Investment Analysts Journal

ISSN: 1029-3523 (Print) 2077-0227 (Online) Journal homepage: https://www.tandfonline.com/loi/riaj20

The inflation hedging properties of South African and international asset classes

Donovan Stefan & Paul van Rensburg

To cite this article: Donovan Stefan & Paul van Rensburg (2019) The inflation hedging properties of South African and international asset classes, Investment Analysts Journal, 48:3, 205-222, DOI: 10.1080/10293523.2019.1643127

To link to this article: https://doi.org/10.1080/10293523.2019.1643127

Published online: 22 Aug 2019.

INVESTMENT ANALYSTS JOURNAL
2019, VOL. 48, NO. 3, 205–222
https://doi.org/10.1080/10293523.2019.1643127

Check for updates

The inflation hedging properties of South African and international asset classes

Donovan Stefan and Paul van Rensburg

Department of Finance and Tax, University of Cape Town, South Africa

ABSTRACT
Within the period 1965 to 2015 all domestic asset class returns (except cash) are found to exhibit negative correlations with the contemporaneous inflation rate. Cash has hedging qualities due to Reserve Bank inflation targeting policy action but has a low real yield. Furthermore, Engle-Granger cointegration tests show that none of the asset class prices displays a long-term equilibrium relationship with the CPI. Using local growth assets as "inflation hedges" in a "CPI plus" mandate is more of an attempt to outperform inflation than to actually hedge against it.

In contrast, it was found that "rand-hedge" asset classes could offer inflation protection. Offshore bond returns exhibited a significant positive contemporaneous relationship with inflation over a one- to three-year horizon and was the only asset class to do so. Looking at non-contemporaneous relationships, the prior 12-month rand returns on all foreign asset classes (and the local RESI) were found to be positively correlated with current inflation due to the return enhancement of rand weakening later feeding through into future imported inflation. Thus, rand hedges offer an "up-front" compensation for future inflation and, understood as such, can provide effective inflation protection for locally based investors.

ARTICLE HISTORY
Received 26 February 2019
Accepted 9 July 2019

KEYWORDS
asset classes; inflation hedge; investments

1. Introduction

The need to protect the purchasing power of capital is a fundamental practical problem in investments. Fama and Schwert (1977) define an asset as an inflation hedge if its nominal return has a positive correlation of one or close to one with inflation, resulting in its real returns being independent of inflation.

Numerous studies have attempted to discover which assets can best shield investors from inflation (see, for example, Roll, 1972; Nelson, 1976; Fama & Schwert, 1977; Brière & Signori, 2013; Spierdijk & Umar, 2015). However, despite the abundance of literature on this topic, there is as yet no general consensus on whether asset classes, such as equities, bonds, property and cash, can provide investors with effective hedging benefits. The literature is also characterised by several methodological differences such as the use of different data sources, sample periods, frequency of data, country and econometric methodology (Arnold & Auer, 2015).

Although South Africa is generally considered a country with highly developed financial markets, it has nonetheless been vulnerable to macroeconomic instability caused by significant political turmoil, government corruption and exchange rate depreciation. From Figure 1 it is evident that historically, South Africa has frequently suffered from double digit to high single digit inflation,

CONTACT Paul van Rensburg paul.vanrensburg@uct.ac.za
Investment Analysts Journal is co-published by NISC Pty (Ltd) and Informa Limited (trading as Taylor & Francis Group)

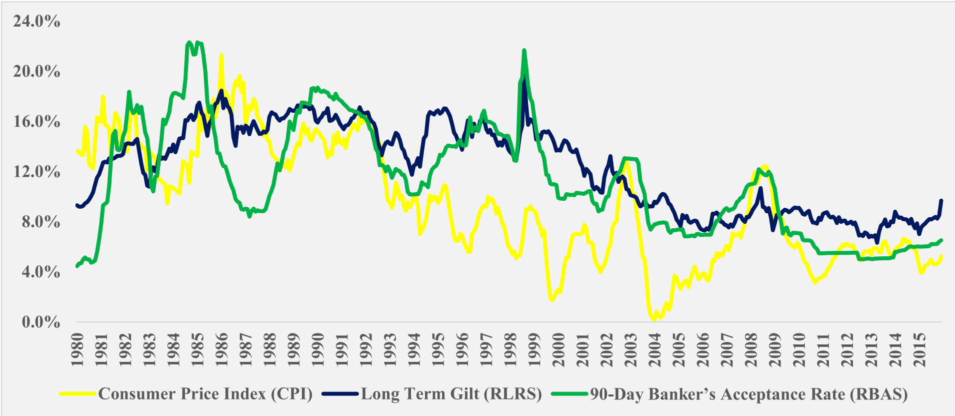

Figure 1. Interest rates and year-on-year percentage changes in CPI from 1980–2016.

peaking at over 20% in the mid-1980s. This adds impetus to the practical need for inflation protection and motivates the primary research question of this study: which asset classes available to the large South African institutional investor protect investors against inflation in both the short and long term?

The study is organised as follows. Section 2 provides a brief description of inflation hedging theory followed by a review of the literature related to the asset classes of cash, bonds, listed property and equities as inflation hedges in section 3. Section 4 provides a description of the data used, followed by section 5 which describes the methodologies applied, which include Pearson correlations, Granger Causality tests, Impulse Response Functions and Engle and Granger Cointegration tests. Section 6 provides descriptive statistics followed by section 7 which presents the results and analysis. Finally, section 8 concludes.

2. Inflation hedging theory

According to Irving Fisher's (1930) theory of interest rates, 'The nominal interest rate can be expressed as the sum of an expected real return and an expected inflation rate' (Fama & Schwert, 1977, p. 115). 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, p. 115). Stated more formally:

$$\mathbf{E}\{\boldsymbol{R_{jt}}|\boldsymbol{\Omega_{t-1}}\} = \mathbf{E}\{\boldsymbol{I_{jt}}|\boldsymbol{\Omega_{t-1}}\} + \mathbf{E}\{\boldsymbol{\pi_t}|\boldsymbol{\Omega_{t-1}}\} \tag{1}$$

where:

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

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

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

As a quantity theorist, Fisher believed that the real and monetary segments of the economy are mostly independent. He, therefore, proposed that real factors would determine the expected real return in equation (1), such as 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.

3. Prior research on the inflation hedging ability of asset classes

3.1 Cash as an inflation hedge

If the Fisher hypothesis holds it would suggest that short-term debt instruments (e.g. treasury bills) should provide a perfect hedge against inflation provided there are no inflationary shocks (Roach & Attie, 2009). The 'inflation targeting' active monetary rule also suggests a positive relationship between real interest rates and inflation as a consequence of central banks responding to inflationary pressures with tightened monetary policy.

A study conducted by Bekaert and Wang (2010) on over 45 countries spanning from 1970–2010, found that treasury bills with a one-month and three-month maturity provided a partial inflation hedge. Spierdijk and Umar (2015) lend further support to the notion that treasury bills provide investors with inflation protection. They found that the three-month, and to a lesser extent the six-month and one-year treasury bill indices have significant hedging capability. Moreover, for each of the three treasury bill indices, the correlation improved with an increasing length of investment horizon.

3.2 Bonds as an inflation hedge

Since a bond's coupons and principal payment are fixed in nominal terms, if inflation rises, the real return an investor receives is less, implying that bonds are not an inflation hedge. This is evident from the bond pricing equation below:

$$\textbf{\textit{Bond price}} = \sum_{t=1}^{T} \frac{\mathbf{C}}{(1+\mathbf{i})^{t}} + \frac{\mathbf{M}}{(1+\mathbf{i})^{T}}$$

C = coupon payment
T = number of payments (the number of coupon periods from the purchase date until maturity)
I = interest rate/yield to maturity
M = maturity/par value

When inflation is unexpectedly high, interest rates and bond yields (i) rise, inducing capital losses. However, this does provide the opportunity for new investments at higher rates.

A seminal 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 good hedges against expected inflation. (The interest rate on a treasury bill which matures at the end of period t was used as a proxy for the expected inflation rate for period t). However, government bonds were found to be poor inflation hedges during periods of unexpected inflation. (Unexpected inflation is measured as the difference between the inflation rate realised *ex post* and the (*ex-ante*) interest rate). Moreover, the negative relationship between government bonds and unexpected inflation was found to strengthen when the time to maturity of the bonds investigated is increased.

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 with inflation. More recently, a study conducted by Brière and Signori (2013) investigated the inflation hedging capabilities of US bonds for different investment horizons and regimes. They used a vector auto-regression (VAR) model with an investment horizon spanning from 1 month to 30 years and two regimes 1973–1990 and 1990–2010. Mixed results were found with regard to the inflation hedging ability of nominal bond returns depending on the regime and hedging horizon.

3.2.1 Inflation linked bonds

The poor inflation hedging capabilities of bonds has led to the emergence of inflation linked bonds (ILBs) which link principal and/or coupon payments to an inflation index. However, the ILB market only represents a very small fraction of South African government debt and is characterised by a substantial lack of liquidity compared to standard bonds. Inflation linked bonds also need to be held to maturity in order to ensure an inflation hedge and just like bonds incur capital losses before the maturity date as short-term interest rates increase in response to inflation. Due to illiquidity and a short data history, ILBs are not investigated in this study. After a longer data history has been gained and liquidity has improved this may be a topic for further research.

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 distinguishes between public and private, residential and commercial as well as between indirect (securitised) and direct (unsecuritised) ways of investing in the real estate sector.

Despite being linked to physical assets, early findings from the late 1970s found the results for securitised real estate to be similar to those of equities (Arnold & Auer, 2015). It was found that REITs appear to be a poor hedge against inflation with either negative or insignificant inflation hedging coefficients. This appears to contradict the complete or partial inflation hedging capabilities found to exist in the case of unsecuritised real estate (see Fama & Schwert, 1977; Simpson, Ramchander, & Webb, 2007). Chatrath and Liang (1998) support the view that REITs, in contrast to direct real estate investments, do not hedge inflation. Studies from the 1990s onward have made use of more advanced econometric techniques such as cointegration. This has produced ambiguous results with respect to the inflation hedging capabilities of securitised and unsecuritised real estate (see Ganesan & Chiang,1998; Glascock, Lu, & So, 2000, 2002; Hoesli, Lizieri & MacGregor, 2008; Le Moigne & Viveiros 2008; Hardin, Jiang, & Wu, 2012; Lee & Lee, 2012).

A key factor to consider in direct real estate investments is that they are typically mortgaged with variable interest rate loans. To the degree that inflationary pressures increase interest rates and thereby debt repayments, the loan portion of the investment will be a strong anti-hedge. Due to data unavailability of direct real estate investments on the I-Net BFA, Data Stream and Bloomberg databases, only listed real estate in investigated in this study.

3.4 Equities as an inflation hedge

From the denominator of the dividend discount model below, it is evident that equity prices are likely to be inversely related to changes in interest rates which impact directly on the required rate of return k.

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

P_{it} = The price of share i in period t.
$E[D_{it+n}]$ = Expected dividend receipt in period t + n.
k_i = The required rate of return on share i.

Notwithstanding the negative relationship implied by the denominator, there are two main arguments in favour of equities being an inflation hedge that are associated with the numerator, of the dividend discount model $E[D_{it+n}]$,which is a nominal amount. First, 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 the overall level of consumer prices (Spyrou, 2004). Second, since most firms employ some degree of leverage in their capital structure and because the firm's long-term obligations to pay fixed nominal amounts decline in real value, investors should benefit from unexpected inflation (Lintner, 1975).

Academic studies post-1970 that conducted an empirical analysis on the ability of equities to shield investors from inflation losses in purchasing power have attracted substantial attention owing to the significantly higher inflation rates affecting countries on a global scale during this period (Arnold & Auer, 2015). Bodie (1976) found that, in contrast to what economists commonly thought, the real return on equities was found to be *negatively* related to both expected and unexpected short-term inflation. This leads to a somewhat surprising conclusion that equities seem to be a poor inflation hedge in the short run. Indeed, in order for equities to be an inflation hedge they must be sold short! This unexpected result is by no means an isolated finding. Academic studies conducted by Nelson (1976), Fama and Schwert (1977), Fama (1981) and Gultekin (1983) all verify the negative relationship between equity returns and inflation in the short run.

Since the mid-1990s cointegration analysis has become a popular methodology to investigate the existence of a possible long-term relationship between macroeconomic variables (Arnold & Auer, 2015). Results indicating a positive relationship, over the long run, between equity returns and inflation have been reported by multiple studies (Boudoukh & Richardson,1993; Solnik & Solnik,1997; Lothian & Simaan,1998; Anari & Kolari,2001; Lothian & McCarthy, 2001). 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, p. 311).

However, many other studies have provided mixed results. Cochran and Defina (1993) are among the earliest authors to apply the error correction model (ECM) in an inflation hedging setting. They found evidence that real equity returns are not independent of inflation and in fact inflation, both actual or unexpected, depresses real equity returns. (Time series forecasting models were used to estimate expected inflation). As a result, US equities tend not to provide a long-term hedge. This finding is supported by Engsted and Tanggaard (2002) who found that for US stocks 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 increases from 1 to 5 to 10 years. Ahmed and Cardinale (2005) examined the relationship between equity returns and inflation for different inflation regimes from 1919–2002. Their study analysed four large and developed countries (US, UK, Germany and Japan). They found that in the short run equities appeared to respond differently during periods of low or high inflation. Kim and Ryoo (2011) confirmed this finding and conclude that equity returns and inflation display asymmetric adjustments to the long-run equilibrium contingent on the inflation regime.

The literature to date on the relationship between equities and inflation within an African context has been scant. Only one study conducted by Alagidede and Panagiotidis (2010) investigated this relationship for six African countries (Egypt, Kenya, Morocco, Nigeria, South Africa and Tunisia). They used both parametric and nonparametric cointegration procedures and monthly data for equity price indices and consumer price indices from 1980–2007. They found that equities tended to provide a hedge against inflation in African countries over the long run but not in the short run.

4. Data

The monthly data used in this study were obtained from the I-Net BFA, Data Stream and Bloomberg databases. The study covers the period 31 January 1965 to 31 December 2015. Where applicable, total return indices (TRIs) are used. All foreign indices were converted into rand values. Due to data limitations when comparing all four domestic asset classes with each other and with foreign asset classes, for a portion of the analysis the sub-period 31 January 1999 to 31 December 2015 is used, primarily because there was no available domestic bond total return index dating back to 1965. This sub-period analysis also provides a check on the time-varying nature of any of the relationships estimated.

Inflation is proxied by percentage changes in the South African CPI index rebased to 100 in 2012. Dividend yields are used to calculate dividends which were added to the price indices to form total return indices for equities in those periods before TRI data was available. The South African Cash Index is constructed by splicing together the Alexander Forbes money market index (GMC1) and the Alexander Forbes short term fixed interest (STEFI) composite index. Table 1 presents the data series used in this study. Note that the real estate indices used represent listed rather than direct property investments. In addition to the All-Share Index, the Financial and Industrial and Resources equity indices are also examined. The resources sector is characterised by a strong rand hedge component and over time has comprised a varying portion of the All-Share Index. Separately examining these two primary JSE indices is motivated by providing more detail as to the nature of the inflation hedging abilities of South African equities.

In this study, only the pre-tax returns of the dominant asset classes available to the large South African institutional investor are examined. Tax regimes and levels have changed over time and vary across investment structures and an investor specific downward adjustment to the estimated mean level of returns may be applied as inputs to portfolio construction in practice.

5. Methodology

5.1 Pearson correlations

The Pearson correlation is commonly used in the prior literature to test the contemporaneous relationship between asset returns and inflation over both the short term (one year) and long term (five 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 one in nominal terms and not significantly different from zero in real terms (Ahmed & Cardinale, 2005).

5.2 Granger causality

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 and Y_t improve the prediction of the current value of Y_t. Testing for Granger causality involves estimating the following unrestricted **(1a)** and restricted **(1b)** ordinary least

Table 1. Asset class indices.

Index	Abbreviation	Data availability
JSE All Share Total Return Index (TRI)	ALSITR	1965M1-2015M12
Financial & Industrial Total Return Index (TRI)	FINDITR	1965M1-2015M12
Resources Total Return Index (TRI)	RESITR	1965M1-2015M12
Government Bond Total Return Index (TRI)	GOVITR	1999M1-2015M12
All Bond Total Return Index (TRI)	ALBITR	1999M1-2015M12
Property Total Return Index (TRI)	PROPERTYTR	1965M1-2015M12
Cash Index South Africa	SACASH	1965M1-2015M12
90-Day Banker's Acceptance Rate	RBAS	1965M1-2015M12
MSCI World Equity Total Return Index (TRI)	MSCI WORLD EQUITY	1970M1-2015M12
Citi-Group World Government Bonds Index	CITI-BONDS	1985M1-2015M12
MSCI World Real Estate Index	MSCI WORLD PROPERTY	1995M1-2015M12
FTSE/EPRA NAREIT Developed Real Estate Index	FTSE PROPERTY	1990M1-2015M12
US 3-Month Treasury Bill (USTB3M)	USCASH	1965M1-2015M12
Consumer Price Index (South Africa)	CPI	1965M1-2015M12

squares (OLS) regression models:

$$\mathbf{Y_t} = \sum_{k=1}^{K} \boldsymbol{\alpha}_k \mathbf{Y}_{t-k} + \sum_{k=1}^{K} \boldsymbol{\beta}_k \mathbf{X}_{t-k} + \boldsymbol{\varepsilon}_t \tag{1a}$$

$$\mathbf{Y_t} = \sum_{k=1}^{K} \boldsymbol{\alpha}_k \mathbf{Y}_{t-k} + \boldsymbol{\varepsilon}_t \tag{1b}$$

where:

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

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

An F test is used to test the null hypothesis that all $\boldsymbol{\beta}_k = 0$. If the null hypothesis cannot be rejected, then it can be said that X_t 'Granger causes' Y_t.

5.3 Augmented Dickey-Fuller and Phillips-Perron tests

In order to test each variable for stationarity both the augmented Dickey-Fuller (ADF) and Phillips-Perron tests are used (Dickey & Fuller, 1979; Phillips & Perron, 1988). The results are similar across the two tests, so just the ADF test results are reported here. This pretesting is conducted to circumvent the Yule (1926) and Granger and Newbold (1974) spurious correlation problem that arises when estimating the relationship between two nonstationary series.

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. 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:

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

where:

α_{i0}: Represents the drift term (constant)

α_{i1t}: Represents a time trend term

$$\varepsilon_{it} \sim \text{iid}(0, \sigma^2)$$

The ADF test implies the rejection of the null hypothesis of a unit root (i.e. nonstationarity) if the values of the t-statistic lie to the left of the DF critical value i.e. H_0: $\beta_{i0}=0$ is rejected. Moreover, the ADF test is conducted such that lagged difference terms are encompassed until the residual of the above equation is white noise and void of serial correlation. The optimal lag length j in the ADF test regressions is estimated by the Schwarz information criterion (SC). If a series was found to be nonstationary it was first differenced and retested.

Three variations of the ADF tests are be conducted: (i) with intercept (ii) trend and intercept, and (iii) neither trend nor intercept. This comprehensive approach checks that the test results are robust across model specifications.

5.4 Vector auto-regression (VAR)

The 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 (y) and K lags is represented as follows:

$$\mathbf{y_{it}} = \boldsymbol{\alpha}_\mathbf{i} \sum_{i=1}^{n}\sum_{k=1}^{K} \mathbf{b_{ik}y_{it-k}} + \boldsymbol{\varepsilon}_{\mathbf{it}} \text{ for all } \mathbf{i} = 1, \ldots, \mathbf{n}$$

The VAR approach is useful as it circumvents the need for structural modelling by treating every endogenous variable in the model as a function of the lagged values of all of the endogenous variables in the model. 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. Through impulse response functions it is seen how asset class returns respond to inflation shocks.

5.5 Cointegration

Cointegration analysis was introduced by Granger (1981) and developed by Engle and Granger (1987) and Johansen (1988). If two variables are nonstationary but cointegrated, then there exists an equilibrium relationship their values in levels. Two variables Y_t and X_t are said to be cointegrated if there exists a parameter β such that

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

Thus, even if both Y_t and X_t are I(1), if there exists a parameter β such that $\mathbf{U_t}$ is stationary, then Y_t and X_t are said to be cointegrated. In order to test for cointegration of Y_t and X_t the Engle-Granger test was conducted between the log CPI level and each asset class's log TRI.

6. Descriptive statistics

Tables 2 and 3 provide descriptive statistics for inflation and all asset classes over different investment horizons ranging from 1 month to 10 years. The monthly inflation and asset class returns are defined as the first differences of their natural logarithms. For purposes of comparison across all asset classes, the sub-period results from 1999 to 2015 are reported.

From Tables 2 and 3 it is apparent that all asset classes, both domestic and foreign (with the exception of foreign cash) tend to earn a (pre-tax) average return that is greater than inflation over all horizons displayed. This finding for domestic asset classes also holds for the extended sample period 1965–2015. However, despite all asset classes providing a higher average return than inflation it does not imply that they are effective inflation hedges. In order for an asset class to be an effective inflation hedge it has to co-vary positively in a close to unitary relationship with inflation. During this period (1999–2015) it is apparent that both listed domestic and foreign property provided the investor with superior average returns over all horizons compared to the other asset classes. However, when extending the sample to 1965 for domestic assets, equities are found to provide investors with superior average returns over all horizons.

Comparing the standard deviations of returns: all domestic asset classes exhibit lower volatility than their foreign counterparts (in rand terms) over the investment horizon of 1 to 10 years. Thus, investors should be aware that their rand returns will have an 'extra layer' of foreign exchange rate risk added when investing in foreign asset classes. However, as will become apparent, this extra risk may be of an inflation hedging nature.

7. Results

7.1 Unit root tests

The null hypothesis of a unit root for the log levels of the variables could be rejected by the ADF test for only three variables (RESI, GOVI, and ALBI). All the other variables were found to be

Table 2. Descriptive statistics for the domestic asset class returns and inflation 1999–2015 (%).

N	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: This table displays sample statistics for the inflation rate and the nominal returns on the aggregate domestic equity, bond, property and cash market indices. Note: μ, σ are the means and standard deviations respectively. Returns and inflation rates are expressed in percentages. 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.

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: This table displays sample statistics for the inflation rate and the nominal returns on the aggregate foreign equity, bond, property and cash market indices. Note: μ, σ are the means and standard deviations respectively. Returns and inflation rates denominated in Rands (ZAR) and are expressed in percentages. 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.

nonstationary under all specifications of the ADF test. As a conservative measure all variables were first differenced and retested. The results are reported in Table 4. The variables that were nonstationary in levels are now stationary in differences.

When extending the domestic asset classes sample period back to 1965 similar results were obtained. Both the ADF and PP unit root tests find that all the time series variables are nonstationary I(1) in log levels. However, after being first differenced and retested both unit root tests conclude that all the time series are stationary. When varying the model specifications similar results were obtained. In unreported tests, when differencing with a 12-month frequency all asset class returns were also found to be stationary.

7.2 Correlations

Table 5 displays the Pearson correlations between the various asset classes and inflation over different investment horizons ranging from 1 month to 10 years. All the t-statistics and p-values were adjusted to correct for the problem of dependence between observations created by rolled

Table 4. Augmented Dickey-Fuller Test on Domestic and Foreign Asset Classes 1999–2015 (Log First Differences)

Variable First difference(**Δ**)	None ADF	P-value	Lags	Intercept ADF	P-value	lags	Trend & Intercept ADF	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% levels in which the null hypothesis of a unit root can be rejected. * denotes significance at the 10% level. ** denotes significance at the 5% level. *** denotes 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.

observations (see Anderson,1997, p. 67). The column labelled 1 Month lagged refers to the prior month's inflation and its correlations with current month index returns.

The evidence from the contemporaneous Pearson correlations suggests that all domestic asset class returns (with the exception of cash) are negatively contemporaneously correlated with inflation in the both the short and long run for the period 1999–2015. Cash displays an insignificantly positive relationship with inflation. Foreign equities and property are negatively contemporaneously correlated with inflation in the short and long run. However, foreign bonds and cash exhibit a positive correlation from a 1-year through to a 10-year investment horizon, suggesting the inflation hedging abilities of these foreign asset classes.

To provide some insight into the dynamics of how asset class returns respond to inflation changes, the correlation between the one-month lag of inflation and current index returns was examined in Table 5. The results provide evidence that domestic current equity returns exhibit a negative correlation with one month's prior inflation. Equities appear to be poor inflation hedges both contemporaneously and in response to lagged inflation. However, domestic bonds, property and cash display a positive correlation with one month's prior inflation. Interestingly, bonds are negatively contemporaneously correlated with inflation. All foreign asset class returns exhibit a negative relationship with one month's prior inflation.

7.3 Granger causality results

From Table 6 it is evident that inflation tends to reliably precede both the ALSI and FINDI returns. This suggests that past values of inflation can help predict movements in the returns in equities for the aforementioned indices. On the other hand, domestic property, bonds and the RESI tend to precede inflation.

The Granger causality test does not reflect the sign of the underlying dynamic 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. The sign of the relationship

Table 5. Domestic and Foreign Asset Classes' Index Returns Pearson Correlation with contemporaneous and lagged Inflation (1999–2015).

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

Notes: * denotes significance at the 10% level. ** denotes significance at the 5% level. *** denotes significance at the 1% level. This table displays the correlation (ρ) between the contemporaneous and lagged inflation rate and the returns on the aggregate domestic and foreign stocks, bonds, property and cash market indices. 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.

was obtained by conducting a regression where current monthly index returns of the various asset classes are regressed on inflation over the previous twelve months.

From Table 7 it is evident that all domestic equity indices exhibited a strong negative relationship with prior inflation with the ALSI and FINDI inflation coefficients significant at the 1% level and the RESI at the 10% level. Property also exhibits a negative but insignificant inflation coefficient of −0.14. The results imply that local listed equities do poorly in periods of high inflation.

Interestingly, bonds exhibit a positive inflation coefficient of 0.10, perhaps reflecting a compensatory higher yield during periods of higher inflation. This supports the previous finding in which the GOVI and ALBI returns both had positive correlations with one month's prior inflation. In line with expectations, domestic cash has a positive and significant inflation coefficient. This suggests cash offers an investor a partial inflation hedge and supports the positive contemporaneous and lagged correlations with inflation found in the Pearson correlation analysis. Considering the foreign asset classes, it is evident that all display negative coefficients to prior inflation with both equities and property being significant at the 1% level.

Table 8, in contrast to Table 7, displays the regression results with inflation as the dependent variable and the prior 12-month returns on the asset classes as the explanatory variable.

It is evident from Table 8 that foreign equities, bonds and cash have positive and significant coefficients. Amongst the domestic asset classes only the RESI has this property. This suggests that rand hedge asset classes provide South African investors with a non-contemporaneous inflation hedge. A possible reason for this finding is because the rand weakens prior to inflation occurring. This is

Table 6. 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 significance at the 10% level. ** denotes significance at the 5% level. *** denotes 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.

evident from the results for US cash which are dominated by the exchange rate component of return. Rand hedges may be an inflation hedge in the sense that they provide returns which may be experienced *prior* to inflation manifesting.

7.4 Impulse response functions

The time path of the response of asset class returns to an unexpected movement in inflation is examined next. A VAR model was conducted for each asset class and inflation. The optimal lag length for each unrestricted VAR was chosen by comparing the following lag criteria; Akaike information criterion (AIC), Schwarz information criterion (SC), Hannan-Quinn information criterion (HQ) and Sequential modified LR test statistic (LR). A maximum lag length of 12 was specified. In each VAR the lag criteria with the lowest number of lags that satisfied all the tests that the VAR's residuals did not exhibit serial correlation at the 5% significance was selected.

The impulse response function in Figure 2 depicts the accumulated responses of the ALSI's monthly returns to a one standard deviation shock in inflation over a forecast horizon of 240 months

Table 7. Regression analysis for current domestic and foreign asset classes' index returns with prior 12 months' inflation (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 significance at the 10% level. ** denotes significance at the 5% level. *** denotes 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.

Table 8. Regression analysis for current inflation with prior 12 months domestic and foreign asset classes' index returns (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 significance at the 10% level. ** denotes significance at the 5% level. *** denotes significance at the 1% level. This table displays the regressions coefficients with their sign for the Granger causality tests between inflation 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.

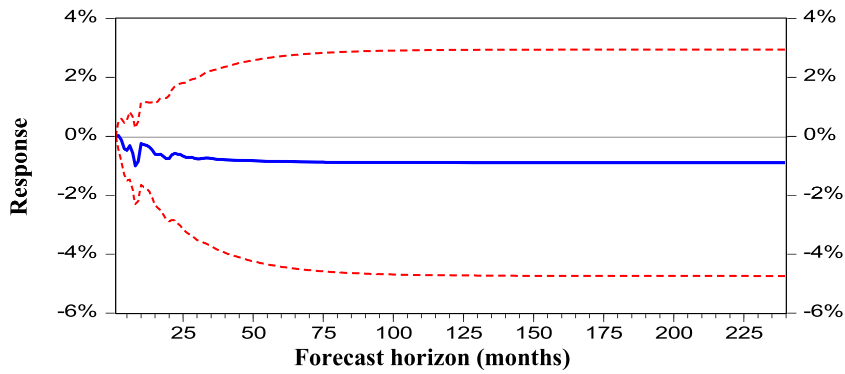

Figure 2. Impulse response function of monthly all share index total returns and monthly inflation (1965–2015).

(20 years) measured on the horizontal axis. Additionally, bands of plus or minus two standard errors are depicted by the dotted lines. The impulse response functions are computed by artificially imposing a one standard deviation inflation shock to the system.

Similar results were found for the FINDI and RESI. All decline immediately after an inflation shock and this poor performance persists for a number of months after the event before bottoming out. This suggests that local equities perform poorly in terms of their ability to hedge against inflation in both the short and long run. It is important to note that this finding does not suggest that equities underperform inflation over the long run (Ibbotson & Sinquefield, 1976; Roache & Attie, 2009). However, the timing of these returns is negatively correlated with inflation.

As evident in Figure 3, after a one standard deviation shock to inflation, cash returns rise gradually. This suggests that cash provides a partial hedge against inflation. Despite the slow adjustment of cash yields to the inflation shock, they are the best performing domestic asset class in terms of their ability to hedge against inflation. Given that South Africa follows an inflation targeting framework, one would expect cash returns to move with inflation, but in a lagged manner, as interest rates rise in response to higher inflation over time. Both the GOVI and ALBI returns and, to a lesser extent listed property, also offered a slight inflation hedge after a shock. The response profiles of the remainder of the asset classes were negative, similar to that of the ALSI displayed in Figure 2.

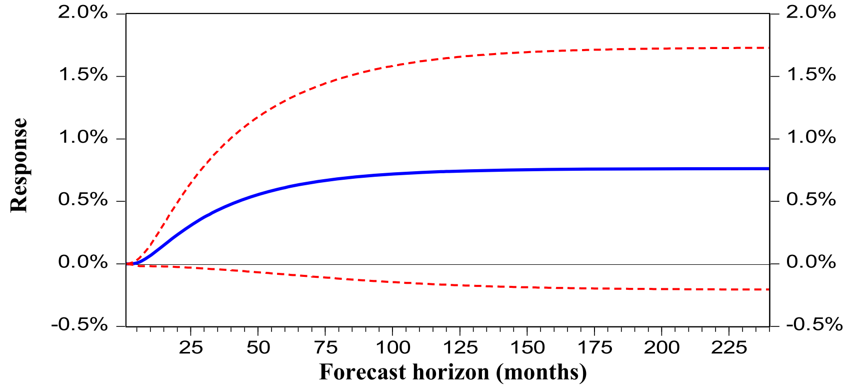

Figure 3. Impulse response function of monthly cash index total returns and monthly inflation (1965–2015).

7.5 Engle-Granger cointegration tests

In order to determine whether a specific asset class and inflation have a long-term relationship the Engle and Granger (1987) residual based tests for cointegration were conducted 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 cointegration model specifications: 1) constant and 2) constant and linear trend. Both the Engle-Granger tau-statistics (t-statistics) failed to reject the null hypothesis of no cointegration in all cases. From Table 9 it is apparent there is no evidence of a cointegrating relationship between any single domestic or foreign asset class return and inflation dating back to the inception of each index. Consequently, none of the asset classes provide a long-run inflation hedge according to the Engle-Granger cointegration tests. The implication of this finding for investment firms whose mandate 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.

In unreported results, the Johansen procedure was found to be very sensitive to the lag length criteria as well as whether a constant, trend, neither or both are included in the model. Ahking (2002)

Table 9. Engle and Granger cointegration tests.

Dependent variable (y) Level	Independent variable(x) Level	Sample period	Constant tau-statistic	P-value	Constant and Linear trend 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. Lag specification was based on the Schwarz information criteria. The p-values above are the MacKinnon (1996) p-values. * denotes significance at the 10% level. ** denotes significance at the 5% level. *** denotes significance at the 1% level. This table displays the results of the Engle-Granger tests for cointegration between the various asset classes and inflation. Monthly data is used covering differing periods depending on the inception of each index. Refer to Table 1 for the full names of each variable.

also found that the results produced using the Johansen approach differed significantly across model specifications (see also Hjelm & Johansson, 2005). In contrast, the simpler and more robust bi-variate Engle-Granger test produced consistent results across model specifications, sample periods and the lag length criteria utilised (AIC, SIC or HQ).

8. Conclusion

Conventional wisdom advises that cash is a poor inflation hedge and an investment in equities is required to protect the purchasing power of one's capital. However, when an inflation hedge is defined as having returns with a positive correlation to inflation, equities are the worst domestic inflation hedge. In contrast, domestic cash provides South African investors with the best inflation hedge in terms of co-moving with current inflation. However, it is unlikely to offer an investor a meaningful real return. In addition, it is typically the most highly taxed asset class when in the hands of the individual. Foreign bond returns displayed the only statistically significant positive correlations with inflation over a one- and three-year period. The relationship of all other asset classes with contemporaneous inflation was found to be negative.

These findings are supported by VAR models and impulse response functions, where it was found that both domestic and foreign equities respond negatively to an inflation shock. Domestic cash was found to exhibit the strongest positive response to an inflation shock. Furthermore, none of the asset classes (both domestic and foreign) provide a contemporaneous hedge against inflation in the long run according to the Engle-Granger cointegration tests.

A key contribution of this study is to draw attention to the effect of lead-lag relations as this possibly provides the most effective source of inflation protection. Foreign equities, bonds, cash as well as the domestic RESI Index have positive and significant coefficients when current inflation is regressed on their prior 12-month returns. This suggests that rand hedges provide returns *prior* to inflation manifesting itself and in that way deliver an 'up front' form of inflation protection. This finding alerts the investor as to the need for a pre-emptive rather than a reactive approach to inflation protection in portfolio construction.

A major implication of these findings is that domestic investment funds, whose benchmarks are based on consumer price indices (e.g. CPI plus 4%) actually rely on the fact that the average returns of various asset classes exceed the average inflation rate in the long run, rather than them being good inflation hedges in the sense of exhibiting any positive co-movement with inflation. A 'cash plus' framework based on asset class and factor return premia may be a firmer foundation for goals-based portfolio construction. A second implication is that restrictions on investing in offshore assets should be further relaxed for South African investors and retirement funds to increase the inflation hedging capabilities of these funds.

References

Ahking, F. W. (2002). Model mis-specification and Johansen's co-integration analysis: An application to the US money demand. *Journal of Macroeconomics*, *24*(1), 51–66. https://doi.org/10.1016/S0164-0704(02)00017-4

Ahmed, S., & Cardinale, M. (2005). Does inflation matter for equity returns? *Journal of Asset Management*, *6*(4), 259–273. https://doi.org/10.1057/palgrave.jam.2240180

Alagidede, P., & Panagiotidis, T. (2010). Can common stocks provide a hedge against inflation? Evidence from African countries. *Review of Financial Economics*, *19*(3), 91–100. https://doi.org/10.1016/j.rfe.2010.04.002

Anari, A., & Kolari, J. (2001). Stock prices and inflation. *Journal of Financial Research*, *24*(4), 587–602. https://doi.org/10.1111/j.1475-6803.2001.tb00832.x

Anderson, R. (1997). *Market Timing Models. Constructing, Implementing and Optimizing a Market Timing-Based Investment Strategy*. Chicago: IRWIN.

Ang, A. (2014). *Asset Management: A Systematic Approach to Factor Investing*. Oxford: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199959327.001.0001

Arnold, S., & Auer, B. R. (2015). What do scientists know about inflation hedging? *The North American Journal of Economics and Finance*, *34*, 187–214. https://doi.org/10.1016/j.najef.2015.08.005

Bekaert, G., & Wang, X. (2010). Inflation risk and the inflation risk premium. *Economic Policy*, *25*(64), 755–806. https://doi.org/10.1111/j.1468-0327.2010.00253.x

Bodie, Z. (1976). Common stocks as a hedge against inflation. *The Journal of Finance*, *31*(2), 459–470. https://doi.org/10.1111/j.1540-6261.1976.tb01899.x

Boudoukh, J., & Richardson, M. (1993). Stock returns and inflation: A long-horizon perspective. *The American Economic Review*, *83*(5), 1346–1355.

Brière, M., & Signori, O. (2013). Hedging inflation risk in a developing economy: The case of Brazil. *Research in International Business and Finance*, *27*(1), 209–222. https://doi.org/10.1016/j.ribaf.2012.04.003

Chatrath, A., & Liang, Y. (1998). REITs and inflation: A long-run perspective. *Journal of Real Estate Research*, *16*(3), 311–326.

Cochran, S. J., & DeFina, R. H. (1993). Inflation's negative effects on real stock prices: New evidence and a test of the proxy effect hypothesis. *Applied Economics*, *25*(2), 263–274. https://doi.org/10.1080/00036849300000032

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366a), 427–431.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, *55*(2), 251–276. https://doi.org/10.2307/1913236

Engsted, T., & Tanggaard, C. (2002). The relation between asset returns and inflation at short and long horizons. *Journal of International Financial Markets, Institutions and Money*, *12*(2), 101–118. https://doi.org/10.1016/S1042-4431(01)00052-X

Fama, E. F. (1981). Stock returns, real activity, inflation, and money. *The American Economic Review*, *71*(4), 545–565.

Fama, E. F., & Schwert, G. W. (1977). Asset returns and inflation. *Journal of Financial Economics*, *5*(2), 115–146. https://doi.org/10.1016/0304-405X(77)90014-9

Fisher, I. (1930). *The theory of interest rates*. New York: Macmillan.

Ganesan, S., & Chiang, Y. (1998). The inflation-hedging characteristics of real and financial assets in Hong Kong. *Journal of Real Estate Portfolio Management*, *4*(1), 55–67.

Glascock, J. L., Lu, C., & So, R. W. (2000). Further evidence on the integration of REIT, bond, and stock returns. *The Journal of Real Estate Finance and Economics*, *20*(2), 177–194. https://doi.org/10.1023/A:1007877321475

Glascock, J. L., Lu, C., & So, R. W. (2002). REIT returns and inflation: Perverse or reverse causality effects? *The Journal of Real Estate Finance and Economics*, *24*(3), 301–317. https://doi.org/10.1023/A:1015221515787

Granger, C. W. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, *37*(3), 424–438. https://doi.org/10.2307/1912791

Granger, C. W. (1981). Some properties of time series data and their use in econometric model specification. *Journal of Econometrics*, *16*(1), 121–130. https://doi.org/10.1016/0304-4076(81)90079-8

Granger, C. W., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics*, *2*(2), 111–120. https://doi.org/10.1016/0304-4076(74)90034-7

Gultekin, N. B. (1983). Stock market returns and inflation: Evidence from other countries. *The Journal of Finance*, *38*(1), 49–65. https://doi.org/10.1111/j.1540-6261.1983.tb03625.x

Hardin, W. G., III, Jiang, X., & Wu, Z. (2012). REIT stock prices with inflation hedging and illusion. *The Journal of Real Estate Finance and Economics*, *45*(1), 262–287. https://doi.org/10.1007/s11146-010-9259-y

Hjelm, G., & Johansson, M. W. (2005). A Monte Carlo study on the pitfalls in determining deterministic components in cointegrating models. *Journal of Macroeconomics*, *27*(4), 691–703. https://doi.org/10.1016/j.jmacro.2004.03.005

Hoesli, M., Lizieri, C., & MacGregor, B. (2008). The inflation hedging characteristics of US and UK investments: A multi-factor error correction approach. *The Journal of Real Estate Finance and Economics*, *36*(2), 183–206. https://doi.org/10.1007/s11146-007-9062-6

Huang, H., & Hudson-Wilson, S. (2007). Private commercial real estate equity returns and inflation. *Journal of Portfolio Management*, *33*(5), 63–73. https://doi.org/10.3905/jpm.2007.698906

Ibbotson, R. G., & Sinquefield, R. A. (1976). Stocks, bonds, bills, and inflation: Year-by-year historical returns (1926-1974). *The Journal of Business*, *49*(1), 11–47. https://doi.org/10.1086/295803

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics & Control*, *12*(2-3), 231–254. https://doi.org/10.1016/0165-1889(88)90041-3

Kim, J. H., & Ryoo, H. H. (2011). Common Stocks as a hedge against inflation: Evidence from century-long US data. *Economics Letters*, *113*(2), 168–171. https://doi.org/10.1016/j.econlet.2011.07.003

Le Moigne, C., & Viveiros, E. (2008). The inflation-hedging ability of Canadian direct real estate return and its components, income, and appreciation. *Journal of Real Estate Portfolio Management*, *14*(2), 141–154.

Lee, M., & Lee, M. (2012). Long-run inflation-hedging properties of United State equity real estate investment trusts (REITs): Before and after the structural break in the 1990s. *African Journal of Business Management*, *6*(6). https://doi.org/10.5897/AJBM11.1181

Lintner, J. (1975). Inflation and security returns. *The Journal of Finance*, *30*(2), 259–280.

Lothian, J. R., & McCarthy, C. H. (2001). Equity returns and inflation: The puzzlingly long lags. *CRIF Working Paper series*. 16. https://fordham.bepress.com/crif_working_papers/16

Lothian, J. R., & Simaan, Y. (1998). International financial relations under the current float: Evidence from panel data. *Open Economies Review*, *9*(4), 293–313. https://doi.org/10.1023/A:1026440213785

MacKinnon, J. G. (1990). *Critical values for cointegration tests*. Oakland: Department of Economics, University of California.

Madsen, J. B. (2007). Pitfalls in estimates of the relationship between stock returns and inflation. *Empirical Economics*, *33*(1), 1–21. https://doi.org/10.1007/s00181-006-0080-7

Nelson, C. R. (1976). Inflation and rates of return on common stocks. *The Journal of Finance*, *31*(2), 471–483. https://doi.org/10.1111/j.1540-6261.1976.tb01900.x

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335–346. https://doi.org/10.1093/biomet/75.2.335

Roache, S. K., & Attie, A. P. (2009). *Inflation hedging for long-term investors*. Washington DC.: International Monetary Fund. https://doi.org/10.5089/9781451872378.001

Roll, R. (1972). Interest rates on monetary assets and commodity price index changes. *The Journal of Finance*, *27*(2), 251–277. https://doi.org/10.1111/j.1540-6261.1972.tb00958.x

Schotman, P. C., & Schweitzer, M. (2000). Horizon sensitivity of the inflation hedge of stocks. *Journal of Empirical Finance*, *7*(3-4), 301–315. https://doi.org/10.1016/S0927-5398(00)00013-X

Simpson, M. W., Ramchander, S., & Webb, J. R. (2007). The asymmetric response of equity REIT returns to inflation. *The Journal of Real Estate Finance and Economics*, *34*(4), 513–529. https://doi.org/10.1007/s11146-007-9023-0

Sims, C. A. (1972). Money, income, and causality. *The American Economic Review*, *62*(4), 540–552.

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, *48*(1), 1–48. https://doi.org/10.2307/1912017

Solnik, B., & Solnik, V. (1997). A multi-country test of the Fisher model for stock returns. *Journal of International Financial Markets, Institutions and Money*, *7*(4), 289–301. https://doi.org/10.1016/S1042-4431(97)00024-3

Spierdijk, L., & Umar, Z. (2015). Stocks, bonds, T-bills and inflation hedging: From great moderation to great recession. *Journal of Economics and Business*, *79*, 1–37. https://doi.org/10.1016/j.jeconbus.2014.12.002

Spyrou, S. I. (2004). Are stocks a good hedge against inflation? Evidence from emerging markets. *Applied Economics*, *36*(1), 41–48. https://doi.org/10.1080/0003684042000177189

Yule, G. U. (1926). Why do we sometimes get nonsense-correlations between time-series? – A study in sampling and the nature of time-series. *Journal of the Royal Statistical Society*, *89*(1), 1–63. https://doi.org/10.2307/2341482