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Equities as a hedge against inflation in South Africa

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Abstract

Conventional wisdom holds that equity investments should provide an effective hedge against inflation. However, empirical tests of this relationship in South Africa have produced conflicting results. We employ both a Vector Error Correction Model (VECM) and Autoregressive Distributed Lag Model (ARDL) to examine the relationship between equity returns and inflation for the Johannesburg Stock Exchange between 1980 and 2015. We find strong evidence of cointegration between equity returns and inflation with a positive coefficient that exceeds unity supporting equities' ability to act as a hedge against inflation. The VECM, however, shows that within the cointegrating relationship it is primarily inflation that responds to changes in equity returns and that this process takes place over an extended length. Thus holding equities as a hedge against inflation is only likely to be effective over longer investment horizons.

Keywords: Inflation; Fisher Effect; Fama's Proxy Hypothesis; ARDL; Johannesburg Stock Exchange.

"In the absence of the gold standard, there is no way to protect savings from confiscation through inflation. There is no safe store of value." – Alan Greenspan

1. Introduction

The impact of inflation is a major concern for any investors concerned about the long-term effect it will have on the value of their investments. Conventional wisdom holds that equities should act as an effective hedge against inflation (Lee, 1992) as they represent a claim against real assets whose real returns should not be affected by inflation (Lee, 2010; Siegel, 2011)[1]. This expectation

1 The same argument applies to other real assets including gold (Bampinas, and Panagiotidis, 2015) and real estate (Inglez-Lots and Gupta, 2013). Arnold and Auer (2015) provide a useful review of the literature examining the ability of these assets to act as a hedge against inflation.

is famously captured in the Fisher Hypothesis that the nominal interest rate is simply the sum of the real interest rate and the expected inflation rate (Gultekin, 1983a; Li, Narayan and Zheng, 2010). Despite the strong theoretical expectation that the returns on equities should be positively related to expected inflation, the empirical evidence has generally not supported this hypothesis with multiple studies finding in fact that the correlation between stock returns and inflation is negative (Fama and Schwert, 1977; Mayya, 1977; Gultekin, 1983a; Day 1984, Kaul, 1990; Li *et al*., 2010; Valcarcel, 2012).

This evidence of a negative relationship has resulted in authors proposing several alternative explanations including the Inflation Illusion Hypothesis of Modigliani and Cohn (1979) Fama's Proxy Hypothesis (Fama, 1981, 1983), the Tax Hypothesis of Feldstein (1980), and the Tax-augmented hypothesis of Anari and Kolari (2001). More recent research, however, reflecting advancements in the modelling of non-stationary time series through the use of cointegration techniques, has found evidence of a positive relationship between the rate of inflation and the rate of return on equities (Gregoriou and Kontonikas, 2010). In addition the empirical evidence suggests that the relationship is time-varying (Prabhakaran, 1989; Lee, 2010) and that it is market dependent (Claude, Campbell and Viskanta 1995; Alagidede and Panagiotidis, 2010). Recent studies that have attempted to apply the cointegration framework using South African data have found conflicting results. Alagidede and Panagiotidis, (2010) found that both inflation and equities were non-stationary in level terms while Eita (2012) found that they were both stationary and Khumalo (2013) concluded that stock prices were stationary whilst inflation was non-stationary.

To overcome the potential problem of series that may not be consistently stationary or non-stationary, as required by the Johansen Cointegration framework, we employ an alternative approach that does not require the assumption that either series is either I(1) or I(0) (Atkins and Coe, 2002; Ahmad, 2010) by modelling the relationship between equity returns and inflation using Pesaran, Shin and Smith's (2001) autoregressive distributed lag (ARDL) model which can be applied regardless of whether the two series are both stationary or not. For comparative purposes, we also follow the approach of Alagidede and Panagiotidis, (2010) and employ the Johansen's Vector Error Correction Model (VECM). This paper thus contributes to our understanding of the relationship between inflation and equity returns by supplementing the traditional VECM approach by employing an alternative method of analysis that can model the relationship between equity returns and inflation more flexibly.

2. Literature review

Fisher (1930) proposed that the nominal interest rate consists of the sum of the real interest rate and the expected inflation rate and so the nominal interest rate will differ from the real interest rate by the expected rate of inflation (Cooray, 2002). The Fisher Hypothesis implies that because the value of equities is inherently based on underlying assets and capital investments, which should maintain a constant real value irrespective of the rate of inflation (Bradley and Jarrell, 2008), the return on stocks should vary positively with the actual rate of inflation, which would make stocks an effective hedge against unexpected inflation (Sharpe, 2000; Alagidede and Panagiotidis, 2010). Until the mid-1970s, it was generally accepted that Fisher's Hypothesis should hold and that the nominal return on equities should be positively correlated with changes in the expected inflation rate (Khil and Lee, 2000).

However, Valcarcel (2012) states that although the theory predicts a strong positive relationship between equity returns and inflation, it is difficult to find empirical evidence to substantiate this prediction. Additionally, Berument and Jelassi (2002) state that there are disparate views in the academic community over for how long a period this relationship exists, with some authors predicting the existence of a positive relationship regardless of the time period considered (Boudoukh and Richardson, 1993) while others find evidence that the relationship exists exclusively in the long run (Mishkin, 1992). Boudoukh and Richardson (1993) argue that the relationship still exists in the short run, but the Fisher effect is stronger over longer time horizons.

Conflicting empirical evidence since the introduction of the Fisher Hypothesis shows that the relationship between inflation and stock prices may be indirect and inconsistent and that the stock-return inflation relationship has in many cases been shown to be significantly negative or less than unity (Khil and Lee, 2000). A potential reason for this is that the real rate of return on equities does not remain constant in light of inflation, because nominal equity returns do not necessarily increase at the same rate as the increase in inflation in reality. Instead the literature shows that nominal equity returns may be subject to an increase that is less than the inflation rate and therefore they do not experience the one-to-one increase alongside the inflation rate as dictated by the classical theory (Bodie, 1976; Nelson, 1976; Fama and Schwert, 1977).

Possibly the most important contribution to the post-classical thinking was made by Fama (1981), who proposed what is termed the Proxy Hypothesis, which sought to prove that the negative relationship between inflation and real stock returns after 1953 can be attributed to proxy effects. Fama's (1981) hypothesis rests on the theory that inflation is merely a proxy for more relevant, "real-activity" variables in models that relate the inflation rate to the rate of real stock returns. According to Ely and Robinson (1997), the negative relationship previously observed between stock returns and the rate of inflation is attributed by the Proxy Hypothesis to two fundamental relationships: firstly, the relationship between inflation and expected economic activity, and secondly, the equity return and expected economic activity relationship. The foundation of the Proxy Hypothesis is not, therefore, based on the direct relationship between equity returns and the inflation rate; rather it is based on the autonomous relationships between each factor and expectations of economic activity.

Several alternative theories have been presented in the literature to try to provide an explanation for why the relationship between equity returns and inflation might be negative. Geske and Roll (1983) present the Reverse Causality Hypothesis. They expand on the Proxy Hypothesis by suggesting that a chain of macroeconomic events would lead to an inaccurate correlation between stock returns and inflation. Geske and Roll (1983) base this proposition on the theory that the relationship between stock prices and future economic activity as proposed by Fama's Proxy Hypothesis is highly correlated with government revenue. Therefore, when economic activity decreases the government experiences a deficit and either borrows or issues money via the Reserve Bank, which leads to inflation, and explains the negative relationship (Jorgensen and Terra, 2006). Kaul (1990) argues that the negative relationship between real stock returns and inflation is dependent on the monetary sector's current equilibrium process, in which a counter-cyclical monetary response is responsible for the negative relationship. Hess and Lee (1999) theorize that supply shocks, including real output shocks, contribute towards a negative relationship between the variables while demand shocks, including monetary shocks, contribute towards a positive relationship.

The relationship between equity returns and inflation has been widely tested internationally (see Arnold and Auer (2015) for an extensive review). Some initial studies did find evidence supporting the Fisher Hypothesis. Firth (1979), for example, found a positive relationship in Britain while Gultekin (1983b) found a relationship greater than unity, a finding consistent with what has now become known as the tax-augmented Fisher Hypothesis. Most early studies, however, found evidence of a negative relationship between inflation and equity returns.

Mayya (1977) found that a negative relationship existed between equity returns and inflation while Prabhakaran (1989) found similar results although he found some evidence that equities provided a partial hedge against inflation but only in a limited number of years. Gultekin (1983a) found across multiple countries that the relationship was generally negative but not statistically significant while Day (1984) found a significant negative relationship. Similarly, Bodie (1976); Nelson (1976); Hess and Lee (1977); Kaul (1990) and Claude *et al.* (1995) all found a significant negative relationships between equity returns and inflation.

These early studies, however, preceded the development of cointegration techniques that facilitated the study of the long-term relationship between time-series variables. In an early study using cointegration theory, Ely and Robinson (1997) failed to find the unitary relationship predicted by the classical theory but did find evidence for most of the 16 countries analysed that equities maintained their values against inflation. Kasman, Kasman and Turgutlu (2006) also found evidence of a significant positive relationship, which varied between being equal to, or less than perfect unity. Kim and Ryoo (2011), on the other hand, found that the relationship was positive and exhibited unitary elasticity. Khil and Lee (2000), however, found that out of 11 sample countries, 10 exhibited evidence of a negative relationship. Using a different approach based on an analysis of quantile regressions, Alagidede and Panagiotidis (2012) found that once a generalised autoregressive conditional heteroscedasticity (GARCH) filter was employed a significant positive relationship approaching unity existed for the G7 countries except for Canada where, although lower, the relationship was still significantly positive.

More recently, several studies have employed the ARDL approach of Pesaran *et al*. (2001) as an alternative approach to testing the Fisher Hypothesis. Atkins and Coe (2002), for example, using an ARDL model find that the long-run relationship between nominal interest rates and inflation in the United States and Canada is close to unity. Ahmad (2010) uses a similar approach and finds some support for the Fisher effect in India, Pakistan, Kuwait and Saudi Arabia but not in Bangladesh while the results for Sri Lanka were mixed. Hassan, Hoque and Rau (2015) examine the Fisher hypothesis for 19 OECD countries and find that all of their long-run Fisher coefficients are statistically significant and greater than one, varying from 1.27 to 1.86. Adusei (2014) finds a negative relationship between inflation and stock market returns for Ghana in the short run but a significantly positive long-run relationship similar to Akmal (2007) who also found a positive relationship in the long run but not in the short run for Pakistan.

The empirical evidence pertaining to South Africa is limited and conflicting. Hancocks (2010), as part of a multi-variate analysis of macroeconomic variables that affected stock prices in South Africa, reported that both inflation and the JSE-ALSI were non-stationary and integrated of the first order. Using a Johansen's cointegration approach, Hancocks (2010) found a significant negative relationship between inflation and the All Share Index in South Africa. This is in direct contrast to the findings of Alagidede and Panagiotidis (2010) who, in a study of six African markets, concluded that not only was the relationship between equity values and inflation positive but that in the case of South Africa exceeded unity. In contrast to the findings of these previous studies, Eita (2012) found that both inflation and equity returns were stationary in levels for South Africa, and were positively related. The finding of stationarity, however, is surprising and would imply that he used the changes in the CPI and All Share Indexes rather than the absolute index levels. To further confuse the picture Khumalo (2013) found that while inflation is non-stationary, stock prices in South Africa were stationary. Khumalo (2013), using a Granger causality test, concluded that inflation has a substantial negative effect on stock prices with stock prices expected to fall by some 31% for a 1% increase in inflation.

3. Methodology

3.1. Research problem

The above discussion clearly highlights the lack of consensus within both the theoretical and empirical literature regarding the nature of the relationship between equity returns and inflation. Internationally it would appear that the earlier findings of a negative relationship may largely be explained by the methodological limitations of these early studies with later studies employing more sophisticated cointegration techniques generally finding evidence of a positive relationship. Nevertheless, even these later studies have produced mixed results regarding the exact nature of the relationship suggesting that it may be time varying (Kim and Ryoo, 2011) and /or country dependent (Claude, Campbell and Viskanta, 1995; Khil and Lee, 2000; Alagidede and Panagiotidis, 2010).

The empirical evidence for South Africa is even more challenging as the limited number of studies that have investigated the relationship between equity returns and inflation have produced such conflicting and confusing results. This study, therefore, attempts to address the important question of what is the long-term relationship between inflation and equity returns in South Africa.

3.2. Data

Following the methodology of Prabhakaran (1989), Ely and Robinson (1997), Alagidede and Panagiotidis (2010), and Kim and Ryoo (2011), the FTSE/JSE All Share Index was used to estimate the price level for all JSE listed companies while the Consumer Price Index (CPI) was used as a proxy for the inflation variable. The actual goods and inflation price data were used as proxies for expected goods prices and inflation after Madsen (2007) illustrated that it is possible for model-based expected inflation to introduce bias into results testing the Fisher Hypothesis. The sample period was from 1980 to 2015, which exceeded the minimum sample size requirement determined by Seo (2006) and used by Kim and Ryoo (2011), who determined stable results within a similar context. Following Kim and Ryoo (2011), the index level data was converted into natural log form prior to the regression analysis in order to avoid the issue of heteroscedasticity.

3.3. Method of analysis

In order to provide a benchmark for comparative purposes, this study initially replicated the standard VECM approach followed by Alagidede and Panagiotidis (2010) before extending the analysis of the long-term relationship between equity returns and inflation by employing the ARDL test procedure of Pesaran *et al*. (2001), which has not previously been used in the South African context. Prior to estimating the VECM and ARDL models, standard descriptive statistics and tests for stationarity were conducted as described below.

In order to ensure that the regression is not spurious we tested for the order of integration prior to testing for cointegration (Gujarati and Porter, 200). This study used the Augmented Dickey Fuller (ADF), the Phillips-Perron (PP) and the Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS) tests in this regard. We applied the ADF test in three different forms, which respectively test for a unit root, a unit root with drift and a unit root with drift around a deterministic time trend (Xu, Sun and Lundtofte; 2010). We then employed the Phillips-Perron (PP) test, which is an alternative non-parametric test for the presence of a unit root in a series which has an advantage over the ADF test in that it does not require a specific selection of the level of correlation while testing the same null and alternative hypotheses (Pelgrin, 2012).

Mahadeva and Robinson (2004) state that unit root tests may suffer from low power and may incorrectly conclude that the variable has a unit root if they are unable to reject the null in certain cases. Thus we also employed the

KPSS test to improve the robustness of the analysis, which is important given the historically conflicting results in the literature. This additional test is further recommended by Ely and Robinson (1997), who state that because the ADF test can potentially suffer from low power the KPSS should also be used. The KPSS test has as its null hypothesis that the variable does not exhibit evidence of a unit root and is thus stationary, tested against an alternative hypothesis of non-stationarity, in contrast to the previous two tests which test the null hypothesis that a series contains a unit root indicating non-stationarity (Alagidede and Panagiotidis, 2010). Following Xu *et al*., (2010) we include both an intercept and a deterministic trend variable, based on graphical inspection of the data which starts above zero and exhibits a very obvious upward trend. These characteristics can be seen in Figure 1.

Subsequently, following the determination that both time series were integrated of the first order, the Johansen's multivariate method was employed, following the methodology common in the literature (Alagidede and Panagiotidis, 2010). We began with the generalized VAR model with *k* lags, specified as:

$$y_t = c + b_1 y_{t-1} + b_2 y_{t-2} + \cdots + b_k y_{t-k} + u_t \tag{1}$$

where *c* represents the intercept, or constant term, if it exists within the specific structure of the model, y_t is a 2x1 matrix where the dependent variable is the stock price and the independent variable is the consumer price index in the context of this study. The current value of y_t depends on different combinations of the independent variables up to *k*, and u_t represents a white noise disturbance term (Brooks, 2008).

The VAR model allows for the determination of the appropriate lag length to be used in the Vector Error Correction Model (VECM), with the optimal lag length being that which minimizes the Akaike (AIC) and Schwarz-Bayesian (SIC) information criterion. The generalized VAR model was then converted into a Vector Error Correction Model in order to use Johansen's (1995) test, as specified below (Alagidede and Panagiotidis, 2010):

$$\Delta y_t = \mu + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{k-1} \Delta y_{t-(k-1)} + \Pi y_{t-k} + u_t \tag{2}$$

where

$$\Pi = (\sum_{i=1}^{k} B_i) - I_g \quad \text{and} \quad \Pi = (\sum_{i=1}^{k} B_i) - I_g \tag{3}$$

According to Brooks (2008) the Johansen test is essentially based on an analysis of the Π matrix, which is interpreted in this context as the long-run coefficient matrix, which under the assumption of an equilibrium condition, would mean that all $\Delta y_{(t-i)}$ would be zero and if the error terms are assumed to match their expected value of zero, $\Pi y_{(t-k)}$ would also take on a value of zero. There are two variants of Johansen's tests, these being the trace test and maximum eigenvalue tests which are formulated as (Tsay, 2014; Brooks, 2008):

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i)$$

and

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i)$$

where: r = the number of cointegrating vectors under the null hypothesis, and, $\lambda_{\hat{i}}$ = the estimated value for the ith ordered eigen value from the Π matrix. The trace statistic tests the null hypothesis that the number of cointegrating vectors is less than or equal to r against a general alternative that there are more than r; while the maximum eigen value test tests the null hypothesis that the number of cointegrating vectors is r against an alternative of r+1 (Enders, 2010). The results of both tests are reported in section 4 of this paper.

Following the determination of cointegration by the Johansen's test, a VECM was constructed for each lag length, which provides an indication of the β coefficient that defines the nature and magnitude of the relationship between equities and inflation. The relationship in terms of the Fisher hypothesis was specified as:

$$LogSP_t = C + \beta LogCPI_t + \varepsilon_t \tag{3}$$

where *LogSP* represents the log of the share price variable, *LogCPI* represents the log of the inflation variable, *C* represents the intercept or constant term, if it exists, and ε_t represents a white noise disturbance term (Brooks, 2002). The β coefficient in the above equation represents the magnitude and nature of the relationship between equities and inflation. In the context of this study, any β coefficient that exceeds unity would make equities an effective hedge against inflation, according to the theory of the tax-adjusted Fisher hypothesis.

In order to expand the analysis to address the conflicting results determined in the South African literature between the studies by Alagidede and Panagiotidis (2010), Eita (2012) and Khumalo (2013), we then employed an ARDL model following the work of Pesaran, Shin and Smith (2001). The main advantage of an ARDL approach is the ability to model the series even when they are not integrated of the same order, which has significant advantages over conventional cointegration tests in the current context (Ahmad, 2010; Van

Hoang, Lahiani and Heller, 2016). The ARDL model is described in detail in Pesaran and Shin (1999) and Pesaran *et al*. (2001), but is often defined differently to suit specific studies by manipulation of a VAR model similar to that shown in Equation 1 (Ahmad, 2010; Atkins and Coe, 2002; Rushdi, Kim and Silvapulle, 2012). Following Ahmad (2010) the VAR is initially written as a VECM of the form:

$$\Delta Y_t = C + \alpha Y_{t-1} + \sum_{j=1}^{p-1} \beta_j \Delta Y_{t-j} + u_t \tag{4}$$

in which Y_t represents a matrix of the dependent and independent variables. In this case the stock price is represented by i_t and the expected inflation rate is represented by $\pi_{(t+1)}$. The inflation rate is thus shown simply by π_t. The model is then extended into the ARDL*(p,q)* form shown as follows (Ahmad, 2010; Atkins and Coe, 2002; Atkins and Chan, 2004):

$$\Delta i_t = \tau + p i_{t-1} + \delta \pi_t + \sum_{j=1}^{p-1} \omega_{i,j} \Delta i_{t-j} + \sum_{j=1}^{q-1} \omega_{\pi,j} \Delta \pi_{t+1-j} + \sigma \Delta \pi_{t+1} + v_t \tag{5}$$

In the ARDL*(p,q)* both the stock price and the inflation rate are allowed to exhibit different lag lengths, with *p* representing the lag length of the first difference of the stock price and *q* the respective representation for the inflation rate. Ahmad (2010) defines the null hypothesis as a state where $p = \delta = 0$ and the alternative hypothesis where *p* and δ independently differ from zero, which is a state where a stable long-run relationship between stock prices and inflation exists (Atkins and Coe, 2002). Atkins and Coe (2002) note that there is no reason why the lag lengths of the first differences on the variables need to be the same, hence we allow for the possibility of varying lag lengths.

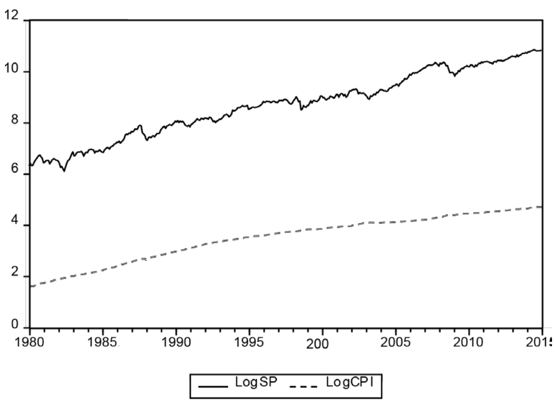
The ARDL*(p,q)* model shown in Equation 5 was estimated using OLS and the F-statistic was calculated for the null and alternative hypotheses. Following Atkins and Coe (2002) we tested the null hypothesis of a stable long-run relationship, using the bounds test approach of Pesaran *et al*. (2001) by comparing the regression's F-statistic to the asymptotic critical values determined by Pesaran *et al*. (2001).

4. Results

4.1. Descriptive statistics

The graphical analysis of the two series in Figure 1 showed an upward trend over time for the log of both stock prices and CPI. The CPI variable exhibited slight levels of volatility, with higher levels of volatility shown by the share price (SP) variable.

Figure 1: Log of Inflation and Share Prices between 1980 and 2015



Descriptive Statistics are reported in Table 1 below:

Table 1: Descriptive Statistics of LogSP and LogCPI variables

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis
LogSP	8.6893	8.8119	10.8473	4.7113	1.2845	-0.1385	1.9947
LogCPI	3.5012	3.7424	4.7113	1.6094	0.8862	-0.5607	2.1231

4.2. Stationarity tests

Table 2 reports the summarized results of the stationarity tests. The ADF test results found that the unit root null hypothesis could not be rejected in levels but was rejected in first differences at the 1% level for both variables indicating that both series are I(1). Similarly the PP test could not reject the null hypothesis of a unit root for CPI in levels, but failed to reject it at the 1% level in first differences. With regards to the stock prices series, however, the PP test rejected the unit root hypothesis for both levels (at the 5% level) and in first differences (at the 1% level) indicating that stock prices are I(0). The KPSS test, however, rejected the null of stationarity in levels at 5% for the stock price but could not reject the hypothesis of stationarity in first differences supporting the ADF test's conclusion that stock prices are I(1). In contrast to both the ADF and PP tests the KPSS test rejected the null hypothesis of stationarity for CPI in both levels (at the 1% level) and in first differences (at the 5% level).

TABLE 2: UNIT ROOT AND STATIONARITY TEST RESULTS: 1980-2015

Test	**ADF Test**		**PP Test**		**KPSS Test**	
statistic	**t-stat**		**Adj. t-Stat**		**LM-Stat**	
Order of Integration	**Levels**	**1st Diff**	**Levels**	**1st Diff**	**Levels**	**1st Diff**
Stock Price	3.2588	-19.0092**	-3.6574*	-18.9607**	0.1892*	0.0229
CPI	-1.8307	-13.9778**	-1.7092	-24.5192**	0.6159**	0.1953*

** indicates significance at the 1% level, * indicates significance at the 5% level

Although the three tests present some conflicting results, at least two of the tests in each case find the variables to be I(1) and so we concluded that both stock prices and CPI in South Africa over the sample period were non-stationary, a conclusion supported by the empirical results of Hancocks (2010), Alagidede and Panagiotidis (2010) and Mahadeva and Robinson (2004). The discrepancy in the ADF and PP tests, however, may point to characteristics in the data series that could, at least partially, explain the conflicting findings obtained by Eita (2007) and Khumalo (2013). These differing results regarding the stationarity of stock prices and inflation point to the possibility that the stationarity of the data series may be time varying. This possibility lends support to the use of an ARDL model to model the relationship between inflation and equity returns with its ability to accommodate variables that are both I(0) and I(1).

4.3. Johansen's test and the VECM

Following the confirmation of stationarity at first differences, the Johansen's test was conducted. Initially the time series were tested for the optimal lag order to be used in the Johansen's test by constructing a VAR model and then analysing the lag structure of the model. Table 3 shows the results of the Johansen's test for the period 1980 to 2015. The lag lengths as dictated by both the AIC and SIC criteria are shown.

TABLE 3: JOHANSEN COINTEGRATION TEST RESULTS: 1980-2015

Range	**1980-2015 (SIC)**	**1980-2015 (AIC)**
Trace Test (0 CE)	60.5882*	53.8944*
	[0.0000]	[0.0000]
Trace Test (max 1 CE)	4.4573*	5.7820*
	[0.0347]	[0.0162]
Max. Eigenval. (0 CE)	56.1209*	48.1122*
	[0.0000]	[0.0000]
Max Eigenval. (Max 1 CE)	4.4573*	5.7820*
	[0.0347]	[0.0162]
Lag Length	2	4

* Denotes rejection of the null hypothesis at the 0.05 level p-values in [ ]

Table 3 shows that over the sample period the cointegrating relationship remained significant between the variables, indicating that there has been a consistent cointegrating relationship over the period. In fact, in line with Alagidede and Panagiotidis (2010), the results of the Johansen's test implied that two cointegrating relationships exist between the variables in each case, because the test statistics for both the trace test and maximum eigenvalue test exceed their respective critical values for a maximum of one cointegrating relationship. The finding of two cointegrating relationships at the 5% level of significance when only one can exist is an indication that the relationship is of greater significance than was initially tested for. For example, the test indicated that we can be 95% sure of the existence of a linear cointegrating relationship, however, the test only provided evidence of one cointegrating relationship when the level of significance was increased to the 0.5% level, indicating that we can be 99.5% confident that a single cointegrating relationship exists between the variables. Following the determination of a cointegrating relationship, the VECM was constructed.

Table 4 shows the summarized results of the VECM model conducted over the sample period. Following the approach of Kim and Ryoo (2011), the share price variable LogSP was used as the dependent variable, according to the Fisher equation. This result confirms that there has been a long-term relationship between the variables with the β coefficient of 2.49 indicating that a one percent increase in inflation is associated with an increase in equity returns of almost two and a half percent. The magnitude of the β coefficient obtained using the South African data is relatively large compared to international studies, such as

Berument and Jelassi (2002) and Kasman *et al*. (2006), which consider a range of other countries including the United States, France, the United Kingdom, Mexico and Zambia. Berument and Jelassi (2002), for example, found values that ranged from 0.113 to 1.302 in developed countries and -.312 to 1.586 in developing countries, for a sample that did not include South Africa. By comparison, the coefficients determined in other African countries by Alagidede and Panagiotidis (2010) were 0.215 for Egypt, 0.292 for Kenya, 0.44 for Nigeria and 0.015 for Tunisia. The value greater than two, however, while slightly larger, is very similar to the value of 2.264 obtained by Alagidede and Panagiotidis (2010). This slight variation between the two studies is consistent with the findings of Valcarcel (2012) who determined that the stock price-inflation relationship does experience a measure of variation over time.

Table 4: The VECM of the Cointegrating Equation: 1980 to 2015

Cointegrating Equation	
LOGSP	1.0000
LOGCPI	-2.4938
	[-17.3881]
C	0.0224

t-stats shown in [ ].

The Error Correction terms for the VECM were constructed using data between 1980 and 2015, based on the SIC criterion in accordance with the work of Xu *et al.* (2010). Only the D(LogCPI) error correction term was significant, showing that about 0.8% of the disequilibrium in each period is corrected by adjustments of the inflation variable. This result indicates that it is the CPI variable that adjusts to correct for disequilibrium in the system, not the stock returns variable.

Table 5: The Error Correction Terms: 1980 to 2015

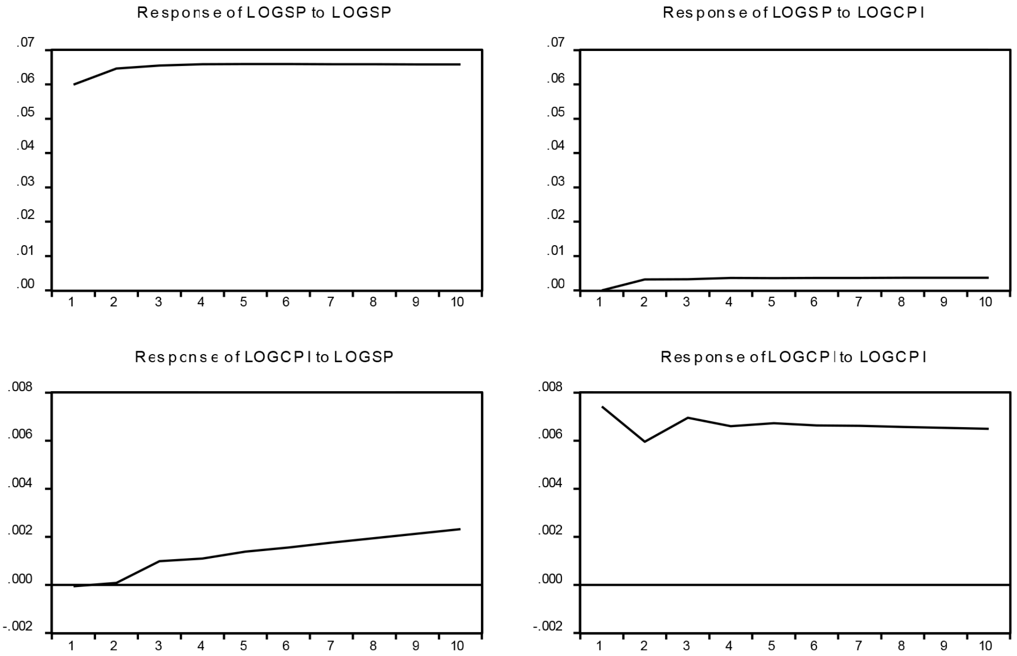
Error Correction Model	D(LOGCPI)	D(LOGSP)
Cointegrating Equation	-0.0083 [-7.6803]	0.0047 [0.5385]
D(LOGCPI(-1))	-0.1891 [-3.921]	0.4222 [1.0833]
D(LOGCPI(-2))	0.1023 [2.1158]	0.0533 [0.1363]
D(LOGSP(-1))	-0.0011 [-0.1881]	0.0800 [1.6293]
D(LOGSP(-2))	0.0121 [2.0010]	0.0096 [0.1960]
C	0.0079 [11.7437]	0.0063 [1.1677]

* Results of the ECM using a cointegration equation with LOGCPI normalised, t-stats are shown in [ ].

Together with the small adjustment per period, this indicates that equities are only able to act as an effective inflationary hedge in South Africa over long investment horizons and that in the short term equity values may not have sufficient time to adjust for inflationary shocks, a conclusion similar to that reached by Mishkin (1992) and Boudoukh and Richardson (1993) for the United States.

The impulse response functions for the VECM are shown in Figure 2, below. Due to the monthly data used, each period indicated in the impulse-response functions effectively represent a month ahead. The top graphs shows that stock prices react initially to shocks to stock prices but have almost no response to shocks to CPI. The bottom right-hand graph shows that goods prices are affected by their own past values but the effect gradually diminishes over time. The bottom left-hand graph shows that CPI initially is unresponsive to a shock to stock prices with a very small negative response of the goods price to the stock's price after one period but subsequently CPI shows a steady increase over time in response to a change in stock prices. Overall the results of the impulse responses functions reinforce the results obtained within the VECM showing that the stock market leads inflation which supports Fama's (1981) Proxy Hypothesis that increases in stock prices reflect an increase in real economic activity which in turn leads to inflationary increases. The small incremental changes and persistence displayed, however, highlights that any adjustment takes an extended period to develop.

FIGURE 2: IMPULSE RESPONSE FUNCTIONS OF THE VAR MODEL



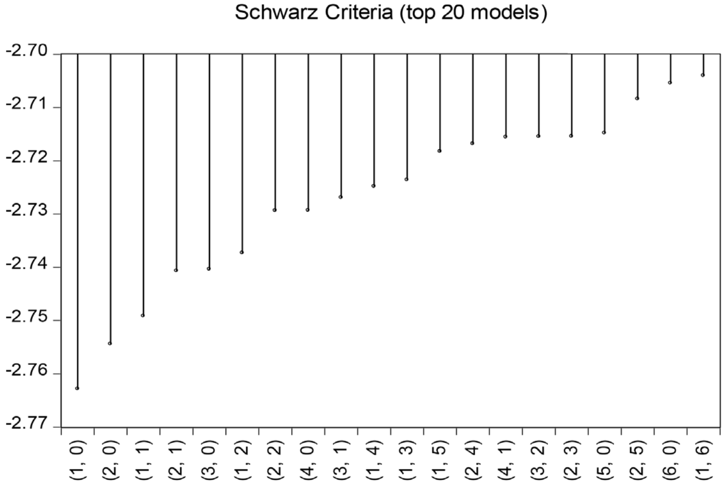
In light of the conflicting evidence presented by other South African studies (Eita, 2007; Hancocks, 2010; and Khumalo, 2013) our results provide strong support for Alagidede and Panagiotidis' (2010) findings and indicate that the South African stock market serves as a highly effective hedge against inflation. Furthermore, our results also corroborate their slightly surprising finding that the inflation coefficient for South Africa is much higher than the results reported for other countries. Alagidede and Panagiotidis (2010) suggest that this strong relationship between equity returns and inflation in South Africa may in part be due to the positive effects on the stock market following the abolishment of apartheid in 1994 alongside the lifting of the sanctions, which resulted in increased capital flows to the country.

The varying results of Eita (2007), Hancocks (2010) and Khumalo (2013), however, may also point to changes in the structures of the underlying data series over time. As a robustness test of our findings we employ an alternative statistical process, namely the ARDL of Pesaran, Shin and Smith (2001), which offers greater flexibility in that it allows for a combination of I(0) and I(1) data and for variables to be assigned different lag lengths (Hassan *et al*., 2015).

4.4. The ARDL and bounds test results

The ARDL model allows for 12 lags for each variable, but based on the results of the specialized estimator in EViews, presented in Figure 3 below, the selected model only uses one lag for the dependent variable, LogSP and zero lags for the regressor, LogCPI.

Figure 3: Top 20 ARDL (X,Y) Models according to the SIC



The test evaluated 156 models, of which the best 20 are shown in Figure 3. The selected ARDL model is ARDL(1,0), showing that a single lag of the dependent variable (x) and zero lags of the independent variable (y) were selected. The remaining results are the standard least squares outputs for the model.

The estimation output, bounds test and ARDL cointegration and long-run form are presented below in tables 6, 7 and 8. Table 6 shows the estimation output of the ARDL model. The number of observations included after the sample is adjusted for the appropriate number of lags is 420.

Table 6: ARDL Estimation Output

Dependent Variable	LOGSP			
Dependent Lags	12			
Selected Model	ARDL (1,0)			
Variable	**Coefficient**	**Std. Error**	**T-Stat**	**Prob**
LOGSP(-1)	0.9798	0.0111	88.5410	0.0000
LOGCPI	0.0274	0.0161	1.7055	0.0889
C	0.0905	0.0427	2.1193	0.0347

Table 7 presents the results of the bounds test of the ARDL. The F-Statistic of 5.68 exceeds all critical values. Using the standard 5% level of significance we can reject the null hypothesis that no long run relationship exists between the variables.

TABLE 7: ARDL BOUNDS TEST RESULT

Test Statistic	**Value**	**K**
F-Statistic	5.68251	1
Critical Value Bounds		
Significance	**I(0) Bound**	**I(1) Bound**
10%	3.0200	3.5100
5%	3.6200	4.1600
2.5%	4.1800	4.7900
1%	4.9400	5.5800

The ARDL cointegration equation in Table 8 shows a coefficient for LogCPI of 1.3539. This effectively represents the β coefficient in the Fisher equation and is of a significantly lower magnitude than that shown by the Johansen's test. However, the β coefficient is still positive and greater than unity, meaning that based on the results of the ARDL model equities are able to act as a hedge against inflation consistent with Feldstein's (1980) Tax hypothesis. The respective Fisher equation for the ARDL model is shown as:

$$LogSP = 4.4691 + 1.3539LogCPI$$

TABLE 8: ARDL COINTEGRATION AND LONG-RUN FORM

Cointegrating Form				
Variable	**Coefficient**	**Standard error**	**T-Statistic**	**Prob.**
D(LOGCPI)	-0.0304	0.3255	-0.0934	0.9256
CointEq(-1)	-0.0209	0.0061	-3.4169	0.0007
Long Run Coefficients				
Variable	**Coefficient**	**Standard error**	**T-Statistic**	**Prob.**
LogCPI	1.3539	0.1681	8.0548	0.0000
C	4.4692	0.7261	6.1550	0.0000

The results of the ARDL cointegration equation provide evidence in support of a cointegrating relationship between stock prices and inflation. Furthermore, the long-run coefficients of the ARDL test provide additional proof that equity returns are able to act as an effective long-run inflationary hedge in South Africa, consistent with the results of Alagidede and Panagiotidis (2010), although at a magnitude that is more comparable to the results obtained by studies in other countries.

6. Conclusion

The empirical evidence concerning the relationship between equity returns and inflation in South Africa is mixed with several studies producing widely contradictory results. This study investigated the relationship between equity returns and inflation, using ALSI and CPI data for the period 1980 to 2015 in order to assess the ability of shares to protect investors from the effects of inflation. Contrary to the findings of Eita (2012) and Khumalo (2013), but supporting Alagidede and Panagiotidis (2010), we find that both equity returns and inflation series are stationary in first differences. Using Johansen's cointegration framework we find strong evidence of cointegration between equity returns and inflation. Our results find that equity investments in South Africa provide good protection against the effects of inflation with equity returns displaying a coefficient of 2.49384, slightly higher than the value of 2.264 found by Alagidede and Panagiotidis' (2010). Under the ARDL framework the β coefficient is 1.3539, less than that shown by the VECM and more in line with international results but still well above the unitary relationship required to support the tax-augmented Fisher hypothesis.

These results support the conclusion that equities are an effective hedge against inflation in South Africa. In extending Alagidede and Panagiotidis' (2010) analysis to interrogate the long-run structure of the cointegrating relationship, however, we found that the results of the impulse response coefficients obtained from the VECM indicate that it is primarily inflation that changes in response to changes in equity returns and that this response develops over an extended number of periods. This result suggests that equity returns will provide greater protection against inflation over longer-term investment horizons than in the short run.

The results of this study contribute to our understanding of this important relationship by helping to clarify the existing confusion resulting from the conflicting findings evident in the empirical literature. Productive areas for further research would be to conduct the analysis on a sectoral basis in an attempt to ascertain which sectors are most responsive to the effects of inflation. Conducting a cointegration analysis allowing for structural breaks also offers potential value in the light of our evidence that the relationship between equity returns and inflation may be time varying. In particular, it would be of interest to investigate the impact upon the relationship, if any, of the introduction of inflation targeting in South Africa in February 2000.

Biographical Notes

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