Long run equilibrium adjustment between inflation and stock market returns in South Africa: A nonlinear perspective

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ABSTRACT: Following the global financial crisis of 2007-2008, the empirical investigation into financial variables affecting the performance of stock markets has gained prominence in the field of research. This study becomes the first to investigate the asymmetric cointegration effects of inflation on the stock market returns for the Johannesburg Stock Exchange (JSE) using monthly data collected from 2003:01 to 2014:12. The empirical model used in the study is the recently developed momentum threshold autoregressive (MTAR) model. Indeed, our results advocate for a negative, nonlinear cointegration relationship between inflation and stock returns in South Africa with causality running uni-directional from inflation to stock returns. Our empirical results suggest two things. Firstly, investors cannot hedge against rising inflation by investing in equity stocks listed on the JSE. Secondly, monetary policy, through the use of inflation targets, can provide a stable financial environment for the growth of equity markets in South Africa.

Keywords: Inflation; Stock market returns; Momentum threshold autoregressive (MTAR) model; Threshold error correction (TEC) model; Johannesburg Stock Exchange (JSE); South Africa; Sub-Saharan Africa (SSA); Developing economies.

JEL Classification Code: C22, C51, C52, E31, G10.

1 Introduction

The empirical investigation into the relationship between inflation and stock market returns is well documented on account of the importance which this relationship bears towards the decisions taken and perceptions formed by economists and policymakers, alike. The relevance of this relationship was first put into perspective by Fisher (1930) who claimed that stocks represent claims against real assets of a business and thus serve as a hedge against inflation. Accordingly, investors would opt to sell their financial assets in exchange for real assets when inflation is foreseen, which in turn,produces a positive correlation between inflation and stock market returns (Omotor, 2010). Fama (1981) countered this argument by proposing that since stock wealth reflects a firm's future potential earnings, an expected economic downturn may encourage firms to sell off the financial stocks hence creating a negative co-movement between inflation and stock prices. Ultimately, Fama's (1981) argument suggests that stock markets do not act as a hedge against inflation.

Based on the contradicting arguments of Fischer (1930) and Fama (1981), a number of empirical studies have investigated these hypotheses and, so far, the current literature has at best produced an indecisive consensus concerning the precise relationship between inflation and stock prices. For instance, a positive relationship between inflation and stock returns has been established in the works of Boudoukh and Richardson (1993) for the US and the UK, Graham (1996) for the US, Choudhry (2001) for Argentina, Chile, Mexico and Venezuela, Akmal (2007) for Pakistan and Alagidede et. al. (2010) for Egypt, Kenya, Morocco, South Africa and Nigeria.On the other hand, a negative relationship between inflation and stock returns has been found in the studies of Floros (2004) for Greece, Ugur and Ramazan (2005) for Turkey, Merika and Anna (2006) for Germany and Adusei (2014) for Ghana. Moreover, other studies, such as those presented in Tripathi and Kumar (2014) for a panel study of BRICS countries, advocate for no relationship between the time series variables.

So far, thevast majority of the existing literature relies on linear estimation techniques to arrive at various contradicting empirical findings. However, a series of recent empirical studies have challenged the notion of a linear relationship between inflation and stock market returns in support of an asymmetric relationship existing between the variables. Inclusive of these studies are the works of Liu et. al. (2005) for France, Switzerland and the US, Hoque et.

al. (2007) for G7 countries and Cakan (2013) for the US economy. Notably, a majority, if not all, of thesestudies have conducted research for industrialized economies, with very little to no empirical evidence documented for developing or emerging economies, and in particular Sub-Saharan (SSA) countries. Empirical research of this nature is of paramount importance to the understanding of financial markets in SSA economies since both theory and empirical evidence tend tosupport the notion of a nonlinear relationship between inflation and stock market returns for industrialized countries (Boyd et. al., 2001). Moreover, SSA countries are historically characterized by relatively high levels of inflation, on one hand, and stock markets which are increasingly becominga significant factor in improving overall economic development, on the other hand. Identifying nonlinearities relationships between inflation and stock returns could provide policymakers with a fresh perspective of financial market stability in emerging African economies.

In our current study, we attempt to model nonlinear cointegration relations between inflation and stock market returns in South Africa which possessesthelargest and most sophisticatedstock exchange in the SSA region. We conduct our empirical research using the newly introduced momentum threshold autoregressive (MTAR) model of Enders and Silkos (2001). We favour this methodology based on the fact that the econometric framework simultaneously allows for unit root testing, cointegration analysis and error correction modelling all under a singular, comprehensive framework. Moreover, the MTAR model allows for different responses in equilibrium correction behaviour depending on whether equilibrium deviations are negative or positive. This later attribute of the model is particularly beneficial in capturing the dynamics of market rigidities in financial markets.

The remainder of the paper is structured as follows. In the following section we give a brief discussion on the evolution of the Johannesburg Stock Exchange (JSE). In the third section, we discuss the inflation developments in the South African economy with emphasis on events which led to fluctuations in the inflation rate. The empirical MTAR model is described in the fourth section of the paper. The empirical analysis is conducted in the fifth section whereas the paper is concluded in the sixth section of the paper.

2 The Johannesburg Stock Exchange (JSE)

The Johannesburg Stock Exchange (JSE)is the second oldest and yet the most prestigious stock exchange market in the African continent and is also the only African exchange to be ranked amongst the top 20 stock exchanges in the world. The JSE was founded in 1887, one year following the discovery of Gold in the Witwatersrand area, in response to the need for capital to fund burgeoning investments in the mining sector (Murinde and Woldie, 2011). Since it's inception, mining activities have remained the backbone for the rapid growth and development of the JSE and this is in contrast to capital markets in other emerging economies, where stock market development is primarily driven by agriculture and trade sectors (Ndako, 2010). Currently the JSE is ranked as the seventeenth largest stock exchange worldwide, the sixth largest amongst emerging markets and the largest within the Africa continent, and lists over 400 listed companies, trades over 900 securities and has a market capitalization of over 1 007 billion US dollars at the end of 2013 (Phiri, 2015). The JSE is also hailed as the most developed stock market in Africa and has recently been ranked by the World Economic Forum global competiveness survey for 2013-2014 as the most efficiently regulated stock exchange in the world. The significance of the JSE in world markets is further evident as the exchange is included in the Morgan Stanley Index and the International Finance Corporation (IFC) Emerging Market Indices, is a member of the World Federation of Exchanges and, is also a key role player in the African Stock Exchanges Association (ASEA) formed in 1993 (Nyasha and Odhiambo, 2015). Furthermore, the JSE has the largest number cross-listed firms in comparison to other African stock exchanges and conducts trades on international platforms such as the London Stock Exchange (LSE), New York Stock Exchange (NYSE), Frankfurt Stock Exchange (FSE) and the SIX Swiss Exchange.

In wake of the political changes which took place in 1994, and in particular the lifting of formal and informal sanctions imposed against the South African economy, the JSE experienced a number of major reforms from late 1995 onwards (Geyser and Lowies, 2001). These reforms came about as recommendations of the JSE Research Committee formed in 1992, which proposed amendments to parliament in 1994 concerning the appropriate future stance of the domestic stock exchange. These amendments were approved in 1995 and were primarily designed to improve the overall efficiency of the stock exchange as well as to enhance the market liquidity of the exchange. The first major change occurred in November 1995, when the Stock Exchanges Control Act opened trading to foreigners and also allowed brokers to buy and sell stock for their own account. In 1996, the JSE gradually phased out open outcry auctions, replacing it with a fully automated JSE Equity Trading (JET) system. The following year, Bond Exchange South Africa (BESA) was granted an exchange license and placed in charge of the development of the bond market in South Africa. In 1998, the JSE introduced an automated clearing and settlement system, the Share Transactions Totally Electronic (STRATE), which is currently South Africa's electronic settlement and depository system for dematerialized equities and replaced the previous paper settlement system (Ndako, 2010). In 2001, the JSE merged with the South African Futures Exchange (SAFEX) and thereby became the leader in both equities as well as futures and option trading (Yartey, 2008). It was also in 2001 when the JSE entered into agreement with the London Stock Exchange (LSE) and in the following year began trading on the LSE using the LSE Stock Exchange electronic trading system (SETS). In 2007 the LSE licensed another trading platform to the JSE; the JSE TradeElect trading system, which was in operation up until 2012. It was under the TradeElect trading system that the bond market (BESA) was formally incorporated into the exchange and has since carried out bond automated trading settlements (Ndako, 2010).

As of 2013, the JSE shifted it'strading engine from London to Johannesburg under a new equity trading platform, the Millennium exchange trading platform. The introduction of this new trading platform has led to the execution of transactions at about 400 times faster than before, the number of trades is up by 57 percent, volumes are up by 4 percent and the value of trades up by almost 21 percent (Yartey, 2008).Thus, in 2014, the JSE was able to introduce 18 colocation centres countrywide as an option for trading equity shares. The colocation facilities allow for algorithmic trading as well as high frequency trading, which in turn, aremeant to increase the liquidity and efficiency of equity markets. Initially, in 2014, colocation accounted for about 5 percent of total equity traded on the JSE. However, within a year, this number has quickly rose to 20 percent of total equity trading. The upgrade in infrastructure has also risen the value of domestic market capitalization from R8.3 trillion in 2013 to R11.6 trillion in early 2016. Moreover, colocation has increased operational speed and reduced trading costs and will thus continue to be key in strengthening the JSE's global competitive position and in attracting international companies to list on the exchange.

3 Inflation developments in South Africa

Historical inflation in South Africa can be categorized into i) low single digit inflation periods (1960-1970) ii) low double digit periods (1971-1985) iii) high double digit periods (1986-1993) iv) high single digit periods (1994-2001) and v) post-inflation targeting periods (2002-2016). During periods of single digit inflation (1960-1970) inflation levels in South Africa were in single low-digits, averaging about 2.62 percent. Monetary policy was then characterized by the Bretton Woods system of fixed (but adjustable) exchange rates, with the American dollar being the anchor of the exchange rate system and convertible into gold at a fixed cost (Mohr and Fourie, 2008). However, it was the then prevailing global economic stability and strong domestic mining export performance which were the main contributors to the sustainability of the low inflation rates experienced in the 1960's. This is evident in the aftermath of the collapse of the Bretton Woods monetary system during the early 1970's and the oil price shocks of 1973 and 1979 which resulted in double digit inflation rates experienced in the 1970's and the early 1980's. In fact, inflation averaged 11.27 percent over the period of 1971 to 1985, which were the highest averages of inflation ever experienced in the country up until that period.

Following intensified apartheid reforms in the mid-1980's, trade sanctions were imposed on the economy by important trade countries and trade blocs such as the European Community (EC), Commonwealth countries, Nordic countries, the United States, Japan, Australia and Hong Kong. As a result of these sanctions and the domestic political unrest, the South African Rand sharply fell, the stock exchange as well as foreign exchange markets were temporarily closed and this ultimately exacerbated the already rising inflation rates (Levy, 1999). From 1986 to 1993, inflation averaged 14.41 percent with inflation reaching a staggering record high annual average of 18.52 percent in 1986. A cornerstone in South African history was in 1994, were the country transitioned from her political apartheid legacy to one of a democratic economy. This transition resulted in the abolishment of trade sanctions, increased financial liberalization as well as political settlement and this largely contributed to the major decline in inflation witnessed in the mid-1990's. Between 1994 and 2001, inflation subsided back to previous single digit figures, averaging 7.01 percent. During this period monetary policy in South Africa transitioned from money supply growth rate targets in the early 1990's to an eclectic monetary policy mandate in 1996. Under this policy, the reserve Bankmonitoredi) changes in bank extension, ii) overall liquidity in banking system, iii) the yield curve, iv) the balance-of-payments position, v) foreign reserve position, vi) the exchange rate and, vii) the inflation rate (Van der Merwe, 2004). And then monetary policy experienced another shift in 1998 when the SARB introduced a repurchase (repo) rate system which saw the Reserve Bank take a decision to strive to keep inflation within a band width of 1 to 5 percent. This was done to ensure that domestic inflation in South Africa was aligned with those of her major trading partners (Casteleijn, 1999).

However, it was in February 2000, when the Reserve Bank publicized its intention to adhere to a formal inflation target measured in terms of changes in CPIX, which is exclusive of the changes in the interest costs of mortgage bonds. Initial targets of 3 to 6 percent were set by the monetary policy committee (MPC) of the SARBand these set targets were to be met in 2002. The target was temporarily narrowed to a 3 to 5 percent band width between 2004 and 2005, which was then changed back to the original target of 3 to 6 percent in 2006, and the target has remained unchanged since then. During the overall post-inflation targeting period (2002-2016), the Reserve Bank has only managed to keep inflation within the targeted 3 to 6 percent band width about 47 percent of the time and inflation has averaged slightly above 6 percent during this period. On one hand, the Reserve Bank can be credited for reducing inflation by more than half of what it used to average throughout 1985 to 2001, and on the other hand, the Reserve Bank can be criticized for producing averages which slightly breach the upper limit of the inflation target. The performance of inflation in the post inflation targeting era has been characterized by a record low inflation rate of 0.21 percent in January 2004 to a peak of 13.7 percent in July 2008 following the financial crash of the US banking system (Phiri, 2016). Since then inflation has been on a more-or-less downward trend, averaging 7.26 percent in 2009, 4.10percent in 2010, 5.01 percent in 2011, 5.75 percent in 2012, 5.77 percent in 2013, 6.13 percent in 2014 and 4.51 percent in 2015.

4 Areview of the South African literature

To the best of our knowledge, the studies of Geyser and Lowies (2001), Alagidede and Panagiotidis (2010), Arjoon et. al. (2011), Eita (2012), Khumalo (2013),Tripathi and Kumar (2014) and Marx and Sruweg (2015) are the available empirical works which have examined the inflation-stock returns relationship for the South Africa economy. Using conventional correlation analysis on annual data collected from 1991 to 2000, Geyser and Lowies (2001) find that companies listed in the mining sector are negatively correlated with inflation whereas companies in other sectors (financial services, information technology and food and beverage sectors) depict a slightly positive correlation with inflation. On the other hand, Alagidede and Panagiotidis (2010) apply parametric and nonparametric cointegration tests and further estimate vector error correction models (VECM's) for 6 African stock exchanges, namely, the JSE, the Egyptian Exchange (EGX), the Nigerian Stock Exchange (NSE), the Nairobi Stock Exchange (NSE-Kenya) and Tunis Stock Exchange (BVMT). The authors find that time path of the response of stock prices to a shock in inflation produces an initial negative short-run response for equities in both the JSE and the EGX, whereas this effect eventually turns positive over the long-run. Conversely, for the NSE, the NSE-Kenya and the BVMT, the real stock price response to innovations in inflation is time-invariant.

The study presented in Arjoon et. al. (2011) estimates a bi-variate structural vector autoregressive (SVAR) of inflation and stock returns for South Africa using quarterly data collected from 1980:Q1 to 2010:Q2. By using three identification schemes on the structure of the SVAR model, the authors find a positive response of real stock prices to a permanent shock in the inflation rate with short-term deviations of real stock prices from their steady-state equilibrium been eventually corrected over the long-run. In another study,Eita (2012) uses conventional granger causality analysis and error correction modelling to investigate the inflation-stock returns relationship for South African quarterly data collected from 1980:Q1 to 2008:Q4. The author uses two proxies to measure stock returns namely i) the all-share index (ALSI), and ii) the gold index. Regardless of which proxy of stock returns is used, the empirical results reveal a positive relationship between inflation and stock returns, even though causality isfound to be bi-directional between ALSI and inflation, whilst causality is unidirectional from inflation to the gold index.

Khumalo (2013) uses an autoregressive distributive lag (ARDL) model and VECM to examine the effect of inflation on stock prices using quarterly South African collected from 1980:Q1 to 2010:Q4. Significant negative cointegration effects between inflation and stock prices are found with causality established to run unidirectional from inflation to stock prices with an unexpected increase in the inflation rates causing a negative response on stock prices in the long-run.Meanwhile, Tripathi and Kumar (2014) investigate the inflation-stock returns nexus for BRICS countries using monthly data collected from 2000:01 to 2013:09. By using bi-variate correlation analysis and granger causality tests the authorsfind a significant positive relationship between inflation and stock returns for Brazil and China, a significant negative relationship for South Africa and no significant relationship in China and Russia. Furthermore, the causality tests point to no causality between the variables for Brazilian data, unidirectional causality from stock returns to inflation for the case of Russia, India and South Africa whereas bi-directional causality is found for Chinese data. Finally, in the study of Marx and Struweg (2015), the authors investigate the effects of stagflation on equity price for the JSE using annual data covering the period of 1969 to 2013.In the empirical study, stagflation is defined as an economic environment where inflation rates above the upper band of the inflation target (i.e. 6 percent) and GDP is below it's potentialgrowth level and thereafter the authors apply multiple regression/correlation (MRC) analysis and provide regressions estimates for periods of stagflation and no-stagflation. During periods of stagflation, the empirical results reveal an insignificant weak negative relationship between inflation and stock market returns, whereas this relationship remains negative but becomes less insignificant during periods of no stagflation.

In summarizingthese reviewed studies, we note that the works ofAlagidede and Panagiotidis (2010), Arjoon et. al. (2011) and Eita (2012) vouch for a significant and positive relationship between inflation and stock prices thus implying that JSE equity stocks can act as a hedge against inflation. Conversely, the studies of Khumalo (2013), Tripathi and Kumar (2014) and Marx and Struweg (2015), who, on account of finding a significant negative inflation-stock returns relationship, infer that JSE equity stocks cannot increase or maintain their real value for investors in the face of expected or unanticipated inflation. However, the empirical results found in the study of Geyser and Lowies (2001) provides an interestingperspective on the issue by implying that investors cannot hedge themselves against inflation in mining stocks and would stand a better chance of hedging against inflation through investing in other sectors of the JSE. It is also worth noting that while the study of Marx and Struweg (2015) points to an overall negative relationship between inflation and stock returns, the established relationship varies over different stages of the economic cycle. By default, this implies the possibility of a nonlinear relationship between inflation and stock market returns for the South African economy. Nevertheless, ambiguouity is clearly demonstrated from the reviewed empirical studies and therefore further deliberation into the subject matter is warranted for the case of South Africa.

5 M*ethodology*

The recently developed MTAR model will be used in this study to examine nonlinear cointegration relations between inflation andstock prices for South Africa. The MTAR model was initially introduced by Enders and Granger (1998) as a framework used for testing for asymmetric unit roots within an individual times and as later modified by Enders and Silkos (2001) as means of allowing for asymmetric cointegration between a pair of time series variables. According to Enders and Granger (1998), a univariate time series can be tested for unit roots by specifying a threshold autoregressive (TAR) version of the Dickey-Fuller testing regression i.e.

$$\Delta y_t = I_t \rho_1 \mu_{t-1} + (1 - I_t)\, \rho_1 \mu_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta \mu_{t-i} + \varepsilon_t \qquad (1)$$

Where I_t is a Heaviside indicator function such that:

$$I_t = \begin{cases} 1 \; if \; \mu_{t-1} \geq \tau \\ 0 \; if \; \mu_{t-1} < \tau \end{cases} \qquad (2)$$

And τ is the threshold value which is unknown apriori and is estimated using the minimization function described in Hansen (2000). The Heaviside indicator function can also be specified in terms of the first differences ofμ_{t-1}as:

$$M = \begin{cases} 1 \; if \; \Delta\mu_{t-1} \geq \tau \\ 0 \; if \; \Delta\mu_{t-1} < \tau \end{cases} \qquad (3)$$

In substituting (2) into (1), we have the TAR specification which captures the deep movements in a sequence in which one end of the series will tend to be more persistence than the other part (Enders and Silkos, 2001). In substituting (3) into (1) results in the MTAR specification which capturesasymmetricadjustment when the series exhibits more momentum in one direction than the other (Enders and Granger, 1998). From equations (1) through (3), the null hypothesis of a unit root(i.e. H_{00}: $\rho_1 = \rho_2 = 0$)can be tested against the alternative of an asymmetric random walk process (i.e. H_{10}: $\rho_1 \neq \rho_2 \neq 0$) using a statistic denoted as ϕ. If the statistic ϕ exceeds it's critical value, then the null hypothesis of a unit root is rejected and one can proceed to test the null hypothesis of lineartime series(i.e. H_{00}: $\rho_1 = \rho_2$) against the alternative of an asymmetric series ((i.e. H_{00}: $\rho_1 \neq \rho_2$).The statistic testing this hypothesis is denoted as ϕ*.

As previously mentioned, Enders and Silkos (2001) built upon Enders and Granger (1998), by modelling the equilibrium error (μ_t) of a long-run regression as a threshold process. Our study estimates two long run regressions of inflation and interest rates. Under the first regression, stock market returns (smr_t) are modelled as being endogenous to the inflation rate (π_t) i.e.

$$smr_t = \beta_{10} + \beta_{11}\pi_t + \mu_{t1} \tag{4}$$

Whereas under the second specification, inflation is modelled as being endogenous to stock market returns i.e.

$$\pi_t = \beta_{20} + \beta_{21}smr_t + \mu_{t2} \tag{5}$$

As before, the equilibrium errors (μ_{ti}) are modelled as a TAR process i.e.

$$\Delta\mu_{ti} = \rho_1\mu_{ti}(\mu_{ti} < \tau) + \rho_2\mu_{ti}(\mu_{ti} \geq \tau) + \nu_t \tag{6}$$

And as a MTAR process i.e.

$$\Delta\mu_{ti} = \rho_1\mu_{ti}(\Delta\mu_t < \tau) + \rho_2\mu_{ti}(\Delta\mu_t \geq \tau) + \nu_t \tag{7}$$

Note that from the TAR and MTAR regressions (4) and (5), respectively,$\rho_1\mu_t$ provides a measure of equilibrium adjustment when μ_t is below its long run equilibrium value, whereas $\rho_2\mu_t$provides a measure of equilibrium adjustment when μ_t is above it's long run value. According to Enders and Silkos (2001), two hypotheses for threshold cointegration must be tested for. Firstly, is the null of no cointegration amongst the time series which is tested as H_{01}: $\rho_1 = \rho_2 = 0$. Secondly, the null hypothesis of no asymmetric cointegration can be tested as H_{00}: $\rho_1 = \rho_2$. The statistics responsible for testing the aforementioned hypotheses are denoted as Φ and Φ^* respectively, and these are standard F-tests with their critical values tabulated in Enders and Silkos (2001).

6 EMPIRICAL ANALYSIS

6.1 Data and unit root tests

The data required for our empirical analysis is the percentage change in total stock prices in South Africa (smr_t), which has been retrieved from the Federal Reserve Economic Data (FRED) database, and the total change in consumer price index (π_t), which has been retrieved from the SARB online database. Both time series have been collected in monthly intervals and for a period dating from 2003:01 up to 2015:10. As a first step in our empirical analysis, we perform the TAR and MTAR unit root tests of Enders and Granger (1998) and report the results in Table 1 below. The order of the lag length for the tests are determined by the Akaike Information Criterion (AIC).

Table 1: TAR and MTAR unit root tests

time series	model	τ	ϕ	ϕ^*
π_t	TAR	0.172	1.91	0.78
	MTAR	0.014	1.48	0.39
smr_t	TAR	-3.019	1.87	0.42
	MTAR	-5.086	4.66*	4.42*

Notes: '*' denotesa 10 percent significance levels.

In referring to the results of the unit root tests reported in Table 1, we observe that both the ϕ and ϕ^* statistics for the TAR and MTAR specifications for the inflation(π_t) variable are less than their critical value at all levels of significance. This implies that the inflation time series cannot reject the null hypothesis of a unit root and is thus a nonstationary process. Seeing that the alterative hypothesis of a stationary threshold process is rejected, then there is no rationale in testing the second null hypothesis of linear process against the alternative of an asymmetric process. Similar inferences can be drawn for the TAR specification of the inflation process as both the ϕ and ϕ^* statistics are less than their critical values, thus implying that the stock returns (smr_t) variables contains a unit root in it's process.However, an exception is noted for the MTAR specification for the stock returns series, as both the ϕ and the ϕ^* statistics, reject the null hypotheses of unit roots and linear processes, respectively. Nevertheless, we consider these results satisfactory as each of the time series fails to reject the null hypothesis of a unit root andthus render both time series as I(1) processes.According to Engle and Granger, this is suffies as evidence of the existence of cointegration vector between the two series and serves as preliminary evidence of cointegration between the variables. Moreover, this result is in compliance with those presented in Alagidede and Panagiotidis (2010), Arjoon et. al. (2011) and Eita (2012) and Tripathi and Kumar (2014),who all find that inflation and stock market returns are nonstationary for South African data, albeit using conventional linear unit root tests.

6.2 Cointegration and error correction analysis

Given the preliminary evidence of cointegration provided by the unit root tests, we proceed to test for cointegration and threshold cointegration effects amongst the TAR and MTAR versions of the equilibrium residuals formed from the long run regression equations (4) and (5). Only if the null hypotheses of no cointergation and that of no threshold cointegration are reject then we provide estimates of the slope coefficient β_{1i}as well as of the equilibrium threshold error terms, ρ_1 and ρ_2. The empirical results of this exercise are reported in Table 2.

Table 2: TAR and MTAR cointegration tests and estimates

dependent variable	smr_t		π_t	
	TAR	MTAR	TAR	MTAR
Φ	55.6***	55.3***	6.12**	5.50***
Φ*	1.85	0.08	3.35*	4.30*
τ	-2.64	0.96	1.35	-0.88
β_{0i}			4.53***	4.53***
β_{1i}			-0.16**	-0.16**
ρ_1			-0.14**	-0.10**
ρ_2			-0.04*	-0.07*

Notes: '***', '**', and '*' denote the 1 percent, 5 percent and 10 percent significance levels.

In testing the null hypothesis of no cointegration effects, we find that the Φ statistics are 55.6 and 55.3 for the TAR and MTAR specifications of equation (4), respectively and these statistics exceed their critical values at all significance levels. Similarly, for the long run regression (5), we find that the Φ statistics of 6.12 and 5.50 for the TAR and MTAR models exceed their critical values at significance levels of 5 percent or greater. Generally, these results imply that there is at least some form of cointegration between inflation and stock returns for all the estimated regressions. However, these results become less optimistic as the Φ^* statistics for the TAR and MTAR models of equation (4) are 1.85 and 0.08, respectively and these values are lower than their critical value at all significance levels. And yet for the TAR and MTAR versions of equation (5) we obtain Φ^* statistics of 3.35 and 4.30, respectively, and these statistics exceed their critical values at a 1 percent level of significance. In view of these results, we further conducted OLS estimates of the slope coeffiecnt and the equilibrium threshold error terms for the TAR and MTAR versions of equation (5).

As is reported in the lower half of Table 2, the estimated slope coefficient is found to be -0.16 for both TAR and MTAR versions of equation (5). Note that similar long-run negative effects have been found in the works of Khumalo (2013), Tripathi and Kumar (2014) and Marx and Struweg (2015), thus implying that stock returns on the JSE do not act as a hedge for inflation in the long-run. The negative inflation-stock returns relationship is very plausible because, as mentioned by Marx and Struweg (2015), evidence presented on stock market movement and inflation post-1953 has, for a majority of the cases, dispelled the notion of a positive relationship between the two variables. We also note that the estimates of the equilibrium threshold terms ρ_1 and ρ_2, for the TAR and MTAR models, satisfy the condition of convergence i.e. $-2 < \rho_1, \rho_2 < 0$ (Enders and Silkos, 2001). In particular, we find that for the TAR model negative deviations from equilibrium (i.e.$\rho_1 = 0.14$) are eliminated at a quicker rate than positive deviations (i.e.$\rho_2 = 0.14$), since ($\rho_1 > \rho_2$). Similar inferences can be deduced for the MTAR specification as the equilibrium threshold error terms are $\rho_1 = 0.10$ and $\rho_1 = 0.07$, and thus also implies that negative deviations from the steady are eliminated at a faster rate in comparison to positive deviations.

Given the finding of TAR and MTAR cointegration existing between inflation and stock returns when inflation is the dependent variable and stock returns is the independent variable, we attempt to model threshold error correction (TEC) effects as a way of capturing short-run and long-run dynamics of asymmetric equilibrium adjustment. In denoting $\gamma^{-}\mu_{t-1}$ and $\gamma^{+}\mu_{t-1}$ as the threshold error correction terms, the TEC specification for the TAR model the corresponding TEC specification is given as:

$$\Delta\pi_t = \alpha_0 + \sum_{i=1}^{n} \psi_i \Delta\pi_{t-1} + \sum_{i=1}^{q} \delta_i \Delta smr_{t-1} + \gamma^{-}\mu_{t-1}(\mu_{t-1} < \tau) + \gamma^{+}\mu_{t-1}(\mu_{t-1} \geq \tau) + \nu_{t1} \quad (8)$$

$$\Delta smr_t = \alpha_0 + \sum_{i=1}^{n} \psi_i \Delta\pi_{t-1} + \sum_{i=1}^{q} \delta_i \Delta smr_{t-1} + \gamma^{-}\mu_{t-1}(\mu_{t-1} < \tau) + \gamma^{+}\mu_{t-1}(\mu_{t-1} \geq \tau) + \nu_{t1} \quad (9)$$

Whilst the corresponding TEC for the MTAR model is specified as:

$$\Delta\pi_t = \alpha_0 + \sum_{i=1}^{n} \psi_i \Delta\pi_{t-1} + \sum_{i=1}^{q} \delta_i \Delta smr_{t-1} + \gamma^{-}\mu_{t-1}(\Delta\mu_{t-1} < \tau) + \gamma^{+}\mu_{t-1}(\Delta\mu_{t-1} \geq \tau) + \nu_{t1} \quad (10)$$

$$\Delta smr_t = \alpha_0 + \sum_{i=1}^{n} \psi_i \Delta\pi_{t-1} + \sum_{i=1}^{q} \delta_i \Delta smr_{t-1} + \gamma^{-}\mu_{t-1}(\Delta\mu_{t-1} < \tau) + \gamma^{+}\mu_{t-1}(\Delta\mu_{t-1} \geq \tau) + \nu_{t1} \quad (11)$$

The term$\gamma^{-}\mu_{t-1}$ measures of the rate of equilibrium revision belowits threshold estimate whereas $\gamma^{+}\mu_{t-1}$measures it below the threshold. Drawing from the TEC regressions (8) – (11), two hypotheses can be further tested for. Firstly, the null hypothesis of no asymmetric TEC effects can be tested as H_{03}: $\gamma^{-} = \gamma^{+}$. Once the null hypothesis is rejected in favour of the alternative of a TEC effects, then causality tests can be performedon the time series. The null hypothesis that inflation does not granger cause stock prices is tested as H_{04}:$\psi_i = 0$, i=1,…,k, whereas the null hypothesis that stock returns do not granger cause inflation is tested as H_{05}: $\delta_i = 0$,i=1,…,k. Table 3 summarizes the results of the tests for TEC effects, the TEC model estimates as well as the granger causality results.

Table 3: asymmetric error correction tests and estimates for TAR and MTAR model

model type	TAR		MTAR	
dependent variable	$\Delta\pi_t$	Δsmr_t	$\Delta\pi_t$	Δsmr_t
equation	(8)	(9)	(10)	(11)
H_{03}: $\gamma^{-} = \gamma^{+}$	1.80 (0.18)	1.10 (0.30)	2.25 (0.13)*	0.61 (0.44)
$\gamma^{-}\mu_{t-1}$			0.01 (0.78)	
$\gamma^{+}\mu_{t-1}$			-0.05 (0.00)***	

H_{04}: $\psi_i = 0$	17.15
	(0.00)***
H_{05}: $\delta_i = 0$	0.20
	(0.82)
DW	2.25
	(0.11)
LB(4)	0.00
LB(8)	0.00
LB(12)	0.00

Notes: '***' and '*' denote the 1 percent and 10 percent significance levels, respectively. p-values reported in parentheses. DW and LB respectively denote the Durbin Watson and Ljung Box statistics and for serial correlation with the LB test being performed up to 12 lags. The diagnostic tests indicate an absence of serial correlation in the estimated regression (10).

Focusing on the results presented in Table 3, note that the null hypothesis of no TEC effects cannot be rejected for equations (8), (9) and (11) thus indicating that there are no asymmetric error correctionmechanismwithin these estimated regressions. An exception is warranted for equation (10) as the null hypothesis of no TEC behaviour is rejected at a 10 percent significance level. We therefore estimate the TEC terms, $\gamma^{-}\mu_{t-1}$ and $\gamma^{+}\mu_{t-1}$ and further perform causality tests among the time series. We find a significant estimate of -0.05 for the γ^{-}coefficient and since this coefficient is both negative and significant, we thus consider the stock price returns variable as being weakly exogenous within the system. This result is re-iterated through the causality tests as the null hypothesis of no causality effects from inflation to stock returns is rejected whilst the null hypothesis of no causality from stock returns to inflation cannot be rejected.Besides, the finding of causality running from inflation to stock returns for South African data has been previously documented for in the works of Eita (2012) and Khumalo (2013).

7 Conclusion

So far, the empirical investigation into the relationship between inflation and stock returns in South Africa has been dominated by empirical works which rely on linear econometric frameworks. However, academics have recently vouched for an asymmetric relationship between the time series variables and this is an important assumption since the linear specification has beenspeculated to produce spurious inferences. Our study sought to explore thisnonlinear phenomenon for the case of South Africa, which boasts the most developed stock exchange in Africa and has a monetary policy mandate which is committed to containing inflation at relatively low levels of between 3 and 6 percent. The empirical analysis was performed using monthly data collected from 2003:01 to 2015:12 and applying the data to the recently developed MTAR framework.Indeed our empirical results point to a negative, asymmetric cointegration relationship between inflation and stock returns for South Africa.The equilibrium threshold terms indicate that positive deviations from the steady-state revert back to equilibrium faster than negative deviations therefore implying upward rigidity or greater resistance to stock prices adjusting upwards.Moreover, our causality tests find unidirectional causality running from inflation to stock returns.

From an investors' perspective, our empirical results firstly indicate that equity stocks listed on the JSE cannot provide a hedge against domestic inflation. Furthermore, our results also imply that investors may use inflation as a predictor of future equity stock returns and this may be used to indicate whether to sell equity stocks in anticipation of a rise in share prices caused by a reduction in inflation rates or to by buy shares when stock prices are anticipated to fall in the event of a rise in the inflation rate. Our study also bears a couple of policy implications. For instance, taking into consideration that the Reserve Bank currently uses inflation targeting as a policy mandate, then our results indicate that policymakers can contribute towards creating a conducive environment for attracting potential investors to invest in the equity shares as well as for attracting international companies to list on the exchange. Also with the recentlyintroduced Millennium exchange trading platformand the colocation centres situated countrywide, domestic monetary policy will undoubtedly play a significant role in ensuring the success of these implemented infrastructures. However, the ability for the Reserve Bank to control the inflation rate has recently been put into question as monetary authorities have struggled to keep inflation within it's set target more especially in the face of external shocks to the economy. As a natural academic development, it would be interesting to investigate whether direct monetary policy instruments (i.e. short-term interest rates) may have significant asymmetric effects on stock market behaviour. However, we leave such academic aspirations as a possible avenue for future empirical research.

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