase in inflation the JSE all share index is expected to rise by 2.26% over the sample period. Furthermore, they find that the initial response of equity prices to inflation for Egypt and South Africa is negative but becomes positive over longer horizons. This suggests that equities tend to provide a hedge against rising consumer prices in African countries over the long-run but not in the short-run. The negative relationship observed between equity prices and consumer prices (also called the "inverted fisher effect") is well documented in the existing literate. These results are consistent with evidence from previous research which suggests a long-run positive relationship between equities and inflation in developed markets. This suggests that, at least in the long-run, investors in African stock markets should be protected from rising consumer prices.

In summary, the present state of scientific knowledge on the inflation hedging capabilities of equities suggest the following: Prior to the 1990s majority of studies mainly made use of OLS techniques and found that equities were not a good inflation hedges both in the short and long-run contradicting the Fisher effect. Post 1990, however, research began to make use of more advanced econometric approaches and have since found that equity returns tend to be a good inflation hedge in the long-run (5 years or longer). These results in fact confirm the theory behind the Fisher effect. However, in the short-run (1 year), research generally supports the idea that equities are an insufficient inflation hedge since inflation tends to be negatively correlated with equities. Furthermore, equities tend to perform poorly as an inflation hedge during periods of high inflation in the short and long-run. Despite the fact that academic studies post 1990 provide promising evidence that equities tend to be a good inflation hedge in the long-run, there is yet an outright consensus in this regard. Moreover, there is scant literature examining this relationship for stock markets in African developing countries; markets which are becoming increasingly important to investors for both global portfolio diversification and potential inflation hedging destinations that provide high returns (Harvey, 1995).

3.2 Bonds (fixed income securities) as an inflation hedge

Another traditional asset class that may potentially provide an investor with protection from inflation is bonds, especially government bonds. Some insight can be extracted from the basic bond pricing formula concerning the relationship that one could expect to observe between bond returns and inflation.

$$\mathbf{Price} = \frac{\mathbf{C}}{(\mathbf{1}+\mathbf{i})^{\mathbf{1}}} + \frac{\mathbf{C}}{(\mathbf{1}+\mathbf{i})^{\mathbf{2}}} + \frac{\mathbf{C}}{(\mathbf{1}+\mathbf{i})^{\mathbf{3}}} + \cdots + \frac{\mathbf{C}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}} + \frac{\mathbf{M}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}}$$

$$= \sum_{\mathbf{1}}^{\mathbf{n}} \frac{\mathbf{C}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}} + \frac{\mathbf{M}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}}$$

$$= \left(\frac{\mathbf{C}}{\mathbf{i}}\right)\left(\mathbf{1} - \frac{\mathbf{1}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}}\right) + \frac{\mathbf{M}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}}$$

C= coupon payment

n= number of payments (the number of coupon periods from the purchase date until maturity)

i= interest rate/YTM

M= maturity/par value

Where: $\sum_{\mathbf{1}}^{\mathbf{n}} \frac{\mathbf{C}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}}$ is the mathematical method of adding together the values of discounted coupon income.

The last term $\frac{\mathbf{M}}{(\mathbf{1}+\mathbf{i})^{\mathbf{n}}}$ represents the maturity/par value discounted to the current date.

From the above bond pricing formula, it is evident that a bond's price is determined by discounting all the future cash receipts to the present date utilising the yield to maturity for that particular bond as the discounting factor (Miles, 1969). When pricing a bond there are two distinct cash flows that need to be discounted. Firstly, the stream of coupon income payments and secondly, the par value that will be received at the maturity of the bond.

The yield to maturity is simply the discount rate that equates the present value of a bond's promised cash flows to its market price. A person who invests in bonds will earn a return equivalent to the yield to maturity if the following two conditions are satisfied. (1) The bond must be held until maturity. (2) All of the coupons received throughout the duration of the bond's life must be reinvested at the same as the original yield to maturity until the bond matures. Assuming no default, the first condition removes the prospect of capital gains or losses because the bond will be worth par at maturity. The second condition guarantees that the reinvested coupons earn the same rate as the original investment. Assume that condition two (reinvestment of the coupons at the original yield to maturity) is dropped but condition one remains, that the bond is held to maturity. This implies that if the coupons are reinvested at a higher rate, the investor's return will also be higher. Conversely, if the coupons are reinvested at a lower rate this implies a lower return than the original yield to maturity. Consequently, the longer the investment horizon, the larger the impact of the reinvestment rate on the realised return. On the other hand, if condition one (holding the bond until maturity) is relaxed and investors hold the bond for only a short period before selling it then the fundamental determinant of the realised return is the price at which the bond is sold (Stewart, Piros & Heisler, 2011:279).

Standard present value analysis implies that if the bond's yield rises, the price of the bond declines and vice versa. This is evident from the above bond pricing equation and at face value one would intuitively expect bonds to be a poor inflation hedge due the inverse relationship. More importantly, when inflation is unexpectedly high (low), interest rates and bond yields rise (fall), inducing capital losses (gains) that are offset by the opportunity to reinvest at higher (lower) rates. This is what one should intuitively expect. Whether the reinvestment component or capital gains and losses component dominate depends on the investment horizon and duration (Stewart, Piros & Heisler, 2011:281). Therefore, as inflation rises to levels that are undesirable the central bank will respond by raising the short-term interest rates, which reduces the value of the bond. If the bond is sold before maturity the investor makes a capital loss because of the impact of inflation. Moreover, even if the bond is held until maturity and the fixed par value is received, that value will be reduced in real terms because of inflation erosion. However, the higher short-term interest rates because of inflation presents a chance for the investor to reinvest their coupon income at higher interest rates and enhance their return to hedge against inflation. Therefore, whether bonds are a good inflation hedge or not depend on the net effect of the reinvestment income and capital gains/losses components of bond returns. If the income component of bond returns dominates the price effect component one would expect bonds to be a good inflation hedge and vice versa. Which effect dominates is depends as stated above on the investment horizon and duration of the bond (Stewart, Piros & Heisler, 2011:281).

In summary since the bond's coupons and principal payment are fixed in nominal terms, if inflation rise the real return an investor receives is less implying that bonds are not an inflation hedge. Conversely, when inflation rises, interest rates and bond yields tend to rise suggesting there might be a hedge in terms of earning a higher interest rate in periods of higher inflation. Therefore, the inflation hedging ability of bonds depends on whether the capital loss as a result of the higher interest rate exceeds the higher future reinvestment rate.

An influential academic study regarding the ability of bonds to hedge inflation was conducted by Fama and Schwert (1977). Using monthly, quarterly and semi-annual data for the USA from 1953-1971, they found that government bonds and bills tend to be complete hedges against expected inflation. Stated differently, Fama and Schwert (1977) found that the expected nominal returns on these instruments fluctuated directly with the expected inflation rate so that their expected real returns were unrelated to the expected inflation rate. Conversely, government bonds were found to be poor inflation hedges during periods of unexpected inflation (using ex post returns). Moreover, the negative relationship between government bonds and unexpected inflation appears to strengthen with the maturity of bonds since longer (future) time periods require larger adjustments for expected nominal returns.

Another academic study conducted by Bekaert and Wang (2010) also found that bonds have a poor ability to hedge unexpected inflation. Using a cross- section of over 45 countries with annual government bond returns from 1970-2010, the authors concluded that, in half the countries, bond returns exhibited a significantly negative relationship to inflation; even earning negative returns in periods of high inflation. According the Bekaert and Wang (2010), such a finding was not surprising because, while expected inflation should be priced into the return of bonds, the bonds themselves will nonetheless be sensitive to unexpected inflation. Indeed, this study showed that the annual government bond returns for 17 out of 19 statistically significant (inflation) betas of bond returns, were either negative or fluctuating between 0 to −3. In conclusion, their results suggest that nominal government bonds are poor inflation hedges in the short and long-run for a vast majority of their large cross section of countries.

Recently, a study conducted by Brière and Signori (2012) in the US used a VAR model with an investment horizon spanning from 1 month to 30 years. The authors found that the inflation hedging capabilities of nominal bonds differed according to the regime and hedging horizon. They analysed two regimes, the first from 1973-1990 and the second from 1990-2010. Results from the first regime suggest that nominal bond returns are negatively correlated with inflation, with coefficients dropping to -0.7. In the second regime, nominal bond returns exhibited a positive relationship with inflation for horizons around ten years. Therefore, in the second regime nominal bonds appear to provide a partial hedge against inflation in the longer run.

3.2.1 Inflation linked bonds

The poor inflation hedging capabilities of bonds has led to the emergence of inflation linked bonds (ILB) which link principal payments, and/or coupon payments, to an inflation index. As such, ILBs provide investors with multiple benefits: they protect an investor's long-term real returns, they increase debt savings due to positive inflation risk premiums, they provide predictable real financing costs, they stabilise financial markets through additional possible payoff structures, *and* reduce the governmental incentive to inflate debt (Garcia & Van Rixtel, 2007). This is partially explained by ILBs exhibiting a low correlation with alternative asset classes and hence a lower volatility of real returns which then allows for protection against inflation risk and diversification within their portfolio (Kothari & Shanken, 2004; Swinkels, 2012). However, despite their numerous benefits, the ILB market only represents a small fraction of government debt, leading to a lack of liquidity compared to standard bonds. Additionally, not only is the cost of issuing ILBs higher than for standard bonds but, as a result of the index measurement being biased or lagged, specific inflation indices may in fact differ from the inflation exposure of a particular investor (Bekaert & Wang, 2010; Campbell & Shiller, 1996). Finally, although inflation linked bonds can potentially provide investors with a good inflation hedge, Dudley (1996) proposes that the inflation hedging ability of inflation linked bonds are significantly affected by the prevailing monetary policy regime.

In summary, the literature suggests that nominal bonds with fixed principal or coupon payments are susceptible to inflation surprises. Nominal bonds tend to exhibit a negative relationship with inflation in the short-term, However, have potential to protect investors from inflation in the very long-run (10+ years). Despite the near-perfect inflation hedging capacity of ILBs in the long-run, investors still seem to opt for nominal bonds. This may be due to both the liquidity issues facing ILBs and the small amount of differing maturities to choose from that restrict their usability for investors.

3.3 Real estate as an inflation hedge

Due to the limitations facing ILB markets, the majority of investors continue to depend on the indirect inflation hedging properties of traditional asset classes (Arnold & Auer, 2015). In this regard, real estate represents yet another potential inflation hedge for investors. This asset class is very heterogeneous and provides a diverse set of investment vehicles for an investor to choose from. Prior literature on the inflation hedging capabilities of real estate distinguish between public and private real estate, residential and commercial real estate as well as indirect (securitised) and direct (unsecuritised) ways of investing in the real estate sector.

Despite the variety of investment methods in real estate, the underlying justification for the potential inflation hedging ability of property is generally the same: that real estate has an underlying value determined by the market and obtains a total return in two typical ways (Arnold & Auer, 2015). Firstly, through income which arises from rent. Secondly, real estate derives a return from capital appreciation (resulting from higher demand for example). Therefore, inflation has several ways of influencing the total return and inflation hedging capabilities of a real estate asset such as through the growth in rental income, the growth in expenses, as well as through the capitalisation rate (Huang & Hudson-Wilson, 2007). The responsiveness of real estate returns to inflation depends significantly on the lease arrangement which consists of influential factors such as the lease length, inflation linked rental increases and the possible pass-through of expenses (Huang & Hudson-Wilson, 2007; Le Moigne & Viveiros, 2008).

Nevertheless, it is possible to protect property investments from inflation by linking rental income to actual inflation indices. Some rental contracts include an explicit tie to an inflation index while others include annual contractual increases (in an effort to predict forthcoming inflation). Unless an inflation index is specified in the rental contract, the terms of the lease play a significant role in inflation sensitivity of real estate returns. Generally, shorter term lease lengths provide better hedging efficacy. To the extent that it reduces an investor's net income, expenses are also a medium through which inflation can impact the total return obtained from real estate. The effect of inflation is stronger when it increases expenses such as maintenance of the property, thereby reducing the real estate's ability to hedge inflation. However, if these factors are accounted for in the lease agreement, and rental income rises with inflation, then real estate may provide a perfect hedge against inflation. For example, a perfect inflation hedge would be a long-term lease with inflation indexed rents and 100% expense and structural pass-through. In contrast, a fixed rent with the owner accountable for expenses and a very long lease would provide minimal hedging against inflation (Huang & Hudson-Wilson, 2007). In summary, the inflation hedging capabilities of real estate can be influenced through the net income process, or through the valuation procedure.

There are two main ways that an investor can invest in real estate: either directly through ownership of the property without financial vehicles, or indirectly through financial vehicles such as real estate investment trusts (REITS) or property indices. However, there are some major drawbacks of investing in real estate directly. These include requiring a large initial capital outlay, the absence of a central market, a need for local market knowledge, low liquidity, high transaction costs, maintenance expenditures and management requirements (Wilson & Zurbruegg, 2003). These shortcomings, in addition to the problems presented by low frequency data and subsequent doubts regarding the reliability of appraisal based returns, have steered the academic focus toward securitised real estate markets; consequently, giving rise to the introduction of real estate investment trust (REITs). REITs are financial vehicles that pool funds of investors in order to invest in income producing mortgages, real estate properties, joint ventures and other hybrid structures. Moreover, REITs can be segmented into mortgage REITs, which hold mortgages and construction loans, or equity REITs, which specialise in income producing properties (Chen & Tzang, 2009). It is important to note that REITs and real estate stocks are different. The underlying assets of REITs are primarily real estate and, although evidence suggests that REITs tend to behave more like equities than real estate, the equity component of REITs may be declining according to Adrangi, Chatrath, and Raffiee, (2004). Nevertheless, REITs enjoy steady cash flows as a result of high dividend payouts - a characteristic that differs from common stocks.

The inflation hedging capabilities of real estate has received considerable attention in the literature since an early paper published by Fama and Schwert (1977). They found that nominal real estate returns do co-vary in a one to one relationship with inflation in the American market. More specifically, Fama and Schwert (1977) illustrate that private residential real estate can offer an effective inflation hedge against expected and unexpected inflation. Later studies have since confirmed this finding, although they differ with respect to the hedging coefficients obtained which are generally smaller than one. Recent research thus shows that private real estate only provides a partial hedge against inflation. Moreover, in contrast to Fama and Schwert (1977), later studies only find evidence that private real estate provides an inflation hedge against expected inflation and not unanticipated inflation (see Simpson, Ramchander & Webb, 2007).

An important question is whether these results are true for securitised forms of real estate. Owing to the problem of data-related pitfalls within unsecuritised real estate, an alternative strand of literature has developed using REIT returns. Hence it is important to consider the literature pertaining to the relationship between inflation and REITs returns. Surprisingly, in contrast to theory which suggests that real estate should provide an inflation hedge, early findings for securitised real estate were similar to those of equities from the late 1970s (Arnold & Auer, 2015). These findings illustrated that REIT returns appear to be a deficient hedge against inflation with either negative or insignificant inflation hedging coefficients. This appears to contradict the partial inflation hedging capabilities of unsecuritised real estate mentioned earlier. Two particular studies by Chatrath and Liang (1998) and Adrangi, Chatrath and Raffiee, (2004), support the traditional view that REITs do not hedge inflation. This is in contrast to direct real estate with similar sample periods from 1972- 1995 and 1972-1999 respectively. One reason for these unexpected findings may perhaps be related to the method by which inflation hedging with REITs test the Fama and Schwert (1977) model and/or its extensions based on "deficient" OLS methods.

The negative relationship between REIT returns and inflation had been documented for various sample periods and countries, and the reasoning behind it was only explained when more advanced econometric models, such as cointegration, were introduced. These more advanced approaches, which can differentiate between the long-run equilibrium and short-run dynamic adjustments, provide possible reasons for this relationship e.g. spurious regressions, differences in information processing between REITs and direct real estate, long and short-run dynamics, regime dependency and asymmetric adjustments of REIT returns to inflation (see Hoesli, Lizieri & MacGregor, 2008)

Obereiner and Kurzrock (2012) investigated three indirect real estate investment vehicles in Germany from 1992 -2009 using monthly data. These were open-end funds (OEF), special funds and real estate stocks. Using the Fama and Schwert (1977) framework they found that none of the three provided a hedge against both expected and unexpected inflation in the short-run. However, when using the ex-post inflation rate which did not separate the effects of expected and unexpected inflation, they found robust evidence that real estate returns are almost independent of inflation in the short-run. Moreover, using the Johansen cointegration method, they found that real estate stocks, OEF and special funds provided a hedge against inflation in the long-term; with Granger causality tests indicating that real estate performance is influenced by inflation in the long- term.

Indeed, most academic studies argue that the inflation hedging capability of real estate depends not only on the specific type of real estate asset, but also on the regime (Ganesan & Chiang (1998); Glascock, Lu, & So (2000, 2002); Hoesli, Lizieri & MacGregor, 2008; Le Moigne & Viveiros (2008); Hardin, Jiang, & Wu (2012)). An academic study by Ganesan and Chiang (1998) utilising the Fama and Schwert (1977) framework found results that differed substantially depending on the type of real estate asset investigated. They found that commercial and residential real estate in Hong Kong had good inflation hedging capabilities with respect to expected and unexpected constituents of inflation for the period of 1984 -1994. Conversely, other private real estate and property stocks did not provide an inflation hedge in the short-run, while, in the long-run, only real estate stocks were found to be cointegrated with inflation.

Glascock, Lu, and So (2002) provide two possible reasons why REITs (securitised real estate) returns and inflation provide counter-intuitive results given that unsecuritised (direct) real estate provides a partial inflation hedge. The first highlights the presence of spurious regressions based on inadequate econometric modelling in past literature that reverse the causal relationship between inflation and REITs returns. Secondly, REITs could be more efficient in information processing than the general real estate sector (see by Glascock, Lu, & So 2002). Glascock, Lu, and So (2002) incorporated the effects of changes in monetary policy and found that evidence of REIT returns as poor inflation hedges are spurious. Additionally, they find that REIT returns granger causes changes in expected and unexpected inflation.

Similar to Glascock, Lu, and So (2002) another study conducted by Lee and Lee (2012) conduct their research on a US total return REIT index. Using dynamic OLS models and cointegration for monthly data from 1972-2007, they found that REITs acted as a long-run positive hedge against expected inflation following the 1993 structural break and the coincident tax reform. This tax reform made it more attractive for institutional investors to invest in REITs. This supports the Fisher hypothesis. Moreover, results showed that the positive hedging capability of REITs is driven by large-cap REITs, since small-cap REITs do not hedge inflation once isolated from the influence of large REITs.

Another academic study by Hardin, Jiang, and Wu (2012) also accounts for the structural break in the US. They made use of monthly data which was segmented into two sub periods of 1980-1992 and 1993-2008. This was done in order to try obtain robust evidence on real estate stocks and REITs. Making use of dividend yield composition, they found that both inflation illusion and hedging effects existed in REITs. However, the effect of inflation illusion seems to dominate throughout the entire period. These results support Modigliani and Cohn's (1979) hypothesis that investors are unable to rapidly reconcile the changes in discount rates and dividend growth rates associated with inflation in stock prices. Therefore, despite the fact that one might observe that REIT stock prices are negatively related to expected inflation, REITs compensate investors for the expected component of inflation through the dividend growth rate.

To summarise, it is evident that early empirical evidence shows that direct (unsecuritised) real estate does tend to provide an investor with a partial hedge against inflation despite the practical shortcomings of OLS being deficient and data related problems. On the other hand, earlier studies have found a negative relationship between REITs (securitised) returns and inflation. Additionally, more recent studies from the 1990s onward have made use of more advanced econometric techniques such as cointegration in the real estate literature which has produced ambiguous results with respect to the inflation hedging capabilities of direct(unsecuritised) and indirect(securitized) real estate. The contradictory results should be understood as indicative of differences in the sample period, type of real estate and inflation regime; factors which undoubtedly impact the relationship between inflation and real estate returns.

3.4 Cash as an inflation hedge

Finally, if an investor is risk averse but would still like to hedge against inflation, then cash could potentially provide a less risky alternative of inflation hedging. As mentioned before the Fisher hypothesis assumes that the real interest rate is independent of expected inflation and constant over time. As such, if this holds it would suggest that short-term debt instruments[2] (e.g. treasury bills) should provide a perfect hedge against inflation provided there are no inflationary shocks[3] (Attie & Roache, 2009). However, this notion has been challenged and studies conducted by Mundell (1963) and Tobin (1965) claim that nominal interest rates change by less than one to one with changes in inflation and consequently, the real interest rate falls during inflation. On the other hand, the active monetary rule suggests a positive relationship between real interest rates and inflation as a consequence of central banks responding to inflationary pressures with tightened monetary policy (Taylor, 1993)

A study conducted by Brière and Signori (2012), which analysed regimes, found that during the first regime (1973-1990) cash tends to have a positive correlation with inflation in the short-run

[2] Frequently referred to as the cash in the investment realm.

[3] The reason for the condition that there be no inflationary shocks is because Fisher believed that the relationship between real interest rates and expected inflation was more probable to hold over the long run as opposed to the short run. Nevertheless, the Fisher hypothesis is frequently used to depict the likely behaviour of short term interests (Attie & Roache, 2009).

and thus provides a partial inflation hedge. Moreover, in the longer run (30 years) cash provides the best correlation with inflation of approximately 0.6; this ahead of inflation linked bonds, real estate, equities and nominal bonds respectively. In the second regime (1991-2010), cash and all the other assets exhibit a close to zero correlation with inflation in the short-run, with cash providing the strongest inflation hedge. In the longer run, the correlations improve and cash provides the best protection against inflation.

Another study conducted by Bekaert and Wang (2010) for over 45 countries spanning from 1970-2010, found that treasury bills with a 1 month and 3-month maturity provided an inflation hedge. A crucial reason for this is because treasury bill returns can swiftly adjust to changes in expected inflation. However, as a consequence, they may not incorporate risk premiums for inflation risk and thus perform poorly as a hedge against unexpected inflation shocks. The inflation betas for the treasury bills are all positive and mostly between 0 and 1. This implies that treasury bills are partial inflation hedges and that, although they adjust to changes in inflation, they do not do so adequately. One need only observe the treasury bill inflation betas with respect to unexpected inflation for approximately half the countries, in order to judge their relative efficacy. While some beta values plummet near 0, others in fact become negative, suggesting that treasury bills are poor hedges against unexpected inflation. This study illustrates that treasury bills do co-move with inflation and hence provide a partial inflation hedge. However, they fail to hedge unexpected inflation. Consequently, inflation-linked bonds are vital to really hedge inflation risk.

Spierdijk and Umar (2015) using monthly data for the US spanning 1983-2012 analysed the inflation-hedging ability of treasury bills at the sub-index level. This study lends further support to the notion that treasury bills provide investors with inflation protection. They found that the 3-month, and to a lesser extent the 6-month and 1-year treasury bill indices, have significant hedging capability. Moreover, for each of the three treasury bill indices, the correlation improved with the investment horizon. This pattern reflects that treasury bills have better inflation hedging abilities in the long-run. For a 10-year investment horizon, the squared correlation corresponding to the 3-month treasury bill index equaled almost 70%. However, the treasury bills' hedging ability decreased with the maturity of the treasury bill. Consequently, there is a trade-off between having treasury bills that are good inflation hedges vs. the return they provide over time. The significantly positive relationship between 3-month treasury bill returns and inflation rates during the 1983–2012 period supports the conclusions of preceding studies, beginning in the 1970s or earlier, with regard to the inflation-hedging capabilities of 3-month treasury bills. The positive short, medium and long-run correlations that the study found for 3-month treasury bills are consistent with the findings of Brière and Signori (2012). Thus, in summary it appears that Spierdijk and Umar (2015) establish that 3-month treasury bills are useful inflation hedges during periods of high macroeconomic volatility, countercyclical supply shocks, as well as during years of low macroeconomic volatility and pro cyclical demand shocks.

Spierdijk and Umar (2015) further distinguish between expected and unexpected inflation. This is essential because assets could have a zero correlation with actual inflation if their returns correlate positively with expected inflation but negatively with unexpected inflation or vice versa. As used in the Bekaert and Wang (2010) study, Spierdijk and Umar (2015) use the previous period's inflation rate as a proxy of expected inflation. The motivation behind selecting this as the proxy for expected inflation stems from the positive autocorrelation observed in realised inflation rates. The unexpected inflation is determined by the one period difference in inflation. They found that the returns on the 3-month treasury bill index correlated significantly with expected inflation irrespective of the investment horizon. Additionally, 3- month treasury bill correlate significantly with unexpected inflation for investment horizons of four years or more. They also found that while shorter-maturity treasury bills are better hedges against expected inflation, longer-maturity treasury bills are better hedges against unexpected inflation.

In summary prior literature suggests that treasury bills do tend to provide partial inflation protection; with the 3-month treasury bill exhibiting the best inflation hedging abilities in relation to both expected and unexpected inflation. This finding suggests that the inflation hedging ability of treasury bills are necessarily affected by their maturities and/or the relative investments horizon.

4. Description of data

All the data used in this study is obtained from either I-Net BFA, Data Stream or Bloomberg databases. The content, source, frequency of data and time period of each data series for domestic and foreign asset classes are presented in a table in appendix A2 and A3 respectively. Our study examines the relationship between the returns on various asset classes both domestic and their foreign counterparts with respect to the domestic inflation rate in South Africa. The study spans from 1965-2015 and makes use of monthly data. Furthermore, where applicable all the total return indices will be used. Below is a detailed description of the indices used.

4.1 Equities

Domestic equity returns are proxied by the FTSE/JSE All-share index. The reason for using this index is because it signifies 99% of the full market capital value, of all ordinary securities listed on the main board of the JSE, subject to minimum free float and liquidity standards (FTSE Russell, 2016). Hence, it is a comprehensive and representative proxy for the entire equity market in South Africa. Furthermore, the FTSE/JSE All-share index equity returns are segmented by obtaining the Financial and Industrials index and the Resources index. The reason underlying this is because these two indices account for a significant portion of the variation in the FTSE/JSE All-share index as established by a number of academic studies (Van Rensburg & Slaney, 1997). Foreign equity returns are proxied with the well diversified MSCI world equity index. It is a comprehensive international equity benchmark that represents large and mid-cap equity performance across 23 developed countries. Additionally, it covers approximately 85% of the free float-adjusted market capitalisation in each country (MSCI, 2016).

4.2 Bonds

To proxy domestic bond returns the Government Bond Index (GOVI) and the All Bond Index (ALBI) are utilised. The GOVI index comprises the top 10 bonds issued by the South African government that make it into the ALBI composite index. In other words, the GOVI index contains a fixed number of 10 bonds issued by the South African government. The ALBI index is a composite index that contains the top 20 vanilla bonds ranked dually by liquidity and market capitalisation. Moreover, the ALBI contains both government and corporate bonds in contrast to the GOVI which contains only Government bonds (JSE, 2016). To proxy foreign government bonds the Citigroup World Government Bond Index is used. The World Government Bond Index is a widely used benchmark that contains sovereign debt from over 20 countries denominated in a variety of currencies. It provides a benchmark for the global sovereign fixed income market. The World Government Bond Index measures the performance of fixed rate, local currency, investment grade sovereign bonds and contains countries that satisfy specific criteria for market size, credit quality and barriers to entry (Citigroup, 2016).

4.3 Real estate

Domestic property will be proxied with a combination of the following indices; the FTSE/JSE SA listed property index (SAPY) which only dates back to 2002 and the property index dating back to 1965 which will be spliced together. The SAPY total return index contains the 20 most liquid firms measured by full market capitalisation in the real estate investment and services sector and Real Estate Investment Trusts Sector, with a primary listing on the JSE (JSE, 2016).

As a proxy for foreign real estate the FTSE EPRA/NAREIT global developed total return index and the MSCI world real estate total return index will be used. The FTSE EPRA/NAREIT global Developed index includes Real Estate Investment Trusts (REITs) and Real Estate Holding & Development companies. It represents general trends in eligible real estate equities globally. Moreover, it is designed to track the performance of listed real estate companies and REITS worldwide (FTSE Russell, 2016). The MSCI world real estate index is also a good proxy for foreign real estate. It is a free float-adjusted market capitalisation index that consists of mid and large-cap equity covering 23 developed markets countries. All securities in the index are classified in the real estate industry group (MSCI , 2016).

4.4 Cash

To proxy domestic cash the Alexander Forbes money market index (GMC1) and the Alexander Forbes short term fixed interest (STEFI) composite index was utilised. Additionally, an index was made out of the 90 day bankers' acceptance rates (RBAS) (see appendix A1). The GMC1 is based only on three-month negotiable certificate of deposit (NCD) instruments. Since over time the money market has evolved to offer a wider range of instruments another index was created by Alexander Forbes called the STEFI. The STEFI is said to more accurately reflect the current variety of money market instruments available to investors. The STEFI index has become the industry benchmark for cash equivalent investments up to 12 months (IT Web Financial, 2001). For the foreign cash proxy, the 3-month US treasury bill rate will be converted into a rand denominated index and used in this study (see appendix A1). This is because most academic studies around the world consistently use the 3-month treasury bill to determine the performance of cash (for example Ibbotson & Sinquefield, 1989). The 3-month treasury bill is widely acknowledged as providing the benchmark for "risk-free" returns (Firer & McLeod, 1999).

4.5 Other variables used in the study

Just as in majority of prior academic studies, inflation will be proxied with the South African CPI index rebased to 100 in 2012. Additionally, the dollar/rand exchange rate, dividend yields and earnings yields were used in the study It is important to note that all the foreign indices were denoted in USD. These were all converted into comparable rand returns using the dollar/rand exchange rate. This was achieved by multiplying the various total return indices by the USD/ZAR exchange rate. The dividend yields were used to calculate dividends which was added to the price indices to form total return indices where required for the domestic assets. The method used to calculate dividends can be seen in below.

4.6 Methodology used to calculate total return indices.

In order to derive the total return indices for the JSE All Share, Financial and Industrial, Resources and Property spanning from 1965-2016 the following methodology was applied. A method similar to Firer and McLeod (1999) was utilised to obtain the dividends for the indices. The reason underlying this calculation is because the above aforementioned indices do not have total return indices spanning all the way back to 1965 and therefore need to be computed.

$$\mathbf{D(t)} = \frac{\mathbf{DY_{(t-1)}PI_{(t-1)} + DY_{(t)}PI_{(t)}}}{\mathbf{2400}}$$

Where:

$\mathbf{D(t)}$= The dividend received for month (t).

$\mathbf{PI_t}$= The price index at time (t).

$\mathbf{DY_{(t)}}$= The dividend yield at time (t).

The reason underlying this modification is because the All Share total return index (J203T) only dates back to the 30th June 1995, whereas the JSE All Share price index(AJ203) dates back to 31st January 1965.

$$\mathbf{AJ203T = AJ203 + D_t}$$

Where:

$\mathbf{AJ203T}$= The derived All Share total return index.

$\mathbf{AJ203}$= The All Share price index.

$\mathbf{D_t}$**=** The dividend received for month (t).

Therefore, the initial step was to calculate the dividend for each month $D(t)$ using the above methodology and then subsequently this was added to the AJ203 price index in order to obtain the total return index.

4.7 Methodology used to merge indices

Subsequently, in order to ensure that the most up to date All Share total return index was used in the study, the derived AJ203T was spliced together with J203T. This was achieved by taking the initial data point of the J203T index which dated back to 30th June 1995 and replacing the AJ203T index with J203T from that point in time onwards. Additionally, the data point of the J203T index which dated back to 30th June 1995 was divided by the derived AJ203T index data point on that same date. This provided us with a ratio which was then used to scale the AJ203T index in proportion to the latest J203T index by multiplying all AJ203T data points prior to 30th June 1995 by the ratio. This can be illustrated as follows:

$$(\mathbf{AJ203T + J203T})_{\mathbf{1965-2016}} = \left[\mathbf{AJ203T_{1965-1995}} * \frac{\mathbf{J203T_{1995}}}{\mathbf{AJ203T_{1995}}}\right] + \mathbf{J203T_{1995-2016}}$$

Where:

$(\mathbf{AJ203T + J203T})_{\mathbf{1965-2016}}$= The combined derived All Share total return index dating back to 1965.

$\mathbf{AJ203T_{1960-1995}}$= The derived All Share total return index.

$\frac{\mathbf{J203T_{1995}}}{\mathbf{AJ203T_{1995}}}$ = Splicing factor used to merge the indices.

$\mathbf{J203T_{1995-2016}}$= The All Share total return index.

The above methodology used to merge the data series was also applied to the Financial and Industrial, Resources, Property and cash price indices in order to obtain the most up to date total return indices dating back to 1965 (see appendix A4). Moreover, appendix A5 contains a table with the merging dates of the relevant indices.

Table 1 below depicts the short hand names to be used for each series in the tables of the results section.

Table 1: Short hand names of the indices.

Time series	Short hand name
All share total return Index	ALSITR
Financial and Industrial total return Index	FINDITR
Resources total return Index	RESITR
Government bond total return Index	GOVITR
All bond total return Index	ALBITR
Property total return Index	PROPERTYTR
Cash Index South Africa	SACASH
90-day banker's acceptance rate	RBAS
MSCI world equity total return Index	MSCI WORLD EQUITY
Citi-group world government bonds Index	CITI-BONDS
MSCI world real estate Index	MSCI WORLD PROPERTY
FTSE/EPRA NAREIT developed real estate Index	FTSE PROPERTY
US 3-month treasury bill (USTB3M)	USCASH
Consumer price index (South Africa)	CPI

The earliest common period for which all domestic and foreign asset classes are directly comparable is 1999-2015 (see appendix A2 and A3). Hence when comparing all four domestic asset classes versus each other and foreign asset classes this period will be the considered period. Total return indices for domestic equities and property did not date back to 1965. In these instances, they were spliced together with total return indices that were created with their respective price indices and dividend yields that did date back to 1965 as explained above in sections 4.6 and 4.7. Finally, the Alexander Forbes money market index and STEFI cash index were spliced together to get the most accurate up to date representation of cash as an asset class (see appendix A4).

5. Methodology

This section gives a detailed description of the different methodologies that are applied in this study to investigate the relationship between the various asset class returns and inflation.

5.1 Pearson correlations

The first step taken to test the relationship between asset returns and inflation is to examine the contemporaneous correlation between asset returns and inflation over both the short-term (1 year) and long-term (5 years or more). If the asset classes are a perfect hedge over the short-term and/or long-term one would expect a correlation close to 1 in nominal terms and not significantly different from zero in real terms (Ahmed & Cardinale, 2005). The Pearson correlation is what most of the literature and practitioners focus on (Ang, 2014). However, when interpreting these correlations, it is important to remember that: 1) only linear relationships, without controlling for the influence of other variables are investigated and 2) given the large number of relationships examined it is likely that few may be spurious in nature despite passing conventional tests of statistical significance (Van Rensburg, 1999).

5.2 Granger causality

The idea behind Granger causality is that a variable X Granger causes variable Y if variable Y can be better predicted using the histories of both X and Y than it can be predicted using the history of Y alone. This can be depicted by the following expectation:

$$\mathbf{E[Y|Y_{t-k}, X_{t-k}] \neq E[Y|Y_{t-k}]}$$

Since contemporaneous correlation ignores lagged effects, the subsequent step is to examine the predictive power of historical values of one variable for subsequent realisations of the other variable (Granger, 1969). In other words, if past values of inflation explain any of the four asset class returns (equities, government bonds, property or cash), then inflation granger causes that particular asset class's return. However, it is important to note that this does not imply "true causality" in any behavioural sense, it just implies that past inflation helps predict the future pattern of asset class returns (i.e. inflation movements precede asset class return movements). Simultaneously, past values of asset class returns could contribute to explaining current inflation, suggesting reverse causality and a more complex pattern. Moreover, lagged adjustment of asset class returns to inflation can also be captured by the Granger causality framework. The correlation and Granger causality analysis helps examine a pattern of association between the individual asset class returns and contemporaneous and past inflation.

Therefore, the presence of dynamic relationships will be examined through the use of granger causality tests. Granger (1969) and Sims (1972) suggested tests for 'causality' between two series (X_t) and (Y_t) based on the estimation of whether past values of (X_t) improve the prediction of the current value of (Y_t). If it is found to be true, then it can be said that (X_t) "Granger causes" (Y_t).

The direct Granger causality test regresses each variable on lagged values of itself and the other explanatory variable. In order to test for Granger causality, it involves estimating the following unrestricted **(1a)** and restricted **(1b)** OLS regression models:

$$\mathbf{Y_t = \sum_{k=1}^{K} \alpha_k Y_{t-k} + \sum_{k=1}^{K} \beta_k X_t - k + D_t + \varepsilon_t} \quad \textbf{(1a)}$$

$$\mathbf{Y_t = \sum_{k=1}^{K} \alpha_k Y_{t-k} + \varepsilon_t} \quad \textbf{(1b)}$$

Where:

$\boldsymbol{\alpha_k}$: The coefficient on the lagged Y-values

$\boldsymbol{\beta_k}$: The coefficient on the lagged X-values

$\mathbf{D_t}$: The deterministics

Starting with a one period lag instead of setting k=0 in order to not include instantaneous causality in the model (instantaneous causality is when the changes in Y and X occur at the same time and are correlated).

If in the regression depicted in **(1a)** of Y_t on lagged values of Y_t and X_t, the coefficients (β_K) of the X_t values are zero then the series of X_t fails to granger cause Y_t. The only difference between the restricted and unrestricted model is that the restricted only includes lags of the dependent variable, whereas the unrestricted model will also include lags of the independent variable as seen above.

To determine whether (X_t) granger causes (Y_t) the F statistic ~ F(K, N-k) where N= the number of observations, is employed to test the null hypothesis that $\beta_1 = \beta_2 ….. = \beta_k = 0$ (non-causality). The rejection of the null hypothesis implies that (X_t) does "Granger cause" (Y_t). In other words, this means that past values of (X_t) do improve the prediction of the current value of (Y_t) (Van Rensburg, 1999).

5.3 Tests for stationarity

In order to test each variable for unit roots both the augmented Dickey-Fuller and Phillips-Perron tests will be utlised (Dicky & Fuller, 1979; Phillips & Perron, 1990). Before conducting any further analysis, all the relevant variables in the dataset will be pretested for stationarity using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The augmented Dickey-Fuller test differs from the basic Dickey-Fuller(DF) test by adding a trend term or lagged first differences until the serial correlation in its error term is zero (Van Rensburg, 2016). In other words, the basic DF tests for stationarity with a random walk and the ADF tests for a random walk with drift which is a more realistic depiction of equities. This pretesting is conducted to circumvent the Yule (1926) and Granger & Newbold (1974) spurious correlation problem that arises when estimating the relationship between two non-stationary series.

Unit root tests will be conducted for both the level series and their first differences, respectively. The principle that should be followed in constructing the ADF test is to ensure that its specification does justice to the true data generating process. The inclusion of a constant term (α_0) allows for the depiction of a random walk with drift and is appropriate in all cases where the mean of the series is not zero (Van Rensburg, 1999). In order to test the null hypothesis that the data generating process has a stochastic trend against the alternative of trend stationarity, a time trend (α_t) is included in the model used to test for the unit roots (Harris, 1995:29). Thus, as a default case the most restricted form of the Dickey fuller test i.e. the least likely to reject the null hypothesis of non-stationarity will be conducted on each series $\{Y_{it}\}$ and is estimated with the following regression:

$$\Delta \mathbf{Y_{it}} = \boldsymbol{\alpha}_{\mathbf{i0}} + \boldsymbol{\alpha}_{\mathbf{i1t}} + \boldsymbol{\beta}_{\mathbf{i0}}\mathbf{Y_{it-1}} + \sum_{\mathbf{j=1}}^{\mathbf{N}} \boldsymbol{\beta}_{\mathbf{ij}}\Delta \mathbf{Y_{it-j}} + \boldsymbol{\varepsilon}_{\mathbf{it}}$$

$$\textbf{Where } \boldsymbol{\varepsilon}_{\mathbf{it}} \sim \mathbf{iid}(\mathbf{0}, \boldsymbol{\sigma}^{\mathbf{2}})$$

Where:

$\boldsymbol{\alpha}_{\mathbf{i0}}$: Represents the drift term (constant)

$\boldsymbol{\alpha}_{\mathbf{i1t}}$: Represents a time trend term

The Dickey-fuller test implies the rejection of the null hypothesis of non-stationarity if the values of the t-statistic lies to the left of the Dickey-Fuller critical value i.e. H_0: $\beta_0=0$, which suggests that the series is stationary. Moreover, the Dickey Fuller test is conducted such that lagged difference terms are encompassed until the residual of the above equation is white noise. Therefore, the augmented Dickey- Fuller test includes lags of the first differences of Y_t to correct for serial correlation.

The optimal lag length j in the ADF test regressions is determined by the Schwarz Information Criterion (SC). Additionally, if a series is found to be non-stationary it will be first differenced and retested. Accepting the null hypothesis means that the variables under examination is non-stationary and a unit root is present (Van Rensburg, 1999). The regression for the PP test is as follows:

$$\Delta \mathbf{Y_{it}} = \boldsymbol{\alpha}_{\mathbf{i0}} + \boldsymbol{\alpha}_{\mathbf{i1t}} + \boldsymbol{\beta}_{\mathbf{i0}}\mathbf{Y_{t-1}} + \boldsymbol{\varepsilon}_{\mathbf{it}}$$

Both the Augmented ADF and PP test the null hypothesis that $\beta=0$ (non-stationary) versus the alternative of $\beta<0$, for any Y. In other words, under the null hypothesis Y_t contains a unit root, $\beta=0$

(Adrangi, Chatrath, & Raffiee, 2004). A significant, negative coefficient signals the rejection of the null and evidence of stationarity.

Three variations of the ADF and PP tests will be conducted; 1) with intercept, 2) trend and intercept, and 3) neither trend nor intercept. This approach insures that the test results are robust in the presence of drifts and trends (Adrangi, Chatrath, & Raffiee, 2004). The PP test may be more appropriate if autocorrelation in the series under investigation is suspected (see Phillips & Perron, 1988). This is because the Phillip-Perron (PP) test is robust to autocorrelation and heteroscedasticity (Glascock, Lu, & So, 2002). One of the advantages of the PP test over the ADF test is that the PP test are robust to general forms of heteroscedasticity in the error term (ε_{it}) and makes a non-parametric correction to the t-statistic. An additional advantage is that you are not required to specific the lag length for the test regression.

5.4 VAR theory

A vector auto-regression (VAR) methodology is used in order to capture the dynamic interrelationships between asset class returns and inflation. Following the method of Sims (1980) each variable is treated symmetrically (i.e. all of the variables are specified as being endogenous). An unrestricted VAR model with n variables and K lags mag be represented as follows:

$$\mathbf{y_{it}} = \boldsymbol{\alpha_i} \sum_{i=1}^{n} \sum_{k=1}^{K} \mathbf{b_{ik} y_{it-k}} + \boldsymbol{\varepsilon_{it}} \ \ \textbf{for all i} = \mathbf{1}, \dots, \mathbf{n}$$

By conducting a VAR one is able to assess the dynamics of the relationship between asset class returns and inflation. More specifically, through impulse response functions it is possible to see how asset class returns respond to inflation shocks which will help determine whether particular asset class is a good or bad inflation hedge.

VAR models are frequently utilised for forecasting systems or interrelated time series and for analysing the dynamic impact of random disturbances on the system of variables. The VAR approach is useful as it circumvents the need for structural modeling by treating every endogenous variable in the model as a function of the lagged values of all of the endogenous variables in the model.

An alternative mathematical representation of a VAR can be depicted as follows:

$$\mathbf{y_t} = \mathbf{A_1 y_{t-1}} + \cdots + \mathbf{A_p y_{t-p}} + \mathbf{B x_t} + \boldsymbol{\varepsilon}_\mathbf{t}$$

Where y_t is a k vector of endogenous variables, x_t is a d vector of exogenous variables, A_1,… A_p and B are matrices of coefficients to be estimated. Lastly ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right hand side variables. Since only lagged values of the endogenous variables appear on the right hand side of the equations, simultaneity is not an issue and OLS yields consistent estimates.

For example, in this study suppose that a particular asset class's return (AR) and inflation (I) are jointly determined by a VAR and let a constant be the only exogenous variable. For illustration purposes assume the VAR contains two lagged values of the endogenous variables then it may be depicted as follows:

$$\mathbf{AR_t = a_{11}AR_{t-1} + a_{12}I_{t-1} + b_{11}AR_{t-2} + b_{12}I_{t-2} + c_1} + \boldsymbol{\varepsilon}_\mathbf{1t}$$

$$\mathbf{I_t = a_{21}AR_{t-1} + a_{22}I_{t-1} + b_{21}AR_{t-2} + b_{22}I_{t-2} + c_2} + \boldsymbol{\varepsilon}_\mathbf{2t}$$

Where a_{ij}, b_{ij} and c_i are the parameters to be estimated.

5.5 Cointegration theory

Subsequently, the relationship between the returns on the various assets classes and inflation will be investigated through the use of cointegration techniques. Prior literature has found that equity returns and inflation tend to exhibit special time series properties. Inflation is slow moving and persistent with much lower variation than equity returns. Consequently, this negatively influences correlation tests between the two variables (see Madsen, 2007). This is because non-stationary variables introduce the problem of spurious regression, which is the detection of significant relationships even though non-existent (see Granger, Hyung, & Jeon, 2001). To avoid the problem of finding spurious relationships recent studies have looked for cointegration between equities and inflation. If the two variables are non-stationary but cointegrated then one may interpret the regression as a cointegrating regression reflecting an equilibrium relationship between equities and inflation. It is possible that returns on the various asset classes do adjust to inflation over a longer time frame. One simple and direct way to test this is using rolling 10 year returns calculated on underlying monthly data and correcting the standard errors for autocorrelation using the standard Newey-West methodology (Ang, 2014). However, cointegration provides a more formal test for the long-run equilibrium relationship between returns and inflation and does not require a postulation ex ante of what the length of the adjustment period should be. Cointegration, first introduced by Granger (1981) and developed by Engle and Granger (1987) and Johansen (1988), is the appropriate technique to investigate this relationship. Cointegration between two variables implies that, if the system is to return to its long-run equilibrium, at least one of the two variables responds to the magnitude of the disequilibrium. Cointegration can be used to ascertain whether there is a long-run equilibrium between inflation and returns. A model of cointegration can be specified as follows:

Two variables Y_t and X_t are said to be cointegrated if there exists a parameter β such that

$$\mathbf{U_t = Y_t - \beta X_t \sim I(0)}$$

Then, Y_t and X_t even if both are I (1) (non-stationary) if there exists a parameter β such that $\mathbf{U_t}$ is stationary than Y_t and X_t are said to be cointegrated.

In order to test for Cointegration of Y_t and X_t a Dickey- Fuller test on the residuals of the initial regression of Y_t and X_t in (log of) levels will be conducted:

$$\Delta\varepsilon_t = \alpha + \beta\varepsilon_{t-1} + u_t$$

If the series are found to be co-integrated they can be regressed on each other and the estimated of β will be consistent (Van Rensburg, 2016).

However since, cointegration regressions only consider long-term dynamics and does not tell us about the short-run dynamics of the adjustment towards the above equilibrium relationship, an error correction model (ECM) will also be utilised in order to analyse short-term dynamics (Van Rensburg,2016). The ECM has been proposed by Granger (1983) and Engle and Granger (1987) and is designed to capture both short-term and long-term effects of one series on another (see Cochran & Defina, 1993). Therefore, the ECM illustrates short-run transitory changes as deviations from the long-run relationship. The ECM is closely related to the theory of cointegration. Several variables, X_t can have unit roots and therefore have non-stationary stochastic trends (Engle & Granger, 1987). Even though each variable may be stationary in first differences it is possible that a linear combination of the variables is stationary in levels. If so, then the variables are said to be cointegrated with a cointegrating vector.

Cointegration consequently suggests a long-run relation, equal to 0, and constrains a system's dynamics. Deviations from the long-run relation can arise as transitory shocks impact each variable. These deviations, nevertheless must eventually be corrected since they are by definition stationary. Engle and Grange (1987) illustrate that movements in co-integrated variables can be represented by an error correction model. ECM's provide a suitable method for describing equity price movements given that equity prices are likely to be I(1). Numerous academic studies have found that equity prices possess a unit root and theory advocates that their stochastic trend is prevalent in other variables (see Campbell & Shiller, 1987; Cochrane & Sbordone, 1988). The error correction model (ECM) can be defined as follows:

The ECM can be applied to cointegrated series and has the following general from:

$$\mathbf{\Delta S_t = \alpha + \sum_{j=0}^{J} \eta_j \, \Delta P_{t-j} + \sum_{k=1}^{K} \gamma_k \, \Delta S_{t-k} - \lambda \varepsilon_{t-1} + u_t}$$

Where $\boldsymbol{\varepsilon_{t-1}} = (\mathbf{S_{t-1} - \alpha - \beta P_{t-1}})$

S= Index price

P= Price level (CPI)

Short-run dynamics are represented by the following terms:

$$\mathbf{\sum_{j=0}^{J} \eta_j \Delta P_{t-j} + \sum_{k=1}^{K} \gamma_k \Delta S_{t-k}}$$

The adjustment to the long-run equilibrium relationship in levels is represented by

$$\mathbf{-\lambda \varepsilon_{t-1}}$$

It is important to be aware that ε_{t-1}'s coefficient (λ) should be negative demonstrating a return to equilibrium. For parameter values between $0<\lambda<1$ this reflects that the adjustment to equilibrium is partial.

6. Results

This section displays the results of the various analysis conducted. Moreover, the results are discussed and interpreted in this section.

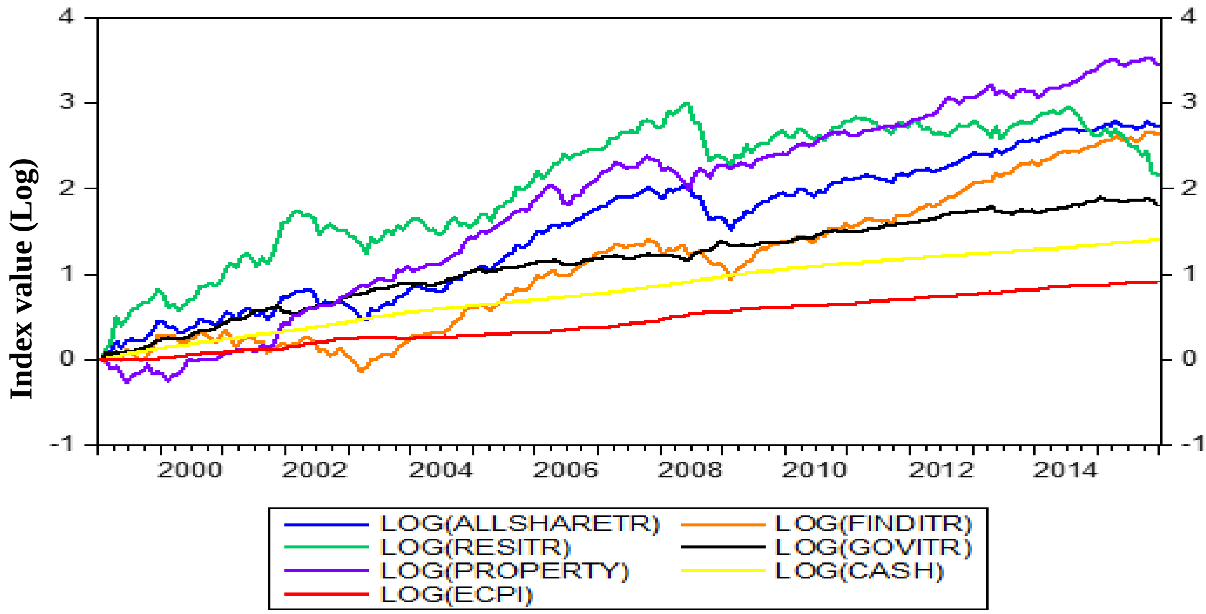

Figure 1a: Total return indices for all domestic asset classes from 1999-2015.

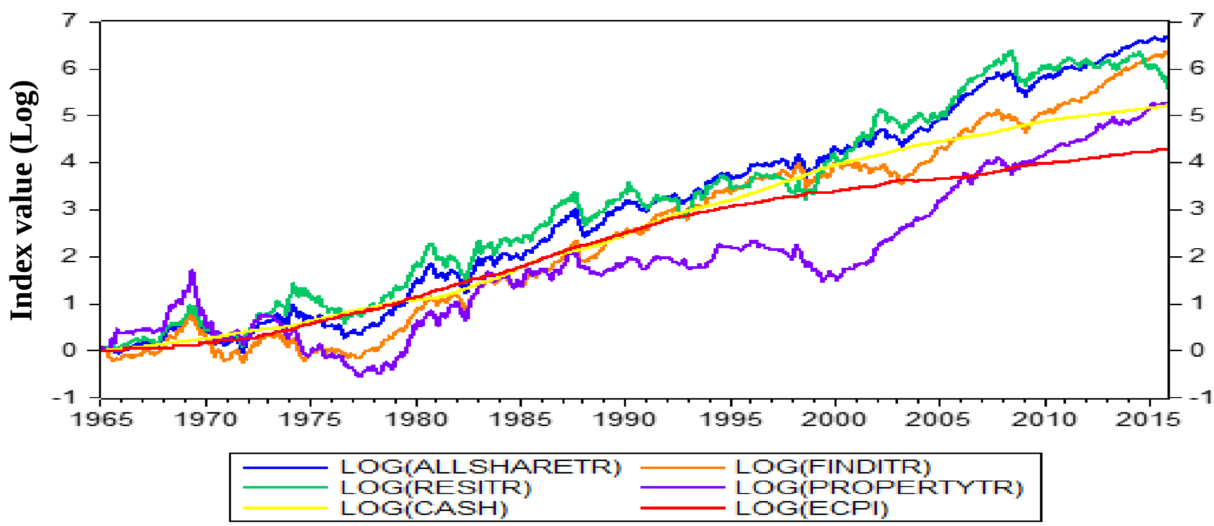

Figure 1b: Total return indices for all domestic asset classes from 1965-2015.

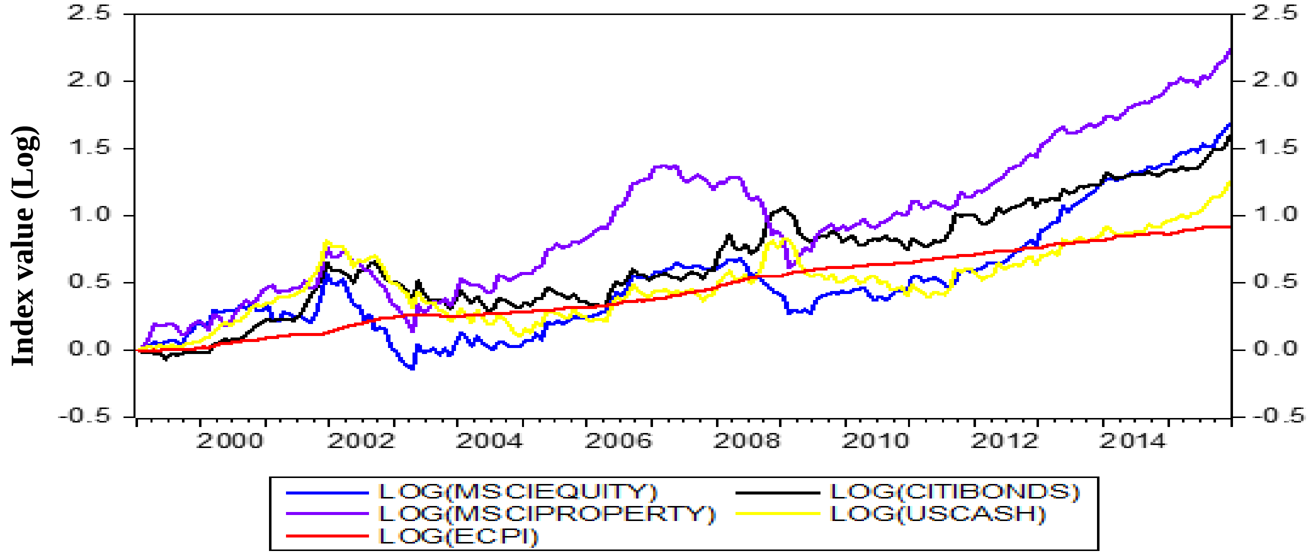

Figure 2: Total return indices for all foreign asset classes from 1999-2015.

Figures 1a and 2 represent the log index values of the domestic asset classes and foreign asset classes between 1999-2015 with the South African consumer price index. Figure 1b contains the log of domestic indices dating back to 1965 excluding the bond asset class for which data was unavailable. The following observation can be made from figures 1a, 1b and 2. They illustrate that the log levels of all the index price series are trending and appear nonstationary, while the logarithmic first differences appear to stationary (see appendix B1-B13). However, this will be investigated further with the ADF and PP unit root tests. Moreover, despite that most asset classes tend to outperform inflation on average this does not imply that they are good inflation hedges. Domestic equities appear to be the asset class that outperforms inflation the most. However, this does not necessarily mean that equities are good inflation hedges in the sense that it covaries in a one to one or close to one relationship with inflation.

6.1 Descriptive statistics

Table 2: Descriptive statistics for the domestic asset classes returns and inflation 1999-2015 (%)

	ALSITR	FINDITR	RESITR	GOVITR	ALBITR	PROPERTYTR	SACASH	Inflation
1 month								
μ	1.3801	1.3467	1.0943	0.8990	0.8968	1.7088	0.6974	0.4546
σ	4.9934	4.9069	8.0013	2.0437	2.0625	4.9301	0.2291	0.4621
Skewness	-0.2436	-0.4312	-0.1726	0.0584	0.0180	-0.3194	0.9846	0.5845
Kurtosis	3.3024	3.4492	3.9892	4.6890	4.8474	4.0455	3.9864	3.6954
Sample period	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12
1 year								
μ	16.0832	15.9822	13.0253	11.0429	11.0671	22.4074	8.2065	5.5836
σ	17.9473	18.7862	29.3132	6.6725	6.6493	16.2179	2.3363	2.4888
Skewness	-1.0963	-0.8012	-0.3305	0.2538	0.1833	-0.5382	0.3708	0.5370
Kurtosis	4.6777	2.7831	2.8632	2.7058	2.6941	3.4042	2.0471	3.5861
Sample period	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12
3 year								
μ	48.1337	47.4972	40.8486	31.9533	32.0329	70.4497	24.4576	16.9862
σ	29.0937	36.9499	47.5238	11.7571	11.6424	27.9909	5.6452	4.4811
Skewness	0.5432	-0.2959	0.5847	0.4929	0.4334	0.1343	-0.1619	-0.0362
Kurtosis	2.3996	2.1293	2.4729	2.3397	2.3200	1.7058	1.6793	2.6942
Sample period	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12
5 year								
μ	81.3774	82.7245	67.6134	52.1428	52.2437	116.6413	40.8866	27.9209
σ	27.6706	31.7577	52.9777	15.1565	14.9619	37.8734	7.0790	4.0437
Skewness	0.2586	-0.0415	-0.3390	0.9087	0.8772	0.4478	-0.3116	0.2076
Kurtosis	2.8213	1.8775	2.2247	2.6293	2.5920	1.9453	2.6637	1.7414
Sample period	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12
10 year								
μ	163.3974	164.1513	140.6389	100.9667	101.0942	229.7288	82.2886	57.2954
σ	14.4817	38.5585	47.6031	16.0239	15.4905	26.6889	9.1359	2.4856
Skewness	0.1503	-0.0999	-0.2772	0.2363	0.2326	-0.4231	0.1070	-0.7429
Kurtosis	2.3482	1.5633	3.0682	2.2774	2.3106	2.2547	1.5848	2.5869
Sample period	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12

Notes: μ, σ are the means and standard deviations respectively. This table displays sample statistics for the inflation rate and the nominal returns on the aggregate domestic equity, bond, property and cash market indices. Returns and inflation rates are expressed in percentages. The investment horizon ranges from 1 month until 10 years. The sample statistics are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

Table 3: Descriptive statistics for the foreign asset classes returns and inflation denominated in rands 1999-2015 (%)

	MSCI WORLD EQUITY	CITI-BONDS	MSCI WORLD PROPERTY	FSTE PROPERTY	USCASH	Inflation
1 month						
μ	0.8523	0.7916	1.0876	1.2278	0.6313	0.4546
σ	4.6899	4.4900	5.0776	4.9604	4.6796	0.4621
Skewness	0.2546	0.4647	-0.0478	-0.1133	0.4563	0.5845
Kurtosis	4.3638	4.0504	5.1292	5.3284	3.8726	3.6954
Sample period	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12	1999M01-2015M12
1 year						
μ	9.1348	8.9424	11.9616	13.9977	6.4873	5.5836
σ	20.1849	14.6377	22.9166	22.7454	18.1164	2.4888
Skewness	-1.1902	-0.1322	-1.3329	-1.3371	-0.5823	0.5370
Kurtosis	4.6687	2.9464	4.5843	4.7349	2.9857	3.5861
Sample period	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12
3 year						
μ	23.3982	25.2372	32.8660	38.7563	14.8871	16.9862
σ	39.3253	23.1981	40.4334	39.1831	31.4154	4.4811
Skewness	-0.0084	-0.3130	-0.3304	-0.6096	-0.3392	-0.0362
Kurtosis	1.6831	2.7297	1.7085	2.1200	2.7927	2.6942
Sample period	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12	2001M12-2015M12
5 year						
μ	34.8389	36.8827	50.5087	58.2873	17.5827	27.9209
σ	37.5266	18.1508	35.6311	36.4469	23.4035	4.0437
Skewness	0.7660	-0.6987	0.1653	-0.3313	-0.0755	0.2076
Kurtosis	2.5013	3.5631	2.1938	2.1195	3.1856	1.7414
Sample period	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12	2003M12-2015M12
10 year						
μ	67.6286	77.1627	94.3191	107.7241	39.9333	57.2954
σ	49.8879	21.2873	34.2420	25.3847	33.2222	2.4856
Skewness	0.2409	-0.2511	0.1266	-0.2243	-0.2199	-0.7429
Kurtosis	1.3003	2.1296	1.3257	1.8181	1.8787	2.5869
Sample period	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12	2008M12-2015M12

Notes: μ, σ are the means and standard deviations respectively. This table displays sample statistics for the inflation rate and the nominal returns on the aggregate foreign equity, bond, property and cash market indices. Returns and inflation rates denominated in rands and are expressed in percentages. The investment horizon ranges from 1 month until 10 years. The sample statistics are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

From tables 2 and 3 the following four observations can be made. Firstly, all asset classes both domestic and foreign with the exception of foreign cash tend to earn an average return that is greater than inflation over all horizons. Foreign cash only has higher average returns than inflation up until the one year investment horizon. This finding for domestic asset classes for the subperiod of 1999-2015 also hold for the extended sample period of 1965-2015, in which all domestic asset classes (equities, property and cash) tend to earn an average return that exceeds that of inflation over all horizons (see appendix C1). The bond asset class however is omitted from the extended sample period as there was no available data for bonds in South Africa prior to 1999. Moreover, results for the foreign asset classes also hold over a longer period from 1995-2015 where all asset classes earn a higher average return than inflation over all horizons with the expectation of foreign cash for the 10-year horizon (see appendix C2). A key point to note here however is that despite the fact that all the asset classes provide a higher average return than inflation it does not imply that these asset classes with be effective inflation hedges. In order for an asset class to be an effective inflation hedge it has to covary positively in a one to one or close to one relationship with inflation.

Secondly, during this period (1999-2015) it is apparent that both listed domestic and foreign property provide the investor with superior average returns over all horizons compared to the other asset classes. When extending the sample to 1965 for domestic assets this result alters in which now equities provide investors with the superior average returns over all horizons relative to the other asset classes (see appendix C1). This suggests that property in South Africa has only recently been outperforming since the 2000s. For the foreign asset classes, the results remain the same with property providing the highest average return compared to the other asset classes. The reason for this result being the same is because certain asset classes date back to different periods and the furthest comparable common period for all foreign assets was to 1995 which is only slightly longer than the 1999 period (see appendix C2).

Thirdly, it is evident that domestic cash as an asset class provides the investor with the lowest average returns overall all horizons and also the lowest risk as measured by standard deviation. On the other hand, foreign cash provides lowest return however not the lowest risk. Foreign bonds appear to provide the lowest risk. Extending the domestic asset classes back to 1965 this result varies slightly. Domestic cash still provides the lowest risk for all horizons as found previously between 1999-2015, however it seems to provide a better average return than property over all horizons (see appendix C1). This supports the previous finding that the property asset class in South Africa has only recently since the late 1990s been a very high performing asset class. In terms of the foreign asset classes dating back to 1995 the result remains the same with bonds providing the lowest risk and cash providing the lowest return over all horizons (see appendix C2).

Fourthly, foreign asset classes are vulnerable to exchange rate volatility making them riskier than their domestic counterparts. Comparing the volatilities (standard deviations) in tables 4 and 5 the following is noted. The ALSI exhibits lower volatility than its foreign counter part the MSCI world equity index over the investment horizon of 1 to 10 years. Moreover, both the GOVI and ALBI exhibit significantly lower volatility than the CITI world bond index over the horizon of 1 month to 10 years. This was also observed for domestic cash exhibiting substantially lower volatility than foreign cash over all horizons. Lastly, domestic property also exhibited lower volatility than the MSCI world real estate index for all horizons with the exception of the 5-year horizon. Therefore, it is evident that foreign asset classes are riskier than their domestic counter parts because of exchange rate volatility.

In summary the important idea to take away from the above descriptive statistics is that even though all the asset classes, both domestic and foreign tend to earn a higher average return than inflation it does not necessarily imply that they are good inflation hedges. Whether an asset class is a good inflation hedge depends on whether it covaries positively in a one to one or close to one relationship with inflation.

6.2 Unit root tests

All domestic and foreign variables are tested to determine whether they are nonstationary. In order to determine if a variable is nonstationary (i.e. has unit root) both the augmented Dickey-Fuller (ADF) Dickey and Fuller, 1981) and Phillips Perron (PP) (Phillips and Perron, 1988) tests were conducted to investigate the presence of a unit root. The PP test is used in addition to the ADF test because it is robust in the presence of heteroscedasticity and serial correlation.

Expected returns theories of asset pricing imply that it is unlikely that the first differences of price levels will be stationary. This is because for a given size of expected returns, first differences in price will increase in absolute size as price levels grow. Instead the log first differences of share price levels would be expected to be I(0). As a result, the natural log values of the share indices were computed for use in the analysis of stationarity (Van Rensburg, 1999).

Table 4: Augmented Dickey-Fuller test on domestic and foreign asset classes 1999-2015 (levels).

Variable	None			Intercept			Trend & Intercept		
Level	ADF statistic	P-value	Lags	ADF statistic	P-value	lags	ADF statistic	P-value	lags
LALSITR	3.7654	1.0000	0	-1.3911	0.5861	0	-2.3187	0.4215	0
LFINDITR	3.9415	1.0000	0	0.3953	0.9824	0	-1.7178	0.7400	0
LRESITR	1.5854	0.9724	0	**-3.4204****	0.0113	0	-1.3187	0.8804	0
LGOVITR	5.8844	1.0000	0	**-3.3690****	0.0132	0	-2.2422	0.4633	0
LALBITR	5.8215	1.0000	0	**-3.2865****	0.0168	0	-2.2161	0.4777	0
LPROPERTYTR	4.6869	1.0000	0	-0.7560	0.8287	0	-1.3478	0.8729	0
LSACASH	2.4618	0.9968	14	-2.5261	0.1108	14	-0.6384	0.9754	14
LRBAS	2.3794	0.9960	4	-2.5492	0.1055	4	-0.8478	0.9585	4
LMSCI WORLD EQUITY	2.6447	0.9981	0	1.1268	0.9976	0	-0.3521	0.9886	0
LCITI-BONDS	2.5108	0.9972	0	-0.0909	0.9477	0	-2.0913	0.5472	0
LMSCI WORLD PROPERTY	3.0756	0.9995	0	0.3235	0.9790	0	-1.0799	0.9289	0
LFTSE PROPERTY	3.5239	0.9999	0	-0.0606	0.9509	0	-1.3047	0.8839	0
LUSCASH	1.8979	0.9863	0	-0.4640	0.8942	0	-1.3757	0.8653	0
LCPI	7.1739	1.0000	1	-0.0782	0.9491	1	-1.9459	0.6267	1

Notes: ADF= Augmented Dickey-Fuller test statistic. The prefix “L” is used to denote the log of the variable. The Augmented Dickey-Fuller tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. *Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1999- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

Table 4 above displays the results from the ADF test for all the variables in log levels for all three assumptions; 1) intercept 2) trend and intercept and 3) no trend nor intercept. In order for a time series to be stationary the mean, variance and serial correlation must remain unchanged over time.

In the event that a time series is nonstationary and stationarity can be brought about by taking k differences then the series is said to be integrated of the kth order in other words the series is I(k) (Glascock, Lu, & So,2000). From table 4 it is evident that the null hypothesis of a unit root in levels could be rejected by the ADF test for only three variables (Resi, Govi, and Albi) at the 5% significance level and only under the assumption of an intercept. All the other variables except the Resi, Govi and Albi are nonstationary and hence contain a unit root in levels. Consequently, the nonstationary variables were subsequently first differenced and retested as can be seen in table 5 below. All the variables that were nonstationary in levels are now stationary in differences. The Phillips-Perron unit root tests lead to the same conclusion that most of the variables are I(1) (appendix D1) and are all stationary in first differences (appendix, D2). The only exception is in levels with that of the cash asset class. The result from the ADF was adopted in which cash was found to be nonstationary at the 1% level.

Table 5: Augmented Dickey-Fuller test on domestic and foreign asset classes 1999-2015 (first difference).

Variable	None			Intercept			Trend & Intercept		
First difference(**Δ**)	ADF statistic	P-value	Lags	ADF statistic	P-value	lags	ADF statistic	P-value	lags
ΔLALSITR	**-13.7702*****	0.0000	0	**-14.7919*****	0.0000	0	**-14.8220*****	0.0000	0
ΔLFINDITR	**-13.1419*****	0.0000	0	**-14.0566*****	0.0000	0	**-14.0707*****	0.0000	0
ΔLRESITR	**-14.4768*****	0.0000	0	**-14.7173*****	0.0000	0	**-15.4348*****	0.0000	0
ΔLGOVI	**-11.2651*****	0.0000	0	**-13.1334*****	0.0000	0	**-13.6575*****	0.0000	0
ΔLALBI	**-11.2748*****	0.0000	0	**-13.1187*****	0.0000	0	**-13.6207*****	0.0000	0
ΔLPROPERTYTR	**-12.5554*****	0.0000	0	**-13.9050*****	0.0000	0	**-13.8802*****	0.0000	0
ΔLSACASH	**-2.0408****	0.0398	13	**-3.2603****	0.0181	13	**-3.8377****	0.0165	13
ΔLRBAS	-1.5233	0.1196	3	**-3.1560****	0.0242	3	**-3.9371****	0.0123	3
ΔLMSCI WORLD EQUITY	**-14.0207*****	0.0000	0	**-14.4470*****	0.0000	0	**-14.5958*****	0.0000	0
ΔLCITI-BONDS	**-13.7346*****	0.0000	0	**-14.1233*****	0.0000	0	**-14.1106*****	0.0000	0
ΔLMSCI WORLD PROPERTY	**-4.6315*****	0.0000	3	**-12.91431*****	0.0000	0	**-12.9238*****	0.0000	0
ΔLFTSE PROPERTY	**-4.4382*****	0.0000	3	**-12.6913*****	0.0000	0	**-12.6705*****	0.0000	0
ΔLUSCASH	**-13.8077*****	0.0000	0	**-14.0221*****	0.0000	0	**-14.0071*****	0.0000	0
ΔLCPI	**-3.3508*****	0.0009	2	**-10.2652*****	0.0000	0	**-10.2388*****	0.0000	0

Notes: ADF= Augmented Dickey-Fuller test statistic. The prefix "L" is used to denote the log of the variable and "**Δ**" denotes the first difference of the variable. The Augmented Dickey-Fuller tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1999- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

When extending the domestic asset classes sample period back to 1965. Both the ADF and PP unit root tests find that all the time series are nonstationary in log levels. However, after being first differenced and retested both unit root tests conclude that all the time series are stationary (see appendix, D3-D6). Therefore, for the period between 1965-2015 all domestic time series are I(1). The same result is found for the foreign asset classes when the sample is extended back to 1995. Both the ADF and PP unit root tests find all time series to be nonstationary in levels. After being differenced once all the time series become stationary suggesting they are I(1) (see appendix, D7-D10).

6.3 Correlations

The initial phase in testing the short and long-run relationship between the returns on the different asset classes (equities, bonds, property and cash) and inflation is to examine the contemporaneous correlation. If any of the above aforementioned asset classes were a perfect inflation hedge over different horizons, one would expect to observe a positive correlation near one in nominal terms. Table 6 below displays the Pearson correlations between the various asset classes and inflation. All the t-statistics and p-values were adjusted to correct for the problem of dependence between observations which was created by overlapping observations. It is important to adjust the t-statistic and hence p-value because overlapping observations can inflate the reported t-statistics and consequently significant t-statistics may in fact be insignificant when the adjusted for the number of independent observations are taken into account (see Anderson,1997:67).

Table 6: Domestic and foreign asset classes' index returns Pearson correlation with inflation 1999-2015.

	1 Month lagged	**1 Month**	**1 Year**	**3 Year**	**5 Year**	**10 Year**
ALSITR	-0.0920 (0.1907)	-0.1006 (0.1521)	**-0.4785**** (0.0309)	-0.5685 (0.1385)	-0.5656 (0.2914)	-0.3580 (0.7506)
FINDITR	-0.0626 (0.3739)	-0.1042 (0.1379)	**-0.6015**** (0.0030)	**-0.6417*** (0.0734)	-0.3786 (0.5288)	-0.3265 (0.7746)
RESITR	-0.0553 (0.4318)	-0.0437 (0.5346)	-0.1487 (0.5491)	-0.1015 (0.8263)	-0.2968 (0.6321)	0.0353 (0.9767)
GOVITR	0.0293 (0.6774)	-0.0959 (0.1723)	-0.2174 (0.3753)	-0.2433 (0.5897)	-0.5194 (0.3496)	-0.0705 (0.9533)
ALBITR	0.0273 (0.6987)	-0.0979 (0.1637)	-0.2342 (0.3377)	-0.2604 (0.5620)	-0.5282 (0.3385)	-0.0762 (0.9495)
PROPERTYTR	0.0099 (0.8881)	-0.0400 (0.5702)	-0.2462 (0.3122)	-0.5827 (0.1244)	-0.7176 (0.1139)	-0.1556 (0.8961)
SACASH	0.0289 (0.6812)	0.0265 (0.7071)	0.2030 (0.4091)	0.2881 (0.5179)	-0.0268 (0.9670)	0.0386 (0.9745)
RBAS	**0.1381**** (0.0488)	**0.1283*** (0.0675)	0.3522 (0.1349)	0.3633 (0.4021)	0.0074 (0.9910)	0.0716 (0.9526)
MSCI WORLD EQUITY	**-0.1243*** (0.0765)	-0.1021 (0.1461)	-0.3505 (0.1371)	-0.2702 (0.5463)	-0.1760 (0.7829)	0.0620 (0.9589)
CITI-BONDS	-0.025204 (0.7205)	-0.0391 (0.5790)	**0.4116*** (0.0732)	**0.6096*** (0.0995)	0.5820 (0.2710)	0.5451 (0.5901)
MSCI WORLD PROPERTY	**-0.1219*** (0.0824)	-0.1047 (0.1363)	**-0.4665**** (0.0367)	-0.5177 (0.1943)	-0.6564 (0.1813)	-0.0305 (0.9798)
FTSE PROPERTY	-0.0935 (0.1836)	-0.0802 (0.2539)	**-0.4122*** (0.0726)	-0.5024 (0.2124)	**-0.7816*** (0.0550)	0.1121 (0.9254)
USCASH	-0.0483 (0.4926)	-0.0351 (0.6186)	0.2479 (0.3086)	0.4396 (0.2933)	0.4550 (0.4315)	0.4856 (0.6453)
Sample period	1999M01-2015M12	1999M01-2015M12	1999M12-2015M12	2001M12-2015M12	2003M12-2015M12	2008M12-2015M12

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the correlation (ρ) between the inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. The investment horizon ranges from 1 month until 10 years. The one-month lagged refers to prior month's inflation and its correlations with current month index returns. The correlation statistics are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

From the above table 6 it is apparent that domestic equities, bonds and property are all negatively contemporaneously correlated with inflation over all horizons except the Resi index becoming positive for the ten-year horizon. Cash is the only asset class that is positively contemporaneously correlated with inflation. In terms of the foreign asset class counter parts both equities and property are negatively contemporaneously correlated with inflation. However, foreign bonds and cash are positively correlated with inflation from one year through to the ten-year horizon. Extending the period of analysis for the domestic asset classes back to 1965 excluding bonds for which data that far back is unavailable similar results are found. Property is negatively contemporaneously correlated with inflation over all horizons. Additionally, equities are also negatively contemporaneously correlated with inflation up to the one-year horizon, however thereafter becoming positively correlated in the longer run. Cash remains positively contemporaneously correlated over all horizons and significant which suggests that it is a good inflation hedge (see appendix, E1). For the foreign asset classes dating back to 1995 the results are very similar as found in the shorter period. Both foreign bonds and cash are positively contemporaneously correlated with inflation from the one to ten-year horizon. Conversely, foreign equity and property are negatively correlated with inflation, with the exception that equities are positive for the five-year horizon (see appendix, E2).

In brief the preliminary evidence from the contemporaneous Pearson correlations suggest the following. All domestic asset classes with the exception of cash are negatively contemporaneously correlated with inflation in the short and long-run for the period 1999-2015. Only cash provides a potential hedge against inflation. These findings are similar for the period from 1965-2015 except that equities may provide a potential hedge against inflation in the long-run after 3 years. On the other hand, foreign equities and property are negatively correlated with inflation in the short and long-run, while bonds and cash exhibit a positive correlation between 1999-2015. These results are similar for extended period for the foreign asset classes.

To provide some insight into the dynamics between asset class returns and inflation in order to investigate how asset class returns respond to inflation changes, analysis examining the correlation between the one-month lag of prior inflation and current index returns was also conducted. The following can be observed for the period between 1999-2015. In terms of domestic asset classes, it is evident that current equity returns exhibit a negative correlation with one month's prior inflation. This suggests that equity returns respond negatively to inflation in the short-run which is consistent with findings of vast amounts of academic literature that find evidence on the inverted

Fisher effect. Therefore, equities appear to be poor inflation hedges both contemporaneously and in response to inflation changes. Conversely, domestic bonds, property and cash display a positive correlation with one month's prior inflation. This suggests that these asset classes respond positively to one month's prior inflation changes in the short-run. However, both property and bonds are negatively contemporaneously correlated with inflation. The monthly returns on the foreign asset classes all exhibit a negative relationship with one month's prior inflation. This suggests that foreign asset classes could potentially be poor hedges against South African inflation. When evaluating the domestic asset classes dating back to 1965 similar results were obtained (see appendix, E1). The ALSI is negatively correlated with the previous month's inflation which suggests that general equities are a poor inflation hedge. However, the FINDI and RESI appear to be positively correlated with the previous month's inflation rate suggesting these sectors may respond better to inflation. Domestic property and cash both respond positively to the prior month's inflation between 1965-2015 which supports the findings that these asset classes may provide investors with protection against inflation and is consistent with the subperiod (1999-2015) findings. The findings for foreign asset classes dating back to 1995 were similar to the subperiod's. All the asset classes except for foreign bonds have a negative relationship with the one month's prior inflation suggesting they are poor inflation hedges (see appendix, E2).

Although the contemporaneous and lagged correlations between asset class returns and inflation do display some sensitivity to the sample period being investigated which has been found to be the case in most academic studies there are some notably consistent findings that resonate. Firstly, domestic equities are negatively contemporaneously correlated with inflation in the short run suggesting they are poor inflation hedges. Moreover, domestic bonds and property exhibit a negative contemporaneous correlation with inflation while cash exhibits a positive correlation with inflation in the short and long-run. Secondly, the ALSI responds negatively to one month's prior inflation suggesting that equities are a poor inflation hedge. On the other hand, domestic bonds, property and cash respond positively to the previous month's inflation Thirdly, foreign equities and property display a negative contemporaneous correlation with inflation in the short and long-run. On the other hand, bonds and cash exhibit positive contemporaneous correlations with inflation. Finally, it is evident that in the short-run all the foreign asset classes respond negatively to one month's prior inflation as seen in table 6.

6.4 Granger causality

Since the Pearson contemporaneous correlations ignore lagged effects, the subsequent step is to investigate the predictive power of past values of one variable for subsequent realisations of the other through the granger causality frame work (Granger, 1969). The Granger causality frame work can be more formally stated in the following way. A variable X is said to Granger-cause Y if past values of X are useful in forecasting Y. For example, if historical values of inflation explain a specific asset class's returns then inflation is said to granger cause that asset class's returns. A key point to note is that this does not imply causality in any behavioural sense, it just implies that prior inflation helps predict the future pattern of the specific asset class's returns. Moreover, historical values of the asset class's return under examination could also contribute towards explaining current inflation, signifying that reverse causality is present. The final relationship that could be observed through the Granger causality is a bidirectional feedback between asset class returns and inflation. This occurs when both prior asset class returns contribute to the explanation of future inflation and prior values of inflation contribute to explaining future asset class returns. This study examines whether prior values of inflation can help forecast asset class returns. The monthly inflation and asset class returns are defined as the first differences of their natural logarithms. Table 7 below illustrates the results from the granger causality tests between domestic and foreign asset classes with domestic inflation.

Table 7: Granger Causality tests for domestic and foreign asset classes' index monthly returns with inflation 1999-2015.

Variable name	Period	Lags	Returns do not Granger cause inflation (p<0.1 reject)	Inflation does not Granger cause returns (p<0.1 reject)
ALSITR	1999-2015	12	0.3140	**0.0340****
FINDITR	1999-2015	12	0.8014	**0.0566***
RESITR	1999-2015	12	**0.0760***	0.3819
PROPERTYTR	1999-2015	12	**0.0586***	0.5904
GOVITR	1999-2015	12	**0.0001*****	0.2496
ALBITR	1999-2015	12	**0.0001*****	0.2854
SACASH	1999-2015	12	**0.0028*****	**0.0000*****
RBAS	1999-2015	12	**0.0005*****	**0.0263****
MSCI WORLD EQUITY	1999-2015	12	**0.0523***	**0.0109****
CITI-BONDS	1999-2015	12	**0.0753***	0.4606
MSCI WORLD PROPERTY	1999-2015	12	0.4279	**0.0129****
FTSE PROPERTY	1999-2015	12	0.5196	**0.0216****
USCASH	1999-2015	12	**0.0872***	0.6305

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the Granger causality tests between the inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. The Granger causality tests is conducted for 12 lags and are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

From the above table 7 the following observations can be made. It is evident that inflation tends to reliably precede both the ALSI and the FINDI. This suggests that past values of inflation can help predict movements in the returns in equities for the above aforementioned indices. On the other hand, domestic property, bonds and the RESI tend to precede inflation meaning past returns of property, bonds and the RESI help predict inflation. The relationship between domestic cash and inflation appear to exhibit reverse causality which is a more complex pattern. In terms of the foreign asset class counter parts the following was observed. Foreign equities exhibit reverse causality while bonds and cash precede inflation. Moreover, inflation tends to precedes property returns suggesting past values of inflation can predict property returns. These results are robust for both 3 months and 6 months lagged for most of the asset classes with minor differences in significance levels (see appendix, F1-F2).

The Granger causality method is limited in the sense that it cannot determine the sign of the underlying relationship between the specific asset class's returns and inflation. Consequently, it prevents one from determining whether a particular asset class is an effective or poor inflation hedge. Therefore, the next step was to determine the sign of the relationship and hence whether a particular asset class is an effective or anti-inflation hedge. This was achieved by conducting a regression analysis in which the monthly current index returns of the various asset classes are regressed on inflation lagged for twelve months. Additionally, subsequent to the regression analysis, VAR analysis is used to determine impulse response functions which also helps shed light on how future monthly returns to various asset classes respond to one standard deviation shocks to inflation.

The results of this regression are exhibited below in table 8. The following was found. All domestic equity indices exhibited a strong negative inflation coefficient with the ALSI and FINDI inflation coefficients significant at the 1% level and the RESI at the 10% level. The coefficients on the ALSI FINDI and RESI were -0.4423, -0.4479 and -0.4310 respectively. This suggests that equities are poor inflation hedges and that equity returns respond negatively to prior increases in inflation. Property also exhibits a negative but insignificant inflation coefficient of -0.1353. Interestingly, bonds exhibit a positive inflation coefficient. The inflation coefficient with respect to the GOVI is 0.0974 and significant at the 10% level. This supports the previous finding in which the GOVI and ALBI both had positive correlations with one month's prior inflation. This result is somewhat contrary to what theory suggest from the bond formula, however may be explained by the detail that the income component of the bond return outweighs the capital return for the GOVI index. In line with expectations domestic cash has a positive and significant inflation coefficient of 0.0405 at the 1% significance level. This suggests cash offers an investor a partial inflation hedge. This supports the positive contemporaneous and lagged correlations with inflation found in the Pearson correlation analysis. With regards to the foreign asset classes, it is evident that all display negative inflation coefficients with both equities and property beings significant at the 1% level with coefficients of -0.4803 for equities and -0.6259 and -0.6062 for the MSCI and FTSE property indices. The signs and significance of the coefficient remain consistent at the 3 month and 6 month lags which adds support to the robustness of these findings (see appendix, F3-F4).

Table 8: Regression analysis for current domestic and foreign asset classes' index returns with prior 12 months' inflation lagged 1999-2015.

Dependent variable	Independent variable	Period	Lags	Coefficient	Standard error	t-stat	Significance
ALSITR	Inflation	1999-2015	12	**-0.4423*** **	0.1382	-3.2011	0.0016
FINDITR	Inflation	1999-2015	12	**-0.4479*** **	0.1329	-3.3702	0.0009
RESITR	Inflation	1999-2015	12	**-0.4310* **	0.2239	-1.9250	0.0557
PROPERTYTR	Inflation	1999-2015	12	-0.1353	0.1366	-0.9905	0.3232
GOVITR	Inflation	1999-2015	12	**0.0974* **	0.0578	1.6844	0.0937
ALBITR	Inflation	1999-2015	12	0.0957	0.0589	1.6244	0.1059
SACASH	Inflation	1999-2015	12	**0.0405*** **	0.0046	8.7948	0.0000
RBAS	Inflation	1999-2015	12	**0.0456*** **	0.0046	9.9538	0.0000
MSCI WORLD EQUITY	Inflation	1999-2015	12	**-0.4803*** **	0.1337	-3.5918	0.0004
CITI-BONDS	Inflation	1999-2015	12	-0.0271	0.1335	-0.2033	0.8391
MSCI WORLD PROPERTY	Inflation	1999-2015	12	**-0.6259*** **	0.1420	-4.4085	0.0000
FTSE PROPERTY	Inflation	1999-2015	12	**-0.6062*** **	0.1400	-4.3290	0.0000
USCASH	Inflation	1999-2015	12	-0.0884	0.1396	-0.6338	0.5270

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the regressions coefficients with their sign for the Granger causality tests between the inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. The regression coefficients represent the strength and sign of the relationship that was found with the Granger causality test of 12 lags and are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

Therefore, in summary equities and property both domestic and foreign appear to be poor inflation hedges in terms of providing a return after inflation has manifested. On the other hand, domestic bonds and cash appear to provide investors with a partial inflation hedge, while foreign bonds and cash exhibit poor inflation hedging capacity.

Conventional wisdom suggests that foreign assets should provide South African investors with protection against inflation because it is a rand hedge. This means that because South Africa is an import dependent economy it is vulnerable to imported inflation through currency effects. Therefore, the negative inflation hedging ability found above for foreign asset classes was explored further. Table 9 below, in contrast to table 8 displays the Granger regression results with inflation as the dependent variable and the asset classes as the independent variable.

Table 9: Regression analysis for current inflation with 12 months prior domestic and foreign asset classes' index returns lagged 1999-2015.

Dependent variable	Independent variable	Period	Lags	Coefficient	Standard error	t-stat	Significance
Inflation	ALSITR	1999-2015	12	0.0027	0.0019	1.4442	0.1503
Inflation	FINDITR	1999-2015	12	-0.0012	0.0017	-0.6949	0.4879
Inflation	RESITR	1999-2015	12	**0.0035*** **	0.0011	3.1344	0.0020
Inflation	PROPERTYTR	1999-2015	12	-0.0012	0.0021	-0.5688	0.5702
Inflation	GOVITR	1999-2015	12	**-0.0149*** **	0.0050	-2.9971	0.0031
Inflation	ALBITR	1999-2015	12	**-0.0152*** **	0.0050	-3.0494	0.0026
Inflation	SACASH	1999-2015	12	0.0048	0.0144	0.3310	0.7410
Inflation	RBAS	1999-2015	12	0.0118	0.0146	0.8087	0.4197
Inflation	MSCI WORLD EQUITY	1999-2015	12	**0.0034** **	0.0016	2.0491	0.0418
Inflation	CITI-BONDS	1999-2015	12	**0.0095*** **	0.0022	4.3274	0.0000
Inflation	MSCI WORLD PROPERTY	1999-2015	12	0.0007	0.0015	0.5047	0.6144
Inflation	FTSE PROPERTY	1999-2015	12	0.0008	0.0015	0.5449	0.5864
Inflation	USCASH	1999-2015	12	**0.0070*** **	0.0018	3.9236	0.0001

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the regressions coefficients with their sign for the Granger causality tests between the inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. The regression coefficients represent the strength and sign of the relationship that was found with the Granger causality test of 12 lags and are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

From Table 9 it is evident that foreign equities, bonds and cash have positive and significant coefficients. This suggests that foreign asset classes provide South African investors with an inflation hedge in terms of a prior return. A possible reason for this finding is because the rand weakens prior to inflation occurring. The reason being that when the rand weakens, subsequently inflation manifests through imported inflation. Therefore, foreign assets may be an inflation hedge in the sense that they provide leading returns which may be taken prior to inflation manifesting. Therefore, investors will need to realise the returns on foreign asset classes in a timeously manner in order to protect against inflation.

6.5 Impulse response functions

The next step was to examine the time path of the response of asset class returns to an unexpected movement in inflation. In addition to the time path it is also important to examine how the monthly returns of the various asset classes react to one standard deviation shocks to monthly inflation as this will provide insight into the particular asset class's inflation hedging capability. This is achieved firstly by estimating VAR models of the various asset classes and inflation and then subsequently through impulse response functions which provide insights into the dynamics of the variables included in the VAR model.

A VAR model was conducted for each asset class and inflation. Since results from VARs are sensitive to the lag length selected attention is paid to the lag length (Hafer and Sheehan,1991). The optimal lag length for each unrestricted VAR was chosen by selecting between the following lag criteria; Akaike information criterion (AIC), Schwarz information criterion (SC), Hannan-Quinn information criterion (HQ) and Sequential modified LR test statistic (LR)[4]. Since monthly data is used in this analysis a maximum lag length of 12 was specified for the lag length criteria tests. In each VAR the lag criteria with the lowest number of lag that simultaneously satisfied the tests that the VAR's residuals did not exhibit serial correlation at the 5% significance was selected in order to obtain a parsimonious model. The Lagrange multiplier (LM) test for autocorrelation was conducted to determine whether the VARs residuals were serially correlated. This tests reports the multivariate LM test statistic for the residual serial correlation up to the lag order specified[5]. The null hypothesis is that there is no serial correlation of lag order L. All VAR models were such that the null hypothesis of no serial correlation could not be rejected at the 5% significance. Moreover, AR roots tables were inspected for each VAR model to ensure that the VAR was stable

4

$$LR = (T - m)\{\log|\textstyle\sum_S| - \log|\textstyle\sum_T|\}$$

Where $\sum_S$ and $\sum_T$ are the restricted and unrestricted covariance matrices, respectively. T is the number of observations and m is a correction factor for small samples. This test is asymptotically distributed as a x^2 statistic with the degrees of freedom equal to the number of restrictions. Note that the sims' (1980) small sample correction uses (T-m) rather than just T.

5 Refer to Johansen (1995, p.22) for the formula of the LM statistic.

(i.e. stationary). The AR roots tables reports the inverse roots of the characteristic AR polynomial (Lütkepohl,2005). In order for the estimated VAR to be stable(stationary) all the roots must have a modulus less than one and lies inside the unit circle. If the VAR is not stable, then certain results such as the impulse response functions and standard errors are not valid (Lütkepohl,2005). All VAR models passed the stability test.

Impulse response functions: Time path of monthly returns to one standard deviation shocks to inflation.

The figures below illustrate the responses of the various asset classes' monthly returns to unexpected movements (i.e. shocks) in inflation generated from the VAR models over a forecast horizon of 120 months (10 years) measured on the horizontal axis. Additionally, bands of plus or minus two standard errors are depicted by the red dotted lines. The impulse response functions reveal the way an unexpected movement in the monthly inflation rate affects the various asset classes' monthly return over time. The impulse response functions are computed by artificially imposing a Cholesky one standard deviation shock to inflation and measuring the response of the asset class in the system. The Cholesky method uses the inverse of the Cholesky factor of the residual covariance matric to orthogonalise the impulses. It is important to note that the estimated impulse response function may be sensitive to the Cholesky method of orthogonalisation of the covariance matrix (Anari and Kolari 2001). Consequently, each impulse response function with inflation and the specific asset class was ordered in two ways. The first way was the asset class followed by inflation and the second way was inflation followed by the asset class. The outcome was that altering the order of the two variables did not change the estimated impulse response functions

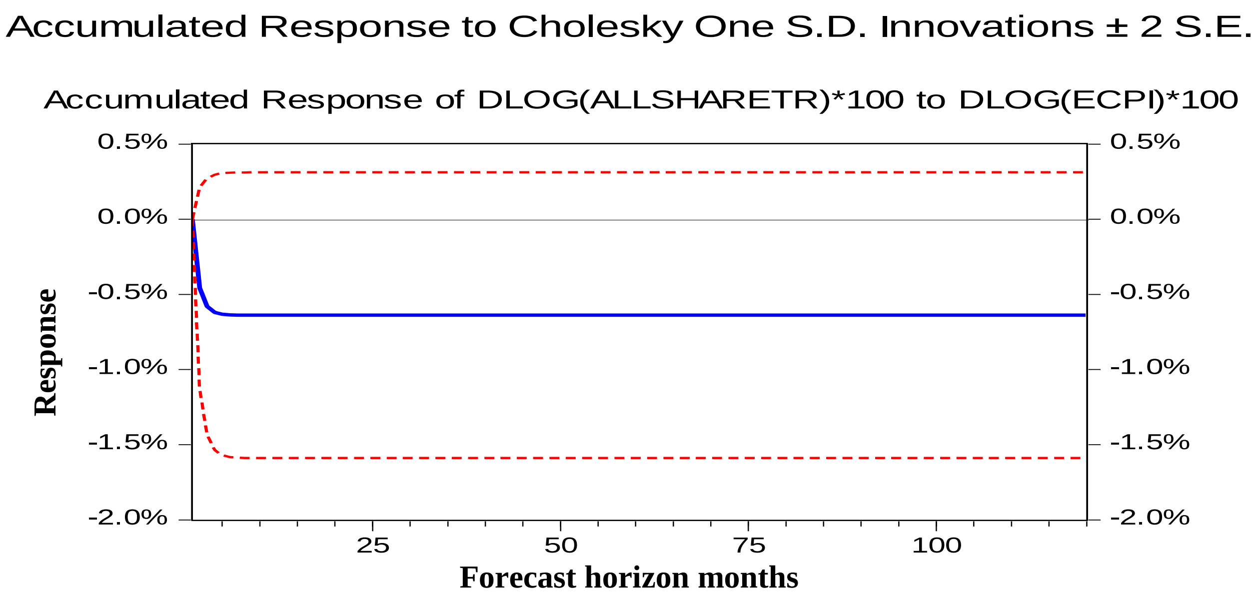

Figure 3: Impulse response function of monthly All share index total returns and monthly inflation 1999-2015

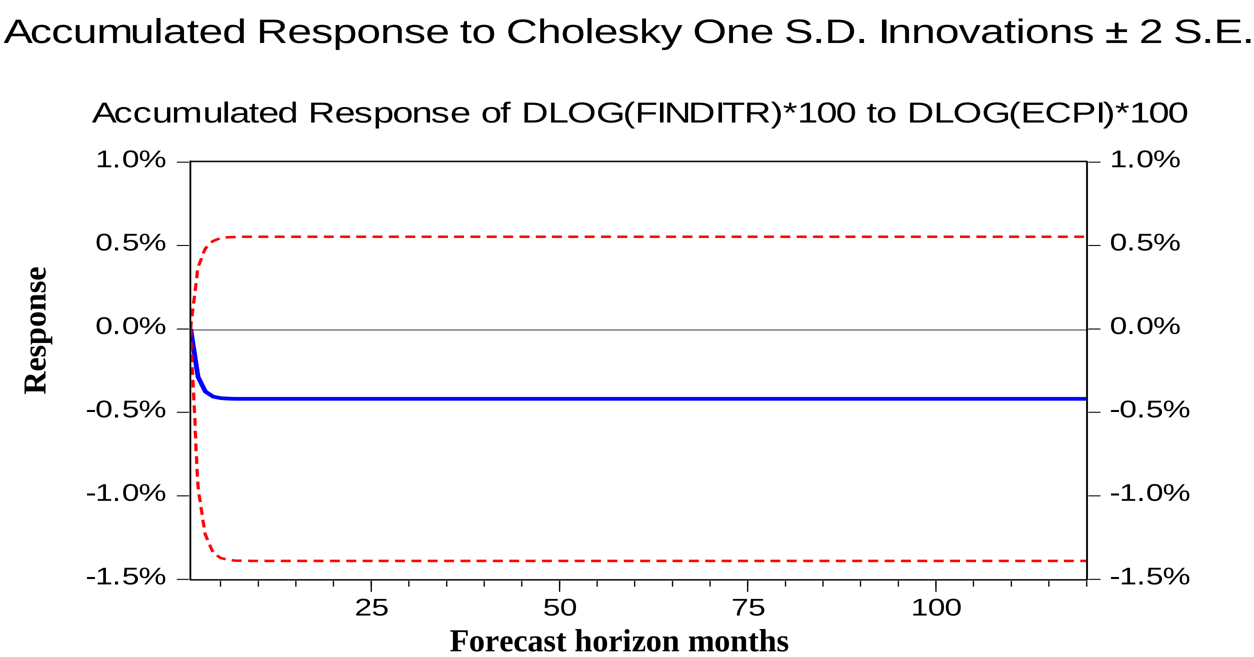

Figure 4: Impulse response function of monthly Financial and Industrial index total returns and monthly inflation 1999-2015

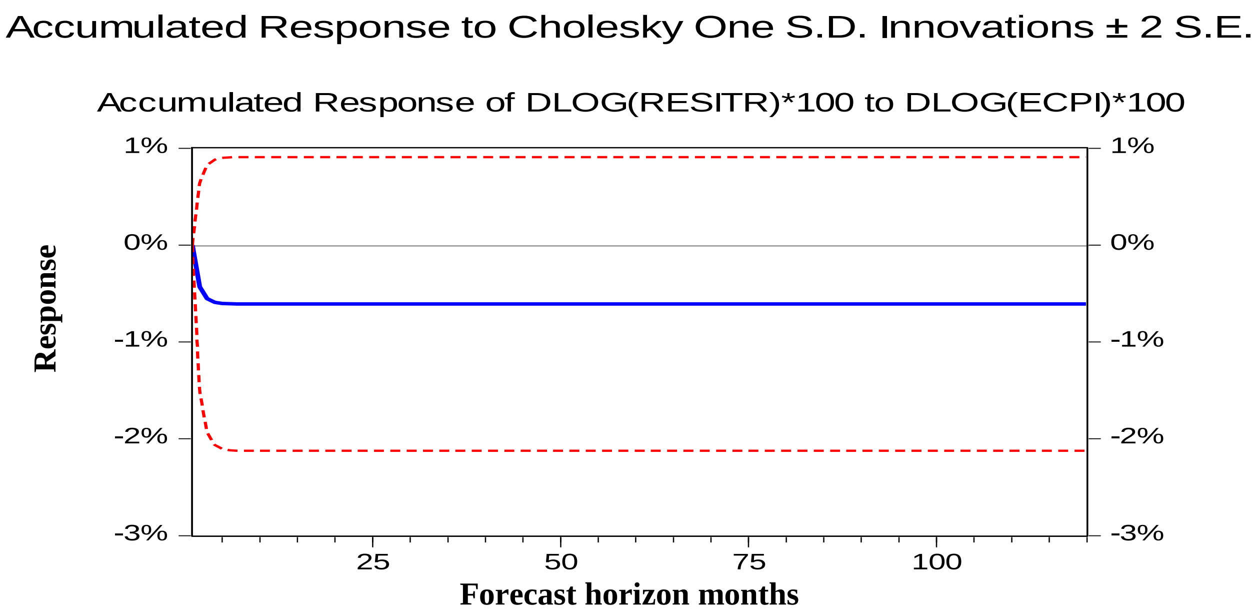

Figure 5: Impulse response function of monthly Resources index total returns and monthly inflation 1999-2015

<u>Domestic Equities</u>

<u>Equities – experience losses, with no recovery (1999-2015).</u>

The monthly equity returns on the ALSI, FINDI and RESI decline in the months subsequent to an inflation shock and do not recover afterwards. Consequently, equities are the worst performing asset class from 1999-2015. Equity returns appear to drop in value almost immediately due to the one standard deviation inflation shock and the full effect of the decline in returns are reached after about 6 months. At this point both the ALSI and RESI have lost about -0.6% and the FINDI slightly less at roughly -0.4%. Equities do not recover after this drop over the 10-year horizon. This suggests that equities are poor inflation hedges in both the short and long-run.

<u>Equities – experience losses, with slight recovery (1965-2015).</u>

Even after extending the sample back to 1965 similar results were obtained which adds robustness to the finding that equities as an asset class are a poor inflation hedge. From the impulse response functions, it is evident that monthly equity returns for the ALSI, FINDI and RESI decline immediately after the inflation shock. This drop in values occurs for about 1 year before bottoming. Thereafter there is a recovery with the eventual loss at about -0.8% and -1.1% for the ALSI and RESI respectively for the rest of the forecasted horizon. The FINDI on the other hand seems to provide the best recovery in the long-run with it returning to a 0% return after three years (see appendix, G1-G3).

These results add to the evidence against the theoretical arguments for equities as a real asset class, which suggests that they should provide investors with inflation protection when inflation is rising. Moreover, these results help strengthen the current evidence in literature in the sense that contrary to theory, equities are in fact poor inflation hedges regardless of whether they are developed market or emerging market equities. This is due to previous academic literature having been centered around developed market equities. It is important to understand that this finding does not suggest that equities underperform inflation over the long-run as there is plenty of evidence demonstrating that equities perform better than other asset classes in real terms over the longer term (Ibbotson & Sinquefield, 1976 and Attie & Roache, 2009). Nevertheless, these results do suggest that investors may potentially be able to improve their returns by tilting their investment portfolios towards or away from the equity asset class depending on whether they expect inflation to be on a downward or upward trend.

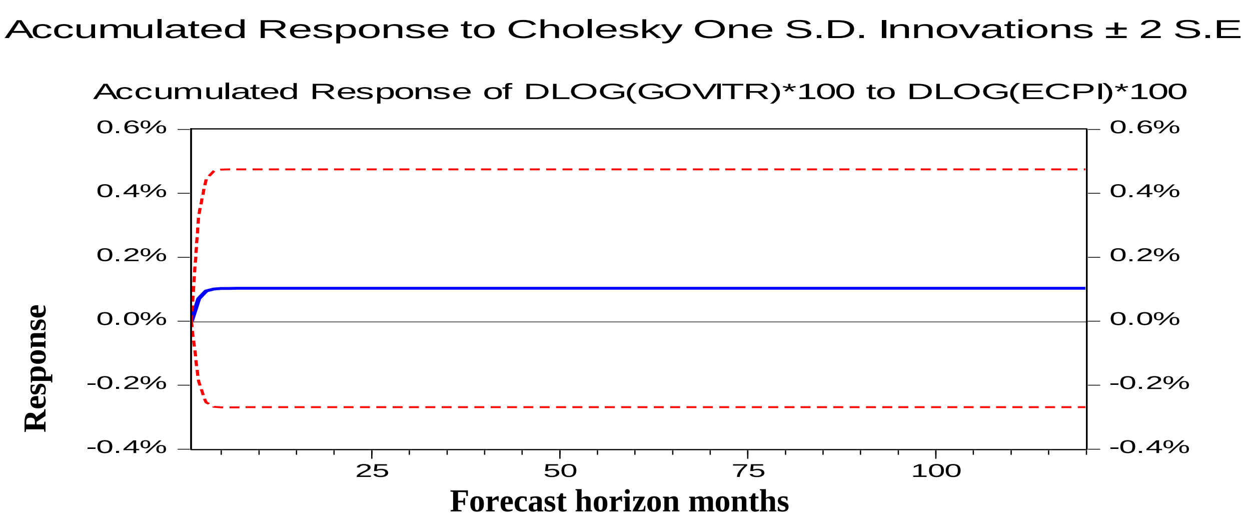

Figure 6: Impulse response function of monthly Government bond index total returns and monthly inflation 1999-2015

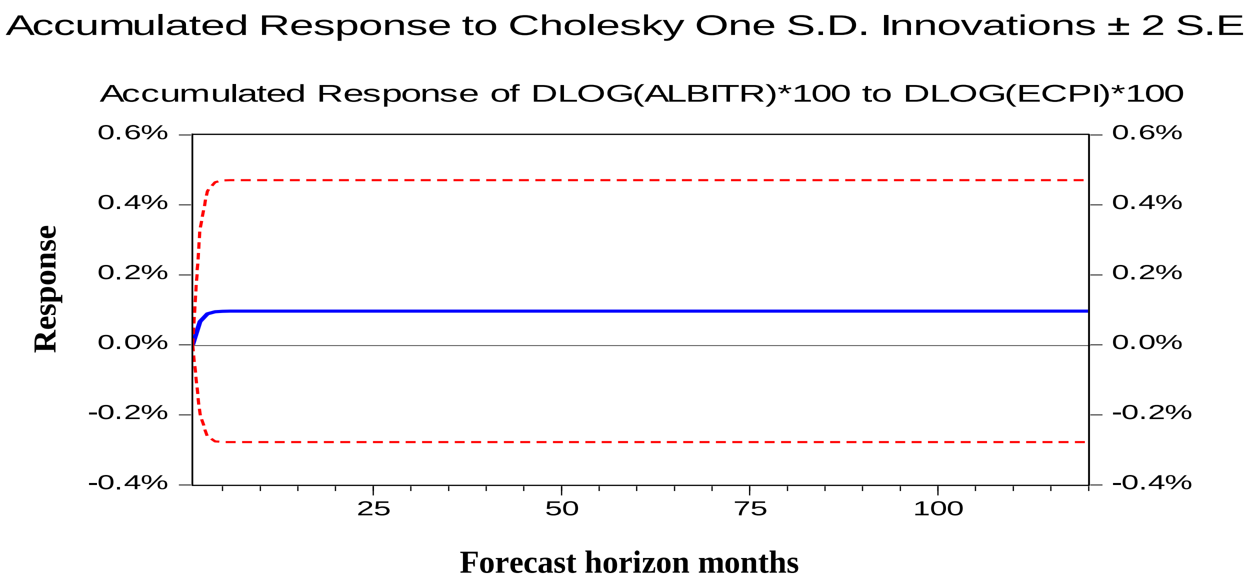

Figure 7: Impulse response function of monthly All bond index total returns and monthly inflation 1999-2015

Domestic bonds

Bonds- Offers a slight hedge (1999-2015).

Immediately after the inflation shock the monthly returns on the GOVI and ALBI respond positively but only slightly. After about five months the cumulative response in bond returns are 0.1% and thereafter remain constant at that level throughout the forecasted horizon. The reasoning behind bonds offering a slight hedge against inflation could be due to the fact that the income component of the bond return marginally dominates that of the capital component. In other words, the higher inflation resulting from the shock, is likely to lead towards higher interest rates and hence higher yields on bonds which could outweigh the capital losses of the higher interest rates.

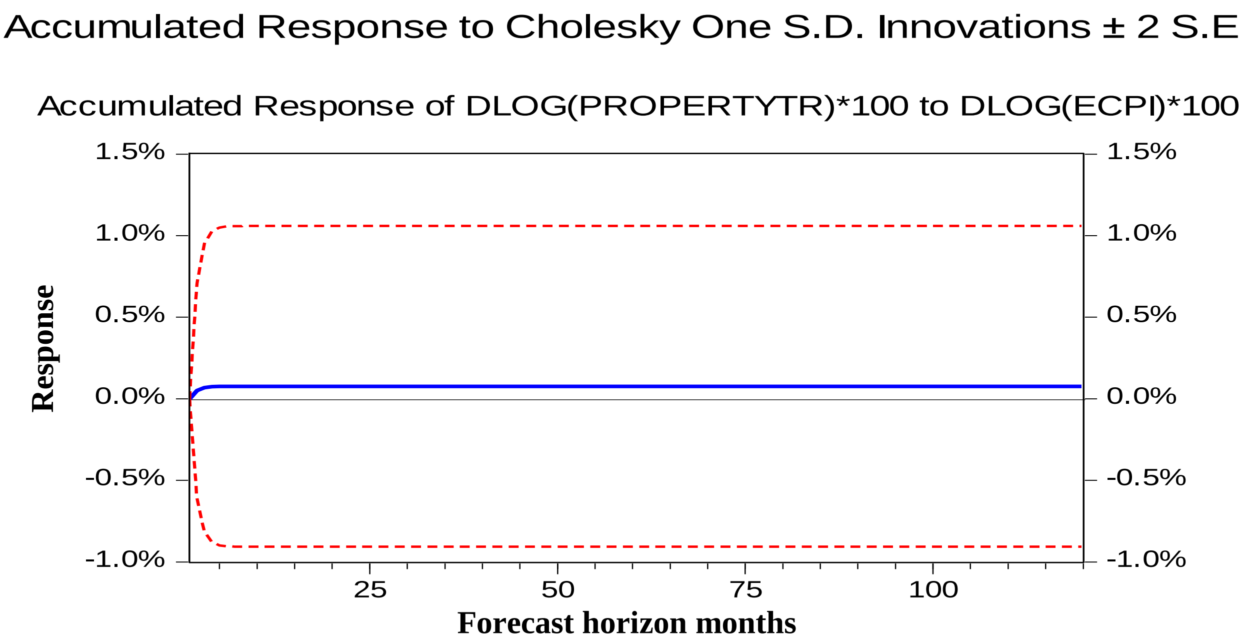

Figure 8: Impulse response function of monthly Property index total returns and monthly inflation 1999-2015

Domestic property

Property – Offers a partial hedge (1999-2015).

Property appears to respond marginally positively to the initial inflation shock. After about 3 months property returns rose to 0.1% thereafter remaining at that level for the rest of the horizon. This suggests that property may provide investors with a slight partial inflation hedge.

Property – Offers a partial hedge (1965-2015).

Extending the sample back to 1965 identical result were obtained adding to the robustness of the findings. Property responds positively in the aftermath of the inflation shock. After 6 months property returns increased by 0.1% subsequently remaining at that level for the rest of the horizons (see appendix, G4). This supports the subperiod finding that property may provide a partial inflation hedge.

This finding is supported by prior academic literature which finds that both residential and commercial real estate protect investors against inflation either completely or partially (Fama and Schwert, 1977, Rubens, Bond and Webb,1989 and Bond and Seile,1998). Moreover, Hoesli, MacGregor, Matysiak and Nanthakumaran (1997) also find similar results however they emphasize that the lag in the property market's response to inflation suggests that property is an imperfect hedge even in the long-run.

However, the literature on whether property provides investors with an inflation hedge is mixed. This is because property is a very heterogeneous asset class and its inflation hedging capabilities are determined by the type of property investment an investor is exposed to. This notion is supported by Gyourko and Linneman (1988). They found evidence that although securitised real estate investment trusts (REITs) display the same negative relationship with inflation found with equities that conversely income-producing property indices are positively associated with inflation.

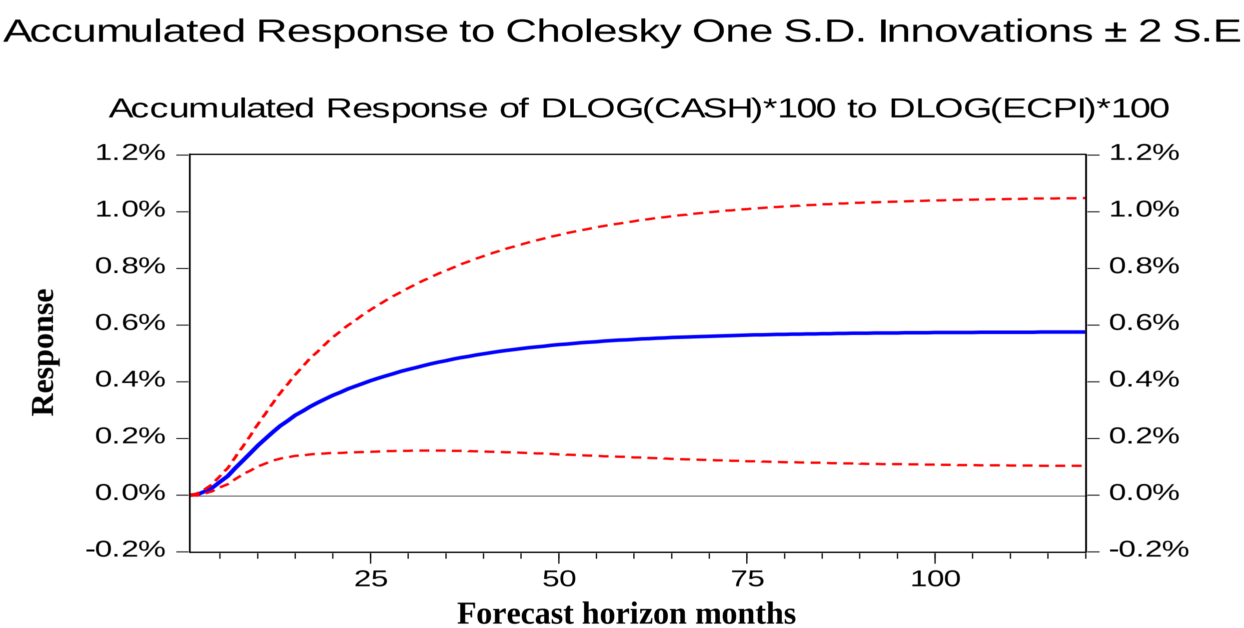

Figure 9: Impulse response function of monthly cash index returns and monthly inflation 1999-2015

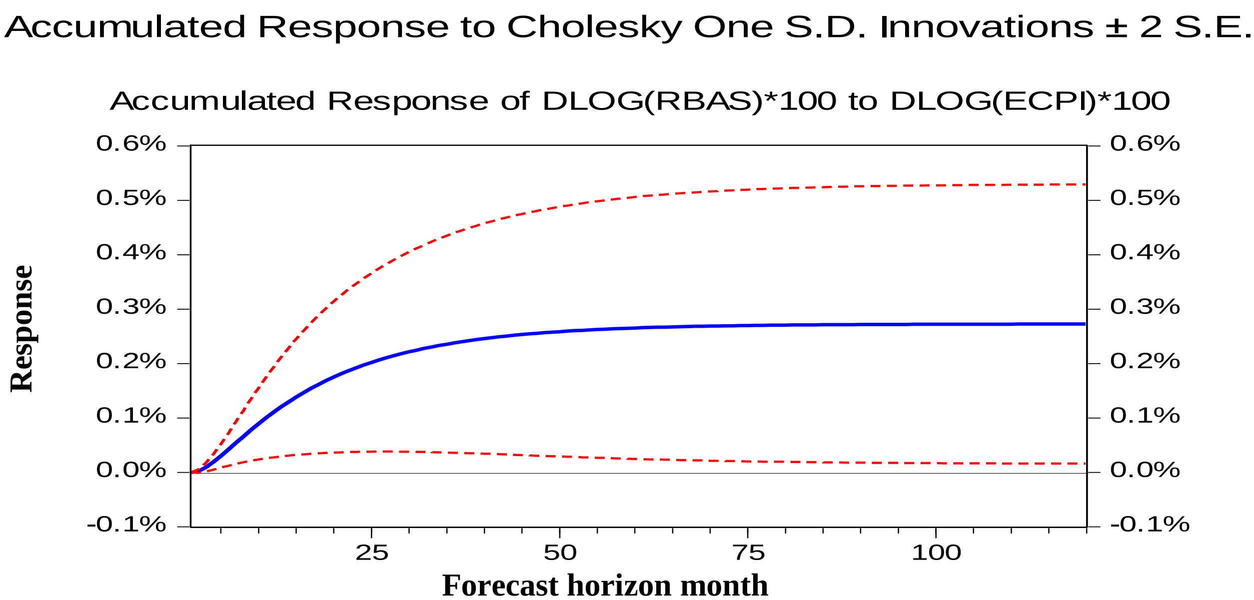

Figure 10: Impulse response function of monthly RBAS index total and monthly inflation 1999-2015

Domestic cash

Cash- provides a partial hedge (1999-2015)

Subsequent to the one standard deviation shock to inflation, cash returns increase at a gradual pace. This suggests that cash does provide a partial hedge against inflation. The cumulate effect on cash returns after one year is about 0.2% and steadily increases to about 0.4% after three years. Despite the slow adjustment of cash returns to the inflation shock they are the best performing asset class in terms of their ability to hedge against inflation. It is important to bear in mind that cash returns will be very reliant and sensitive to monetary policy and the real interest rate they target. Given that South Africa follows an inflation targeting framework, you would expect cash returns to move with inflation but in a lagged manner as interest rates rise in response to higher inflation over time.

Cash- provides a partial hedge (1965-2015)

The findings from the impulse response functions for cash dating back to 1965 were similar to the subperiod (1999-2015). After a one standard deviation shock to inflation cash returns rise gradually. The cumulative effect reaching about 0.2% and 0.4% after one and three years respectively as found for the sub period. It eventually tops out at about 0.8% after five years (see appendix, G5). This suggests there is potential for investors to protect their wealth in real terms in a rising inflation environment by possibly tilting their portfolios to cash.

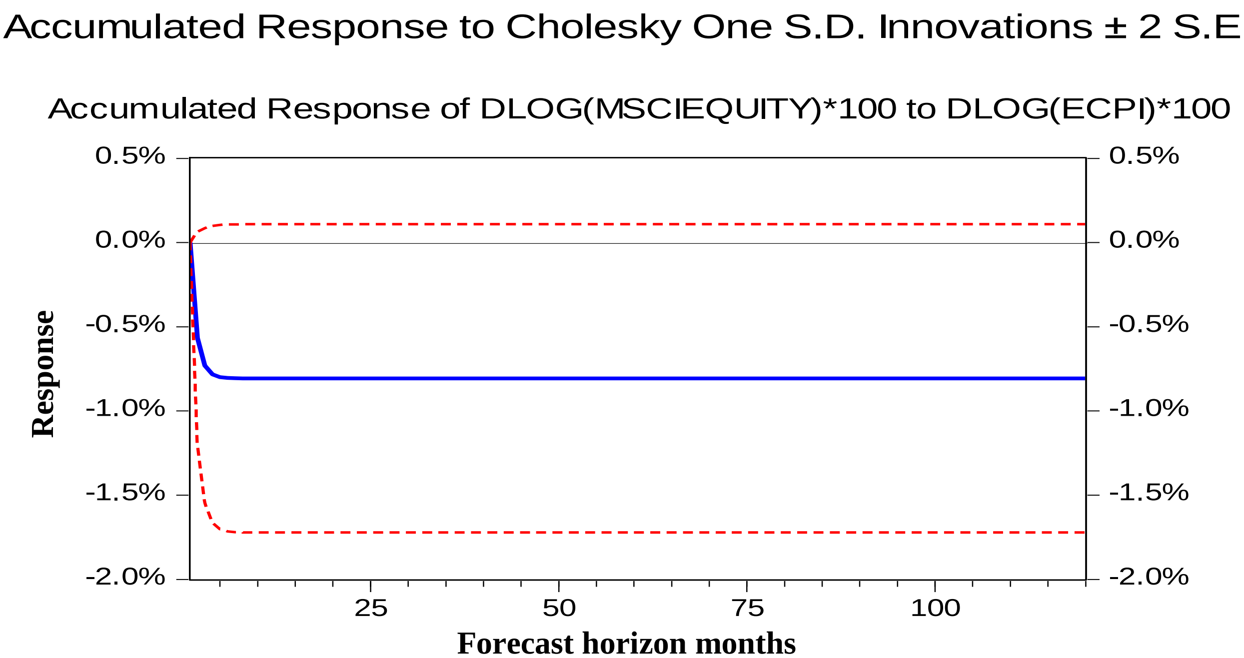

Figure 11: Impulse response function of monthly MSCI world equity index total returns and monthly inflation 1999-2015

<u>Foreign equities</u>

<u>Equities – experience losses, with no recovery (1999-2015).</u>

In line with the findings regarding domestic equities, foreign equities also provide poor inflation hedging properties. From figure 11 it is evident that foreign equity returns decline immediately and sharply in response to a positive inflation shock. After 6 months the returns on foreign equities have dropped to about -0.8% and thereafter do not recover over the forecasted horizon. The fact that both domestic and foreign equities are found to be a poor inflation hedge supports the robustness of the results and also provides further support to the literature that contrary to theoretical expectations equities are in fact poor inflation hedges.

Equities – experience losses, with no recovery (1970-2015).

For the extended sample of foreign equities, the findings were identical to the subperiod (1999-2015). The monthly equity returns decline immediately in response to the one standard deviation shock in inflation. After about one year the equity returns bottom at -0.9% and thereafter do not recover for the rest of the forecasted horizon (see appendix, G7). This suggests that foreign equities are in fact a poor hedge against South African inflation. This finding that equities are a poor inflation hedge is consistent with the subperiod findings in this study as well as many academic studies that conclude that equities are poor inflation hedges.

In brief, it is apparent that equities as an asset class both foreign and domestic appear to be poor inflation hedges in the short and long-run as they respond negatively to a one standard deviation shock in inflation and not recover over forecasted horizon.

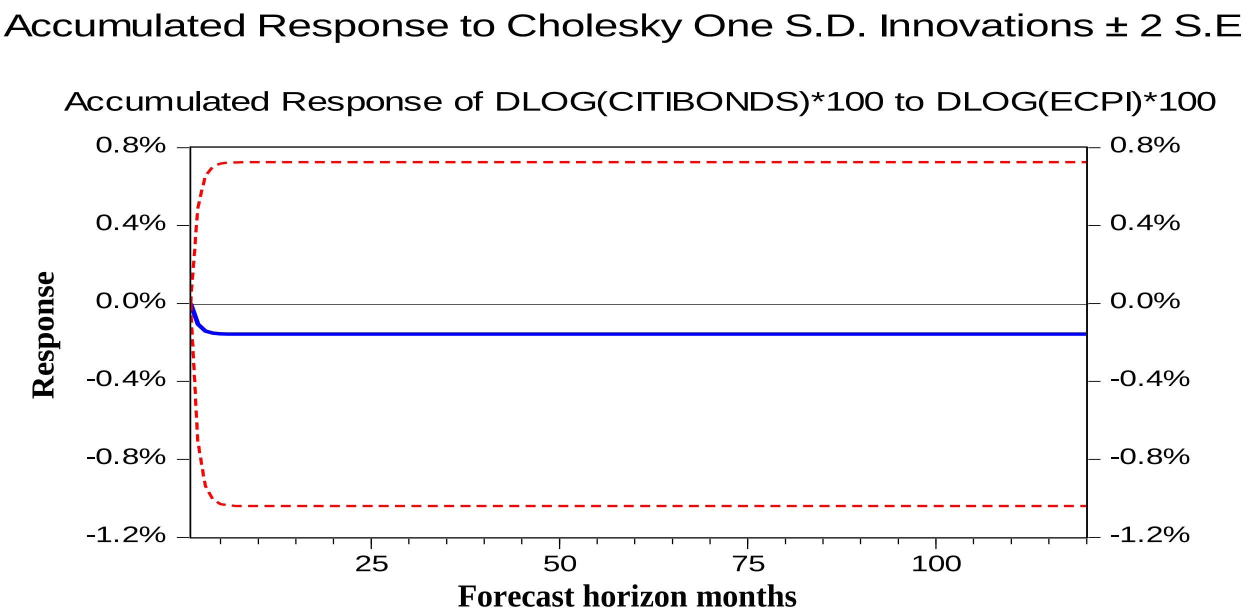

Figure 12: Impulse response function of monthly Citi-group world government bond index total returns and monthly inflation 1999-2015

Foreign bonds

Bonds- experience losses, no recovery (1999-2015).

From figure 12 it is evident foreign bonds are poor inflation hedges. Monthly bond returns respond negatively to a positive inflation shock. After about 6 months the returns have declined by -0.1% and subsequently do not recover over the rest of the horizon. This result is in contrast to domestic bonds which were found to provide a partial hedge against inflation. Three potential reasons for the contrast in findings is that firstly, there could be an exchange rate effect at play. Secondly, it could be that in the foreign bond indices the capital component is outweighing the income component of the bond returns. Thirdly, the foreign interest rate policies and bond ratings may differ to domestic bonds.

Bonds- experience losses, with a recovery (1985-2015).

Looking at foreign bonds for an extended period it is evident that immediately after the one standard deviation shock to inflation bonds respond negatively with monthly returns declining to a bottom of -0.3% after about 6 months. This is in line with the subperiod (1999-2015) findings. However, it appears as if foreign bonds start to recover after 6 six months peaking at 1.8% just after 2 years (see appendix, G8). A potential reason for the recovery could be that after the capital loss resulting from higher inflation and hence higher interest rates the income component of the bonds starts to outweigh the capital loss with the higher yields.

In brief, it appears that domestic bonds offer a partial inflation hedge against inflation while the foreign bond findings appear to be time and lag sensitive however both find that foreign bonds are a poor inflation hedge in the short-run.

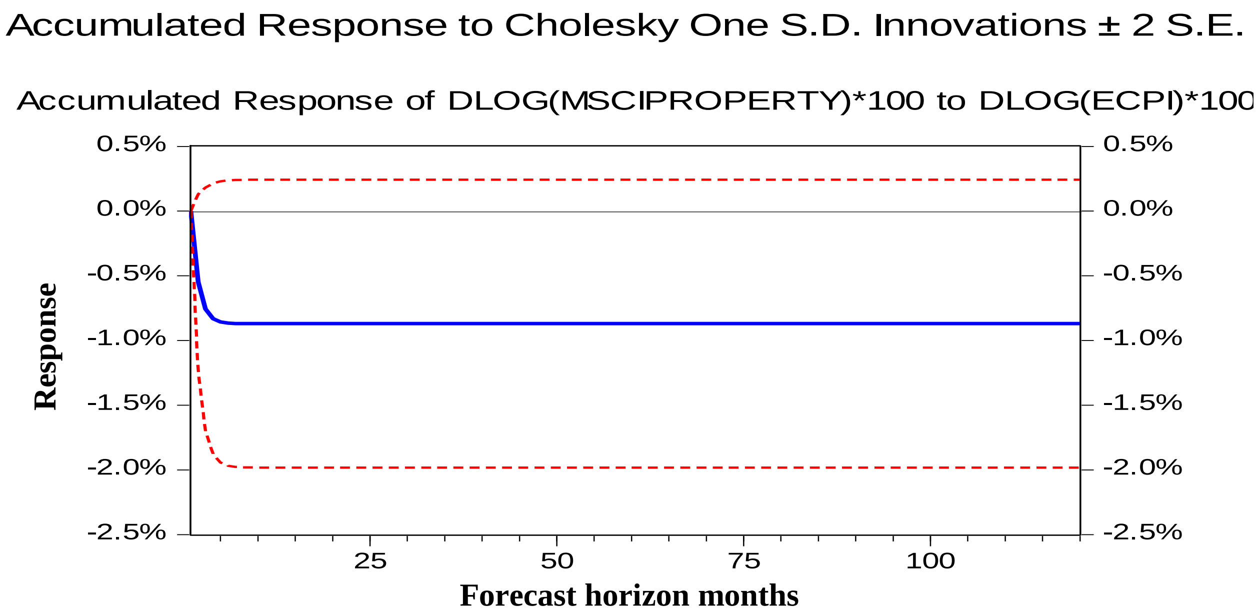

Figure 13: Impulse response function of monthly MSCI world property index total returns and monthly inflation 1999-2015

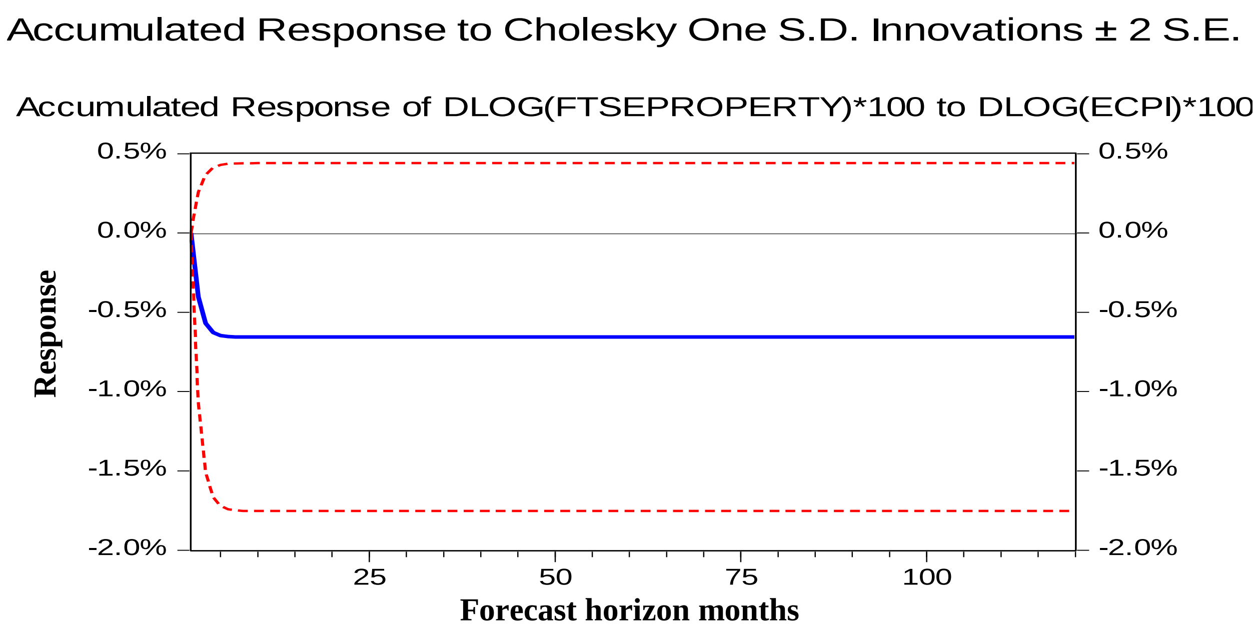

Figure 14: Impulse response function of monthly FTSE/EPRA NAREIT property index total returns and monthly inflation 1999-2015

Foreign Property

Property – experiences losses with no recovery (1999-2015).

Foreign property returns for both the MSCI world real estate and FTSE EPRA/NAREIT indices appear to respond negatively to a positive inflation shock. Both the MSCI and FTSE monthly returns drop in value immediately after the inflation shock and after about 6 months' reach losses of -0.9% and -0.6% respectively and do not recover. This suggests that foreign property is a poor inflation hedge with respect to South African inflation. This result is in contrast to domestic property which offers a partial inflation hedge. As mentioned before the literature on property as an inflation hedge is very nuanced and mixed due to the heterogeneous nature of property. These results agree with prior literature and suggest there are many factors that may determine whether property as an asset class has inflation hedging abilities.

Property(MSCI) – experiences losses with no recovery (1995-2015).

As found in the subperiod (1999-2015) foreign property returns respond negatively to a positive one standard deviation shock to inflation in the extended sample period. Immediately, after the inflation shock monthly property returns drop in value by -0.4% in six months. Subsequently returns do not recover over the forecasted horizon. This suggests that foreign property is poor inflation hedge for South African investors (see appendix, G9).

Property(FTSE)– experiences losses with no recovery (1990-2015).

Similar results were obtained for the FTSE property index in which monthly returns respond negatively in the immediate aftermath of a positive one standard deviation shock to inflation. After about six months the returns on the FTSE index has dropped -0.5% in value and remains at this level for the rest of the forecasted horizon with no recover. This is in line with both the subperiod (1999) findings for the FTSE and MSCI property index as well as the extended sample periods (see appendix, G10).

In a nutshell, domestic property appears to provide a partial inflation hedge and this finding is robust to time sensitivity. Conversely, foreign property appears to be a poor inflation hedge and is also robust to different time frames.

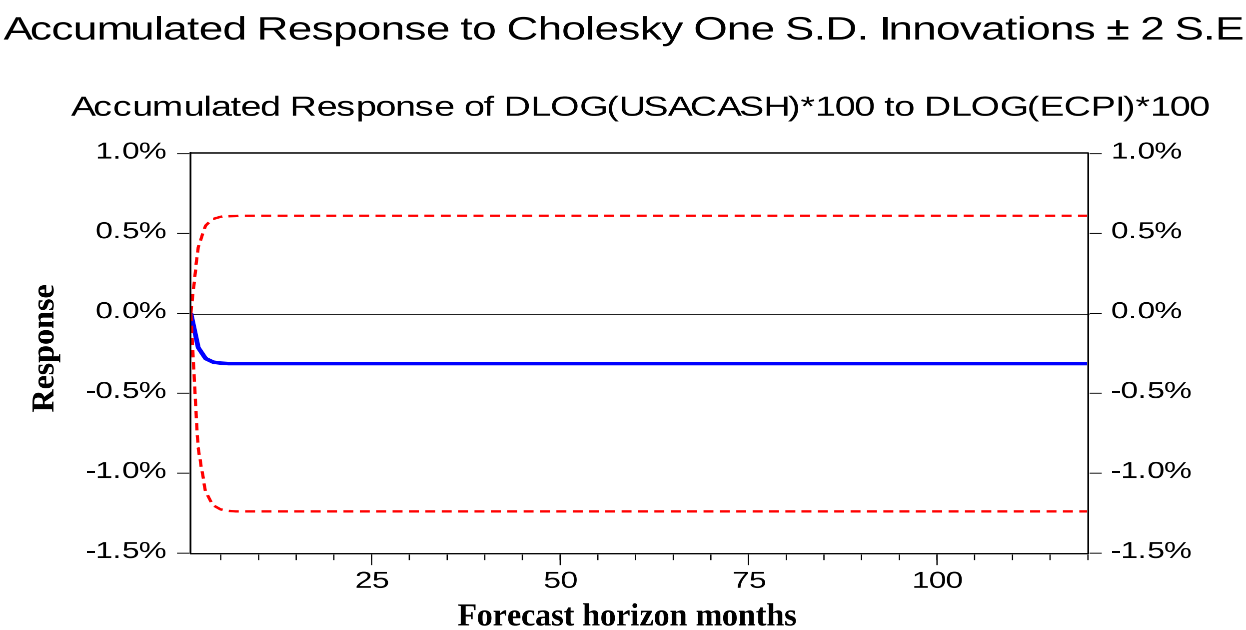

Figure 15: Impulse response function of monthly US cash index returns and monthly inflation 1999-2015

<u>Foreign cash</u>

<u>Cash- provides a poor inflation hedge (1999-2015)</u>

Foreign cash returns decline in response to a positive inflation shock. After approximately 5 months cash returns have declined by about -0.4% and do not recover over the forecasted horizon. These results suggest that foreign cash is not an effective hedge against South African inflation. These findings differ from domestic cash which is found to be a partial inflation hedge. There are a number of reasons that could potentially be causing these differences. Firstly, interest rates in the USA are close to zero compared to South Africa which are much higher. additionally, USA interest rates do not respond to inflation in South Africa. Secondly, there could be an exchange rate effect creating the disparity and finally, it could be as a result of different monetary policy frameworks being adopted.

Cash- provides a poor inflation hedge (1965-2015)

The findings of the longer sample period are in line with that of the subsample. Foreign cash responds negatively immediately after the one standard deviation shock to inflation. After about 3 months' foreign cash returns have dropped in value by -0.18% and thereafter exhibits no recovery from that loss for the rest of the forecasted horizon (see appendix, G11).

To sum up, it is evident domestic cash appears to be a good inflation hedge and is robust to different sample periods. On the other hand, foreign cash appears to be a poor inflation hedge.

6.6 Engle-Granger Cointegration

In order to determine whether a specific asset class and inflation have a long-term relationship the Engel and Granger (1987) residual based tests for cointegration was conducted and appropriate for the bi-variate system. The null hypothesis under this test is that there is no cointegration. The test was conducted allowing for the following two cointegrating relationships; 1) constant and 2) constant and linear trend. Both the Engle-Granger tau-statistic (t-statistic) and normalised autocorrelation coefficient (termed the z-statistic) fail to reject the null hypothesis of no cointegration which adds robustness to the findings. From tables 10 and 11 below it is apparent that there is no evidence of a cointegrating relationship between any single domestic or foreign asset class total return index and inflation, according to the Engle-Granger test for the common period of 1999-2015.

Table 10: Engle and Granger cointegration test of the bivariate model between asset classes and inflation 1999-2015 (tau-statistic)

Dependent variable (y)	Sample period	Independent variable(x)	Constant		Constant and Linear trend	
Level		Level	tau-statistic	P-value	tau-statistic	P-value
LALSITR	1999-2015	LCPI	-2.0257	0.5159	-2.5012	0.5245
LFINDITR	1999-2015	LCPI	-1.4563	0.7798	-2.4592	0.5473
LRESITR	1999-2015	LCPI	-1.6382	0.7064	-1.0966	0.9715
LPROPERTYTR	1999-2015	LCPI	-1.2581	0.8433	-1.7406	0.8660
LGOVITR	1999-2015	LCPI	-1.9806	0.5393	-1.8410	0.8344
LALBITR	1999-2015	LCPI	-2.0092	0.5245	-1.8332	0.8370
LSACASH	1999-2015	LCPI	-2.2032	0.4241	-0.8757	0.9842
LRBAS	1999-2015	LCPI	-1.9773	0.5410	-0.6515	0.9916
LMSCI WORLD EQUITY	1999-2015	LCPI	-0.3286	0.9740	-0.5139	0.9944
LCITI-BONDS	1999-2015	LCPI	-2.3661	0.3437	-2.5405	0.5032
LMSCI WORLD PROPERTY	1999-2015	LCPI	-2.0386	0.5092	-1.5325	0.9164
LFTSE PROPERTY	1999-2015	LCPI	-2.1300	0.4617	-1.7678	0.8579
LUSCASH	1999-2015	LCPI	-1.4140	0.7948	-1.5420	0.9145

Notes: The prefix "L" is used to denote the log of the variable. The null hypothesis (H_0) of the Engle-Granger residual based cointegration test is that the series are not cointegrated. Automatic lag specification was based on the Schwarz information criteria. The P-values above are the MacKinnon (1996) p-values. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. This table displays the results of the Engle-Granger tests for cointegration between the various asset classes and inflation with the p-values and t-statistics. Monthly data covering the period January 1999- December 2015 is utilized. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

Table 11: Engle and Granger cointegration test of the bivariate model between asset classes and inflation 1999-2015 (z-statistic)

Dependent variable (y)	Independent variable(x)	Sample period	Constant		Constant and Linear trend	
Level	Level		z-statistic	P-value	z-statistic	P-value
LALSITR	LCPI	1999-2015	-7.3338	0.5404	-13.3012	0.4401
LFINDITR	LCPI	1999-2015	-4.3865	0.7788	-9.3862	0.6881
LRESITR	LCPI	1999-2015	-5.2847	0.7066	-3.7593	0.9650
LPROPERTYTR	LCPI	1999-2015	-3.4979	0.8447	-7.2272	0.8221
LGOVITR	LCPI	1999-2015	-6.7162	0.5893	-6.3855	0.8675
LALBITR	LCPI	1999-2015	-6.9669	0.5692	-6.5815	0.8574
LSACASH	LCPI	1999-2015	-5.9223	0.6541	-3.3122	0.9743
LRBAS	LCPI	1999-2015	-4.9250	0.7359	-2.0749	0.9904
LMSCI WORLD EQUITY	LCPI	1999-2015	-0.9153	0.9697	-1.4467	0.9947
LCITI-BONDS	LCPI	1999-2015	-13.1140	0.2030	-15.2107	0.3382
LMSCI WORLD PROPERTY	LCPI	1999-2015	-12.3640	0.2334	-6.0367	0.8845
LFTSE PROPERTY	LCPI	1999-2015	-12.5177	0.2269	-7.1322	0.8275
LUSCASH	LCPI	1999-2015	-5.6541	0.6762	-6.6543	0.8536

Notes: The prefix "L" is used to denote the log of the variable. The null hypothesis (H_0) of the Engle-Granger residual based cointegration test is that the series are not cointegrated. Automatic lag specification was based on the Schwarz information criteria. The P-values above are the MacKinnon (1996) p-values. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. This table displays the results of the Engle-Granger tests for cointegration between the various asset classes and inflation with the p-values and z-statistics. Monthly data covering the period January 1999- December 2015 is utilized. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

Even when testing for cointegration for each asset class and inflation dating back to the inception of each index the findings remain consistent that there is little evidence of cointegration between asset class returns and inflation. This can be seen in table 12 and 13 below. The only exception being the FTSE EPRA/NAREIT property index and only under the z-statistic that cointegration is found. This supports the subperiod (1999-2015) findings and adds to the robustness that there appears to be no evidence of a cointegrated relationship between inflation and asset classes despite them being I(1). Since there is no evidence of cointegration between each asset class and inflation it suggests that there is no long-run relationship. Consequently, none of the asset classes provide a hedge against inflation in the long-run according to Engle-Granger cointegration tests. The implication of this finding for investment firms whose mandate generally stipulates CPI as a benchmark, is that they are relying on the specific asset class to have higher average(mean) returns than inflation in the long-run rather than there being any relationship that results in a positive co-movement between asset class returns and inflation.

Table 12: Engle and Granger cointegration test of the bivariate model between asset classes from their respective inceptions and inflation (tau-statistic)

Dependent variable (y)	Independent variable(x)	Sample period	Constant		Constant and Linear trend	
Level	Level		tau-statistic	P-value	tau-statistic	P-value
LALSITR	LCPI	1965-2015	-1.4843	0.7693	-2.9904	0.2713
LFINDITR	LCPI	1965-2015	-1.0939	0.8832	-2.3474	0.6045
LRESITR	LCPI	1965-2015	-2.1450	0.4527	-2.3452	0.6057
LPROPERTYTR	LCPI	1965-2015	-0.7893	0.9336	-1.9330	0.7995
LSACASH	LCPI	1965-2015	-0.5056	0.9620	-1.8889	0.8161
LRBAS	LCPI	1965-2015	-0.4440	0.9666	-1.9580	0.7897
LMSCI WORLD EQUITY	LCPI	1970-2015	-1.7947	0.6332	-2.0484	0.7519
LCITI BONDS	LCPI	1985-2015	-2.7457	0.1860	-2.7334	0.3973
LMSCI WORLD PROPERTY	LCPI	1995-2015	-1.5723	0.7345	-2.4493	0.5517
LFTSE PROPERTY	LCPI	1990-2015	-2.9903	0.1156	-2.0341	0.7589
LUSCASH	LCPI	1965-2015	-2.286357	0.3806	-2.252717	0.6541

Notes: The prefix "L" is used to denote the log of the variable. The null hypothesis (H_0) of the Engle-Granger residual based cointegration test is that the series are not cointegrated. Automatic lag specification was based on the Schwarz information criteria. The P-values above are the MacKinnon (1996) p-values. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. This table displays the results of the Engle-Granger tests for cointegration between the various asset classes and inflation with the p-values and t-statistics. Monthly data covering differing periods depending on the inception of each index see tables 2 and 3. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

Table 13: Engle and Granger cointegration test of the bivariate model between asset classes from their respective inceptions and inflation (z-statistic)

Dependent variable (y)	Independent variable(x)	Sample period	Constant		Constant and Linear trend	
Level	Level		z-statistic	P-value	z-statistic	P-value
LALSITR	LCPI	1965-2015	-5.5696	0.6858	-15.6087	0.3302
LFINDITR	LCPI	1965-2015	-3.7217	0.8296	-9.1800	0.7062
LRESITR	LCPI	1965-2015	-9.2996	0.4050	-14.3146	0.3944
LPROPERTYTR	LCPI	1965-2015	-2.2711	0.9184	-6.8633	0.8439
LSACASH	LCPI	1965-2015	-0.6730	0.9754	-5.7339	0.8988
LRBAS	LCPI	1965-2015	-0.5646	0.9778	-6.1960	0.8777
LMSCI WORLD EQUITY)	LCPI	1970-2015	-6.1572	0.6378	-7.1545	0.8281
LCITI-BONDS	LCPI	1985-2015	-14.3663	0.1641	-14.6783	0.3722
LMSCI WORLD PROPERTY	LCPI	1995-2015	-5.9670	0.6513	-10.6843	0.6048
LFTSE PROPERTY	LCPI	1990-2015	**-20.1164***	0.0509	-7.9417	0.7815
LUSCASH	LCPI	1965-2015	-10.84017	0.3140	-10.78568	0.6032

Notes: The prefix "L" is used to denote the log of the variable. The null hypothesis (H_0) of the Engle-Granger residual based cointegration test is that the series are not cointegrated. Automatic lag specification was based on the Schwarz information criteria. The P-values above are the MacKinnon (1996) p-values. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. This table displays the results of the Engle-Granger tests for cointegration between the various asset classes and inflation with the p-values and z-statistics. Monthly data covering differing periods depending on the inception of each index see tables 2 and 3. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable.

The Engle-Granger residual based cointegration test is preferred to the Johansen procedure because results tend to be very sensitive to the lag length criteria used and hence the lag length[6] (Alagidede & Panagiotidis, 2010). Additionally, it is sensitive to the assumptions of whether a constant, trend, neither or both are included in the model (see appendix, H). This notion is supported by Ahking (2001) who found that the results produced using the Johansen approach differed significantly when the models varied in the deterministic components included in the cointegration model. Consequently, empirical findings can differ based on the deterministic component included (e.g. a constant or linear trend etc.). Therefore, choosing the incorrect model specification can lead to academics drawing erroneous conclusions from the data (Hjelm and Johansson, 2005). Conversely, the Engle-Granger test produced consistent results in both scenarios with a constant or linear trend and across different sample periods. Additionally, results remained the same regardless of the lag length criteria utilised (AIC, SIC or HQ)[7].

[6] The above critique was found to be true when the Johansen test was applied to the data used in this study. The results for Johansen varied depending on which lag length criteria (AIC, SIC, HQ or LR) was selected as the optimal lag length.

[7] This was found to be true when conducting the Engle-Granger cointegration analysis in this study.

7. Conclusion

This study examines the empirical relationship between inflation and the returns for four different types of asset classes (equities, bonds, property and cash) both domestically and abroad. This study has attempted to address the question of how an investor can best protect their real income and wealth from the deleterious effects of inflation that erodes an investor's real purchasing power. This question has largely been ignored for developing countries in Africa with no study comprehensively investigating the hedging properties of all four of the above aforementioned asset classes for South Africa.

The main finding of this study are as follows.

1. Over the period between 1999-2015 which forms the comparative analysis between domestic and foreign asset classes the following was found. Both domestic and foreign equities exhibit poor inflation hedging properties in the short-run with contemporaneous and lagged inflation. However, foreign equites do tend to provide a leading return before inflation manifests. Domestic bonds although contemporaneously negatively correlated with inflation tend to respond positively after an inflation shock suggesting they are a partial inflation hedge. Domestic cash is both contemporaneously positively correlated with inflation and responds positively shortly after an inflation shock suggesting that cash provides a partial inflation hedge. The findings mentioned above are robust to the different methods used to analyse the relationship. On the other hand, foreign bonds and cash responding negatively to inflation shocks suggesting that these asset classes are poor inflation hedges with prior inflation. However, as found with foreign equities, foreign bonds and cash provide a leading return which may provide investors with inflation protection. Finally, the results for domestic property are sensitive to the methods used however, on the balance property appears to respond positively to an inflation shock as seen from the impulse response functions. Foreign property on the other hand is a poor inflation hedge responding negatively to inflation shocks. This was the case for both the FTSE EPRA/NIREIT and MSCI world property indices.

The implications of the above results for an investor who wants to protect their income and wealth from inflation are as follows. Firstly, they should be aware that foreign asset classes tend to provide protection against inflation in terms of leading returns, however do not protected investors against contemporaneous or lagged inflation. Conventional wisdoms suggest that foreign assets will be a good inflation hedge because they are rand hedges. However, it appears that foreign asset classes are not as a great inflation hedge as one would think, in the sense of foreign asset class returns covarying contemporaneously in a positive one-to-one or close to one relationship. In other word, foreign asset classes do not offer protection against contemporaneously or lagged inflation, however foreign asset returns do tend to lead inflation and as a result if profits are taken early enough it can provide an inflation hedge. Secondly, equities domestically must be avoided as they exhibit poor inflation hedging capabilities in the short-run (1 year). This provides support for the negative relationship between equities and inflation in the short-run (also known as the inverted fisher effect) which is widely recognised in existing literature. Finally, in order for inflation averse investors to effectively protect themselves from inflation they should tilt their portfolios towards domestic cash, bonds and potentially property asset classes with the biggest portion being allocated to the cash asset class which exhibits the strongest inflation hedging properties.

2. The comparative analysis exclusively focusing on domestic asset classes dates back to 1965, excluding bonds due to data constraints. The findings suggest equities, are negatively contemporaneously correlated with inflation up to 1 year which is consistent with subsample findings. Moreover, when evaluating how equity returns respond to inflationary shocks through impulse response functions it is clear that equities respond negatively, which is in line with the subperiod findings and reinforces the notion that equities are a poor inflation hedge. With regards to domestic property, the findings are similar to the subperiod (1999-2015) which found that property responds positively to inflation changes and as a result may provide investors with a potential inflation hedge. Finally, domestic cash is also found to be a partial inflation hedge which is consistent with the subperiod results and tends to exhibit the strongest inflation hedging properties of all the asset classes.

The implications of the above findings suggest that as an inflation averse investor one would want to avoid equities in the short-run and potentially in the long-run as well. On the other hand, in order to protect your real income and wealth from inflation erosion one should tilt their portfolio to the cash and property asset classes with the cash asset class providing the strongest inflation hedge.

3. The following was found for the comparative analysis of foreign asset classes with each other. All foreign asset classes were found to either be negatively contemporaneously correlated with inflation or respond negatively to inflation shocks with the exception of foreign bonds. The evidence for foreign bonds is mixed. Foreign bonds tend to exhibit a positively contemporaneous correlation with inflation however, from the impulse response function, foreign bonds appear to respond negatively to inflationary shocks but thereafter recover over time (see appendix E, figure E8). However, it was found that foreign asset classes can protect investors from inflation with a leading return. Therefore, foreign asset classes may provide investors with an inflation hedge if profits are realised prior to inflation manifesting.

4. Lastly, there appears to be no evidence of a long-term relationship between the respective asset classes and inflation according to Engle-Granger cointegration. This suggests that neither of the asset classes both domestic and foreign are good inflation hedges in the long-run. As previously mentioned this means that asset managers whose benchmarks' contain CPI, rely on the fact that the mean returns of these asset classes exceed mean inflation in the long-run rather than there being any positive relationship. This result provides support to the strand of literature that finds evidence against the Fisher effect, which states that equites should be a good inflation hedge in the long-run.

Overall the findings of this study elicit three useful pieces of insight for an inflation averse investor seeking to protect oneself from South African inflation. Firstly, it is better to invest in domestic asset classes as opposed to their foreign counter parts unless the returns from foreign assets are realised before inflation manifests. Secondly, it is best to avoid domestic equities as an asset class as it is the worst asset class when it comes protecting the real purchasing power of one's assets over time. Thirdly, it beneficial to rather allocate your funds between domestic cash, bonds and/or property when seeking to protect against the harmful effects of inflation to one’s purchasing power. More specifically, domestic cash seems to exhibit the strongest inflation hedging properties.

It is worth emphasizing two final points. Firstly, despite nearly all the asset classes having an average return in excess of the average inflation rate in the short and long-run it does not imply that these asset classes will be a good inflation hedge which is about the comovement of asset class returns and inflation. This was seen with cointegration whereby no asset class exhibits a long-run relationship with inflation. Secondly, although equities exhibit the worst inflation hedging properties, meaning that they do not covary positively with inflation, it does not necessarily imply that equities in real terms will underperform the others asset classes in the long-run that do provide inflation protection.

8. Future research/ suggested extensions

As eluded to in this study, literature on this topic for developing countries in Africa has been scant. To the best of our knowledge there is no prior study that investigates and compares the inflation hedging abilities for equities, bonds, property and cash in South Africa and in addition compares them to foreign counter parts. It is hoped that this study provides a platform to be built upon for which further research can be conducted on the relationship between asset class returns and inflation in South Africa and other African countries. This is particularly important since the deleterious nature of inflation is more severe and prevalent in African countries.

Possible beneficial avenues within this topic to explore which will provide valuable insights for investors seeking to protect themselves from the erosion of their assets purchasing powers are the following. The relationship between equities and inflation could be explored on a sector basis. This may provide valuable insights into whether equities in certain sectors may be good inflation hedges in contrast to the findings that equities as represented by the broad indices of the ALSI, FINDI and RESI are poor inflation hedges. If equities in certain sectors do tend to be good inflation hedges than this will provide investors with the opportunity to diversify their portfolios with these equities. In addition to getting the opportunity to earn the higher returns that equites generally offer, compared to bonds, property and cash as well as ensure they are protected from inflation. Furthermore, the same analysis could be applied to different types of bonds and property assets in which mixed results in prior literature have been found as a consequence of property being such a heterogeneous asset class (Gyourko and Linneman (1988). Another way for future research to add value to this topic would be to use different methodologies and data frequencies and see if the relationships found in this study are the same. This is because prior research on this topic has found that results tend to be sensitive to methods used, frequencies and sample periods (Arnold & Auer, 2015). Finally, it could be valuable to determine whether the above findings hold when real returns are used instead of nominal returns as this could add robustness to the results. Given the suggestions stated above this study provides a platform for future research into the relationship between asset class returns and inflation within South Africa and Africa.

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Appendix C

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C.2 Descriptive statistics of Foreign assets

Appendix D

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D.3 Augmented Dickey-Fuller test on domestic asset classes levels

D.4 Augmented Dickey-Fuller test on domestic asset classes first differences

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D.7 Augmented Dickey-Fuller test on foreign asset classes levels

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Appendix E

E.1 Pearson correlations for domestic asset classes and inflation

E.2 Pearson correlations for foreign asset classes and inflation

Appendix F

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F.3 Regressions for Granger causality 3 lags

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Appendix A

A1: Methodology used to derive indices for RBAS and the US 3-month treasury bill

Below is the method followed to construct and index from the 90 day bankers' acceptance rate. The initial starting value for the index was chosen to be 1. In order to convert RBAS into an index the previous index value each time was multiplied by 1 plus the RBAS in the current period divided by 1200. It is divide by 1200 in order to get the monthly RBAS in percentage decimal form. This is depicted below:

The Index value beginning growing from an initial starting value of 1.

$$RBAS_{index} = [Index\ value_{t-1}]^{*}\left[1 + \left(\frac{rbas}{1200}\right)\right]$$

Where:

$RBAS_{index}$ = The created index with 90 day bankers' acceptance rate.

$Index\ value_{t-1}$= Is the previous months' index value with an initial starting index value of 1 at inception.

$\left(\frac{rbas}{1200}\right)$ = The 90 day bankers' acceptance rate converted into a monthly percent in decimal form.

Creating an index from the US 3-month treasury bill rate consisted of four steps. Step 1 involved calculating the percentage change in the USDZAR exchange rate. Step 2 was to convert the US 3-month treasury bill rate in to rands. This was achieved by multiplying one plus the US 3-month treasury bill divided 1200 by one plus the % change in the exchange rate. The reason the 3-month treasury bill is divided by 1200 is to make it a monthly rate in percentage decimal form. Step 3 involved getting the US 3-month treasury bill into a percentage by subtracting 1 and multiplying by 100. Finally, step 4 the previous index value each time was multiplied by one plus the current period US 3-month treasury bill in rands % divided by 100.

Creating a US 3-month cash index in Rands

Step 1: Get the % change in the USDZAR exchange rate.

$$\%\ change\ in\ USDZAR = \frac{(new - old)}{(old)}$$

STEP 2: convert the US 3-month rate into rands

$$USTB3M\ in\ rands = \left[\left(1 + \left(\frac{USTB3M}{1200}\right)\right)\right] * [1 + \%\ change\ in\ USDZAR]$$

STEP 3: $USTB3M\ in\ rands\ as\ a\ \% = (USTB3M\ in\ rands - 1) * 100$

STEP 4: $[Index\ value_{t-1}]^{*} \left[1 + \left(\frac{USTB3M\ in\ rands\ \%}{100}\right)\right]$

A2: Table data description of each domestic variable since inception

Data series	Source	Duration	Type	Asset class /other	Domestic/ local	Code
Adjusted All-Share index	I-Net	1965-2015	Monthly	Equities	Domestic	AJ203
All-share total return index	I-Net	1995-2015	Monthly	Equities	Domestic	J203T
Financial & Industrial Index	I-Net	1965-2015	Monthly	Equities	Domestic	F121F
Financial & Industrial total return Index	I-Net	1995-2015	Monthly	Equities	Domestic	J213T
Adjusted Resources Index	I-Net	1965-2015	Monthly	Equities	Domestic	AJ000
Resources total return Index	I-Net	1995-2015	Monthly	Equities	Domestic	J210T
Government Bond Index	I-Net	1999-2015	Monthly	Bonds	Domestic	BW.GOVI
All Bond Index	I-Net	1999-2015	Monthly	Bonds	Domestic	ALBI
Property Index	I-Net	1965-1999	Monthly	Property	Domestic	IX46X
Property Index	I-Net	1993-2002	Monthly	Property	Domestic	IX46
SA listed property	I-Net	2002-2015	Monthly	Property	Domestic	J253T
Alexander Forbes Money market index	I-Net	1965-2015	Monthly	Cash	Domestic	GMC1
Stefi Composite Index	I-Net	2000-2015	Monthly	Cash	Domestic	STFIND
90 day bankers' acceptance (RBAS)	I-Net	1965-2015	Monthly	Cash	Domestic	RBAS
Consumer Price Index (CPI)	I-Net	1965-2015	Monthly	Inflation	Domestic	ECPI
USDZAR Exchange rate	I-Net	1965-2015	Monthly	Exchange rate	Domestic	USDZAR

A3: Table of data description of each foreign variable since inception

Data series	Source	Duration	Type	Asset class /other	Domestic/ local	Code
MSCI World Equity Index- Total Returns	Bloomberg	1970-2015	Monthly	Equites	Foreign	MXWO
Citi World Government Bond Index- Total Return	Data Stream	1985-2015	Monthly	Bonds	Foreign	SBWGUII(RI)
FTSE EPRA NAREIT Developed - Total Return Index	Bloomberg	1999-2015	Monthly	Property	Foreign	RUGL
MSCI World Real Estate- Total Return	Bloomberg	1995-2015	Monthly	Property	Foreign	MXWOORE
USA 3-Month Treasury Bill	I-Net	1965-2015	Monthly	Cash	Foreign	USTB3M

A4: Methodology used to merge indices

Financial and Industrial

The F121FT which represents the derived Financial and industrial total return index was combined with the Financial and Industrial total return index (J213T). The reason underlying this modification is because the Financial and Industrial total return index (J213T) only dates back to the 30th June 1995, whereas the derived Financial and Industrial total return index (F121FT) dates back to 31st January 1965.

$$\mathbf{FI21FT = FI21F + D_t}$$

Where:

FI21FT= The derived Financial and Industrial total return index.

$\mathbf{FI21F}$= The Financial and Industrial price index.

$\mathbf{D_t}$= The dividend received for month (t).

Therefore, the initial step was to calculate the dividend for each month $D(t)$ using the above methodology and then subsequently this was added to the F121F price index in order to obtain the total return index(F121FT).

Subsequently, in order to ensure that the most up to date Financial and Industrial total return index was used in the study, the derived F121FT was spliced together with J213T. This was achieved by taking the initial data point of the J213T index which dated back to 30th June 1995 and replacing the F121FT index with J213T from that point in time onwards. Additionally, the data point of the J213T index which dated back to 30th June 1995 was divided by the derived F121FT index data point on that same date. This provided us with a ratio which was then used to scale the F121FT index in proportion to the latest J213T index by multiplying all F121FT data points prior to 30th June 1995 by the ratio. This can be illustrated as follows:

$$(\mathbf{FI21FT} + \mathbf{J213T})_{\mathbf{1965-2016}} = \left[\mathbf{FI21FT_{1960-1995}} * \frac{\mathbf{J213T_{1995}}}{\mathbf{FI21FT_{1995}}}\right] + \mathbf{J213T_{1995-2016}}$$

Where:

$(\mathbf{FI21FT} + \mathbf{J213T})_{\mathbf{1965-2016}}$ = The combined derived Financial and Industrial total return index dating back to 1965.

$\mathbf{FI21FT_{1960-1995}}$= The derived Financial and Industrial total return index.

$\frac{\mathbf{J213T_{1995}}}{\mathbf{FI21FT_{1995}}}$ = Splicing factor used to merge the indices.

$\mathbf{J213T_{1995-2016}}$= The Financial and Industrial total return index.

The above methodology was also applied to the Resources, Property and cash indices when merging the indices.

Resources

$$\mathbf{AJ000T = AJ000 + D_t}$$

Where:

$\mathbf{AJ000T}$= The derived Resources total return index.

$\mathbf{AJ000}$= The Resources price index.

$\mathbf{D_t}$= The dividend received for month (t).

$$(\mathbf{AJ000T + J210T})_{\mathbf{1965-2016}} = \left[\mathbf{AJ000T_{1960-1998}} * \frac{\mathbf{J210T_{1998}}}{\mathbf{AJ000T_{1998}}}\right] + \mathbf{J210T_{1998-2016}}$$

Where:

$(\mathbf{AJ000T + J210T})_{\mathbf{1965-2016}}$= The combined derived Resources total return index dating back to 1965.

$\mathbf{AJ000T_{1960-1998}}$= The derived Resources total return index.

$\frac{\mathbf{J210T_{1998}}}{\mathbf{AJ000T_{1998}}}$ = Splicing factor used to merge the indices.

$\mathbf{J210T_{1998-2016}}$= The Resources total return index.

Property

$$\boldsymbol{IX}\mathbf{46XT_{1965-1993} = IX46X_{1965-1993} + D_t}$$

Where:

$\boldsymbol{IX}\mathbf{46XT_{1965-1993}}$= The derived Property total return index.

$\mathbf{IX46X_{1965-1993}}$ = The Property price index.

$\mathbf{D_t}$= The dividend received for month (t).

$$\mathrm{I}\mathbf{X46T_{1993-2002} = IX46_{1993-2002} + D_t}$$

$\mathrm{I}\mathbf{X46T}_{\mathbf{1993-2002}}$ = The derived Property total return index

$\mathbf{IX46}_{\mathbf{1993-2002}}$ = The Property price index.

$\mathbf{D_t}$= The dividend received for month (t).

$$(\mathbf{IX46T} + \mathbf{IX46XT})_{\mathbf{1965-2002}} = \left[\mathbf{IX46XT}_{\mathbf{1965-1993}} * \frac{\mathbf{IX46T}_{\mathbf{1993}}}{\mathbf{IX46XT}_{\mathbf{1993}}}\right] + \mathbf{IX46T}_{\mathbf{1993-2002}}$$

Where:

$(\mathbf{IX46T} + \mathbf{IX46XT})_{\mathbf{1965-2002}}$ = The combined derived Property total return index dating back to 1965.

$\mathbf{IX46XT}_{\mathbf{1965-1993}}$ = The derived Property total return index.

$\frac{\mathbf{IX46T}_{\mathbf{1993}}}{\mathbf{IX46XT}_{\mathbf{1993}}}$ = Splicing factor used to merge the indices.

$\mathbf{IX46T}_{\mathbf{1993-2002}}$= The derived Property total return index.

$$(\mathbf{IX46T} + \mathbf{IX46XT} + \mathbf{J253T})_{\mathbf{1965-2016}} = \left[(\mathbf{IX46T} + \mathbf{IX46XT})_{\mathbf{1965-2002}} * \frac{\mathbf{J253T}_{\mathbf{2002}}}{(\mathbf{IX46T} + \mathbf{IX46XT})_{\mathbf{2002}}}\right] + \mathbf{J253T}_{\mathbf{2002-2016}}$$

Where:

$(\mathbf{IX46T} + \mathbf{IX46XT} + \mathbf{J253T})_{\mathbf{1965-2016}}$= The combined derived Property total return index dating back to 1965.

$(\mathbf{IX46T} + \mathbf{IX46XT})_{\mathbf{1965-2002}}$**=** The derived Property total return index.

$\frac{\mathbf{J253T}_{\mathbf{2002}}}{(\mathbf{IX46T+IX46XT})_{\mathbf{2002}}}$ = Splicing factor used to merge the indices.

$\mathbf{J253T}_{\mathbf{2002-2016}}$= The Property total return index.

Cash

To ensure that the most up to date cash indices were used in the study in order to accurately depict the money market, the Alexander Forbes cash index(GMC1) was spliced together with the STEFI composit cash index (STFIND). This was achieved by taking the initial data point of the STEFI index which dated back to 29 February 2000 and replacing the Alexander Forbes index(GMC1) with the STEFI from that point in time onwards. Additionally, the data point of the STEFI index which dated back to 29 February 2000 was divided by the GMC1 index data point on that same date. This provided us with a ratio which was then used to scale the GMC1 index in proportion to the latest STEFI index by multiplying all GMC1 data points prior to 29 February 2000 by the ratio. This is demonstrated below.

$$(\mathbf{GMC1} + \mathbf{STFIND})_{\mathbf{1965-2016}} = \left[\mathbf{GMC1}_{\mathbf{1960-2000}} * \frac{\mathbf{STFIND}_{\mathbf{2000}}}{\mathbf{GMC1}_{\mathbf{2000}}}\right] + \mathbf{STFIND}_{\mathbf{2000-2016}}$$

Where:

$(\mathbf{GMC1} + \mathbf{STFIND})_{\mathbf{1965-2016}}$= The combined cash index dating back to 1965.

$\mathbf{GMC1}_{\mathbf{1960-2000}}$= The Alexander Forbes cash index.

$\frac{\mathbf{STFIND}_{\mathbf{2000}}}{\mathbf{GMC1}_{\mathbf{2000}}}$ = Splicing factor used to merge the indices.

$\mathbf{STFIND}_{\mathbf{2000-2016}}$= The STEFI composite cash index.

A5: Table of merging dates for the equity, property and cash indices

Merged indices	Merged dates	Asset class /other	Domestic/ local	Codes
Adjusted All-Share index + All-share total return index	30 June 1995	Equities	Domestic	AJ203 + J203T
Financial & Industrial Index + Financial & Industrial total return Index	30 June 1995	Equities	Domestic	F121F + J213T
Adjusted Resources Index + Resources total return Index	28 February 1998	Equities	Domestic	AJ000 + J210T
Property Index + SA listed property	28 February 1993 and 31 March 2002	Property	Domestic	IX46X + IX46 + J253T
Alexander Forbes Money market index + Stefi Composite Index	29 February 2000	Cash	Domestic	GMC1 + STFIND

Appendix B

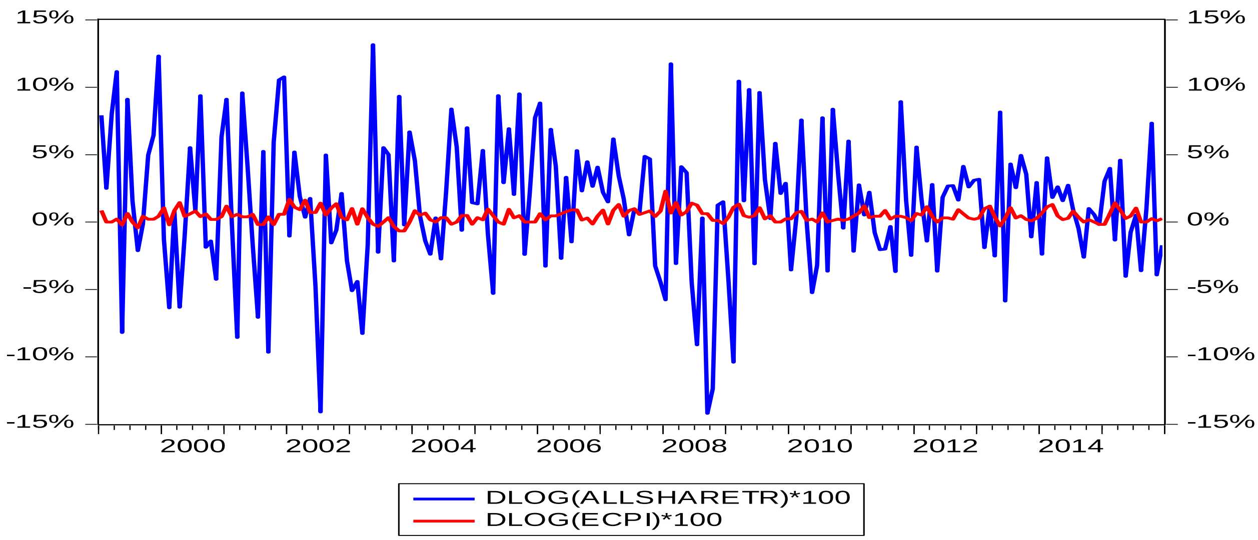


Figure B1: Monthly All share index total returns and monthly inflation 1999-2015

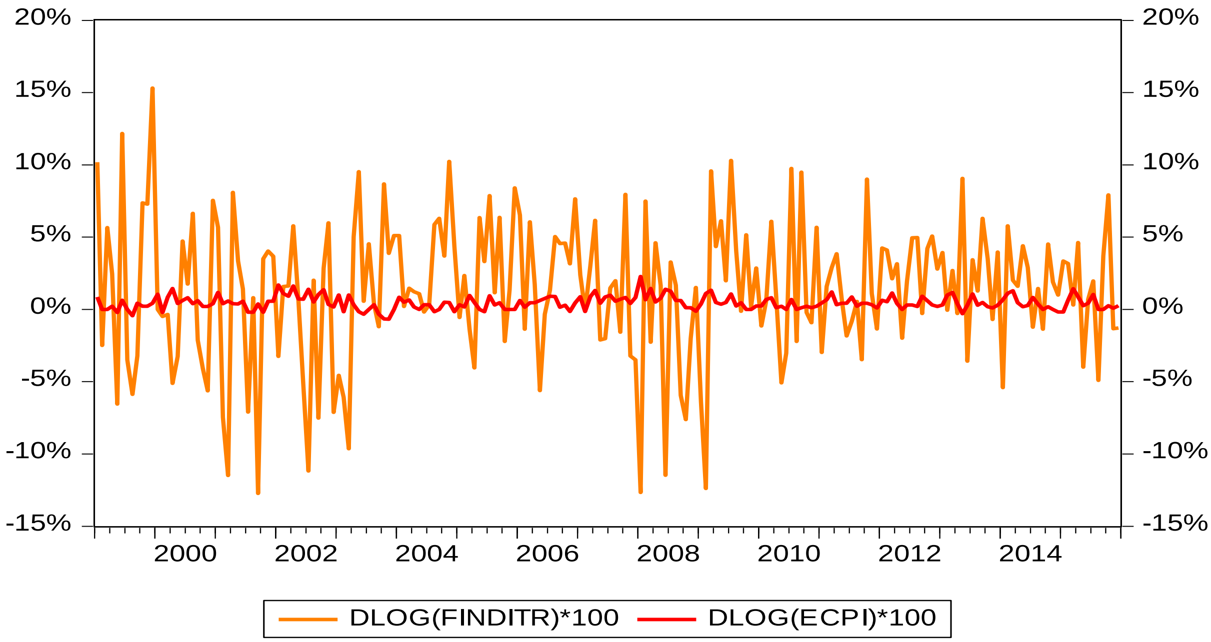


Figure B2: Monthly Financial and Industrial index total returns and monthly inflation 1999-2015

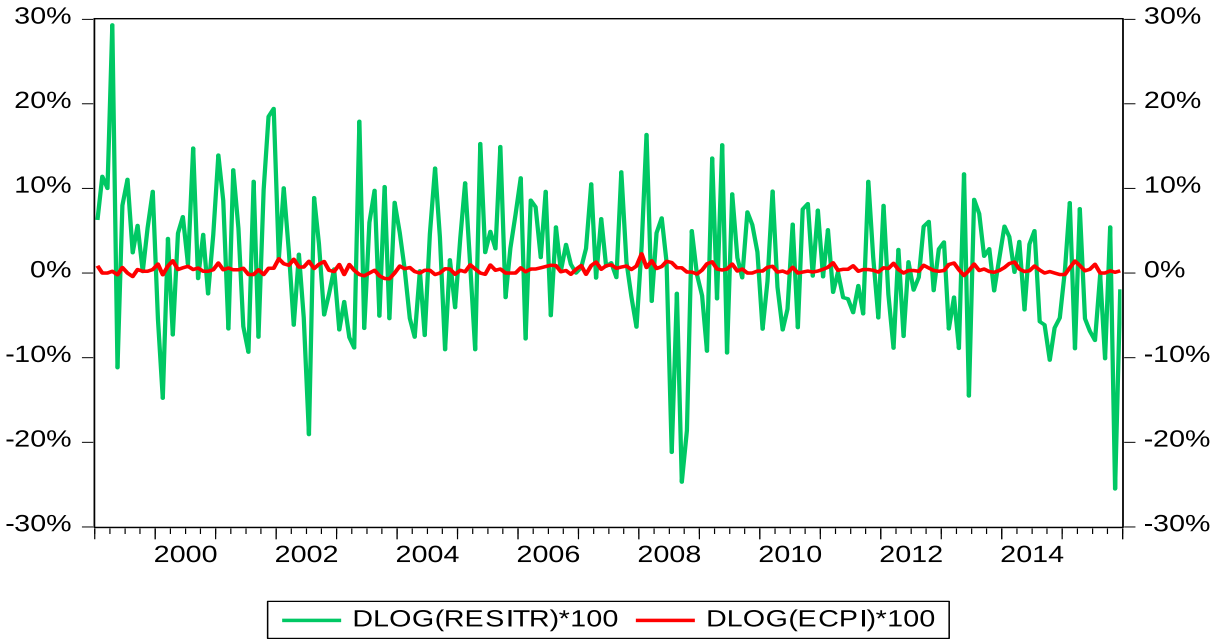


Figure B3: Monthly Resources index total returns and monthly inflation 1999-2015

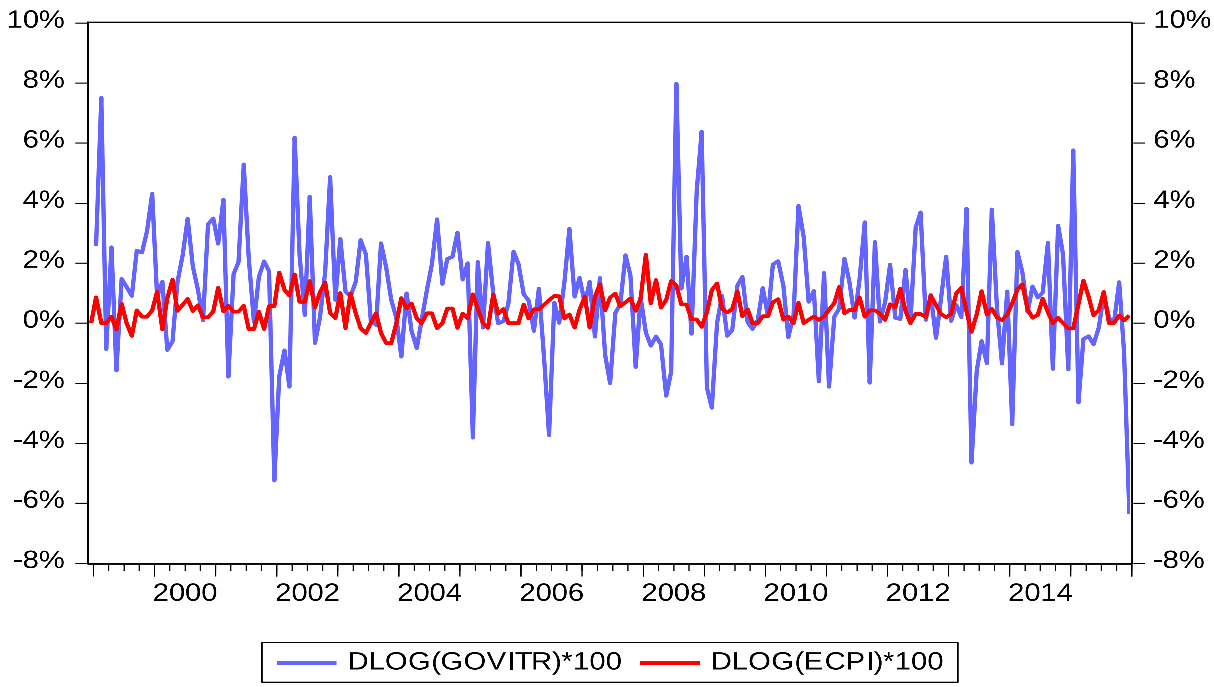


Figure B4: Monthly Government bond index total returns and monthly inflation 1999-2015

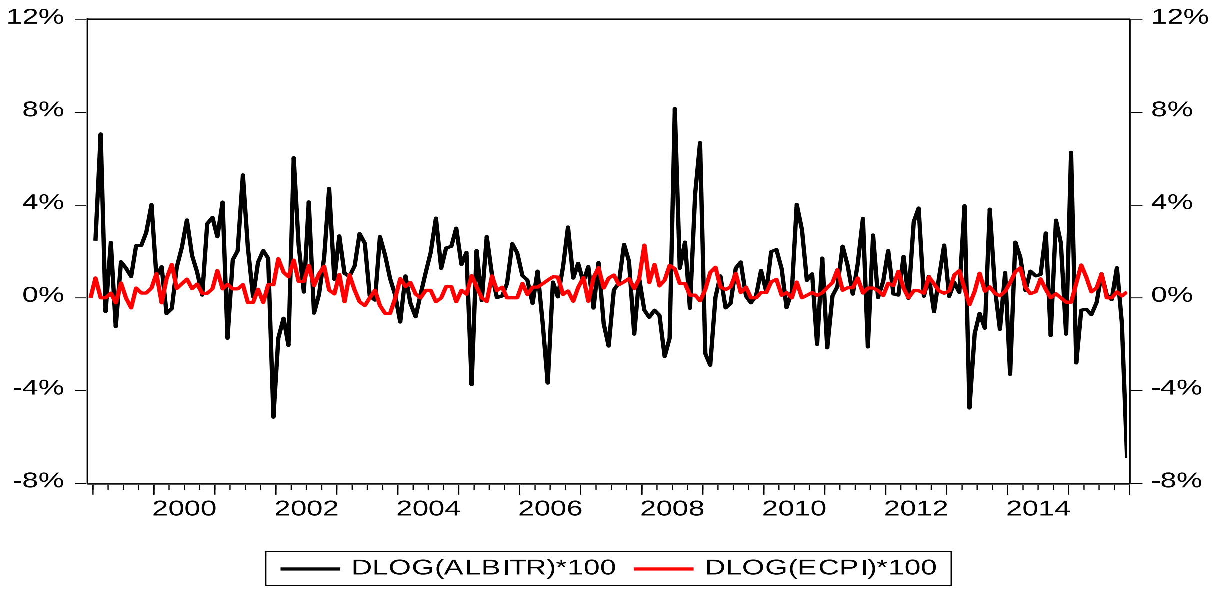


Figure B5: Monthly All bond index total returns and monthly inflation 1999-2015

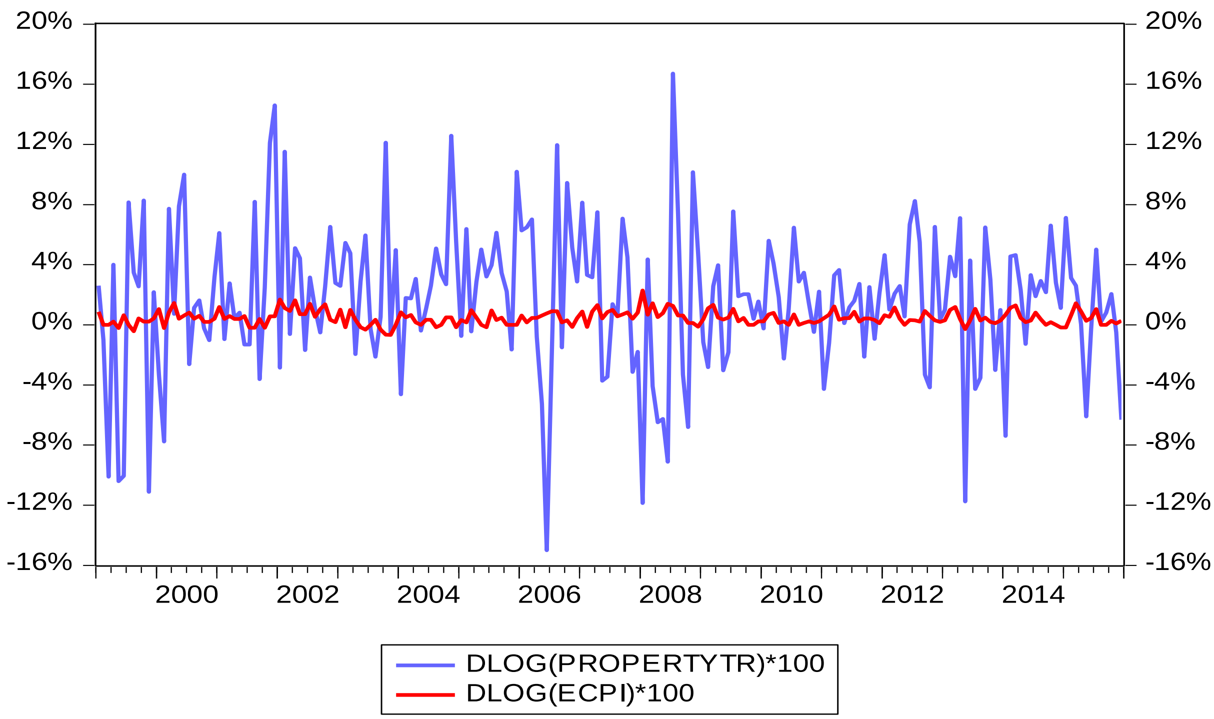


Figure B6: Monthly Property index total returns and monthly inflation 1999-2015

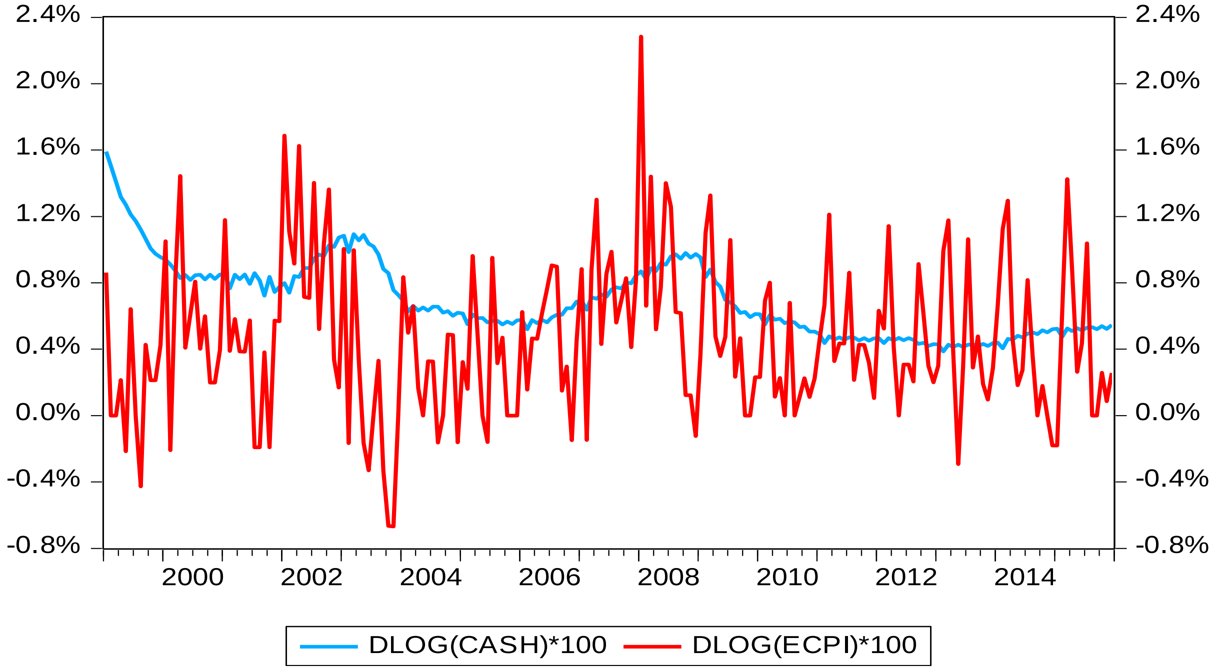


Figure B7: Monthly All share total returns and monthly inflation 1999-2015

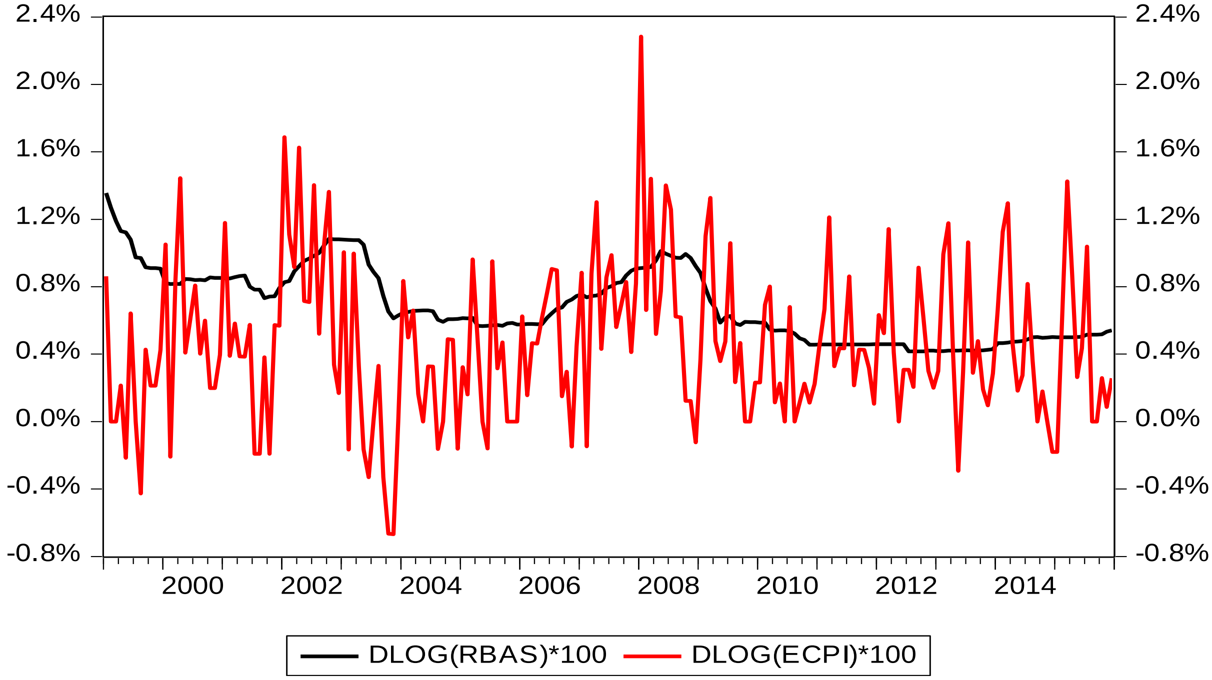


Figure B8: Monthly RBAS returns and monthly inflation 1999-2015

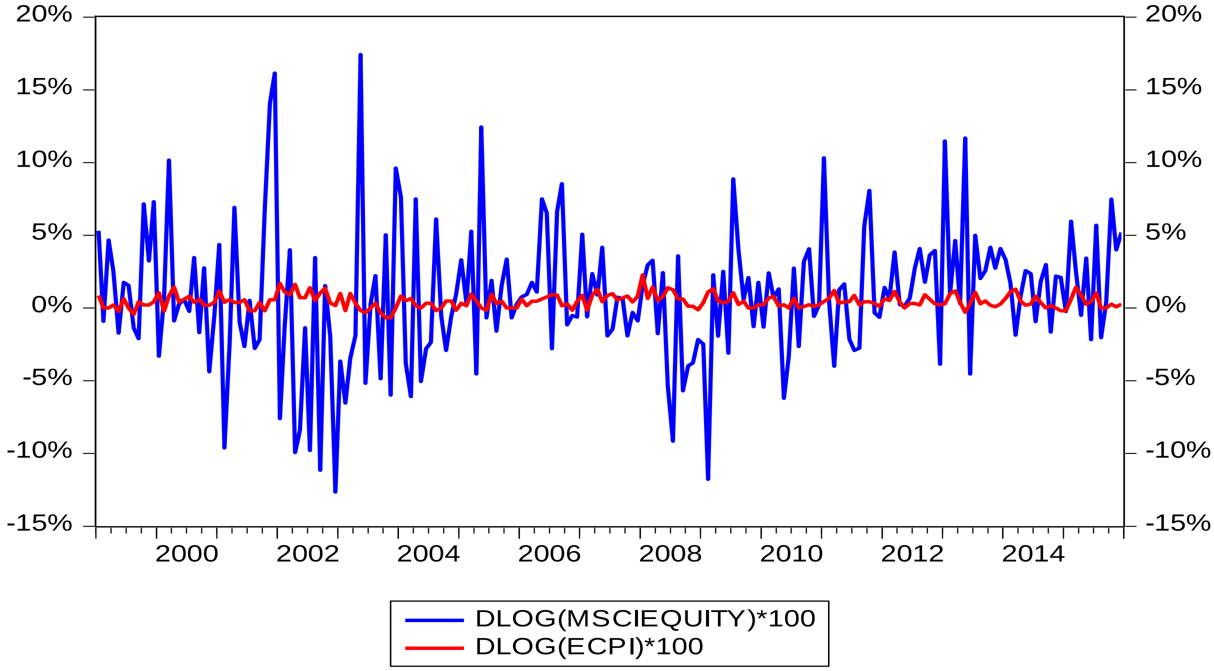


Figure B9: Monthly MSCI world equity index total returns and monthly inflation 1999-2015

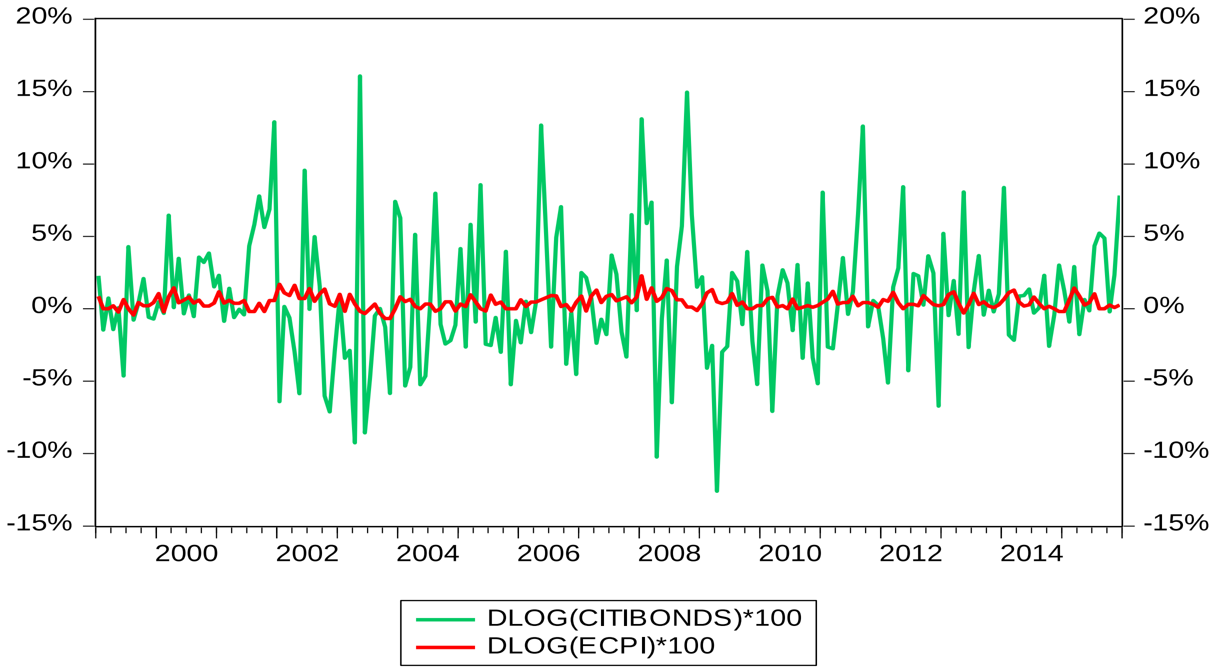


Figure B10: Monthly Citi-group world government bond index total returns and monthly inflation 1999-2015

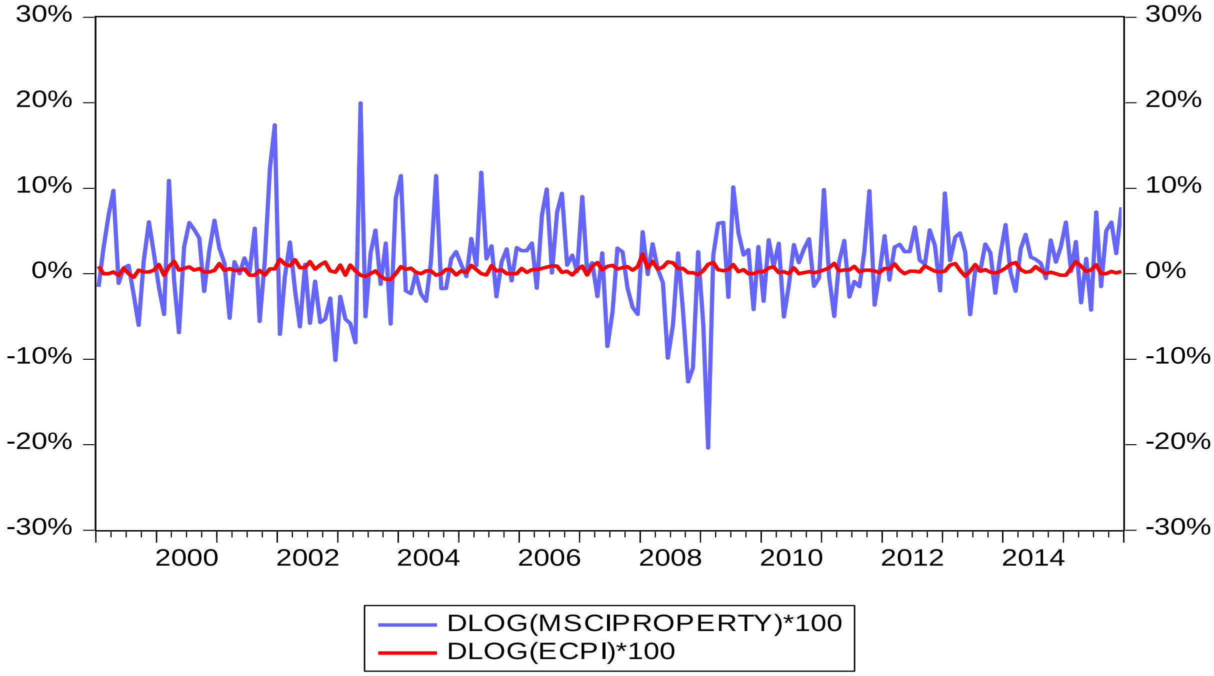


Figure B11: Monthly MSCI world property index total returns and monthly inflation 1999-2015

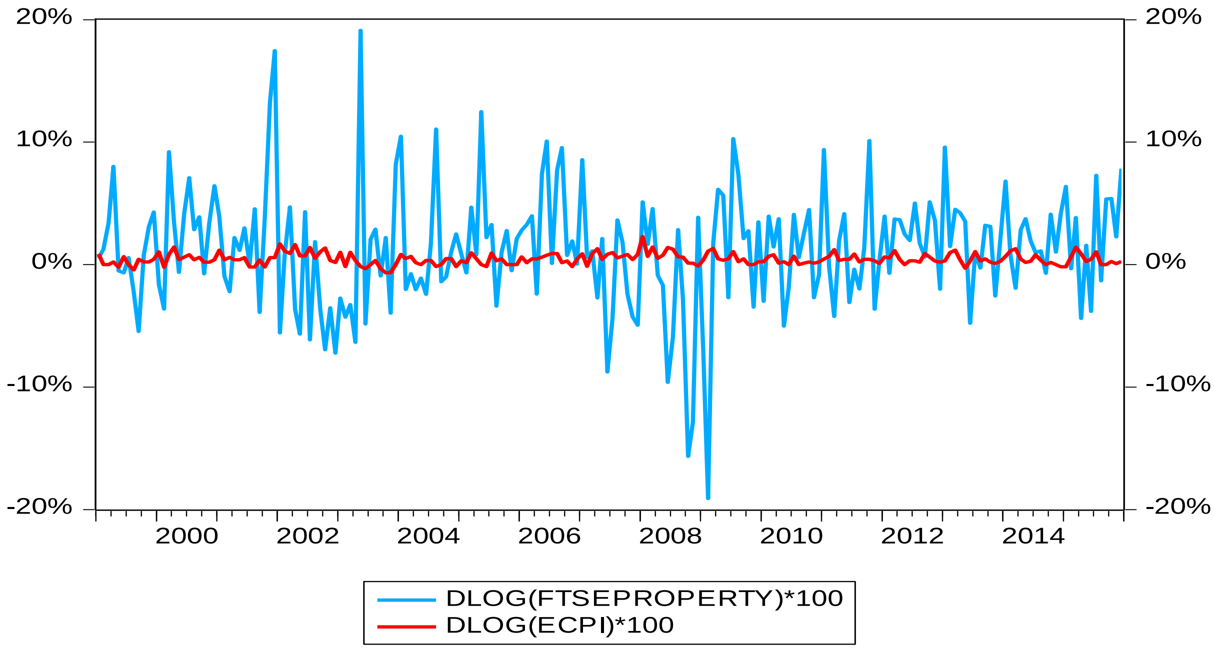


Figure B12: Monthly FTSE EPRA/NAREIT index total returns and monthly inflation 1999-2015

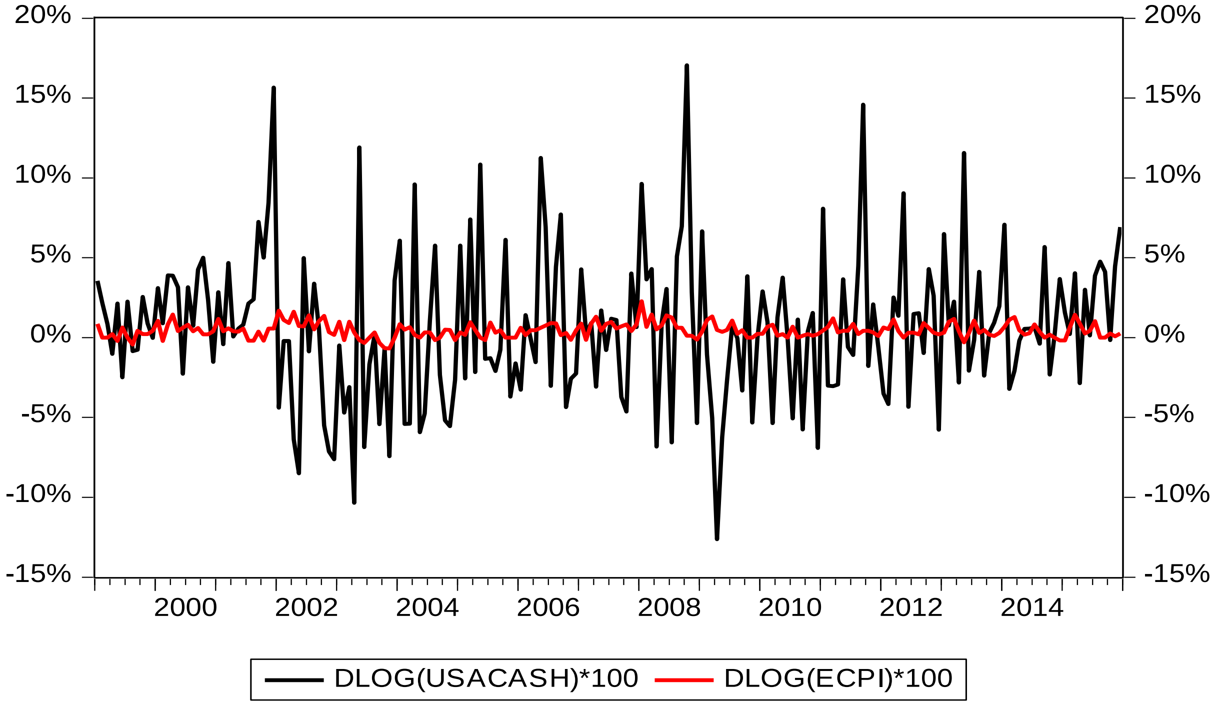


Figure B13: Monthly US cash index returns and monthly inflation 1999-2015

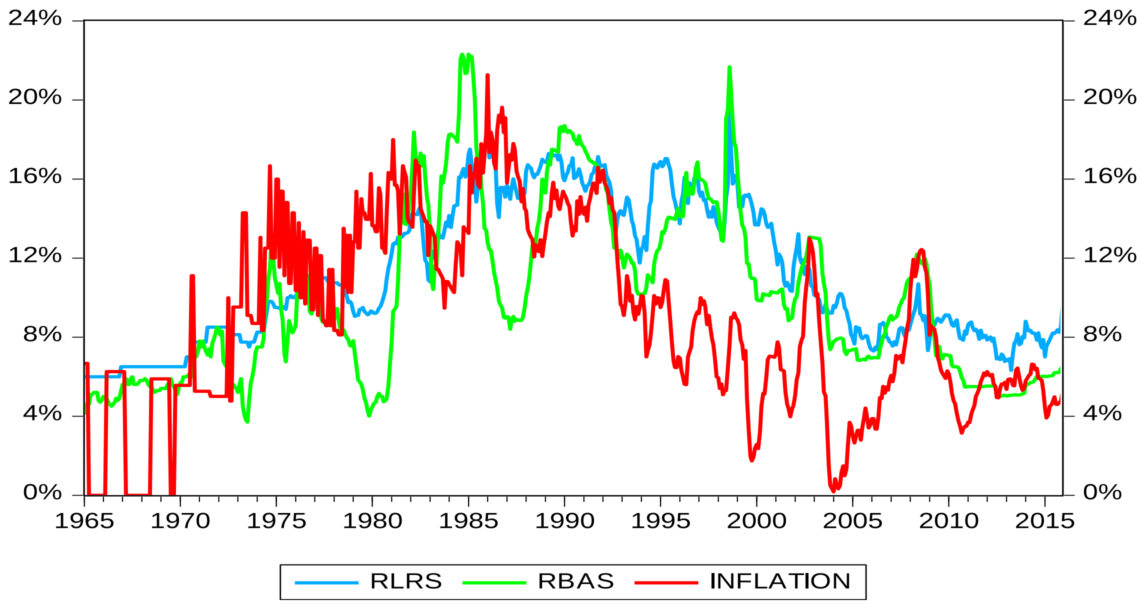


Figure B14: RLRS, RBAS and inflation year on year from 1965-2015.

Appendix C

C1: Table of descriptive statistics for the domestic asset classes returns and inflation 1965-2015 (%)

	ALSITR	FINDTR	RESITR	PROPERTYTR	SACASH	RBAS	Inflation
1 month							
μ	1.0879	1.0431	0.9092	0.8478	0.8552	0.8339	0.7011
σ	6.1317	5.8958	8.1406	6.9659	0.3739	0.3619	0.9591
Skewness	-0.8134	-0.9601	-0.3042	-0.0599	0.6732	0.6773	2.1423
Kurtosis	5.6087	7.2645	4.0214	4.6711	2.5101	2.5259	9.7702
Sample period	1965M01-2015M12	1965M01-2015M12	1965M01-2015M12	1965M01-2015M12	1965M01-2015M12	1965M01-2015M12	1965M01-2015M12
1 year							
μ	13.2381	12.7389	11.6505	10.1608	10.3514	10.0895	8.5307
σ	22.7468	22.6852	29.3939	30.0206	4.3246	4.1848	4.2587
Skewness	-0.4171	-0.7613	-0.1934	-0.4589	0.5925	0.5808	0.0520
Kurtosis	3.2250	3.8956	2.5042	4.5110	2.3203	2.2872	2.1942
Sample period	1965M12-2015M12	1965M12-2015M12	1965M12-2015M12	1965M12-2015M12	1965M12-2015M12	1965M12-2015M12	1965M12-2015M12
3 year							
μ	40.1813	38.4899	36.9758	29.3214	31.6686	30.8546	26.1270
σ	34.3327	37.4447	43.5062	55.8314	11.5401	11.1859	11.1908
Skewness	-0.1571	-0.4320	0.3237	-0.2906	0.3851	0.3660	0.1554
Kurtosis	3.4647	2.9045	2.7297	2.3511	1.9414	1.9073	1.7985
Sample period	1967M12-2015M12	1967M12-2015M12	1967M12-2015M12	1967M12-2015M12	1967M12-2015M12	1967M12-2015M12	1967M12-2015M12
5 year							
μ	65.8227	61.8870	62.3854	45.9207	53.8944	52.4881	44.5326
σ	36.5592	47.0749	45.4815	76.5218	17.1299	16.6431	17.3101
Skewness	0.0211	-0.5333	0.1769	-0.0808	0.1527	0.1215	0.1778
Kurtosis	2.6205	2.4730	2.4610	2.3967	1.6091	1.5910	1.5465
Sample period	1969M12-2015M12	1969M12-2015M12	1969M12-2015M12	1969M12-2015M12	1969M12-2015M12	1969M12-2015M12	1969M12-2015M12
10 year							
μ	137.6945	128.6892	134.1994	95.0740	112.8954	109.9570	93.1699
σ	48.4833	63.4137	58.0291	105.0280	28.7448	27.9834	30.8845
Skewness	-0.7494	-0.7947	0.3309	-0.2616	-0.0544	-0.0884	0.0908
Kurtosis	3.7465	2.9385	2.6999	2.3107	1.5968	1.5939	1.4202
Sample period	1974M12-2015M12	1974M12-2015M12	1974M12-2015M12	1974M12-2015M12	1974M12-2015M12	1974M12-2015M12	1974M12-2015M12

Notes: μ, σ are the means and standard deviations respectively. This table displays sample statistics for the inflation rate and the nominal returns on the aggregate domestic equity, property and cash market indices. The bond asset class is omitted due to the data limitation of the South African bond index only dating back to 1999. Returns and inflation rates are expressed in percentages. The investment horizon ranges from 1 month until 10 years. The sample statistics are based on monthly data covering the period January 1965-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

C2: Table of descriptive statistics for the foreign asset classes returns with inflation 1995-2015

	MSCI WORLD EQUITY	CITI-BONDS	MSCI WORLD PROPERTY	FSTE PROPERTY	USCASH	Inflation
1 month						
μ	1.1660	0.9811	1.1241	1.3071	0.7929	0.4874
σ	4.6691	4.3006	5.3801	4.8465	4.4389	0.4707
Skewness	0.1837	0.4555	-0.1958	-0.1751	0.4417	0.6236
Kurtosis	4.3056	4.2559	5.0524	5.2024	4.2820	3.8892
Sample period	1995M01-2015M12	1995M01-2015M12	1995M01-2015M12	1995M01-2015M12	1995M01-2015M12	1995M01-2015M12
1 year						
μ	13.2879	10.7750	12.7524	15.0489	8.7948	5.8365
σ	20.1859	14.4284	23.1789	21.7402	17.3248	2.4423
Skewness	-1.2707	-0.2315	-1.1447	-1.2705	-0.7670	0.2723
Kurtosis	4.9331	2.9228	4.1320	4.9649	3.3694	3.2150
Sample period	1995M12-2015M12	1995M12-2015M12	1995M12-2015M12	1995M12-2015M12	1995M12-2015M12	1995M12-2015M12
3 year						
μ	35.6585	30.9656	33.4107	40.9150	23.7460	17.3962
σ	42.4906	23.4877	36.6468	35.6395	32.5608	4.2599
Skewness	-0.2667	-0.5805	-0.3791	-0.7775	-0.6081	-0.1634
Kurtosis	1.7357	2.7945	2.0135	2.6055	2.7348	2.8305
Sample period	1997M12-2015M12	1997M12-2015M12	1997M12-2015M12	1997M12-2015M12	1997M12-2015M12	1997M12-2015M12
5 year						
μ	48.9976	48.0285	52.3267	64.2595	34.2267	28.7495
σ	46.9439	26.4980	32.1720	34.0377	37.2388	3.9230
Skewness	0.5675	0.2056	0.0422	-0.6611	0.4693	-0.1828
Kurtosis	2.0617	2.8602	2.5027	2.5594	2.4768	1.7227
Sample period	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12	1999M12-2015M12
10 year						
μ	84.2056	86.1397	103.9653	126.4546	54.6998	56.6394
σ	47.1355	21.6340	30.8398	32.9942	33.6670	2.4906
Skewness	-0.4271	-0.6613	-0.5280	-0.3425	-0.7593	-0.3733
Kurtosis	1.4837	2.5576	1.7184	1.9402	2.3618	2.1395
Sample period	2004M12-2015M12	2004M12-2015M12	2004M12-2015M12	2004M12-2015M12	2004M12-2015M12	2004M12-2015M12

Notes: μ, σ are the means and standard deviations respectively. This table displays sample statistics for the inflation rate and the nominal returns on the aggregate foreign equity, bond, property and cash market indices. Returns and inflation rates are expressed in percentages. The investment horizon ranges from 1 month until 10 years. The sample statistics are based on monthly data covering the period January 1995 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

Appendix D

D1: Table of Phillips-Perron test on domestic and foreign asset classes 1999-2015 (levels)

Variable	None			Intercept			Trend & Intercept		
Level	PP statistic	P-value	BW	PP statistic	P-value	BW	PP statistic	P-value	BW
LALSITR	3.6208	0.9999	4	-1.3766	0.5932	4	-2.4758	0.3399	5
LFINDITR	3.9419	1.0000	2	0.3953	0.9824	2	-1.7383	0.7307	1
LRESITR	1.3510	0.9556	6	**-3.2795****	0.0171	6	-1.4511	0.8429	6
LGOVITR	5.5805	1.0000	2	**-3.8989*****	0.0025	10	-2.1727	0.5018	8
LALBITR	5.5485	1.0000	2	**-3.7034*****	0.0047	9	-2.1421	0.5189	8
LPROPERTYTR	4.5620	1.0000	3	-0.7565	0.8286	5	-1.4082	0.8560	3
LSACASH	11.1866	1.0000	11	**-5.8761*****	0.0000	11	-1.8211	0.6911	11
LRBAS	11.2054	1.0000	11	**-5.5414*****	0.0000	11	-1.0302	0.9364	11
LMSCI WORLD EQUITY	2.2731	0.9947	7	0.8183	0.9942	7	-0.6707	0.9732	7
LCITI-BONDS	2.4789	0.9970	3	-0.1119	0.9454	3	-2.2558	0.4557	5
LMSCI WORLD PROPERTY	2.4310	0.9965	8	-0.0464	0.9523	8	-1.6613	0.7648	8
LFTSE PROPERTY	2.7352	0.9986	8	-0.3382	0.9156	8	-1.8711	0.6658	8
LUSCASH	1.7603	0.9812	5	-0.6266	0.8607	5	-1.6135	0.7845	6
LCPI	9.4388	1.0000	7	-0.0439	0.9525	0	-2.1009	0.5418	7

Notes: PP= Phillips-Perron test statistic. PP bandwidth (BW) selection based on Newey-West. The prefix "L" is used to denote the log of the variable. The Phillips-Perron tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1999- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D2: Table of Phillips-Perron test on domestic and foreign asset classes 1999-2015 (first difference)

Variable	None			Intercept			Trend & Intercept		
First difference (Δ)	PP statistic	P-value	BW	PP statistic	P-value	BW	PP statistic	P-value	BW
ΔLALISTR	**-14.1088*****	0.0000	7	**-14.7871*****	0.0000	4	**-14.8138*****	0.0000	4
ΔLFINDITR	**-13.2091*****	0.0000	4	**-14.0558*****	0.0000	2	**-14.0690*****	0.0000	3
ΔLRESITR	**-14.7064*****	0.0000	7	**-14.8281*****	0.0000	6	**-15.3854*****	0.0000	5
ΔLGOVITR	**-11.7065*****	0.0000	5	**-13.1263*****	0.0000	5	**-13.6838*****	0.0000	10
ΔLALBITR	**-11.7323*****	0.0000	5	**-13.1158*****	0.0000	5	**-13.6014*****	0.0000	9
ΔLPROPERTYTR	**-12.7750*****	0.0000	5	**-13.9067*****	0.0000	6	**-13.8826*****	0.0000	6
ΔLSACASH	**-2.7121*****	0.0068	8	**-4.2603*****	0.0007	8	**-4.2926*****	0.0039	8
ΔLRBAS	**-2.1605****	0.0299	9	**-3.4340****	0.0109	9	**-3.6442****	0.0286	9
ΔLMSCI WORLD EQUITY	**-14.4238*****	0.0000	8	**-14.6063*****	0.0000	7	**-14.6870*****	0.0000	7
ΔLCITI-BONDS	**-13.7741*****	0.0000	5	**-14.1267*****	0.0000	3	**-14.1136*****	0.0000	3
ΔLMSCI WORLD PROPERTY	**-13.1103*****	0.0000	9	**-13.2571*****	0.0000	8	**-13.2496*****	0.0000	8
ΔLFTSE PROPERTY	**-12.8729*****	0.0000	9	**-13.0704*****	0.0000	8	**-13.0498*****	0.0000	8
ΔLUSCASH	**-13.8907*****	0.0000	6	**-14.0696*****	0.0000	5	**-14.0530****	0.0000	5
ΔLCPI	**-6.7789*****	0.0000	6	**-10.4014*****	0.0000	4	**-10.3761*****	0.0000	4

Notes: PP= Phillips-Perron test statistic. PP bandwidth (BW) selection based on Newey-West. The prefix "L" is used to denote the log of the variable and "**Δ**" denotes the first difference of the variable. The Phillips-Perron tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1999- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D3: Table of Augmented Dickey-Fuller test on individual domestic asset classes 1965-2015 (level)

Variable	None			Intercept			Trend& intercept		
Level	ADF statistic	P-value	lags	ADF statistic	P-value	lags	ADF statistic	P-value	lags
LALSITR	4.1661	1.0000	0	0.2644	0.9763	0	-2.9629	0.1437	0
LFINDITR	4.4611	1.0000	0	1.0117	0.9968	0	-2.4245	0.3663	0
LRESITR	2.1867	0.9935	0	-0.9681	0.7659	0	-2.4283	0.3644	0
LPROPERTYTR	2.5565	0.9977	1	0.5093	0.9870	1	-1.4272	0.8523	1
LSACASH	0.9962	0.9161	16	-0.6267	0.8618	16	-1.3362	0.8777	16
LRBAS	0.4553	0.8125	2	-0.7179	0.8399	2	-1.9070	0.6496	2
LCPI	1.4813	0.9661	12	-1.5843	0.4900	3	1.0530	0.9999	0

Notes: ADF= Augmented Dickey-Fuller test statistic. The prefix "L" is used to denote the log of the variable. The Augmented Dickey-Fuller tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1965- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D4: Table of Augmented Dickey-Fuller test on individual domestic asset classes 1965-2015 (first difference)

Variable	None			Intercept			Trend & intercept		
First difference (**Δ**)	ADF statistic	P-value	lags	ADF statistic	P-value	lags	ADF statistic	P-value	lags
ΔLALSITR	**-22.2962*****	0.0000	0	**-22.9216*****	0.0000	0	**-22.9189*****	0.0000	0
ΔLFINDITR	**-22.0331*****	0.0000	0	**-22.6411*****	0.0000	0	**-22.6986*****	0.0000	0
ΔLRESITR	**-24.7874*****	0.0000	0	**-25.0793*****	0.0000	0	**-25.0725*****	0.0000	0
ΔLPROPERTYTR	**-20.7380*****	0.0000	0	**-20.9831*****	0.0000	0	**-21.0241*****	0.0000	0
ΔLSACASH	-1.0323	0.2721	15	**-3.0357****	0.0323	15	-3.0029	0.1322	15
ΔLRBAS	-0.9199	0.3177	1	-2.5113	0.1132	1	-2.4634	0.3464	1
ΔLCPI	**-1.6427***	0.0949	11	**-11.9282*****	0.0000	2	**-12.0700*****	0.0000	2

Notes: ADF= Augmented Dickey-Fuller test statistic. The prefix "L" is used to denote the log of the variable and "**Δ**" denotes the first difference of the variable. The Augmented Dickey-Fuller tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1965-December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D5: Table of Phillips-Perron test on individual domestic asset classes 1965-2015(level)

Variable	None			Intercept			Trend & Intercept		
Level	PP statistic	P-value	BW	PP statistic	P-value	BW	PP statistic	P-value	BW
LALISTR	4.0080	1.0000	1	0.2292	0.9743	1	-3.1038	0.1063	2
LFINDITR	4.2749	1.0000	1	0.9423	0.9960	1	-2.5175	0.3195	3
LRESITR	2.0289	0.9902	4	-0.9722	0.7645	4	-2.7533	0.2155	6
LPROPERTYTR	2.5543	0.9977	8	0.4854	0.9862	9	-1.4716	0.8384	9
LSACASH	8.0459	1.0000	18	0.1602	0.9699	18	-1.3905	0.8631	18
LRBAS	7.0399	1.0000	18	0.2814	0.9772	18	-1.5381	0.8156	18
LCPI	7.0693	1.0000	15	-1.4660	0.5504	10	0.6591	0.9996	10

Notes: PP= Phillips-Perron test statistic. PP bandwidth (BW) selection based on Newey-West. The prefix "L" is used to denote the log of the variable. The Phillips-Perron tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1965-December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D6: Table of Phillips-Perron test on individual domestic asset classes 1965-2015 (first difference)

Variable	None			Intercept			Trend & Intercept		
First difference (**Δ**)	PP statistic	P-value	BW	PP statistic	P-value	BW	PP statistic	P-value	BW
ΔLALISTR	**-22.4395*** **	0.0000	5	**-22.9459*** **	0.0000	3	**-22.9422*** **	0.0000	3
ΔLFINDITR	**-22.1648*** **	0.0000	6	**-22.6421*** **	0.0000	1	**-22.6924*** **	0.0000	2
ΔLRESITR	**-24.8853*** **	0.0000	6	**-25.1164*** **	0.0000	4	**-25.1098*** **	0.0000	4
ΔLPROPERTYTR	**-21.0570*** **	0.0000	9	**-21.1261*** **	0.0000	8	**-21.1139*** **	0.0000	7
ΔLSACASH	-0.9603	0.3009	13	**-2.6761* **	0.0788	13	-2.6252	0.2691	13
ΔLRBAS	-0.9464	0.3066	10	**-2.6418* **	0.0851	11	-2.5723	0.2933	10
ΔLCPI	**-26.3476*** **	0.0000	16	**-27.0045*** **	0.0000	11	**-27.0149*** **	0.0000	11

Notes: PP= Phillips-Perron test statistic. PP bandwidth (BW) selection based on Newey-West. The prefix "L" is used to denote the log of the variable and "**Δ**" denotes the first difference of the variable. The Phillips-Perron tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1965- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D7: Table of Augmented Dickey-Fuller test on foreign asset classes 1995-2015 (levels)

Variable	None			Intercept			Trend & Intercept		
Level	ADF statistic	P-value	lags	ADF statistic	P-value	lags	ADF statistic	P-value	lags
LMSCI WORLD EQUITY	3.8844	1.0000	0	-0.9838	0.7594	0	-1.6595	0.7662	0
LCITI-BONDS	3.5242	0.9999	0	-1.2007	0.6747	0	-2.6672	0.2513	0
LMSCI WORLD PROPERTY	3.2784	0.9998	0	-0.2526	0.9283	0	-1.7283	0.7359	0
LFTSE PROPERTY	4.2070	1.0000	0	-0.6465	0.8564	0	-1.8846	0.6596	0
LUSCASH	2.6999	0.9984	0	-1.2636	0.6469	0	-1.9331	0.6341	0
LCPI	8.1999	1.0000	1	-1.2410	0.6570	1	-2.3866	0.3857	1

Notes: ADF= Augmented Dickey-Fuller test statistic. The prefix “L” is used to denote the log of the variable. The Augmented Dickey-Fuller tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1995- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D8: Table of Augmented Dickey-Fuller test on foreign asset classes 1995-2015 (first difference)

Variable	None			Intercept			Trend & Intercept		
First difference (**Δ**)	ADF statistic	P-value	lags	ADF statistic	P-value	lags	ADF statistic	P-value	lags
ΔLMSCI WORLD EQUITY	**-14.4396*** **	0.0000	0	**-15.2623*** **	0.0000	0	**-15.2363*** **	0.0000	0
ΔLCITI-BONDS	**-14.6256*** **	0.0000	0	**-15.3285*** **	0.0000	0	**-15.3123*** **	0.0000	0
ΔLMSCI WORLD PROPERTY	**-14.3403*** **	0.0000	0	**-14.9293*** **	0.0000	0	**-14.9010*** **	0.0000	0
ΔLFTSE PROPERTY	**-5.2175*** **	0.0000	3	**-14.1987*** **	0.0000	0	**-14.1707*** **	0.0000	0
ΔLUSCASH	**-14.8443*** **	0.0000	0	**-15.2715*** **	0.0000	0	**-15.2478*** **	0.0000	0
ΔLCPI	-1.5172	0.1210	11	**-11.7569*** **	0.0000	0	**-11.8101*** **	0.0000	0

Notes: ADF= Augmented Dickey-Fuller test statistic. The prefix "L" is used to denote the log of the variable and "**Δ**" denotes the first difference of the variable. The Augmented Dickey-Fuller tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1995- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D9: Table of Phillips-Perron test on foreign asset classes 1995-2015 (levels)

Variable	None			Intercept			Trend & Intercept		
Level	PP statistic	P-value	BW	PP statistic	P-value	BW	PP statistic	P-value	BW
LMSCI WORLD EQUITY	3.4098	0.9998	6	-1.0162	0.7480	6	-1.8381	0.6833	7
LCITI-BONDS	3.3763	0.9998	3	-1.2000	0.6750	3	-2.7916	0.2018	4
LMSCI WORLD PROPERTY	2.7404	0.9986	8	-0.4393	0.8990	8	-2.2353	0.4675	8
LFTSE PROPERTY	3.3512	0.9998	8	-0.7314	0.8355	8	-2.3299	0.4158	8
LUSCASH	2.4861	0.9970	5	-1.2904	0.6345	4	-2.0534	0.5688	5
LCPI	10.6824	1.0000	8	-1.1546	0.6942	7	-2.5095	0.3234	7

Notes: PP= Phillips-Perron test statistic. PP bandwidth (BW) selection based on Newey-West. The prefix "L" is used to denote the log of the variable. The Phillips-Perron tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1995- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

D10: Table of Phillips-Perron test on foreign asset classes 1995-2015 (first difference)

Variable	None			Intercept			Trend & Intercept		
First difference (**Δ**)	PP statistic	P-value	BW	PP statistic	P-value	BW	PP statistic	P-value	BW
ΔLMSCI WORLD EQUITY	**-15.0671*****	0.0000	8	**-15.3893*****	0.0000	6	**-15.3641*****	0.0000	6
ΔLCITI-BONDS	**-14.7200*****	0.0000	6	**-15.3441*****	0.0000	3	**-15.3277*****	0.0000	3
ΔLMSCI WORLD PROPERTY	**-14.9841*****	0.0000	9	**-15.1708*****	0.0000	8	**-15.1455*****	0.0000	8
ΔLFTSE PROPERTY	**-14.2510*****	0.0000	9	**-14.5142*****	0.0000	8	**-14.4884*****	0.0000	8
ΔLUSCASH	**-14.9868*****	0.0000	6	**-15.3215*****	0.0000	4	**-15.2980*****	0.0000	4
ΔLCPI	**-7.6637*****	0.0000	7	**-12.0107*****	0.0000	5	**-12.0592*****	0.0000	5

Notes: PP= Phillips-Perron test statistic. PP bandwidth (BW) selection based on Newey-West. The prefix "L" is used to denote the log of the variable and "**Δ**" denotes the first difference of the variable. The Phillips-Perron tests the null hypothesis that the series has a unit root. Reported are the probability values associated with the null hypothesis. Figures in bold denote significance at the 90%, 95% and 99% level in which the null hypothesis of a unit root can be rejected. * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. Monthly data covering the period January 1995- December 2015 is utilised. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

Appendix E

E1: Table of domestic asset classes' index returns vs each other Pearson correlation with inflation 1965-2015

	1 Month lead/lag	**1 Month**	**1 Year**	**3 Year**	**5 Year**	**10 Year**
ALSITR	-0.0124	-0.0410	-0.0157	0.0584	0.2136	0.2131
	(0.7602)	(0.3112)	(0.9120)	(0.8152)	(0.5079)	(0.6592)
FINDITR	0.0100	-0.001742	-0.0091	0.1054	0.3004	0.3865
	(0.8045)	(0.9657)	(0.9487)	(0.6720)	(0.3404)	(0.3970)
RESITR	0.0082	-0.0391	-0.0068	0.0107	0.0432	-0.1093
	(0.8394)	(0.3340)	(0.9619)	(0.9659)	(0.8958)	(0.8242)
PROPERTYTR	0.0133	-0.0007	-0.0855	-0.1260	-0.0794	-0.1309
	(0.7425)	(0.9859)	(0.5447)	(0.6120)	(0.8094)	(0.7894)
SACASH	**0.1936*****	**0.1894***	**0.4998***	**0.5671***	**0.6019**	0.5570
	(0.0000)	(0.0000)	(0.0001)	(0.0061)	(0.0227)	(0.1755)
RBAS	**0.1920***	**0.1935***	**0.4943***	**0.5474***	**0.5754**	0.5217
	(0.0000)	(0.0000)	(0.0001)	(0.0092)	(0.0335)	(0.2167)
Sample period	1965M1-2015M12	1965M1-2015M12	1965M12-2015M12	1967M12-2015M12	1969M12-2015M12	1974M12-2015M12

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. *** Significance at the 1% level. This table displays the correlation (ρ) between the inflation rate and the returns on the aggregate domestic stock, property and cash market indices. The bond asset class is omitted due to the data limitation of the South African bond index only dating back to 1999. The investment horizon ranges from 1 month until 10 years. The correlation statistics are based on monthly data covering the period January 1965 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

E2: Table foreign asset classes' index returns Pearson correlation with inflation 1995-2015

	1 Month lead/lag	1 Month	1 Year	3 Year	5 Year	10 Year
MSCI WORLD EQUITY	-0.1415	-0.0984	-0.1992	-0.0671	0.1043	-0.1618
	(0.0247)	(0.1194)	(0.3652)	(0.8697)	(0.8518)	(0.8643)
CITI-BONDS	0.0054	-0.0245	**0.4361****	**0.6067***	0.5998	0.1875
	(0.9315)	(0.6989)	(0.0316)	(0.0635)	(0.1826)	(0.8422)
MSCI WORLD PROPERTY	-0.0591	**-0.1089***	**-0.3494***	-0.4691	-0.5187	-0.1622
	(0.3503)	(0.0843)	(0.0974)	(0.1956)	(0.2804)	(0.8639)
FTSE PROPERTY	-0.0640	-0.0895	-0.2987	-0.4151	-0.5317	-0.2419
	(0.3114)	(0.1565)	(0.1637)	(0.2661)	(0.2641)	(0.7949)
USCASH	-0.0359	-0.0387	0.2917	0.4452	0.5210	0.0966
	(0.5707)	(0.5404)	(0.1748)	(0.2257)	(0.2775)	(0.9194)
Sample period	1995M01-2015M12	1995M01-2015M12	1995M12-2015M12	1997M12-2015M12	1999M12-2015M12	2004M12-2015M12

Notes: *Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the correlation (ρ) between the inflation rate and the returns on the aggregate foreign stocks, bonds, property and cash market indices. The investment horizon ranges from 1 month until 10 years. The correlation statistics are based on monthly data covering the period January 1995 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

Appendix F

F1: Table of Granger Causality tests for domestic and foreign asset classes' index monthly returns with inflation 1999-2015

Variable name	Period	Lags	Returns do not Granger cause inflation (p<0.05 reject)	Inflation does not Granger cause returns (p<0.05 reject)
ALSITR	1999-2015	3	0.8806	**0.0316****
FINDITR	1999-2015	3	0.3318	0.2063
RESITR	1999-2015	3	0.1717	**0.0652***
PROPERTYTR	1999-2015	3	**0.0846***	0.6138
GOVITR	1999-2015	3	**0.0000*****	0.1972
ALBITR	1999-2015	3	**0.0000*****	0.2191
SACASH	1999-2015	3	0.8223	**0.0000*****
RBAS	1999-2015	3	**0.0000*****	**0.0635***
MSCI WORLD EQUITY	1999-2015	3	0.2470	**0.0022*****
CITI-BONDS	1999-2015	3	0.1586	0.2823
MSCI WORLD PROPERTY	1999-2015	3	0.2078	**0.0104****
FTSE PROPERTY	1999-2015	3	0.2902	**0.0106****
UScash	1999-2015	3	**0.0704***	0.3783

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the Granger causality tests between the inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. The Granger causality tests is conducted for 3 lags and are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

F2: Table of Granger Causality tests for domestic and foreign asset classes' index monthly returns with inflation 1999-2015

Variable name	Period	Lags	Returns do not Granger cause inflation (p<0.05 reject)	Inflation does not Granger cause returns (p<0.05 reject)
ALSITR	1999-2015	6	0.5680	**0.0053*** **
FINDITR	1999-2015	6	0.6116	**0.0217** **
RESITR	1999-2015	6	**0.0970***	0.1540
PROPERTYTR	1999-2015	6	**0.0737***	0.4255
GOVITR	1999-2015	6	**0.0001*** **	**0.0819***
ALBITR	1999-2015	6	**0.0000*** **	**0.0831***
SACASH	1999-2015	6	**0.0015*** **	**0.0000*** **
RBAS	1999-2015	6	**0.0001*** **	**0.0171** **
MSCI WORLD EQUITY	1999-2015	6	0.4668	**0.0017*** **
CITI-BONDS	1999-2015	6	**0.0180** **	0.2138
MSCI WORLD PROPERTY	1999-2015	6	0.5570	**0.0568***
FTSE PROPERTY	1999-2015	6	0.6872	**0.0515***
UScash	1999-2015	6	**0.0285** **	0.5654

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the Granger causality tests between the inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. The Granger causality tests is conducted for 6 lags and are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

F3: Table of regression analysis for domestic and foreign asset classes' index returns with 3 months' inflation lagged 1999-2015

Dependent variable	Independent variable	Period	Lags	Coefficient	Standard error	t-stat	Significance
ALSITR	Inflation	1999-2015	3	**-0.9440*****	0.3501	-2.6961	0.0076
FINDITR	Inflation	1999-2015	3	**-0.6552***	0.3462	-1.8923	0.0599
RESITR	Inflation	1999-2015	3	**-1.2114****	0.5650	-2.1441	0.0332
PROPERTYTR	Inflation	1999-2015	3	-0.3574	0.3488	-1.0249	0.3067
GOVITR	Inflation	1999-2015	3	0.0826	0.1427	0.5789	0.5633
ALBITR	Inflation	1999-2015	3	0.0782	0.1447	0.5402	0.5897
SACASH	Inflation	1999-2015	3	**0.0265***	0.0148	1.7976	0.0738
RBAS	Inflation	1999-2015	3	**0.0536*****	0.0140	3.8315	0.0002
MSCI WORLD EQUITY	Inflation	1999-2015	3	**-1.0067*****	0.3287	-3.0627	0.0025
CITI-BONDS	Inflation	1999-2015	3	-0.0760	0.3230	-0.2354	0.8142
MSCI WORLD PROPERTY	Inflation	1999-2015	3	**-0.9545*****	0.3578	-2.6674	0.0083
FTSE PROPERTY	Inflation	1999-2015	3	**-0.8132****	0.3524	-2.3076	0.0220
UScash	Inflation	1999-2015	3	-0.2113	0.3363	-0.6284	0.5305

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the regressions coefficients with their sign for the Granger causality tests between the inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. The regression coefficients represent the strength and sign of the relationship that was found with the Granger causality test of 3 lags and are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

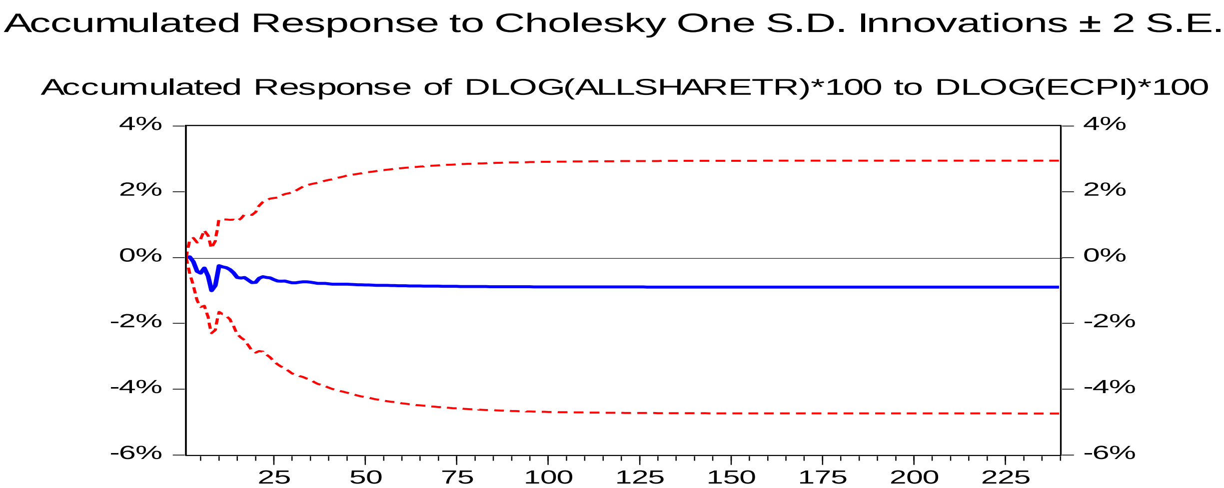
F4: Table regression analysis for domestic and foreign asset classes' index returns with inflation lagged 1999-2015

Dependent variable	Independent variable	Period	Lags	Coefficient	Standard error	t-stat	Significance
ALSITR	Inflation	1999-2015	6	**-0.8077*** **	0.2110	-3.8272	0.0002
FINDITR	Inflation	1999-2015	6	**-0.6797*** **	0.2102	-3.2327	0.0014
RESITR	Inflation	1999-2015	6	**-0.9482*** **	0.3388	-2.7990	0.0056
PROPERTYTR	Inflation	1999-2015	6	-0.1981	0.2128	-0.9308	0.3531
GOVITR	Inflation	1999-2015	6	**0.1646* **	0.0886	1.8577	0.0647
ALBITR	Inflation	1999-2015	6	**0.1645* **	0.0900	1.8280	0.0691
SACASH	Inflation	1999-2015	6	**0.0349*** **	0.0084	4.1329	0.0001
RBAS	Inflation	1999-2015	6	**0.0515*** **	0.0080	6.4460	0.0000
MSCI WORLD EQUITY	Inflation	1999-2015	6	**-0.7947*** **	0.2038	-3.8995	0.0001
CITI-BONDS	Inflation	1999-2015	6	0.1490	0.2023	0.7366	0.4622
MSCI WORLD PROPERTY	Inflation	1999-2015	6	**-0.7525*** **	0.2211	-3.4034	0.0008
FTSE PROPERTY	Inflation	1999-2015	6	**-0.6767*** **	0.2184	-3.0986	0.0022
UScash	Inflation	1999-2015	6	-0.0214	0.2116	-0.1011	0.9195

Notes: * Denotes the level of significance. *Significance at the 10%. **Significance at the 5%. ***Significance at the 1% level. This table displays the regressions coefficients with their sign for the Granger causality tests between the inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. The regression coefficients represent the strength and sign of the relationship that was found with the Granger causality test of 6 lags and are based on monthly data covering the period January 1999 January-December 2015. Refer to table 1 for the full names of each variable and section 4 for the in depth description of each variable in the study.

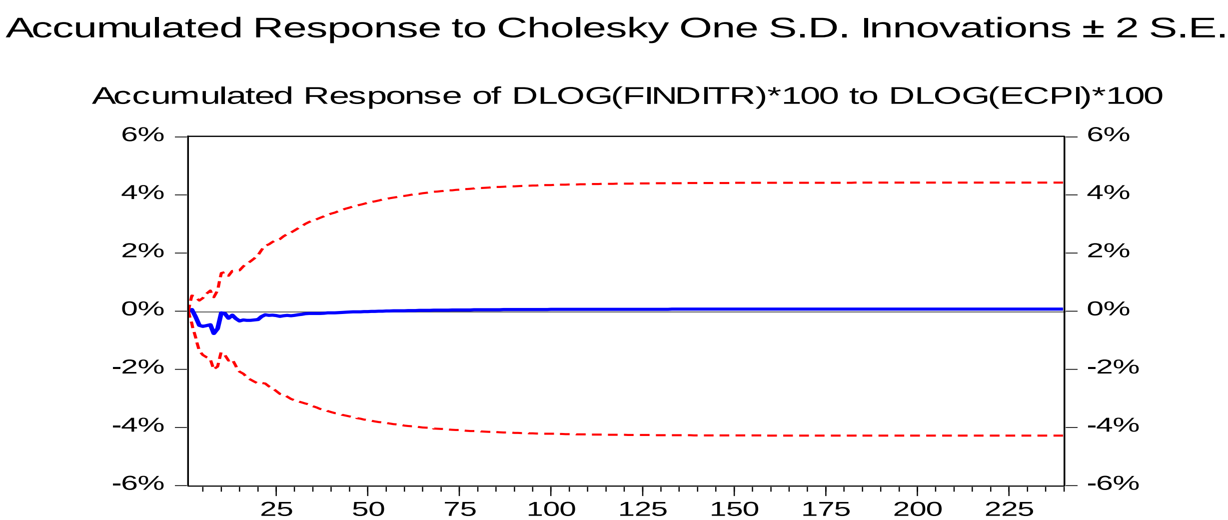
Appendix G

The figures below illustrate the response of monthly returns on the various asset class to one standard deviation shock to monthly inflation generated from the VAR models. The forecasted horizon is 240 months (20 years).



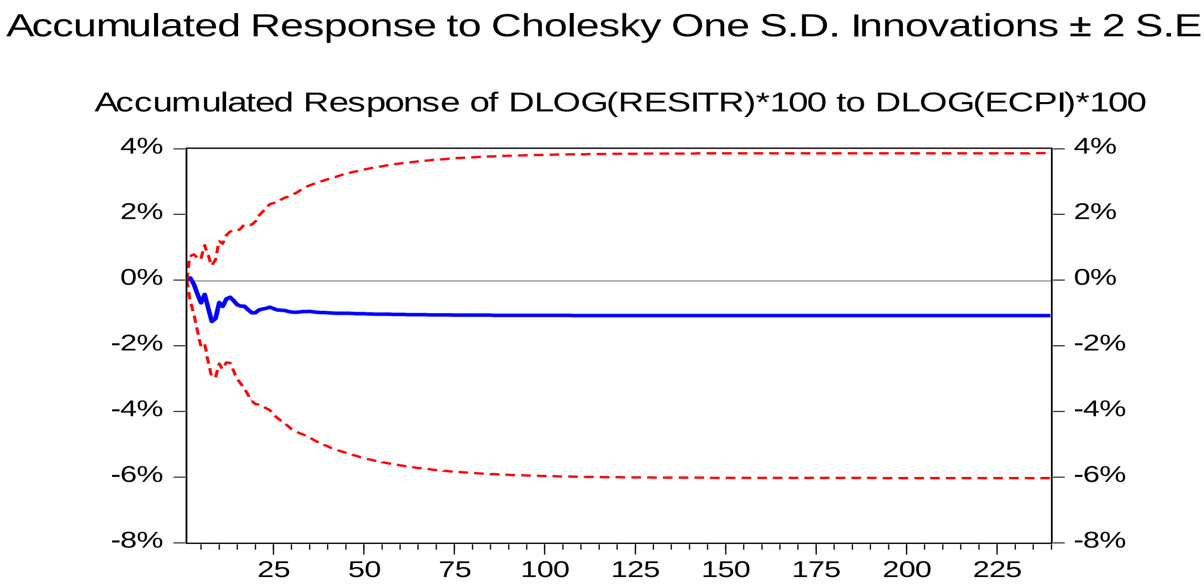
Forecast horizon months

Figure G1: Impulse response function of monthly All share index total returns and monthly inflation 1965-2015



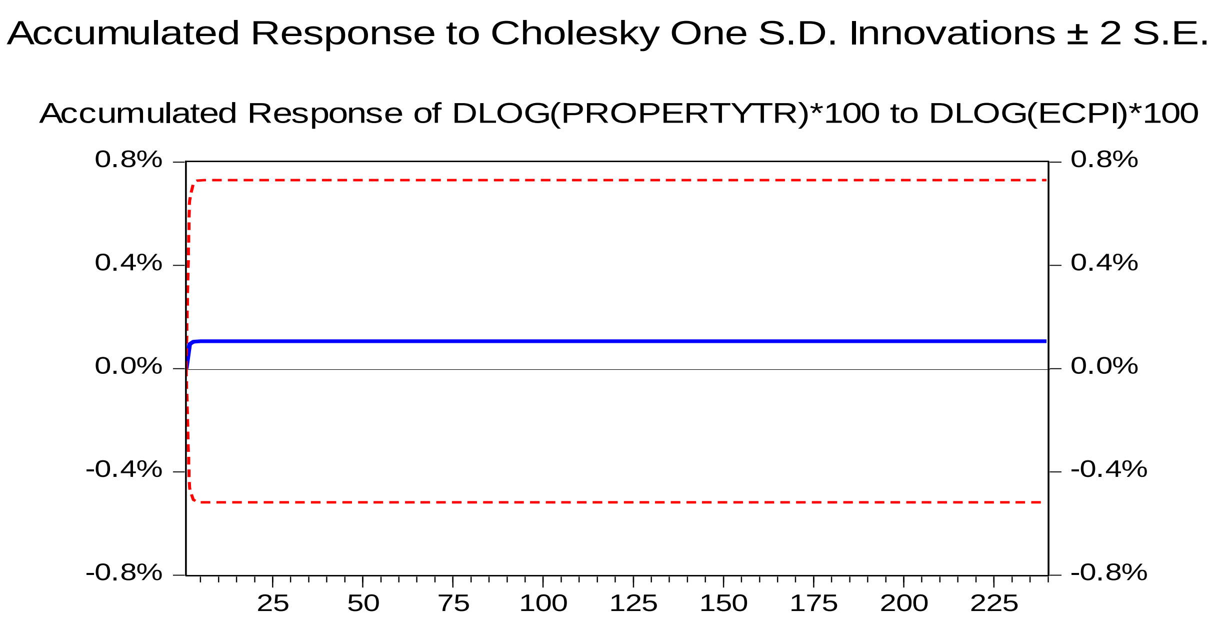
Forecast horizon months

Figure G2: Impulse response function of monthly Financial and Industrial index total returns and monthly inflation 1965-2015



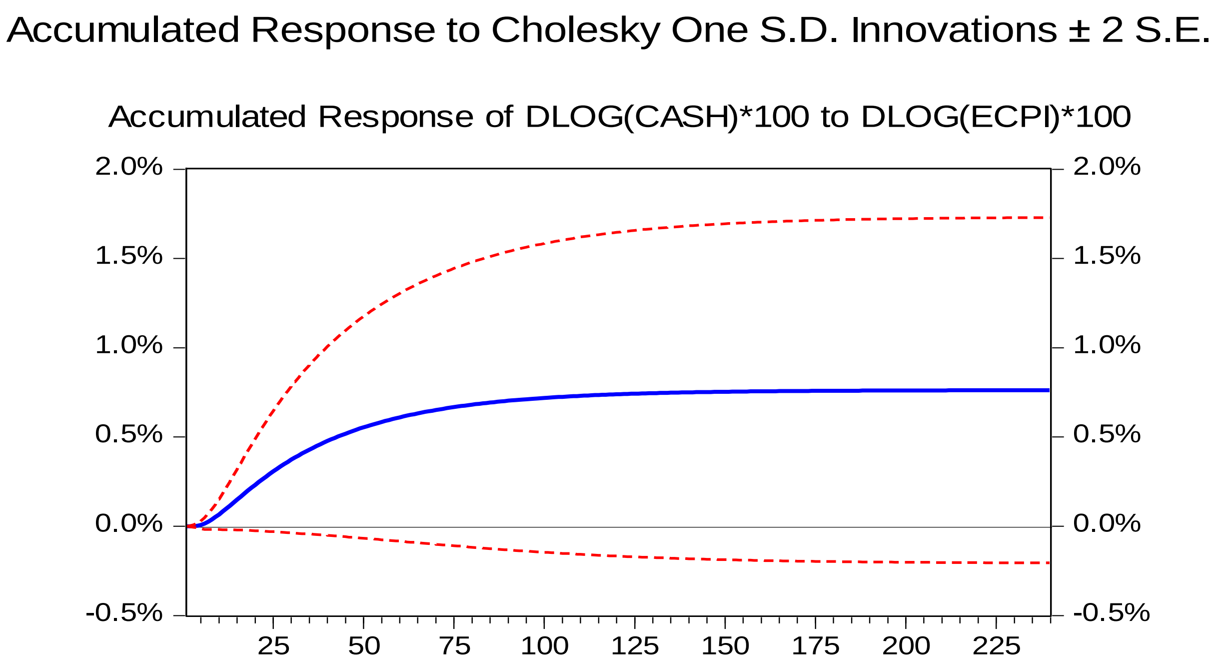
Forecast horizon months

Figure G3: Impulse response function of monthly Resources index total returns and monthly inflation 1965-2015



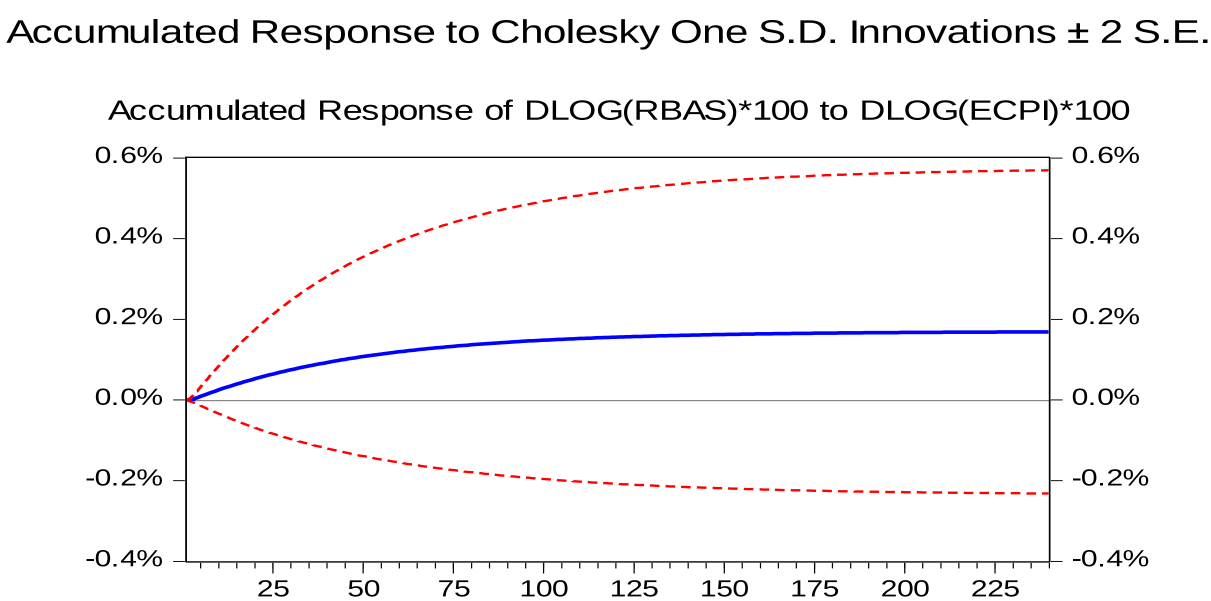
Forecast horizon months

Figure G4: Impulse response function of monthly Property index total returns and monthly inflation 1965-2015



Forecast horizon months

Figure F5: Impulse response function of monthly cash index total and monthly inflation 1965-2015



Forecast horizon months

Figure G6: Impulse response function of monthly RBAS index returns and monthly inflation 1965-2015

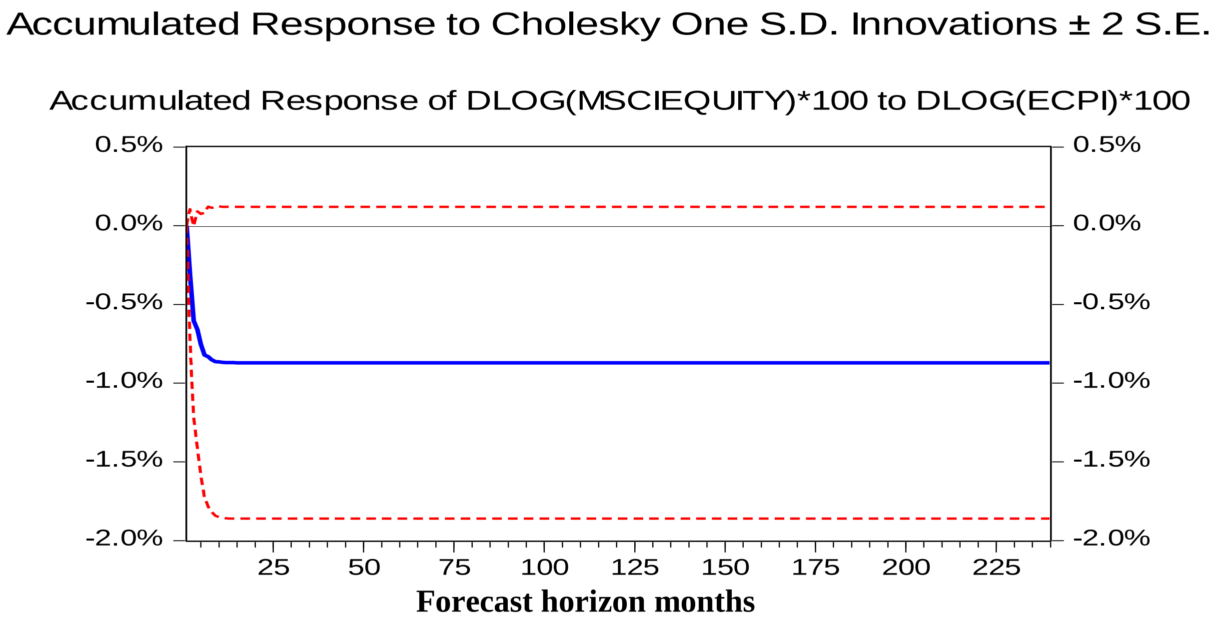


Figure G7: Impulse response function of monthly MSCI world equity index total returns and monthly inflation 1970-2015

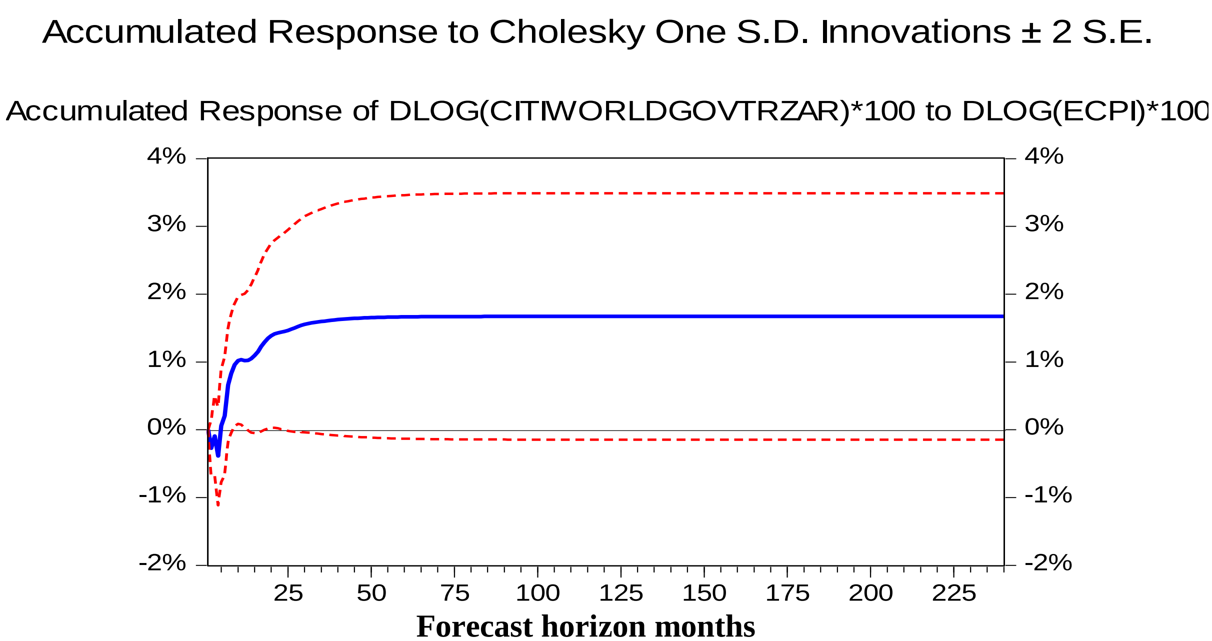
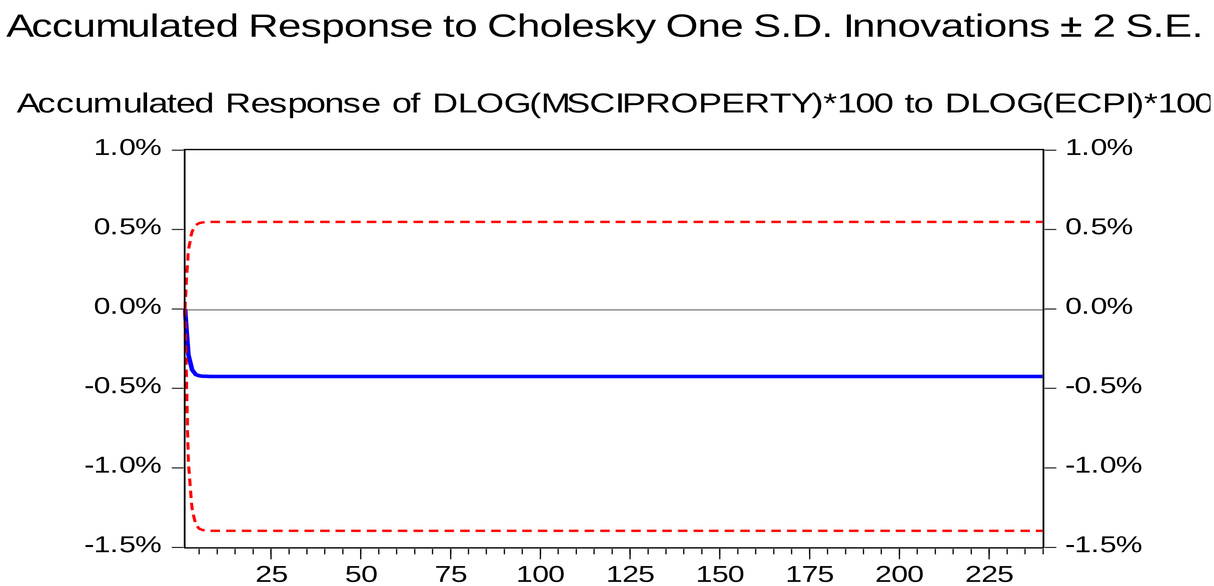
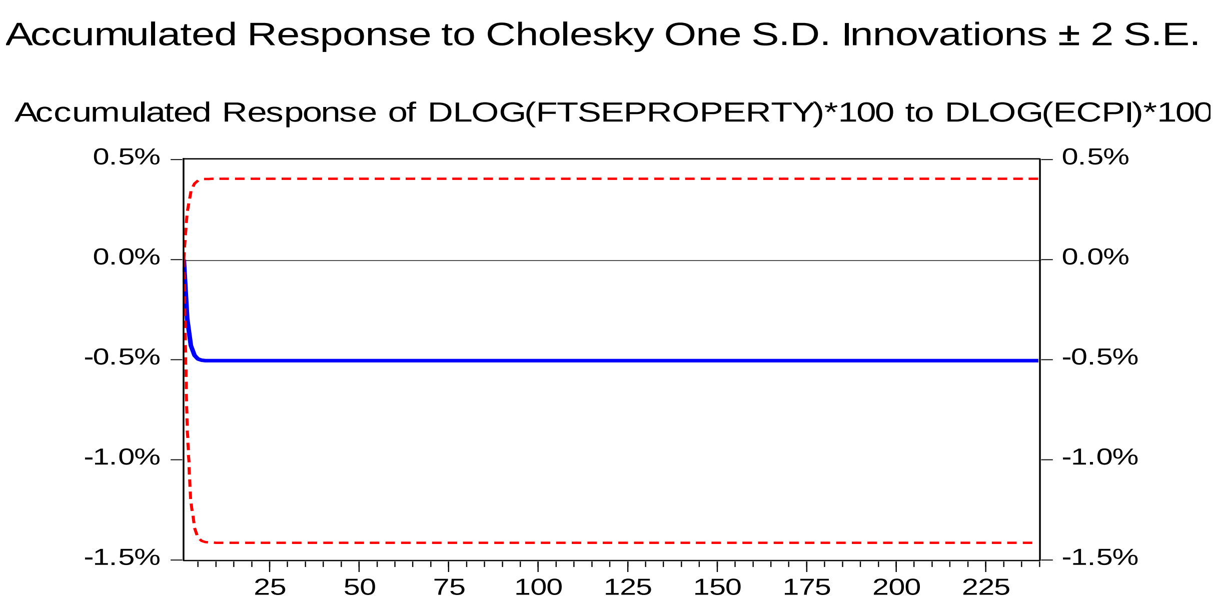


Figure G8: Impulse response function of monthly Citi-group world government bond index total returns and monthly inflation 1985-2015



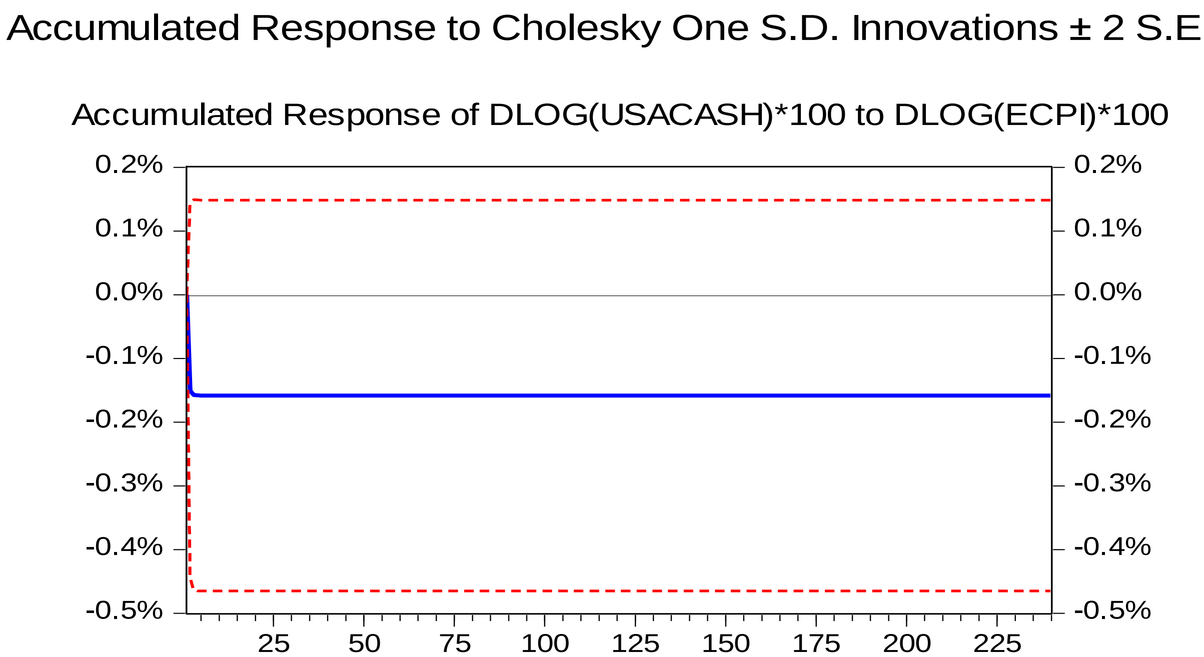
Forecast horizon months

Figure G9: Impulse response function of monthly MSCI world property index total returns and monthly inflation 1995-2015



Forecast horizon months

Figure G10: Impulse response function of monthly FTSE/EPRA NAREIT property index total returns and monthly inflation 1990-2015



Forecast horizon months

Figure G11: Impulse response function of monthly US cash index returns and monthly inflation 1965-2015

Appendix H

For illustration purposes below are a few summary tables displaying how the results for Johansen cointegration varied for various asset classes and inflation according to the model selected. From the tables below it is evident how the Johansen cointegration results differed with regards to cointegration according to model the specification and sample period.

H1: Table displaying results for the All share total return index and consumer prices 1965-2015

Sample: 1965M01 2015M12
Included observations: 612
Series: LOG(ALLSHARETR) LOG(ECPI)
Lags interval: 1 to 7

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	0
Max-Eig	1	1	0	0	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

H2: Table displaying results for the Resources total return index and consumer prices 1965-2015

Sample: 1965M01 2015M12
Included observations: 612
Series: LOG(RESITR) LOG(ECPI)
Lags interval: 1 to 7

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	0
Max-Eig	1	1	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H3: Table displaying results for the Financial and Industrial total return index and consumer prices 1965-2015

Sample: 1965M01 2015M12
Included observations: 612
Series: LOG(FINDITR) LOG(ECPI)
Lags interval: 1 to 7

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	2	1	2	0	1
Max-Eig	2	1	2	0	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

H4: Table displaying results for the property total return index and consumer prices 1965-2015

Sample: 1965M01 2015M12
Included observations: 612
Series: LOG(PROPERTYTR) LOG(ECPI)
Lags interval: 1 to 7

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	0
Max-Eig	1	1	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H5: Table displaying results for the South African cash index and consumer prices 1965-2015

Sample: 1965M01 2015M12
Included observations: 612
Series: LOG(SACASH) LOG(ECPI)
Lags interval: 1 to 7

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	1	1	1	2
Max-Eig	0	1	1	1	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

H6: Table displaying results for the All share total return index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(ALLSHARETR) LOG(ECPI)
Lags interval: 1 to 12

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	2
Max-Eig	1	1	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H7: Table displaying results for the Financial and Industrial total return index and consumer prices 1999- 2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(FINDITR) LOG(ECPI)
Lags interval: 1 to 12

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	0
Max-Eig	1	1	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H8: Table displaying results for the Resources total return index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(RESITR) LOG(ECPI)
Lags interval: 1 to 12

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	2	2	1	0	0
Max-Eig	0	0	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H9: Table displaying results for the property total return index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(PROPERTYTR) LOG(ECPI)
Lags interval: 1 to 12

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	0	0	0	1
Max-Eig	0	0	0	0	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

H10: Table displaying results for the South African cash index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(SACASH) LOG(ECPI)
Lags interval: 1 to 12

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	1	1	1	0
Max-Eig	0	1	1	1	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H11: Table displaying results for the MSCI world equity total return index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(MSCIEQUITY) LOG(ECPI)
Lags interval: 1 to 2

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	0
Max-Eig	1	1	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H12: Table displaying results for the Citi-group world government bond total return index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(CITIBONDS) LOG(ECPI)
Lags interval: 1 to 2

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	0
Max-Eig	1	1	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H13: Table displaying results for the MSCI world property total return index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(MSCIPROPERTY) LOG(ECPI)
Lags interval: 1 to 2

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	2
Max-Eig	1	1	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

H14: Table displaying results for the FTSE developed property total return index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(FTSEPROPERTY) LOG(ECPI)
Lags interval: 1 to 2

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	2
Max-Eig	1	1	0	0	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

H15: Table displaying results for the Foreign cash index and consumer prices 1999-2015

Sample: 1999M01 2015M12
Included observations: 204
Series: LOG(USCASH) LOG(ECPI)
Lags interval: 1 to 2

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	0	0	0
Max-Eig	1	1	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)