UNIVERSITY OF KWAZULU-NATAL

An Econometric Analysis of the Equity Returns-Inflation Relationship in South Africa

By

Peter Moores-Pitt

212556668

A dissertation submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (Finance)

School of Accounting, Economics and Finance

College of Law and Management Studies

Supervisor: Prof. Mike Murray

Co-Supervisor: Dr. Kerry McCullough

2019

DECLARATION 1: PLAGIARISM

I, Peter Brian Denton Moores-Pitt, declare that:

(i) The research reported in this dissertation/thesis, except where otherwise indicated, is my original research.

(ii) This dissertation/thesis has not been submitted for any degree or examination at any other university.

(iii) This dissertation/thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

(iv) This dissertation/thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
   a) their words have been re-written but the general information attributed to them has been referenced;
   b) where their exact words have been used, their writing has been placed inside quotation marks, and referenced.

(v) Where I have reproduced a publication of which I am author or co-author, I have indicated in detail my contribution and have fully referenced such publications.

(vi) This dissertation is primarily a collection of material, prepared by myself, published as journal articles or presented at conferences. In some cases, additional material has been included.

(vii) This dissertation/thesis does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source being detailed in the dissertation/thesis and in the References sections.

PMooresPitt

Signed: Mr PBD Moores-Pitt

Date:

DECLARATION 2: PUBLICATIONS

While the sections detailing each paper contain a Statement of Contribution by Co-Authors, this serves as a General Declaration that the work of all papers included here are the original work of PhD Candidate Mr Peter Brian Denton Moores-Pitt.

Prof. Mike Murray, Dr Kerry McCullough and Mr. Barry Strydom, in serving as supervisors, have contributed in their supervisory role by providing overall guidance to the coherence of this body of work. Their contributions have been advisory in nature; the writing of the work in its entirety was done by the PhD Candidate. In submitting papers for consideration for publication, PhD Candidate Mr Peter Moores-Pitt has been the primary and corresponding author.

PMooresPitt

Signed: Mr PBD Moores-Pitt

Date:

LIST OF PUBLICATIONS

Chapter 4 – Paper 1 (Published)

Title: Equities as a hedge against inflation in South Africa.

Published: African Review of Economics and Finance (AREF), 2017.

DHET Accredited Journal, ISSN: 2042-1478

Citation: Moores-Pitt, P. and Strydom, S.S. (2017). Equities as a hedge against inflation in South Africa. *African Review of Economics and Finance.* 9(1), pp. 156-179.

Chapter 5 – Paper 2 (Published)

Title: Investigating temporal variation in the equity returns-inflation relationship in South Africa.

Published: African Journal of Business and Economic Research, 2018.

IBSS and Scopus Accredited Journal, ISSN: 1750-4554

Citation: Moores-Pitt, P. (2018). Investigating temporal variation in the equity returns-inflation relationship in South Africa. *African Journal of Business and Economic Research*. 13(1), pp: 51-79.

Chapter 6 – Paper 3 (Under Review)

Title: Accounting for threshold effects and asymmetric adjustment between inflation and equity returns in South Africa.

Under Review: Studies in Economics and Econometrics (SEE)

DHET Accredited Journal, ISSN: 0379-6205

Status: Under Review

Chapter 7 – Paper 4 (Being prepared for submission)

Title: An analysis of the non-linear dynamics of the equity returns-inflation relationship in South Africa: an NARDL approach.

Being prepared for submission to the Investment Analysts Journal

DHET and WOS Accredited Journal, ISSN: 1029-3523

Status: Being prepared for journal submission

ABSTRACT

Previous empirical evidence regarding the nature and magnitude of the relationship between equity returns and inflation has proven to be conflicting and inconsistent. Although several papers have considered this issue, there is still a lack of consensus as to the nature of the relationship between equity returns and inflation. This represents a considerable point of concern as it is this relationship that acts as an indicator of the historical efficacy of equities as an inflationary hedge. While the classical theory dating back to the 1930's dictates that equities should function as an effective hedge against inflation because they are based on underlying assets with a fixed real value, a substantial number of studies have obtained results that contradict this theory. Many attempts have been made to explain this phenomenon and to resolve the debate since the 1980's, notably with the application of cointegration theory and methods (which were developed in the 90's). Despite advances in econometrics, the issue remains unresolved on an international scale, with conflicting results still occurring in recent studies (Chaves and Silva, 2018; Bhanja and Dar, 2018; Al-Nassar and Bhatti, 2018). The literature that focuses on the South African case is a typical example of the disparity: relatively modern studies using fairly similar statistical approaches find vastly differing results as to the capacity for equities to act as an inflationary hedge, including findings of positive and negative results (Alagidede and Panagiotidis, 2010; Khumalo, 2013), as well as approaches that failed to produce conclusive results (van Rooyen and Jones, 2018).

This thesis aims to resolve the issue for the South African case in order to determine whether or not equities have acted as a historically effective inflationary hedge. The South African economy represents a perfect natural experiment for the study due to its high volatility, especially in terms of macroeconomic indicators such as inflation, over the past thirty-five years. The analysis makes use of the Consumer Price Index (CPI) as a proxy for inflation and the Johannesburg Stock Exchange's All Share Index (ALSI) as a proxy for equity returns over the period 1980 to 2015. The study is undertaken as a collection of publications that each seek to address particular issues, mostly of an econometric nature, that arise when studying the relationship. The first of these papers deals with the disparity in the South African economy regarding the order of integration of the two variables and seeks to provide a comparative analysis with previous studies. Further, the research contained in paper one seeks to identify possible explanations for the conflicting results in previous studies. The study finds that a significant, positive cointegrating relationship between inflation and equity returns exists in South Africa, at least when using conventional cointegration techniques, implying that equities

have exhibited the historical capacity to act as an effective historical hedge against inflation, in contrast to the findings of much of the literature. Further, it resolves previous issues with differing findings as to the orders of integration of the variables, which represents a particularly prevalent problem in studies using South African data.

While these initial findings would appear to lend support to the conventional theory that equities are able to act as an effective inflationary hedge in South Africa, when examining the issue more deeply it becomes evident that this finding may potentially be impacted by the inherent assumptions of the models employed. Based on the results of previous studies and the results of the first paper, the second paper posits that the equity-inflation relationship is both time and country dependent, potentially contributing to the aforementioned disparities in the existing literature. The implication of potentially flawed model assumptions is that the results of the first paper may be inaccurate (the model risk of a poor model choice giving unreliable results). As a result of this potential limitations bias, the remaining papers of this doctoral dissertation delve into the assumptions behind the classic model, reflecting more deeply on the nature of the data employed and seeking to determine if this relationship holds when various, arguably more realistic, alternate assumptions are considered.

The first of these assumptions that is critiqued is that the relationship is time-invariant, such that the equity-inflation relationship does not exhibit variance over time. In an economy such as South Africa, which has shown exceptional macroeconomic volatility, such an assumption may well be inaccurate and is likely to have reduced the integrity of the conventional tests. Relaxing the assumption of time-invariance allows one to consider that the relationship may have experienced shifts over time as a result of exogenous shocks. This idea is tested by investigating the possibility of structural breaks in the individual time series, as well as in the relationship itself. Structural breaks here refer to an unexpected shift in a time series that can lead to forecasting errors, compromising the reliability of the model. Should a model rely on the assumption of time-invariance it is unable to account for the existence of such structural breaks, leading to compromised results.

In the second paper, significant evidence for the existence of structural breaks was found in the case of both variables as well as in the overall relationship. Using the most significant structural break as a breakpoint and investigating the relationship preceding and subsequent to the break pointed to clear evidence that the relationship does change over time. As previous studies have generally assumed the series do not contain breaks, the assumption of time-invariance in previous work may have led to inherently flawed conclusions. However, what this second paper was able to demonstrate, was that even when accounting for breaks, equities maintained their capacity to act as a hedge against inflation in South Africa on either side of that structural break. Further, cointegration testing allowing for structural breaks indicated that the overall relationship was significant and positive and affirmed the prior conclusion that equities are an effective inflationary hedge in the long-run. That is, even when relaxing the assumption of time-invariance and accounting for structural breaks, the overall conclusion for the South African case – that equities are able to perform a hedging function against inflation – remains true. This thesis then continues by developing on this idea of addressing the previous assumptions that may affect this type of analysis, building towards a final, more robust, conclusion.

Two additional assumptions remain which require consideration. In recent literature the question of asymmetric adjustment has arisen, including in the analysis of the relationship between equity returns and inflation. Such studies have aimed to deal with the idea that there is no compelling reason to assume that adjustments of the relationship between equity returns and inflation have necessarily been symmetric. Further, it is possible that the relationship may have been subject to a threshold effect, where it exhibits different characteristics depending on whether stocks are underpriced or overpriced relative to goods. It was shown that the adjustment coefficients differ substantially depending on whether they are above or below a certain threshold, and thus that the assumption of linear adjustment is flawed as the relationship exhibits asymmetric adjustment in reality. Further testing for asymmetric adjustment and allowing for such adjustments in the relationship led to the conclusion that the relationship has experienced asymmetric adjustment over the sample period and that the relationship between equity returns and inflation is more appropriately modelled using threshold cointegration techniques. Such findings drastically improve our understanding of the dynamics of the equity returns-inflation relationship and emphasize the importance of accounting for these factors in similar studies.

The weakness in previous cointegration testing is somewhat exposed by the strength of the evidence of asymmetric adjustment and effectively questions the findings of the majority of the previous literature which has relied on these techniques. The model far more accurately estimates the relationship between equity returns and inflation and provides new evidence that it experiences a measure of variance around an endogenously determined threshold. Due to the relative power of the model as well as the fact that it has accounted for these factors it can be stated with far greater certainty that South African equities are able to provide an effective hedge against domestic inflation. The evidence of threshold effects is of importance to investors and policy makers, as it is at this point that the adjustment coefficients will vary in terms of their response to exogenous shocks. This is particularly important in the context of this thesis because of the evidence of multiple structural breaks in the cointegrating relationship (found in the second publication) indicating that the relationship has been affected by exogenous shocks at multiple points over the sample period.

These factors, namely structural breaks, threshold effects and asymmetric adjustment, are a likely reason why previous studies, on an international scale, have exhibited such conflicting results. Should these studies be reconsidered to incorporate such effects, it would vastly improve the robustness of the results of these studies. It should be noted that the magnitude of the relationship is likely to differ across countries and time periods due to the variation in structural dynamics and macroeconomic conditions. It is therefore improbable that some standard measure of the relationship, such as the conventional theory by Fisher, would accurately estimate the relationship regardless of the sample country or sample period, given the findings in this thesis that the relationship is affected by exogenous factors.

Due to the findings of asymmetric adjustment in the third research paper, it is not only the magnitude of the relationship that will cause varied responses, but also potentially the direction of the adjustment. This is investigated further in the fourth paper of this thesis, which aims to disaggregate the overall adjustment coefficient in order to better understand the effects of positive and negative adjustments when they differ substantially from the long-term aggregate relationship.

Disaggregating the overall adjustment coefficient into its positive and negative components provided a novel understanding of the dynamics of the relationship. The results of the disaggregation were surprising due to the magnitude of the disparity between the positive and negative adjustments coefficients and indicated that it is important to consider the possibility of imminent fluctuations in inflation when best deciding how to hedge against it. Collectively however, this thesis has proven that equities are able to function as an effective long-run hedge against inflation in South Africa. Further this thesis demonstrates that the inherent assumptions in conventional cointegration techniques, especially those of time-invariance and symmetric adjustment are flawed and have likely contributed to the disparities in the previous literature.

ACKNOWLEDGEMENTS

Any attempt to compile a comprehensive list of all those who I would like to acknowledge for their contribution to the composition of this PhD would be futile. I do hope though, that each of you, are somewhat aware of the difference even the slightest encouragement or kind word has made, even when a tired brain could not find the words to recognize or acknowledge it at the time.

A heartfelt thank you firstly, to my supervisors over the course of writing this PhD; Barry Strydom, Kerry McCullough and Mike Murray. Your guidance during this journey has been invaluable. Barry, you set me on the path and I sincerely appreciate the confidence that you showed in my ability to complete this project those many years ago. Kerry, thank you for taking on the task of seeing the final stages through. The amount of work you have put in, both as a mentor and as a supervisor, has been incredible.

To the National Research Foundation of South Africa, who provided me with the honour of a PhD Scholarship for Innovation (Unique Grant #95066), thank you.

To my colleagues at UKZN, a sincere thank you for the guidance and encouragement over the past few years. It is truly a privilege to work alongside such an amazing team. Ailie, Shelley and Paul, please know that your extra assistance and effort is appreciated greatly. Similarly, thank you to Varuna and Jerusha, I would have been hopelessly lost within the system without your help.

To my friends, Ali and Bridge, your support and encouragement has helped more than you will ever know. Thank you for the conversations, gestures, banter and laughs that have proven to be the critical difference in so many ways.

Finally, to my parents, I don’t have the words, but suffice it to say that you have remained the cornerstone in my life and have proven to be the singular constant in a volatile world over many turbulent years, and for that I am ever grateful. Thank you.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 7:

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

"Inflation is as violent as a mugger, as frightening as an armed robber and as deadly as a hit man." – Ronald Reagan

1.1 Introduction

Inflation is a phenomenon that occurs in modern economies which effectively reduces the purchasing power of monetary based assets. The Miriam-Webster dictionary defines inflation as "a continuing rise in the general price level usually attributed to an increase in the volume of money and credit relative to available goods services." Inflation results in a general devaluation of monetary assets in real terms over time, essentially reflected as a decrease in the purchasing power of the asset – that is, the same amount of currency is able to purchase fewer goods than before. Therefore, as the price level rises due to inflation an equal amount of money will be able to purchase fewer goods and services. The real value of a good is defined as the nominal value of the good, adjusted for inflation. It is calculated by removing inflation or price level variations from the nominal value of time series data.

Van Rooyen and Jones (2018: 1) state that "the erosion of purchasing power due to inflation is a source of concern for investors who invest in stocks over long time horizons." In order to avoid the decline in real wealth resulting from the gradual erosion of the real value of a monetary asset it is necessary to discover an efficient mechanism which is able to provide a hedge against inflation. A hedge is defined as "a way of protecting oneself against financial loss" which, in this context, implies that it exhibits co-movement with inflation, which effectively negates the negative impact on assets caused by inflation. To act effectively as a hedge, this mechanism would need to consistently increase in real terms at a rate at least equal to the rate of inflation in the long-run. It has been proposed that capital assets would provide such a mechanism, as they are thought to maintain their real value during inflationary periods. As such, securities such as common stocks, which are inherently based on capital assets, should also maintain their real value during inflationary periods. According to Ely and Robinson (1997), equities represent claims to underlying assets which are thought to maintain a constant real value during inflationary periods and should maintain their real value in the face of increases in the price level. While this thesis focuses on equities as a hedging mechanism, for completeness sake it is noted that other potential hedges considered in the literature have included minerals such as gold and silver (Van Hoang, Lahiani and Heller, 2016; Bampinas and Panagiotidis, 2015) as well as real estate and housing investments (Yeap and Lean, 2017; Bahram, Arjun and Kambiz,. 2004).

The evidence for the capacity of equities to act as a hedge against inflation in modern times is conflicting and inconsistent (Kim and Ryoo, 2011). As quoted in the Financial Times (2018: 1), L'Hoir states that, "Our analyses reveal that equities can constitute a natural hedge against inflation if these inflationary pressures are driven by demand shocks". This has been the view of typical investors and policymakers over the last several decades, who tend to hold to the opinion that equities should act as an effective hedge against inflation (Lee, 1992). This would support the theory that equities are able to provide an average return that is greater or equal to the rate of inflation and that they should be a profitable investment option and an effective hedge.

This conventional wisdom has stemmed partly from Fisher's theory, which proposes that any increase in the inflation rate can be offset by an increase in nominal asset values. This would be matched by an increase in nominal equity returns which would allow equities to maintain a consistent real return in light of inflation (Ely and Robinson, 1997). Indeed, Khil and Lee (2000) state that according to the Fisher Hypothesis and common sense, stocks should act as a hedge against inflation. The Fisher theory states that the nominal interest rate is comprised of the sum of the real interest rate and the expected inflation rate (Gultekin, 1983a). As such the Fisher theory supports the use of equities as an inflationary hedge. Simply put, the theory states that because equities represent claims on real assets, such as land and equipment which appreciate alongside the rise in the general price level, they should maintain their real value in light of inflation (Siegel, 2011).

In direct contradiction to this theory, according to Valcarcel (2012), several historical empirical studies provide evidence that the opposite is in fact true. Essentially, such studies show that the relationship between inflation and equity return is negative, or only slightly positive, which would mean that equities typically do not perform as an inflationary hedge (Mayya, 1977; Gultekin, 1983b; Day, 1984). The primary argument against the Fisher Hypothesis was developed by Fama in 1981 and has become known as the Proxy Hypothesis. The Proxy Hypothesis is based on a significant amount of empirical evidence of a negative relationship between inflation and equity returns. The Proxy Hypothesis theorises that equity returns and the inflation rate are independently related to real economic activity; equity returns being positively related while inflation is negatively related. Therefore, according to the Proxy Hypothesis (Fama, 1981) should inflation increase, real economic activity will experience a decrease, leading to a decrease in equity returns.

While the modern literature has evolved somewhat with the invention of new econometric methodologies, the issue remains unresolved. This is exhibited in recent international studies such as that by Al-Nassar and Bhatti (2018), who found that common stocks provide a good hedge against inflation in slightly more than one-third of the 28 countries they examined, suggesting that the relationship varies on a case-by-case basis. Similarly, the potential for variation in the relationship over time, and consequently the capacity for equities to act as an inflationary hedge is another factor that has been considered in more recent literature (Bhanja and Dar, 2018). These issues have yet, to the best of the author's knowledge, to be addressed in the South African context.

1.2 Problem Statement, Research Questions and Objectives

Valcarcel (2012) states that fluctuations in general economic conditions are a primary factor in the determination of asset values, but that if asset values accurately express the real return on the asset under the assumption of money-neutrality, equity prices should not be affected by inflationary shocks in the long-run. However, Valcarcel (2012) puts forward that in the short and medium terms it is agreed that inflation can have an effect on stock prices. The idea that this conflict has not been effectively resolved is somewhat surprising; given the impact such information would have on investor decision making.

Lunar Capital (2018: 3) presents an interesting summary of the factors affecting the interaction between inflation and stock returns. The South African company states the following:

> There are several conflicting factors at play here: As inflation increases, the returns on your investments should be lower in real terms, so arguably the share price should reduce. However, inflation also implies that companies can charge higher prices for their goods or services. In this way they will earn higher revenues. So, this should negate the impact of lower real returns discussed the above. Factoring in higher inflation rates into valuation models should also have a negative impact on share valuations, which could lead to lower prices. Markets also operate in complex ways – from exuberance to pessimism, from forward looking to backward looking. So, at any point in

> time these factors may overshadow whatever inflation may or may not be doing. It is thus not entirely obvious how inflation impacts stock prices. However, what one should look out for is any significant shifts in inflation. When South Africa broke the back of double digit inflation in the 1990's, share prices and price earnings multiples increased commensurately. It is thus advisable to look out for any significant and sustainable shifts in inflation.

As is evident, even in recent times the relationship between stock returns and inflation remains unclear and as such this study seeks to resolve the debate as to whether or not equities in South Africa have historically acted as a hedge against inflation. This study analyses the time-dependant relationship between nominal equity returns and the inflation rate to determine the potential of equity investment to counteract the negative effect of inflation on real wealth.

Should the Fisher Hypothesis hold nominal interest rates should move parallel to the rate of inflation, meaning that any increase in the inflation rate would have no long-term effect on the real interest rate (Alagidede and Panagiotidis, 2010). Therefore, when inflation is regarded as neutral, nominal equity returns will increase on a one-to-one basis with inflation, making them a perfect inflationary hedge. If the *ex-ante* real interest rate is assumed to be constant, investors will require a nominal rate of return on their investment which is able to compensate for the sum of the relinquished marginal utility and the decrease in the purchasing power of their money caused by inflation (Alagidede and Panagiotidis, 2010).

Further, this study challenges the underlying assumptions used in the models employed by many previous studies. These fall into three primary categories. Firstly, the idea that the variables may in fact be stationary and therefore unsuited to conventional cointegration tests is investigated. Secondly, the assumption that the relationship is time-invariant is challenged, with the use of structural break testing. Third, the possibility of a threshold and differing regimes in which the relationship may differ is considered. Finally, the assumption of linear adjustment is relaxed with the consideration of asymmetric adjustment, a common source of error in recent literature. Accounting for these assumptions substantially improves the power of the econometric analysis and provides a considerable robustness improvement when considering the equity returns-inflation relationship in South Africa.

Accurate econometric modelling is critical to the assessment and use of equities as an inflationary hedge. If investment decisions are based on flawed models, the resulting decisions are unlikely to be accurate, and certainly not optimal. More accurate models allow for a better understanding of the link between the two variables and the variations in the data, allowing for more accurate hedging, ultimately leading to improved profitability and returns on investment. Even cases where slight econometric improvements lead to a more accurate estimation of the relationship and slightly improved investment efficiency, enhancements to profitability could be made simply due to the scale of the asset management industry.

In providing an analysis of each of these issues within the scope of the broader research problem four empirical papers are presented. The broad research question related to the overarching title of this doctoral thesis is specified as:

Do equities act as an effective long-run hedge against inflation in South Africa?

In addressing this core research question, four papers are presented. Each of the four complete research papers form the basis of a chapter of this study, with their own independent literature reviews, data, methodology, results and discussion sections, and are typically aimed at addressing at least one of the gaps that has been identified in the existing literature. Chapter 2 provides a discussion of the fundamental theoretical underpinnings of the equity returns-inflation relationship, while Chapter 3 provides a literature review that highlights the historical issues of testing the relationship. This literature review is far more extensive than that of the independent studies by virtue of the fact that it is not limited by the same publication restrictions and aims to provide the reader with an idea of the development, and disparity, of the research prior to this doctoral dissertation's collection of research papers. The research objectives of each of the four research papers are as follows:

Chapter 4: To examine the nature of the equity-returns inflation relationship in South Africa using the longest available data set in order to resolve prior disparities in the literature with regards to the order of integration of the variables, and to identify any issues with prior research.

Chapter 5: To relax the assumption identified in Chapter 4 that the relationship is typically assumed to be time-invariant. This paper aims to identify whether structural breaks have occurred in the relationship, and if so, if they have had a significant effect on the relationship.

Chapter 6: To determine whether the relationship has been subject to threshold effects, essentially due to inconsistent responses by investors to shifts in expected inflation. Furthermore, this study introduces the issue of potential asymmetric adjustment in the relationship and considers the subsequent effect on the relationship.

Chapter 7: Based on the results of the previous studies, this chapter aims to further interrogate the effect of asymmetric adjustment on the relationship and aims to independently estimate the magnitude of the adjustment coefficients for positive and negative adjustments.

1.3 Plan of the Thesis

Due to the fact that a PhD by Publications inherently differs in terms of the format used to that of a traditional PhD thesis, this section is aimed at demonstrating the coherency of the individual chapters that comprise this thesis. Chapters 1, 2 and 3 constitute Introduction, Theory and Literature Review chapters, as found in standard dissertations, and these precede the publication chapters. Chapters 4 through 7 then present each of the four studies in accordance with the formatting used for a PhD by Publications. Some formatting differences may therefore be observed, as these are intended to mimic the papers as prepared and submitted for publication and are a result of differences in journal style guidelines (and resultant length restrictions).

Each chapter that contains a publication is preceded by an introduction and an original contribution section which help to provide linkages between chapters, explain the motivations for particular studies, and detail the novel contributions made by each paper. Furthermore, each paper is succeeded by a conclusion section which assists in drawing out the key findings and the rationale behind the transition to the subsequent chapter. The conclusion section to each of these publication chapters allows for a discussion of the findings of that chapter's research paper within the overall framework of the thesis, linking it back to the overarching research question.

To further detail this transition, while chapters 1, 2, 3 and 8 are similar to those of a typical thesis, chapters 4, 5, 6 and 7 are designed with the intention of presenting the papers that they contain. While the papers have been formatted to a certain extent to provide consistency, it is a requirement of a PhD by Publications that the research papers are presented as published/submitted for publication, which inevitably results in minor formatting differences due to differences in the stylistic requirements of journals. The only substantial difference between each of the papers presented in this thesis and their published counterparts is the inclusion of an amalgamated reference list at the end of the thesis as opposed to independent reference lists for each paper.

Finally, a conclusions chapter is presented (Chapter 8) which summarises the combined results of the thesis and discusses potential avenues for further research.

By way of a brief summary of the major contributions of this study it was concluded that equities have historically acted as an effective long-run hedge against positive inflation in South Africa. This sits in accordance with the theory of the Fisher Hypothesis, and deems equities as able to protect real returns against both positive and negative inflationary variations. Based on the different components of this thesis, the recommendation is made that investors can effectively utilise an aggregate portfolio in order to mitigate the detrimental effects of inflation in South Africa in the long-run. Investors should however, be cautioned that the relationship can be expected to fluctuate over time and is likely to differ substantially in terms of its absolute magnitude depending on whether the adjustment is positive or negative. In fact, these findings would indicate that future research needs to look at developing the hedge decision making process into one which builds in these sorts of real-world data considerations. Further, those conducting studies of a similar nature in the future are advised to consider that the results of models that assume time-invariance or asymmetric adjustment are likely to be misleading and such factors may heavily influence the integrity of their results.

CHAPTER 2: THE THEORETICAL UNDERPINNINGS OF THE EQUITY RETURNS-INFLATION RELATIONSHIP

2.1. Introduction

There are two main schools of thought that have provided a foundation for understanding the relationship between equity returns and the inflation rate. The first of these, termed the classical theory, was developed by Fisher in 1930. The classical theory hypothesizes that there should be a positive long-term relationship between the goods price and the stock price which should allow equities to act as an effective inflationary hedge. The second school of thought was developed by Fama in 1981 in response to empirical evidence of a negative relationship between equity returns and inflation. This theory was termed the "Proxy Hypothesis' and it argues in support of the empirical evidence of a negative relationship between the variables.

Since the development of the Proxy Hypothesis there has been a progression in the theory of cointegration. Cointegration analysis allows one to avoid sources of error caused by the occurrence of spurious regressions while examining the long-run equilibrium adjustments of the goods price and the stock prices. Studies which have incorporated modern revisions of cointegration have shown the models to exhibit greater power properties than was previously possible. This has allowed for the development of superior insights into the relationship between inflation and equity returns and, by extension, the capacity for equities to function effectively as an inflationary hedge.

The first section of this chapter considers the theory of stock valuation and basic valuation models. The second considers the effect of inflation on stock valuation and presents a discussion of the theory behind the Fisher and Proxy hypotheses. In the second section a selection of empirical evidence produced prior to the development of cointegration theory is discussed. Finally, cointegration theory is introduced prior to a review of a selection of studies included in the literature.

2.2. Financial Valuation Methods

2.2.1 Discounted Cash Flow Analysis

In a discounted cash flow (DCF) model the value of a company is estimated by discounting projected future cash flows at a specified discount rate which is designed to incorporate the risk factor associated with the future cash flows (Wilkinson, 2013). Discounted cash flow analysis includes the Net Present Value (NPV) model and several refinements of it which can be used to determine the present value of projected future cash flows investors may expect as a return on their equity investments. In order to use the DCF formulae to value stocks one would discount future cash flows by the return that can be earned in the capital market by investing in securities that are equally risky. The cash flows received by shareholders are in the form of dividends, so the present value of the stock is equal to the present value of all expected future dividends (Brealey, Myers and Allen, 2010).

The theory of discounted cash flow valuation is based on the idea that an asset's value is based on its capacity to provide future cash flows to investors. Discounted cash flow valuations are able to provide an indication of the total value of a company, including both equity and debt. There are several approaches to discounted cash flow analysis, including the Dividend Discount Model (DDM) and the Free Cash Flow approaches with its variants - the Free Cash Flow to Firm (FCFF) approach and the Free Cash Flow to Equity holders (FCFE) approach. In each approach to DCF analysis a discount rate is used to discount the future value of a project to a present value. The discount rate can be considered as the sum of the risk-free rate and a risk premium which is associated with the uncertainty surrounding the receipt of expected nominal net cash flows (Cooley, Roenfeldt and Chew, 1975). This discount rate includes an inflation premium, which remains constant regardless of the approach in which it is used. However, in each approach the estimation of cash flow varies because each of the basic approaches treats cash flows differently. The discount rate is briefly considered in the next section, followed by a discussion of the NPV, the DDM and the FCF models.

Fisher (1930) presented what has become known as the Fisher Effect, which states that the real interest rate is equal to the nominal interest rate minus the expected inflation rate. This has led to the traditional view, termed the Fisher Hypothesis, in which expected nominal asset returns should move one-for-one with expected inflation (Cooray, 2002). In order for this to be the case firms need to be able to increase the price of their products alongside inflation in order to pass on the costs of inflation to the consumer, otherwise the value of the firm, and the value of its shares, will experience a decrease in real terms. Should the firm be able to fully pass on the increase in costs associated with inflation, it satisfies the inflation-neutral condition. Additionally, because stock returns represent a claim on real assets, they should theoretically exhibit a positive relationship with actual inflation, which would make them a hedge against unexpected inflation (Sharpe, 2000). The original model used in DCF analysis, the NPV model, is considered below:

2.2.2 Net Present Value (NPV)

Financial theory dictates that share prices are typically determined by the present value of all expected future cash flows, the Net Present Value (NPV) (Ehrhardt and Brigham, 2011). The NPV is equal to the sum of each cash flow after it has been discounted back to its present value. It proposes that the total value of a firm is equal to the sum of the present values of all its future projects. The NPV equation is specified as:

$$NPV = \sum \frac{CF_t}{(1+k)^t}$$

Where *NPV* represents the Net Present Value, CF_t represents the cash flows at time t, k represents the discount rate and t represents the time of the cash flow.

If it is assumed that cash flows will increase at the same rate as inflation, significant errors may occur when calculating the NPV of a project in reality. The NPV equation assumes that a firm has an accurate knowledge of the value of all the cash flows of all projects that are going to be conducted in the future. However, this is an unrealistic assumption as it is not viable for a firm to be able to predict the cash flows of all future projects as in the long-run new projects may be developed or external factors may have an effect on the value of future projects' cash flows.

Such potential errors have led to refinements of the model such as the Free Cash Flow (FCF) and Dividend Discount Models (DDM), which have been developed in an attempt to deal with the complexity surrounding the issue of the estimation of the cash flows of future projects. These models attempt to aggregate the value of cash flows in order to provide an estimation of the cash flows of future projects in an effort to complete the same function as the NPV equation, that being to estimate the present value of an asset by using future cash flows and a discount rate. The DDM and FCF models are considered below:

2.2.3 The Dividend Discount Model (DDM)

According to Damodaran (2012) the simplest method for equity valuation is the Dividend Discount Model (DDM) which can be used as a useful tool to provide an indication of equity value. Michaud and Davis (1982) note that the DDM is a natural generalization of the yield-to-maturity concept which is typically used to value bonds. Damodaran (2012) notes that in the strictest sense the only cash flow received by investors that have purchased public stock from the firm, while they hold the stock, is in the form of dividends. Therefore, the general model is based on the idea that an investor should receive two types of cash flows as a result of buying a stock, which are the dividends received during the holding period and the expected price when the stock is sold. The price expected to be received at the end of the holding period is essentially determined by future dividends and as such the value of the stock is equivalent to the sum of a perpetual stream of future dividend payments (Damodaran, 2012). In its simplest form the DDM uses forecasts of earnings, dividends, earnings growth rates and payout ratios in order to derive expected future dividend payouts (Michaud and Davis, 1982). The theory behind the general model is that the value of any asset is equivalent to the present value of all expected future cash flows that have been discounted at a rate which incorporates the risk factor of the future cash flows. Bodie, Kane and Marcus (2010: 397) summarize this theory by stating that the DDM is “A formula for the intrinsic value of a firm equal to the present value of all expected future dividends.”

Due to the problem of projecting dividend payments throughout infinity several simple versions of the DDM have been developed in order to make the analysis more practically applicable. These are based on a few different assumptions regarding future growth (Bodie *et al*., 2010). The simplest of these versions is the Gordon Growth Model which can be used to value a firm that is in a state of steady dividend growth, at a rate which is sustainable indefinitely (Damodaran, 2012). This model is also referred to as the Constant-Growth DDM or Constant Growth Model (CGM) because of this characteristic.

The constant growth model is based on the assumption that a company will make a choice between two options at the end of the period. This first of these options is that the company will pay out its income to shareholders in the form of dividends or add the income to its retained earnings (Kiechle and Lampenius, 2012). The constant growth model is essentially a reduction of the DDM which incorporates the constant dividend growth assumption (Kuhlemeyer, 2004). This assumption proposes that dividends experience constant growth over time (Howells and

Bain, 2008). Bodie *et al.* (2010) state that in the CGM it is assumed that the rate of capital appreciation will be maintained at a constant rate perpetually. For the Fisher Hypothesis to be consistent with the CGM - where equities would function as a perfect inflationary hedge - the growth rate of dividends, or in effect the nominal increase in share value, would need to equal the inflation rate in order to maintain a consistent real return on shares. The CGM is comprised of the expected dividend payout after a year, the perpetual dividend growth rate, or rate of capital appreciation, and the Required Rate of Return (RRR).

The Gordon-Growth Model is specified by Damodaran (2012) as:

$$Value\ of\ Stock = \frac{DPS_1}{K_e - g}$$

Where DPS_1 is the expected dividend payout after year one, K_e is the required rate of return for equity investors (also referred to as the market capitalization rate) and g is the perpetual dividend growth rate.

According to Bradley and Jarrell (2008) the failure to account for inflationary effects in certain cases has led to a misspecification when using the model. These cases include those in which the company is assumed to make either no net new investments or to invest solely in projects that have a net present value of zero. They are able to show that this produces an error that is statistically significant even at moderate levels of expected inflation. Kiechle and Lampenius (2012) state that during periods of stable prices economic growth primarily influences the income of growing companies, while during inflationary periods economic growth has an effect on almost all companies. Kiechle and Lampenius (2012) believe that due to the current concern regarding potential future inflation the accurate assessment of growth during the use of the CGM is likely to become increasingly more important.

2.2.4 Free Cash Flow (FCF)

The FCF model is based on the amount of cash that has been generated using the business assets that would be available for distribution to shareholders. Free cash flow can be defined as the amount of cash a company is able to generate subsequent to payment of the costs required to maintain its assets i.e. cash flow available to equity holders net of capital expenditures (Bodie, Kane and Marcus, 2010). Free cash flow is seen to be important in a company as it allows the company to undertake ventures or make investments that improve the value of its shares, yielding a profit to shareholders. FCF models are particularly useful for the valuation of firms that pay no dividends, in which case the DDM does not provide an optimal valuation of the firm. FCF models can be utilised from either the perspective of free cash flow to the firm or free cash flow to equity.

The FCFF formula is specified by Bodie *et al* (2010) as:

$$FCFF = EBIT(1 - t_c) + Depreciation - Capital\ expenditures - Increase\ in\ NWC$$

Where EBIT represents earnings before interest and taxes, t_c represents the corporate tax rate and NWC represents net working capital.

In the above equation FCFF is representative of the cash flow generated by the firm's operations after deducting the costs of capital and net working capital. Net working capital (NWC) can be defined as the company's current assets minus its current liabilities (Drake, 2006). The alternative approach is the Free Cash Flow to Equity holders (FCFE) which varies with the FCFF model purely in that it includes after-tax interest expenditures and cash flow deducted in the form of net issuance, which is the difference between the debt paid by the firm and new borrowings. The FCFE model is specified Bodie *et al* (2010) as:

$$FCFE = FCFF - Interest\ Expense\ \times\ (1 - t_c) +\ Increases\ in\ net\ debt$$

Where FCFF represents the Free Cash Flow to the Firm model as specified above and t_c represents the corporate tax rate.

If the cash flows being discounted are cash flows to equity it is then necessary to use the cost of equity as the discount rate, whereas if the cash flows are to the firm it is then appropriate to use the cost of capital as the discount rate (Damodaran, 2002a). The appropriate cost of capital and free cash flow is dependent on whether the equity or firm value is being determined. In the former the cost of capital is the cost of equity and in the latter case the cost of capital is the weighted average cost of capital for the firm (Drake, 2006).

2.3 Valuation Under the Effects of Inflation

As mentioned previously, the discount rate can be considered as the sum of the risk-free rate and a risk premium which is associated with the uncertainty surrounding the receipt of expected nominal net cash flows (Cooley, Roenfeldt and Chew, 1975). The discount rate function in the previously considered DCF models is therefore a function of the riskiness of the estimated cash flows, being higher when assets are riskier and lower for less risky projects (Damodaran, 2002a). Inflation and the discount rate have a positive relationship, so if there is an increase in the rate of inflation it is expected that the discount rate will also increase. Should cash flows remain constant during this inflationary increase the discount rate would increase and the value of the firm would therefore experience a decrease in real terms. This is the case where the firm is termed to be non-neutral to the effects of inflation. Valcarcel (2012) states that theoretical finance models, such as those that have been considered previously, imply that subsequent to an inflationary shock that stems from monetary expansion, a positive short-run response should occur. In the case of the CGM, this is indicated by the positive relationship between expected dividend growth rates and stock prices and the negative relationship between stock prices and the required rate of return on the equity.

The required rate of return (RRR) on equity is the sum of an acceptable least risk rate and a risk premium based on the risk associated with the equity (Harris, 1986). Shemer (2013) states that the RRR is the return required by an investor that compensates for the riskiness of an investment, and as such if the RRR falls below the expected real return on an investment, the investor will not proceed to make the investment. Reilly, Johnson and Smith (1971) add that an investment is made in order for the investor to derive a return that compensates for the time period over which the money is committed and for the level of risk involved. This return which compensates investors for the commitment of funds for a certain time period is known as the risk-free rate of return. When risk is added investors require an expected return that is greater than this risk-free rate, to account for the risk premium (Reilly *et al.*, 1971).

Following this logic, the RRR is typically calculated as the sum of the Risk-Free rate added to the product of a risk coefficient and the difference between the expected return and the risk-free rate. According to Kennon (2013) the RRR is determined by five factors which must be compensated for before investors will deem the project worthy of investment. These factors are the real risk-free interest rate, an inflation premium, a liquidity premium, a default risk premium and finally a maturity premium. Should any of these factors increase, the investors

RRR would increase and so the real return on the project would have to increase to match or exceed the RRR in order for the investor to make the investment. In terms of inflation, should an investor expect an increase in the general price level to occur, the inflation premium component of the RRR would be higher, which might cause the combination of the risk premiums to cause the investors RRR to exceed the expected real rate of return and so the investor would not undertake the investment (Reilly *et al.*, 1971).

In the case of the RRR, the expected inflation factor has a significant effect on the expected rate of return in real terms, as the expected rate of return would need to include an inflation premium equal to the expected rate of inflation. The real rate of return is the annual percentage return earned from an investment which has been adjusted for nominal price changes resulting from inflation or other external price effects. By adjusting the real rate of return for factors such as inflation, investors are able to determine how much of their nominal return is in fact real return. If inflation is positive the real return on the investment would be reduced by the rate of inflation, as the rate of inflation would have to be subtracted from the nominal rate of return in order to accurately indicate the real rate of return. Should this real expected rate of return fall below the RRR the investor would refuse to undertake the investment as it would not adequately compensate for the associated risk. The inflation premium is essentially the rate of return that has been added to an investment to account for future expectations of inflation (Kennon, 2013).

Inflation however, also has an effect on the real risk-free interest rate. Damodaran (2012) states that under the assumption of purchasing power parity, both cash flows and the discount rate are affected by expected inflation and as such a low discount rate caused by a low risk-free rate will be offset by a decrease in the expected nominal growth rates for cash flows. The opposite would then also be true due to the positive nature of the relationship between inflation and the discount rate. In the event of an increase in the nominal discount rate, nominal cash flows should also increase to offset the effect, meaning that the share value would remain constant. In theory, this would cause the valuation of the present value of the investment to remain unchanged regardless of changes in inflation, assuming that the inflationary effect on the discount rate and cash flows exactly offset each other.

When incorporating the effects of inflation into the valuation of stocks it is necessary to do so from either a nominal or real valuation viewpoint, in order to account for inflation (Damodaran, 2002b; Hillier, Ross, Westerfield, Jaffe and Jordan, 2010). When approaching the issue from a nominal valuation perspective it is necessary to add an inflation premium in order to adjust cash flows in each period for inflationary effects. On the other hand, approaching the matter from a real value perspective would require that inflation is stripped from the discount rate in order to provide an accurate assessment of the value of the share (Damodaran, 2012). When working in real terms a discount rate is typically used which does not adjust cash flows for inflationary effects, and so it becomes necessary to consider inflationary effects separately. In the case of a nominal valuation a nominal discount rate which includes inflation may be incorporated into the analysis, although potential issues may arise because not all cash flows are equally affected by inflation.

Investigations into the valuation of inflation have occurred for some time. For example, Ezzell and Kelly (1984) stated that the literature regarding the effect of inflation on capital budgeting has apparently reached a consensus that if a project's cash flows are accurately adjusted for inflation and if the real discount rate is adjusted upwards by the rate of inflation by a nominal discount rate then NPV calculations correctly account for inflation. Assuming depreciation allowances are completely indexed for inflation, the previous literature has concluded that the NPV of a project would not experience any effect due to inflation and the use of real cash flows alongside a real discount rate would produce the same result as the use of nominal cash flows alongside a real discount rate that has been grossed up by the inflation rate (Bradley and Jarrel, 2008; Hill and Gough, 1981; Moore, Boardman, Vining, Weimer and Greenberg, 2004).

This line of thinking has typically led to the recommendation "discount nominal cash flows by nominal rates and real flows by real rates" (Mehta, Curley and Fung, 1984). This statement is logically consistent and appealing, in part due to its simplicity, but it is inherently flawed as it does not account for several important issues in the capital budgeting procedure. These two approaches are respectively referred to as "the real based approach" and "the nominal based approach" to capital budgeting. Should the assumptions hold and the two approaches produce the same result, inflation would be neutral (Ezzell and Kelly, 1984). For inflation to be neutral, cash flows would need to increase alongside the discount rate during inflationary periods, in order for the NPV to remain constant in real terms. For this to occur firms would need to increase their cash inflows by the same rate as the rate of inflation which is not always possible in reality. If a firm is able to pass on the increased costs of inflation to its customers by increasing nominal cash flows at the same rate as inflation the NPV of the firm would remain consistent. This is referred to as the inflation-neutral case, where inflation has no effect on the real value of the firm as the nominal value of the firm is able to increase at the same rate as inflation (Bodie, Kane and Marcus, 2010).

This situation is best illustrated using the NPV formula discussed previously. In the inflation non-neutral case the firm is unable to increase cash flows and so the numerator in the equation, cash flows, remains constant. However, the denominator in the equation, a function of the discount rate, increases due to inflation, causing the denominator to increase. The net effect is therefore a decrease in the NPV of the investment. This decrease in the NPV of the investment due to the inability to increase cash flows in line with the increase in the discount rate means that the real rate of return on the investment would be negatively affected by inflation, ultimately precluding the investment as an effective inflationary hedge, in line with Fama's (1981) hypothesis discussed later in this chapter. In the case of equities according to the Fisher (1930) hypothesis, equities only act as an inflationary hedge if there is a positive relationship greater or equal to unity between the rate of inflation and the return on the equity, so if the firm is unable to increase cash flows in line with the discount rate to prevent the decrease in the real return on the equity, the relationship would be less than unity and the equity would not function as an effective inflationary hedge. However, should the firm be able to increase cash flows to offset the inflationary effect on the discount rate the associated equity would then function as an effective inflationary hedge.

Furthermore, because depreciation allowances are based on historic costs in reality, total nominal cash flows are not always increased at a rate equal to the rate of inflation at the same time that the discount rate is fully grossed up by the inflation rate, resulting in a decline in the NPV as a result of inflation. Based on this discussion, two important conclusions are developed in the literature. The first of these is that, at best, inflation will not affect NPV's but will more generally have a negative impact on them. Secondly, nominal cash flows that are discounted by an appropriate nominal discount factor which includes inflation give the same NPV as real cash flows which are discounted by a real discount rate (Ezzell and Kelly, 1984). However, in reality, there are a number of reasons in reality not to assume that inflation is neutral.

2.4 Criticisms of the Neutrality Assumption

Cases where inflation is non-neutral, which are generally thought to occur more often and step outside the bounds of such simple finance theory as has been previously discussed, occur when the effect of inflation on cash flows is different to the effect on the discount rate. The most common of these cases is where the firm cannot increase nominal cash flows in line with inflation costs and so would experience a decrease in real value. In this case the elasticity between inflation and cash flows would be less than unity, meaning that if inflation increases by 1% cash flows would increase by less than 1%. In the more extreme case, it is possible that inflation and cash flows might have a negative elasticity for several reasons (Farsio and Fazel, 2008). For example, a decrease in the real wealth of consumers due to inflation may influence purchases of substitutes for a firm's goods and could, if the elasticity between inflation and cash flows is negative, cause an increase in inflation to have a negative impact on cash flows, which would drastically decrease the NPV of the firm. Another cause of this negative elasticity might be the negative relationship between inflation and real equity returns alongside the positive relationship between real activity and equity returns proposed by Fama (1981), a concept discussed in more detail in later on in this chapter. In this case an inflationary increase would negatively impact on real economic activity which, in turn, would negatively impact equity prices as a result of decreased activity of the firm, based on the negative relationship between equity prices and real economic activity. The alternate non-neutral case is when the elasticity between inflation and cash flows is greater than 1, where a 1% increase in inflation would result in an increase in cash flows of more than 1%. While this would theoretically be rare in practice as it would be unlikely for firms to increase profits following an increase in real costs, it should be noted at this point however, that such occurrences have been observed in the literature, some of which are discussed in chapter 3, including the findings of Alagidede and Panagiotidis (2010).

Damodaran (2012) states that under inflationary conditions valuation is often conducted in real terms. This means that cash flow estimation is conducted using real growth rates while excluding the growth resulting from price inflation. In order for the results to be accurate and reliable, the discount rates used in such cases need to be the real discount rates. In order to determine a real expected rate of return, a real risk-free rate must be calculated. Government and treasury bills are usually used as a determination of the risk-free rate, but these are only risk free in nominal terms because they cannot account for expected inflationary volatility. The most reliable measure of the determination of a real risk-free rate is to subtract the expected inflation rate from the nominal interest rate, which can then be used to calculate the real expected rate of return (Damodaran, 2012). For the sake of simplicity, it has generally been acceptable to observe inflation as a neutral process that does not have lasting effects on relative prices; however, it has been recognized in the literature that the impact of inflation on the real and market rates of return is essentially inconsistent. Changes in these rates generally lead to an adjustment of the required rate of return, which is discussed in the next section, or a disproportionate adjustment of the nominal rate of return for the particular project (Mehta *et al.*, 1984).

The inflation-neutral case discussed previously is a scenario that links to the Fisher (1930) hypothesis discussed in the next section (Bodie *et al*., 1999). This illustrates that when the NPV, or real return, of an investment is unaffected by inflation due to an increase in cash flows equal to the increase in the discount rate, that investment would act as a perfect inflationary hedge.

The assumption included in the CGM that a firm makes no new net investments and has a nominal growth rate of zero in the long-run – based on the theory that in the long-run competition and technological innovation will result in normal rates of return - effectively ignores the effect of inflation on the company's total capital investment which should in fact grow at the same rate as inflation (Bradley and Jarrell, 2008). Following this logic, under the assumption of a consistent real return on capital investment, the company's nominal cash flow derived from these investments should experience an equal growth rate. Therefore, in the presence of inflation, the Constant-Growth model tends to value a firm beneath its true value (Bradley and Jarrell, 2008).

Often common fundamental financial textbooks (Hillier, Ross, Westerfield, Jaffe and Jordan, 2010) teach that valuation must be conducted from either a real or nominal viewpoint in order to handle the effects of inflation. This theory holds if inflation is neutral, but as previously mentioned, there are a number of reasons in reality not to assume that inflation is neutral. One such reason investigated by Ezzell and Kelly (1984) is tax-related capital structure considerations, which have not been adequately incorporated into previous work on the effect of inflation on capital budgeting theory. They discovered that the previously held conclusions regarding inflationary effects hold only if the personal tax rate on debt is equivalent to the corporate tax rate or in the case where leverage is irrelevant. When the tax effects of debt-financing are limited to the corporate tax shield and the personal tax liability on the firm's interest, the levered market value of a project can be defined as the sum of the values of the equity and debt claims against the total expected cash payoff for the project at the end of one period.

Ezzell and Kelly (1984) demonstrated that when leverage matters and when inflation has a uniform effect on cash flows inflation has three unanticipated effects. Firstly, they demonstrated that inflation would in fact raise the NPV of projects under the aforementioned conditions i.e. that the NPV under the effects of inflation is greater than the NPV when inflation is disregarded. Secondly that the appropriate discount rate for nominal cash flows is less than the discount rate calculated by grossing up the real discount rate by the rate of inflation and finally that the discount rate that is appropriate for valuing real cash flows declines as the inflation rate rises. For a description of the models used to arrive at these conclusions the reader is referred to the original paper by Ezzell and Kelly (1984). Ezzell and Kelly (1984) state that the implication of these results is that if the cost of capital that was appropriate during a period of no inflation is scaled up by the rate of inflation and used to discount nominal cash flows, some projects which would raise a firms levered value would in fact be rejected. On the other hand, if projected nominal cash flows when inflation was positive were converted into real cash flows and discounted by the cost of capital taken when inflation was zero, then some projects would also be rejected which would have had a positive impact on the value of the firm.

The impact of inflation on the discount rate is essentially uneven, as discussed in detail by Mehta *et al.* (1984) who specify distinct formulations for the valuation of the present value of a project's cash flows in three cases, these being the incremental real profit per unit, the nominal cash flows and the real cash flows valuations techniques. They state that in the case where inflation is assumed to be neutral and uniform processes and taxes are ignored all three valuation techniques are identical. Mehta *et al.* (1984: 49) later state: "*However, inflation is not neutral.*" Additionally, they state that subsequent to the recognition that inflation has uneven effects on various cash flows and by extension on the value of the firm, one must recognize that the risks linked to the various firm's cash flows are also unequal. They write that a capital project would provide a full inflationary hedge in the case where the total inflationary risk does not influence the capital project, where the real rate of return on the project adjusts independently of inflationary variations. Should this not be the case, inflation would have varying effects on various firm's cash flows which would cause the magnitude of risk to be associated with each of the firms to differ, based on their capacity to provide an inflationary hedge. Mehta *et al.* (1984) point out that in an efficient market this inequality would be recognized and would subsequently be incorporated into firm's capitalization rates, which would mean that the determination of a nominal discount rate by multiplying the real discount rate by the rate of inflation would be unlikely to correctly capture the markets' required adjustment, as was also determined in the previously discussed study by Ezzell and Kelly (1984).

Mehta *et al.* (1984) provide an interesting discussion of how the introduction of corporate taxes further aggravates the aforementioned issue of inconsistency. To summarise their discussion, they present the example of the depreciation tax shield, which is a fixed, nominally defined cash flow whose real value is inflation-dependent. In two otherwise identical firms, which differ only in their capital intensities, the firm with a greater capital/labour ratio would pass a greater proportion of aggregate cash flow through its depreciation tax shield. As such, this firm would be more hard-pressed to provide sufficient real returns to act as an inflationary hedge and, furthermore, would experience a greater variability in cash flows due to inflationary adjustments; further increasing the risk associated with this more capital-intensive firm. By extension, even when the real cost of capital is equal under a specific inflation rate for two firms, their real cost estimates may be different should the inflation rate adjust. For this reason, it is unlikely that adjusting the real required rate of return for inflationary changes would result in the correct cost of capital for the firm, instead it would result in an incorrect estimation of the value of a project (Mehta *et al.*, 1984). Based on these arguments that present potential flaws in the neutrality assumption, it is unlikely that the Fisher Hypothesis, which proposes that the real interest rate is comprised of the nominal interest rate minus the inflation rate, would in fact hold in reality.

Even in the case where the firm is able to fully pass on the costs associated with inflation to its customers the consideration of the impact of the nominal price increases on the sales of the product must be taken into account. In addition, the uneven effects of inflation on capital costs as well as the on labour would also have an effect on the capital budgeting procedure of a firm during an inflationary period, all of which are factors that make it increasingly unlikely for inflation to be neutral, thus violating the neutrality assumption of the Fisher Hypothesis. The arguments for neutrality and non-neutrality of inflation are reflected by two of the fundamental arguments regarding the theory in the literature, these being the Fisher Hypothesis and the Proxy Hypothesis, which are discussed in the next two sections of this chapter.

2.5 The Fisher Hypothesis

Irving Fisher is generally regarded as the developer of the original theory linking inflation rates and asset returns. Jaffe and Mandelker (1976) state that the basic theory of the effects of inflation on financial assets is commonly attributed to Fisher (1930). Fisher (1930) (cited in Sharpe, 2000) presented the classical view in which expected nominal asset returns should move one-for-one with expected inflation based on the idea that, because stock returns represent a claim on real assets, they should exhibit a positive relationship with actual inflation, which would make them a hedge against unexpected inflation (Sharpe, 2000; Luintel and Paudyal, 2006). The Fisher Hypothesis is in essence based on the theory that there is a positive relationship between interest rates and the expected rate of inflation (Berument and Jelassi, 2002). 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).

When examining the relationship between stock valuation and the inflation rate it is important to fully grasp the relationship between the real interest rate and the inflation rate. In a market economy under the effects of inflation lenders are influenced by their rate of time preference, which is dependent on the real interest rate that they can obtain over the course of the investment. The real interest rate concerns rational investors, but cannot be directly observed and is dependent on the inflation rate over the course of the investment, as dictated by the Fisher effect (Howells and Bain, 2008). The Fisher effect states that the real interest rate obtained on an investment is approximately equal to the inflation rate subtracted from the nominal interest rate, given by what is often referred to as the Fisher equation in its simplest form:

$$r \approx i - \pi$$

Where r is the real interest rate, i is the nominal interest rate and π is the inflation rate.

It is this equation that has led to the Fisher Hypothesis that the nominal rate of interest consists of a stable real rate of interest and a premium which closely follows the rate of inflation (Howells and Bain, 2008). The Fisher Hypothesis is based on the assumption that the real return on stocks over time will remain consistent, independent of fluctuations in the inflation rate due to automatic adjustments of the nominal rate of return, so the theory can then be utilized to determine the present value of shares, which include dividend payments at an expected growth rate (Howells and Bain, 2008). Fisher's theory essentially separates the nominal interest rate into two component parts, the real interest rate plus an expected rate of inflation, and puts forward the proposition that in a perfectly efficient economy a one-to-one relationship should exist between the inflation rate and the nominal interest rate, the difference between the two being equal to the real interest rate (Cooray, 2002).

In addition, Fisher's theory dictates that the nominal interest rate fully reflects all available information of the possible future values of the inflation rate. Gultekin (1983a) states that the generalized Fisher Hypothesis assumes that the market is efficient and that fluctuations of the expected real return on common stock are not directly dependent on the expected inflation rate. Ultimately this results in an aggregate compensation to investors for decreases in purchasing power caused by inflation, due to the fact that stocks are theoretically able to maintain their real value. Nelson (1976) states that in the early 70's, prior to the empirical evidence that led to the Proxy Hypothesis, the proposition that rates of return on common stocks move directly with the rate of inflation was widely agreed upon, both in the academic and non-academic communities. The application of the Fisher Hypothesis to the equity returns-inflation relationship rests on the theory that 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). Under this assumption of a consistent real return on capital investment, the company's nominal cash flow derived from these investments should experience a growth rate equal to the rate of inflation (Bradley and Jarrell, 2008). Should the one-to-one relationship between the returns on an asset and inflation hold true, in accordance with the Fisher Hypothesis, then the asset in question acts as an effective hedge against inflation.

Katzur and Spierdijk (2010) state that the Fisher Hypothesis postulates that the anticipated rate of inflation is fully integrated into the *ex-ante* nominal interest rate while simultaneously disqualifying the existence of a relationship between the expected real interest rate and expected inflation. The idea that *ex-ante* nominal returns are able to integrate the expected inflation rates in the market can be applied to all assets, implying that expected nominal returns on any asset, including equities, should move on a one-to-one basis with inflation (Katzur and Spierdijk, 2010). This proposition implies a link between all capital assets and inflation, indicating that all real assets should act to some extent as an inflationary hedge when their value increases as a result of an increase in inflation. According to Alagidede and Panagiotidis

(2010), if the *ex-ante* real interest rate is assumed to remain constant, economic agents will require a nominal rate of return that is able to compensate for any decreases in the purchasing power of money due to inflation. In the context of stock markets, the Fisher Hypothesis implies that a positive one-to-one relationship exists between stock market returns and inflation, making stock market returns an effective inflationary hedge because the real rate of return on the stock would mitigate the loss in real wealth caused by inflation (Alagidede and Panagiotidis, 2010).

The Fisher Hypothesis predicts that the returns on common stocks when taken as an average will act as a hedge against inflation when the fluctuations in expected nominal return on common stocks are parallel to fluctuations in the expected inflation rate (Gultekin, 1983a). Barsky (1987) describes the Fisher Hypothesis as one of the cornerstones of neoclassical monetary theory, and states that the Fisher Hypothesis essentially dictates that the nominal interest rate should experience a "point-for-point' correlation with the expected rate of inflation. Sharpe (2000) states that the general view of financial economics is that because stocks represent a claim on a real, or “physical asset”, that the return on stocks should vary positively with the actual rate of inflation, which would make stocks an effective hedge against unexpected inflation. This is due to the fact that whenever inflation experiences an unexpected increase the nominal value of a stock would experience an equivalent increase, causing the real value of the stock to remain constant.

According to Berument and Jelassi (2002), there is a disparity in the academic community over how long a period this relationship exists for, with some authors predicting the existence of a positive relationship regardless of the time period considered, such as Boudoukh and Richardson (1993), and others, such as Mishkin (1992), who found evidence that the relationship exists exclusively in the long-run. Boudoukh and Richardson (1993) argue that the relationship still exists in the short-run, but that the Fisher effect is stronger over longer time horizons. They provide strong evidence of a positive relationship over long horizons but also state that their evidence should be consistent with certain sub-periods during the past two centuries. This debate develops into the idea that the time period considered may have an influential effect when testing for the presence of the Fisher Hypothesis within a data set. Several studies using modern revisions of cointegration theory to test the Fisher effect have provided evidence in support of a positive relationship between inflation and nominal interest rates that is at least equal to unity. These include studies by Kim and Ryoo (2011), who provided evidence of a positive relationship greater than unity in the US, and by Alagidede and

Panagiotidis (2010) who provided evidence of a relationship between inflation rates and nominal stock returns that actually exceeds unity in South Africa. These studies, which lend support to the Fisher Hypothesis, are discussed further in chapter three.

Berument and Jelassi (2002) provide a slightly more developed form for the equation used to test the Fisher Hypothesis, which although mathematically equivalent, provides a marginally more revealing insight into the nature of the equation:

$$i_t = \alpha + \beta \pi_\tau^{e}$$

Where i_t represents the nominal interest rate, π_τ^{e} represents the expected inflation rate for the period, α represents the real interest rate and β is the coefficient which assumes the value of one should the Fisher Hypothesis hold.

The slight difference between this form of the model and the previous model is the addition of β to the equation, which is expected to take on the value one, which reflects the one-to-one relationship between interest rates and the expected inflation rate, as is expected should the Fisher Hypothesis hold, a case that is referred to by Berument and Jelassi (2002) as the strong form of the Fisher Hypothesis. In its weak form β still takes on a positive value, but this value is less than one. In the case of the strong form of the Fisher Hypothesis the β value of one, which reflects a one-to-one relationship between nominal interest rates and the expected rate of inflation, implies that equities are able to act as a full hedge against inflation, while the weak form case of the Fisher Hypothesis implies that equities are only able to act as a partial hedge against inflation. The β coefficient can also take on a negative value, which would mean that equities are unable to provide even a partial inflationary hedge. Alagidede and Panagiotidis (2010) state that in the case where return on equities is subject to taxes the β coefficient would need to assume a value greater than unity for equities to be an effective hedge against inflation.

Alagidede and Panagiotidis (2010) utilise a similar model as was specified above to represent the theory of the Fisher Hypothesis, which they then develop into a regression of stock returns on contemporaneous inflation. This regression, specified below, contributes further to an understanding of the concept of the Fisher Hypothesis:

$$\Delta S_t = \alpha + \beta E(\Delta P_t | \varphi_{t-1}) + \varepsilon_t$$

Where ΔS_t represents the nominal stock return, ΔP_t represents the inflation rate, α represents the expected real rate of stock return, β is the coefficient which assumes the value of one should the Fisher Hypothesis hold and $E(\Delta P_t|\varphi_{t-1})$ in the model represents inflationary expectations at time $t-1$ based on all available information, given by φ_{t-1}.

The variable φ_{t-1}, which represents all available information, would be subject to significant variation based on data availability and as such the variable is removed from the equation when it is run after which the equation is based on a regression of observable data. As was the case in the earlier equation, a regression that yields a β coefficient value of one suggests that equities are able to act as a hedge against inflation, while a β coefficient of less than one suggests that equities are unable to provide a full inflationary hedge. Of course, as stated by Alagidede and Panagiotidis (2010) the β coefficient is able to exceed unity to satisfy the case where equity returns are subject to taxes and would therefore be required to exceed the rate of inflation by the equivalent of the tax rate in order to provide a full inflationary hedge. This is consistent with the tax-augmented Fisher Hypothesis, which is the idea that the return on stocks must be in excess of the inflation rate instead of simply equal to it, in order to compensate for the loss in real wealth of tax-paying investors. To rephrase, a finding of above-unity elasticity as indicated by a positive β coefficient greater than one would be consistent with the tax-augmented Fisher Hypothesis (Luintel and Paudyal, 2006).

According to Khil and Lee (2000) it was commonly thought, up until the mid-1970's, that Fisher's theory should hold and that stock returns and inflation should be positively related, causing nominal asset returns to be closely correlated with expected inflation. Stocks' values are based on a specific underlying asset and are therefore expected to have consistent real returns based on Fisher's theoretical prediction that the real interest rate is unaffected by expected inflation (Khil and Lee, 2000). Note that the nominal asset returns should therefore, in theory, be positively correlated with changes in the expected inflation rate. For example, in the case of stock markets, an X percentage increase in inflation should be followed by an X percentage increase in stock returns, allowing stocks to be used as a perfect hedge against inflation (Alagidede and Panagiotidis, 2010). However, as pointed out by Barsky (1987) there was virtually no evidence of the Fisher effect in data sets taken from the United States and Britain prior to 1939. Barsky (1987) compares the relationship between the US three-month commercial paper rate with the *ex-post* inflation rate between 1860 and 1939 and discovers that it is negatively correlated, with a figure of -0.17. The lack of empirical evidence of a positive relationship between inflation and common stock returns in the US prior to the development of the Fisher Hypothesis casts into question the validity of the theoretical underpinnings on which the hypothesis is based.

This being said however, recent empirical studies have provided new evidence of the existence of a positive relationship between the rate of inflation and the nominal interest rate (Alagidede and Panagiotidis, 2010; Kim and Ryoo, 2011; Eita, 2012). This evidence leads to the question of whether less modern modelling techniques have been able to incorporate the requisite factors needed to provide an accurate assessment of the relationship and whether historical results have been consistent with modern techniques for modelling the relationship. The next section introduces what is possibly the most famous counter argument to the Fisher Hypothesis, before the modern empirical evidence and modelling techniques are discussed in chapter three.

2.6 The Proxy Hypothesis

Fama (1981) developed a model, now 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: the stock return; and inflation rates independent relationships with expected economic activity. In other words, according to Ely and Robinson (1997) the Proxy Hypothesis is primarily dependent on two independent relationships: firstly, the inflation rate and expected economic activity relationship, 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 independent relationships between these factors and expectations of economic activity.

Fama (1981) refers to evidence of a negative relationship between common stock returns and inflation during the post 1953 period as documented by several studies that provide evidence of a negative relationship between stock returns and both expected inflation and unexpected inflation (Fama and Schwert, 1977; Jaffe and Mandelker, 1976; Bodie, 1976; Nelson, 1976). Fama (1981) then points out that this is strange considering the previously accepted wisdom of the classical theory, which relied on a positive relationship between common stock returns based on real income generated by real assets in order to advocate the function of equities as a reliable inflationary hedge. Fama's (1981) paper aims to explain the conflicting relationship between stock returns and inflation using the Proxy Hypothesis, which effectively theorises that the negative relationship between inflation and stock returns in fact acts as a proxy for real variables, from which equity values are essentially determined. In order to understand Fama's (1981) theory it is necessary to consider the authors belief that the negative relationship between stock returns and inflation was basically a result of a negative relationship between the inflation rate and real activity. Fama (1981) uses values of real variables and accepted measurements of the rate of inflation, both expected and unexpected, within the structure of the Proxy Hypothesis in order to eliminate the conflicting relationships between stock returns and inflation.

Khil and Lee (2000) pointed out that many studies have shown since the 1970's, specifically in the United States and in several European countries, that the relationship between stock returns and expected inflation has been decidedly negative with the exception of the equity return - inflation relationship in the US during the pre-war period. This is in contrast to the theory that was proposed by the Fisher (1930) hypothesis but lends support to Fama's (1981) Proxy Hypothesis. There are several hypotheses highlighted by the same authors that posit explanations for the deviation from Fisher's theory. Included in these are Fama's (1981, 1983) hypothesis, which is referred to in many similar studies as well as the theories of Geske and Roll (1983), Kaul (1990) and Feldstein (1980) who each provided different arguments that attempted to explain why the relationship may be negative. In addition, the authors mentioned an interest in the methodological approach taken by Hess and Lee (1999) who proposed the existence of aggregate supply and demand shocks which have an effect on the relationship between equity returns and inflation. Essentially, Hess and Lee (1999) theorised 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.

Fama (1981) determined that evidence exists that stock returns are positively related to measures of real activity, and provided evidence of a negative relationship between the inflation rate and real activity. These relationships correlate most strongly with measures of future real activity, which is consistent with the theory of rational expectations in which current prices within the market are dependent on expectations of future variables (Fama, 1981). Kaul (1990) states that Fama's (1981) hypothesis, based on money-demand factors, has held up well in light of empirical evidence. Kaul (1990) summarised the theory of the Proxy Hypothesis and stated that under this hypothesis both the inflation and stock return variables are simultaneously determined by real shocks. In addition to Kaul (1990) a number of other authors have discovered empirical evidence in support of the Proxy Hypothesis, including Lintner (1975), Bodie (1976), Jaffe and Mandelker (1976), Nelson (1976), which are cited by Hess and Lee (1999). Some of these studies that have found evidence supporting the Proxy Hypothesis are discussed in more detail in chapter three.

Essentially, Fama (1981) determined that fluctuations in equity returns are not a direct function of inflationary volatility *per se*, but rather hypothesized that equity returns and the rate of inflation do not directly correlate with each other, rather that these independent variables are themselves directly linked to measures of real activity. The idea that inflationary expectations do not directly result in a change in the value of equity returns lends weight to the possibility of a negative long-run correlation between the two variables. Kaul (1990) notes that, based on a given money supply, money demand theory effectively demonstrates a negative relationship between real shocks and inflation. Inversely, real shocks and stock returns demonstrate a positive relationship and as such the negative relationship between inflation and stock returns merely acts as a proxy for the positive relationship between stock returns and real variables (Kaul, 1990).

According to Balduzzi (1995) the Proxy Hypothesis is based on two stylized facts which are briefly summarized as follows: The first of these is that low growth rates of real economic activity are typically expected following high rates of inflation, because the economic-activity growth rate is expected to decrease in the future, causing a decrease in the growth rate of money demand, which ultimately causes an increase in current and future-expected inflation (Balduzzi, 1995). Balduzzi's (1995) second fact is that high real stock returns typically occur before a high economic growth rate in the future. Therefore, anticipated business fluctuations have the opposite effect on the inflation rate to the effect on stock returns causing a negative correlation to exist between the two variables (Balduzzi, 1995). According to Fama (1981) this theory is based on a simple rational expectations version of the quantity theory of money, which effectively matches higher anticipated growth rates of real activity with lower rates of current inflation. Fama (1981) states that this negative correlation has been observed consistently during the post-1953 period and traces the negative correlation between the real activity and inflation variables to the fact that the nominal quantity of money does fluctuate adequately with real activity to offset the negative real activity-inflation correlation.

Fama (1981) then analysed the relationships between stock returns and the variables which are thought to be its primary determinants, specifically the quantity of investments available to firms that will yield a return greater than their costs of capital - a factor that is considered to be crucial in the valuation of equities. The model that Fama (1981) proposed considers increases in output to have a positive influence on the real return on capital of an investment. However, they also lead to an increase in capital expenditures and therefore it is proposed that changes in output result in changes in real returns which ultimately reflect as changes in capital expenditure. Fama's (1981) final tests observe the relationship between common stock returns and other real variables, inflationary measures and finally a combination of these real variables and the included inflationary measures. It was observed that common stock returns are positively related to real variables including capital expenditures and output and that stock returns typically have a leading effect on the real variable.

Fama (1981) states that due to these relationships stock returns typically exhibit a strong negative correlation with measures of expected and unexpected inflation. In essence, Fama’s (1981) Proxy Hypothesis concludes that when measures of inflation and measures of real activity are used as explanatory variables to determine real stock returns, the effects of inflation are typically dominated by the effects of real activity. This means that the expected real return on equity is primarily determined by real activity and as such, relationships between the inflation rate and expected real returns are found to be spurious. These results have come about due to the effects of inflationary variation, which has occurred to accommodate increased money demand as real activity has increased, instead of increases in the nominal rate of money growth (Fama, 1981). It is due to these two relationships that regression results using stock returns on the inflation rate have shown a significant negative coefficient, which would preclude stocks as a hedging option against inflation (Ely and Robinson, 1997).

Other authors have since provided evidence that the relationship between real stock returns and inflation is either negative or positive, in support of, or in contrast to the Proxy Hypothesis respectively, by empirically testing the Proxy Hypothesis (Ely and Robinson, 1997). Included amongst these authors are Geske and Roll (1983) who agree that the negative relationship between stock returns and inflation is spurious but argue that the relationship between inflation and real activity is because ‘reverse causality’ exists in the stock market when the central bank engages in debt monetization. The effect of this is that an increase in stock returns indicates an increase in expected inflation, instead of increased inflation indicating an increase in the real return on stocks (Ely and Robinson, 1997). Geske and Roll (1983) argue that the countercyclical fiscal policy that was adopted in the US in the post-war period caused what is termed by Balduzzi (1995) as a pro-cyclical behaviour of money supply due to debt monetization which the authors believe causes the 'reverse causality' in the stock market. According to Geske and Roll (1983) this behaviour then reinforced the theory on which the Proxy Hypothesis is based due to the higher rates of inflation that occurred during recessions (Balduzzi 1995).

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 (Khil and Lee, 2000). Kaul (1990) illustrated that the relationship between inflation and equity returns vary systematically as a result of an influence on the relationship by money supply and demand factors (Kaul, 1990). Kaul (1990) states that these money demand effects acted in combination with a counter-cyclical monetary response during the post-war period to cause a negative relationship to exist between stock returns and inflation. In contrast, during the 1930's the combination of money demand factors and a pro-cyclical monetary policy resulted in a positive relationship between the two variables. Based on this evidence, Kaul (1990) states that an apparent link exists between the Federal bank's monetary policy during each period and the relationship between stock returns and inflation. Using data from four developed countries Kaul (1990) further investigated the relationship between the variables and their dependence on monetary policy regimes, eventually concluding that the evidence from each country showed that, while the relationship was generally negative, the relationship during the post-war period varied systemically depending on the monetary policy regime.

Additionally, Kaul (1990) notes that the negative relationship between the two variables appeared to be stronger during interest rate regimes than during money supply regimes and those countries that maintained a single monetary regime over the sample period exhibited no change in the relationship. As mentioned earlier, Kaul (1990) determined that when money supply is given, money demand theory is able to effectively demonstrate the negative relationship between stocks returns and inflation as well as the positive relationship between real activity shocks and stock returns. As such, support is lent to the Proxy Hypothesis because, as stated by Kaul (1990) the negative relationship between stock returns and inflation is merely a proxy for the positive relationship between stock returns and real activity variables, the latter being negatively related to inflation.

Hess and Lee (1999) attempted to further the knowledge base using a hypothesis that real aggregate demand and supply disturbances have a significant effect on the relationship, in which supply-side shocks are proposed to contribute negatively while demand-side shocks are proposed to contribute positively to the stock-returns inflation relationship. Hess and Lee (1999) state that supply shocks are a reflection of real output shocks and contribute to a negative relationship between stock returns and inflation. Demand shocks, on the other hands, are caused by monetary shocks and contribute towards a positive relationship between stock returns and inflation. Hess and Lee (1999) note that although a number of studies support Fama's (1981) conclusion that the relationship between stock returns and inflation is dependent on the money supply (Kaul, 1990), others, including Geske and Roll (1983) provide evidence in support of a counter-cyclical monetary response that contributes to the negative relationship between real activity and inflation (Hess and Lee, 1999).

Hess and Lee also make reference to a study by Danthine and Donaldson (1986) who developed a rational expectations equilibrium model which determined a negative stock returns-inflation relationship caused by non-monetary sources such as a real output shock. In the model developed by Danthine and Donaldson (1986) it was concluded that stocks represent an effective hedge against only monetary inflation. Hess and Lee (1999) note that equilibrium models tend to produce results that show the relationship to be either positive or negative in contrast to the consistently negative results dictated by the Proxy Hypothesis. As such Hess and Lee (1999) explore the idea that the stock returns-inflation relationship develops as a combination of supply side and demand side disturbances. In their model supply side shocks are attributed to real output shocks which contribute to a negative relationship, and demand side shocks are the result of monetary disturbances and contribute to a positive stock-return inflation relationship.

Further studies propose a number of reasons and theoretical models in an attempt to explain the relationship between stock prices and inflation. A number of models have been developed to explain the apparent negative relationship between stock returns and inflation since the publication of Fama's (1981) study which developed the Proxy Hypothesis. Many of these studies provides a different theory as to the factors that contribute to the nature of the relationship, often developed as an extension to the Proxy Hypothesis, such as the studies previously mentioned in this section. The theory behind a number of these studies and the models developed to explain the relationship are summarised and discussed in more detail in the following section, which is intended to provide a review of the literature that attempts to define and understand the relationship between real equity returns and the inflation rate over time. The studies that have been reviewed in the next section were selected from the extensive base of literature in order to provide an overview of the development of the theory regarding the equity returns-inflation relationship, beginning with empirical evidence that contributed to the development of the Proxy Hypothesis up until the general acceptance of cointegration theory.

2.7 An Introduction to Cointegration

Cointegration occurs when two time series are individually integrated of order one and are thus individually non-stationary, but a vector exists that forms a stationary linear combination of the time series (Sorenson, 2005). Non-stationarity is an important consideration in econometric testing for a number of reasons, due to the effect it has on the properties of a given series. In a non-stationary series the effects of an external shock to the system will exist perpetually, while in the case of a stationary series the effects of any shock to the system will decrease over time as the system returns to equilibrium (Brooks, 2008). Possibly the most significant property of a regression run using non-stationary series is the occurrence of a spurious regression, which is the appearance of a long-run relationship between two independent series that are trending over time, even when the two series are entirely unrelated.

The concept of cointegration was introduced by Granger in 1982 and can be defined as the existence of a stationary linear combination between at least two integrated non-stationary series (Stigler, 2012). Economically this can be interpreted as the presence of a long-run equilibrium relationship between the variables. Other studies of a similar nature have previously used cointegration theory to determine the nature of the long-run relationship between equity returns and the inflation rate (Ely and Robinson, 1997; Khil and Lee, 2000; Alagidede and Panagiotidis, 2010). These typically used the Engle Granger method, as developed by Engle and Granger in 1987 or Johansen's methodology, known as the Vector Error Correction Model, which was developed in 1996.

To test for non-stationarity a unit root test is used, such as the test developed by Dickey and Fuller (1979) who formulated what is known as the Dickey-Fuller (DF) test. The DF test provides a set of test statistics and critical values to be used for the determination of a unit root in a series, which is an indication of non-stationarity. This unit root test tests the null hypothesis of a unit root against an alternate hypothesis of stationarity. Other unit root tests, which are used in this study, include the extension the DF test, the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. In addition, the order of integration can be tested using a stationarity test which uses an alternate hypothesis to the unit root tests, a null of stationarity which is tested against an alternate hypothesis of non-stationarity. An example of a stationarity test, which is used in this study, is the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Should the series in the regression be found to be non-stationary, but integrated of the same order, i.e. integrated of the first order, or $I(1)$, they can be tested for a cointegrating relationship using tests such as the Engle-Granger or Johansen's tests.

Cointegration is more conclusively defined by Johansen (2000: 361) in the following extract:

> If X is integrated of order 1 but some linear combination, $\beta' X_t$, b $\neq$ 0 can be made stationary by a suitable choice of $\beta' X_{0,}$ X_t is called cointegrated and β is the cointegrating vector. The number of linearly independent cointegrating vectors is called the cointegrating rank, and the space spanned by the cointegrating vectors is the cointegration space.

For the purposes of this study a set of variables will be defined as cointegrated if a linear combination of these variables is stationary. This implies that certain factors influence the series and that they are bound by a relationship in the long-run, therefore although the cointegrating variables may experience a deviation from their long-term relationship in the short-term, in the long-term the equilibrium relationship will eventually be realized (Brooks, 2008). In the case where there is no long-term relationship between two series the series would experience a perpetual deviation and would not have a constant mean to which they return in the long-run. In this case all of the linear combinations of the series would be non-stationary and therefore the series would not be cointegrated (Brooks, 2008). The mechanism linking cointegrated series is a type of causality in that certain turning points in a series are shown to precede turning points in another series (Alexander, 1999). The specific mechanics of the cointegration tests employed in this study are discussed in each of the relevant chapters that follow the literature review.

CHAPTER 3: A CHRONOLOGICAL REVIEW OF THE LITERATURE

3.1 Introduction

This chapter presents a chronological review of selected studies in the literature. These studies were selected in order to demonstrate the conflict in the academic community regarding the correct methodology that should be used to analyse the equity returns-inflation relationship, as well as to show the development in the theory prior to the general acceptance of cointegration modelling. Due to the extent of the research of the relationship it would be impractical to review every study conducted that includes inflation and equity returns, therefore the studies reviewed in this study were selected with the intention of providing an overview of the development of the general theory of the relationship between inflation and equity returns.

The theory behind the use of equities as a hedge against inflation began with the Fisher Hypothesis, which was generally accepted for a long period on a theoretical basis. In order for the Fisher condition to hold, where a one-to-one relationship exists between inflation and equity returns, firms need to be able to pass on the costs of inflation to their customers via nominal increases in the price of their products. Should firms be able to fully pass on the costs of inflation it implies that unit elasticity exists in the market and equity returns would provide an effective hedge against both expected and unexpected inflation. In this context, The Fisher Hypothesis has been discussed in depth.

However, many studies over the period provided empirical evidence of a negative relationship between equity returns and inflation and as such Fama (1981) developed the Proxy Hypothesis. According to the Proxy Hypothesis the evidence of a negative relationship was attributed to two simultaneous relationships. The first of these was the negative relationship between inflation and real economic activity and the second, the positive relationship between real economic activity and equity returns. As such Fama (1981) proposed that the linkage between inflation and equity returns is in fact indirect, but the two variables link directly with measures of real economic activity. In this case a positive movement in inflation would be expected to slow down the growth rate of future economic activity, which in itself would have a negative effect on equity returns. The initial theories that developed subsequent to Fama’s (1981) hypothesis have also been considered in the previous chapter.

In order to further discuss the theories that were developed prior to the general acceptance of cointegration theory, this chapter included reviews of a number of studies intended to illustrate the development, as well as conflict, in the academic community regarding the testing of the nature of the equity returns-inflation relationship. It is interesting to note the development in the theory over time, from the general confidence in a positive relationship between the variables following the development of Fisher's hypothesis (1930), to the theory that the relationship was in fact negative or spurious during the post-war period (Fama, 1981). Finally, a modern debate has arisen based on developments in the theory of cointegration that provides empirical evidence showing that there may in fact be a significant positive relationship between the variables (Ely and Robinson, 1997; Kim and Ryoo, 2011).

The first group of studies reviewed are those that were undertaken prior to the development and subsequent application of cointegration theory, while the latter group include studies that have applied various cointegration techniques. This chapter is constructed with the intention of illustrating the development of studies of this nature over time, as well as to highlight the relative disparities in the literature based on the time period or country that is analysed.

3.2.1 The Empirical Evidence that Contributed to the Proxy Hypothesis.

(Bodie, 1976; Jaffe and Mandelker, 1976; Nelson, 1976; Fama and Schwert, 1977)

Fama (1981) states that a significant amount of evidence exists of a negative relationship between common stock returns and inflation between 1953 and the publication of his paper, in 1981. Fama (1981) referred to studies by Bodie (1976), Jaffe and Mandelker (1976), Nelson (1976) and Fama and Schwert (1977) as examples of studies that have documented a negative relationship between stock returns and both expected and unexpected inflation. Fama (1981) notes that these results are confusing when considering the previously accepted theory of the Fisher Hypothesis that advocated equities as an effective inflationary hedge.

In the study by Bodie (1976) the author used the framework of the Markowitz-Tobin-Mean-Variance model of portfolio choice in order to determine the effectiveness of common stocks as an inflationary hedge. Bodie (1976) measured this as the attainable reduction in the variance of the real return on a representative portfolio constructed of single period nominal bonds for which there was no risk of default. Bodie (1976) focused primarily on a minimum variance portfolio, from the perspective that that an inflationary hedge is basically taking the aforementioned bond as the initial point and combining it with other securities to reduce the variance of its real return as much as possible.

Bodie (1976) acknowledged that the definition of an inflationary hedge used in this paper is not the only possible definition and that the term has been employed in other distinct ways in the literature. Bodie (1976) referred to one such definition, by Reilly, Johnson and Smith (1971), which defined a security as an effective hedge against inflation if it offers "protection" against inflation, in that it reduces the possibility that the real rate of return on the security will fall below a "floor" value such as zero. Bodie (1976) notes that studies that used this definition of an inflationary hedge often found that the nominal rate of return on common stock was frequently less than that of inflation and so it does act as an effective inflationary hedge, due primarily to the significant variance experienced by equity returns. The author refereed to a second definition of an inflationary hedge as a security that has a real return which is independent of the rate of inflation, as used by Branch (1974), Fama and Macbeth (1974) and Oudet (1973). This theory relates closely to the Fisher Hypothesis in that it proposes that because stocks represent a claim to real capital assets, which maintain a constant real value during inflationary periods, they maintain a real value which is independent of inflation – therefore the real value of stocks should match any changes in the rate of inflation. This is expressed as a positive relationship between the rate of inflation and the rate of return on equity.

Using a formula derived in the same paper which measures the effectiveness of equity as an inflationary hedge, Bodie (1976) proceeded to determine the magnitude of this capacity by determining the parameters on which the effectiveness of the capacity of common stocks as an inflationary hedge was dependent. The first of these parameters was the ratio of the variance of the non-inflation component of the real return on common stocks to the variance of unanticipated inflation – for which the author notes that the greater the ratio, the less effective equity was as an inflationary hedge. The second parameter was the discrepancy between nominal returns on nominal bonds and the coefficient of unanticipated inflation in an equation considering real equity returns. Bodie (1976) notes that the more significant this difference was in absolute value terms, the more effectively equity was able to act as an inflationary hedge. Bodie (1976) used annual, quarterly and monthly data between 1953 and 1972 using the Consumer Price Index (CPI) as the inflationary variable and nominal returns derived from holding NYSE common stocks as the equity variable. Risk-free nominal returns were based on Treasury Bills with a matched maturity (Bodie, 1976). The results indicated that, contrary to the popular beliefs of the period, that the real return on equity is negatively related to both anticipated and unanticipated inflation. Bodie (1976: 469) states this to be a "somewhat disturbing conclusion that to use common stocks as a hedge against inflation one must sell them short."

Nelson (1976) states that in 1968 there was little doubt in both the academic and non-academic communities that the rate of return on common stocks moved directly with the rate of inflation in accordance with the Fisher Hypothesis. However, Nelson (1976) notes that over the years belief in the application of Fisher's hypothesis to stock returns deteriorated as a result of the appearance of contradictory evidence. Nelson (1976) also investigated the relationship between common stocks and the rate of inflation and discovered evidence of a negative relationship between stock returns and both anticipated and unanticipated changes in the rate of inflation during the period. Nelson (1976) used a series of regression tests on monthly data between 1953 and 1972 in the United States, with the stock returns variable being based on a portfolio of common stocks and the inflationary variable being based on the consumer price index. To summarise the results obtained by the regression tests, Nelson (1976: 474) is quoted as writing: "The most striking features of these results is the uniformly negative and generally statistically strong correlation between rates of return and inflation."

Jaffe and Mandelker (1976) state that the relationship between the real interest rate and the inflation rate has been empirically tested with differing results further noting that relatively few studies directly examine the relationship between inflation and returns on risky assets. To address this, Jaffe and Mandelker (1976) used the Lawrence Fisher Index, which represented an equally-weighted portfolio of all of the securities listed on the NYSE as the stock price variable and the consumer price index (CPI) as their measure of the price level for the period 1953 to 1971. Using a regression analysis, in which stocks were defined as either a complete or partial hedge against inflation when the relationship between the variables was positive, i.e. the coefficient of determination was positive, or were shown to be unable to act as a hedge when the relationship was negative, they found a significant negative relationship between inflation and common stock returns. They concluded that the stock market does not act as even a partial hedge against inflation, and that the diminishing effects on real wealth caused by inflation would be compounded by the low returns on the stock market.

These studies, among others, served as the primary motivation for the development of a theory that could explain the significant negative relationship between stock returns and inflation, which eliminated the stock market as an effective hedging option. Fama (1981) attempted to fill this gap in the literature with the development of the Proxy Hypothesis using a similar regression analysis as previously discussed. Working with the hypothesis that the negative relationship between inflation and stock returns can be attributed to proxy effects, specifically that the negative relationship is a direct consequence of the negative relationship between inflation and real activity Fama (1981) conducted a series of empirical assessments. These tests provided evidence of a positive relationship between real stock returns and measures of real activity such as capital expenditures, the average real rate of return of capital and output.

Additionally, they determined consistent evidence of a significant negative relationship between the rate of inflation and these measures of real activity. Fama (1981) states that a detailed examination of the only regression which completely explains the effects on stock returns of expected inflation, that of the regression which includes the base growth rate, revealed that either the regression between real stock returns and either the base growth rate or the expected rate of inflation were spurious. Fama (1981) concluded that both common stocks and bond returns are determined in the real sector and so the proxy effect exists, but that spurious negative relationships between inflation and the expected real rate of returns are then caused by the fact that variations in real money demand in response to variations in real activity have been dealt with by offsetting inflationary variations instead of through growth in the nominal money supply.

The following studies have also attempted to address the issue of a lack of a clear and consistent methodology that measures the relationship between inflation and real equity returns. Due to the extent of the literature it would be impractical to review every study conducted. The studies which are presented below have been selected in order to demonstrate the conflicting views over the period prior to the development of cointegration theory.

3.2.2 Mayya (1977)

The results obtained by Mayya (1977) provided empirical evidence of a negative relationship between inflation and equity returns. Mayya's (1977) methodology did not incorporate the use of models to determine the presence of cointegration, or any statistical models for that matter, but was instead based on observations of the price indices movements for various categories of equities. Equity data was obtained from between 1961 and 1973 from common indices in India, an economy that experienced exceptionally high rates of inflation on aggregate prior to the study. During the period the wholesale price level, which represented the inflation rate, experienced continued increases between 3.7% and 18.3% except during 1968 when it experienced a decline of 1.1%. The average inflation rate over the period was 7.8%. In contrast to this virtually continual inflationary increase, the index value of equity shares rose in only five of the twelve years, while experiencing decreases in the seven remaining years. During the entire period, the average increase in net value was only 0.9%.

Mayya (1977) concluded that there is evidence of an aggregate inability of equity value increases to match the rate of inflation during the period measured and therefore it can be said that equities were unable to provide an effective hedge against inflation. However, in specific years during the period the value of the equities increased by more than the rate of inflation, effectively acting as more than a hedge and actually providing an additional profit on the equity investments. Overall, the equities provided greater returns than the inflation rate in three of the twelve years and partial protection against inflation in another two of the years during the period when the equity values and inflation rate were positively related. However, in the remaining seven years, the relationship became negative and as a result, equities did not even provide a partial hedge against inflation.

Mayya (1977) looked further into the data by sub-dividing the index of all the industries into twenty-six individual sub-groups, such as certain types of textiles, chemical products, electrical appliances and rubber products of which six of the sub-groups provided at least a full hedge against inflation. Ten of the sub-groups experienced value increases during the period, but of a magnitude less than the wholesale rise in the price level, as a result providing a partial hedge against inflation. The remaining ten sub-groups actually experienced a decrease in value during the period which meant that they did not function at all as a hedge against inflation, in fact exacerbating the loss in investor wealth caused by the inflation rate (Mayya, 1977). It is interesting to note that, although on an aggregate level equities were generally ineffective as a hedge against inflation, investment in a specific portfolio of equities would have provided an increase in the value of the equities greater than the inflation rate. They would therefore have provided a full hedge against inflation and in fact have increased the investors’ real wealth.

Mayya (1977) concluded that on aggregate equities have failed to protect investors against the general increase in the price level. The susceptibility of share prices and equity values to bull and bear markets adds an element of risk to the use of equities as a hedge against inflation, which tended to experience a more or less continual increase over time.

3.2.3 Firth (1979)

Firth (1979) used a data set based on the UK market to examine the relationship between equity returns and the inflation rate by testing the simple form of the Fisher Hypothesis. Specifically, this is defined by the author as the theory that expected rates of equity returns are the sum of the real returns on equities and the expected inflation rate and that the real rate of return and the expected rate of inflation are variables that act independently of one another.

The study used the percentage monthly stock market returns as determined by the London Business School as the share price variable and the monthly Index of Retail Prices (IRP), which is determined by using prices from a single day midway through each month and producing a comparison of these points, as the inflationary variable. The Wholesale Price Index was used in addition to the IRP to ensure accuracy and produced nearly identical results. Firth (1979) extended the monthly data set in order to provide an analysis of the data so as to consider the nature of the long-term relationship back until 1935 using the Financial Times Ordinary Share Index. This index is estimated as the equally weighted geometric mean of the returns on thirty major stocks. The annual data was extended back until 1919 using the de Zoete and Bevan Equity Index, which is estimated as the weighted average of the returns on thirty stocks.

Firth (1979) pointed out the potential limitations of using stock indices as the equity return variable which are based on such a limited number of stocks as opposed to an index comprised of all stocks in the market, such as an all-share index, but tested the data set using only thirty share values and found that the results approximated those obtained when using the all share values fairly well. Therefore, the author concluded that the indices based on thirty shares may act as a proxy for a market index which would still produce adequate results.

Firth's (1979) methodology consisted of running a regression of equity returns on the anticipated inflation rate in order to test the Fisher effect. The equation used is specified as follows:

$$R_{mT} = \alpha + \beta I_{AT}$$

where R_{mT} represents the return on the market portfolio during month T and I_{AT} represents the anticipated inflation rate during the same month. If the Fisher effect holds true then β would be expected to be equal to one, in which case equity returns would equal the rate of inflation and so equities would serve as an effective inflationary hedge (Firth, 1979). After running the regression analysis Firth (1979) discovered that, even in the presence of low coefficients of determination for anticipated inflation, the regression coefficients were predominantly positive as predicted by the Fisher Hypothesis and were statistically significant for the overall period. In fact, in every period excluding one, the coefficients assumed a value greater than one, which is indicative of a higher rate of return than the inflation rate, meaning that the specific equity investments included in the study provided a return even greater than would have constituted an effective inflationary hedge. The results are greater than the unitary value required to support the theory of the Fisher Effect and provided a substantial contrast to the results obtained specifically in the United States, on which the Proxy Hypothesis was essentially based in subsequent years. Firth (1979) states, however, that at the time of publication there was no conclusive explanation for this disparity between the results between studies based on British or American data.

3.2.4 Gultekin (1983a)

Gultekin (1983a) used a time series regression model which was estimated by considering three estimates of the inflation rate in order to determine the nature of the relationship between nominal stock returns and the inflation rate. The initial interest in the field that provided the incentive for a study of the nature of the equity return - inflation relationship was sparked by the significant increase in prices since 1973, which led to a renewed interest in the capacity for equities to act as an inflationary hedge (Gultekin, 1983a). The author referred to evidence of a negative relationship between expected inflation and expected equity returns in the United States, provided by Lintner (1975), Oudet (1973), Bodie (1976), Jaffe and Mandelker (1977) and Nelson (1976), which was determined at the same time that a positive relationship was shown to exist between the variables in the United Kingdom. Such evidence would match the theory of the Fisher Hypothesis, based on the evidence provided by Firth (1979). It therefore became necessary to analyse the data available from other countries to obtain a more comprehensive understanding of the relationship.

Gultekin (1983a) obtained estimates of the nature of the relationship between monthly nominal equity returns and the expected inflation rate in 26 countries and found that in general few countries exhibited evidence of a positive relationship. The three estimates of the expected inflation rate used in the regression model included the use of contemporaneous inflation rates as proxies for expected inflation, an ARIMA model that separates the inflation rate into expected and unexpected components and the use of the short-term interest rates as an indication of predicted inflation. The data set considered consisted of international inflationary data in monthly intervals taken from 26 countries between the period 1947 and 1979 which were calculated as percentage price changes in the Consumer Price Indices (CPI) and stock market returns data taken from two sources. The first of these sources was International Finance Statistics (IFS), which reported stock market indices for 26 countries and from the Capital

International Perspective (CIP), which was a Swiss based investment firm which provided stock market indices for share prices listed on multiple stock exchanges.

Gultekin's (1983a) methodology followed the process of testing the generalized Fisher Hypothesis. The generalized Fisher Hypothesis assumes market efficiency and that the expected real equity returns and the expected inflation rate are able to fluctuate independently, meaning that on aggregate investors will be compensated for exogenous adjustments of purchasing power. The model used by Gultekin (1983a) is specified as follows:

$$\hat{\mathrm{R}}_{\alpha} = \alpha + \beta E(\pi | \Phi_{t-1}) + \varepsilon_t$$

where $\hat{\mathrm{R}}_t$ is the nominal return on a stock and π_t represents the expected inflation rate. Φ_{t-1} represents the set of information available to investors when forming their expectations and E is the mathematical expectations operator. ε_t represents the error term. The above regression model allows for the estimation of the expected value of the equity returns as a function of the expected inflation rate and so a β value which statistically approximates a value of one is consistent with the hypothesis that variations in expected nominal equity returns fluctuate on a one-to-one basis with the expected rate of inflation. This means that equities would have the capacity to act as an inflationary hedge. In addition, this value of β which approximates unity is consistent with the assumption that expected equity returns and the expected inflation rate fluctuate independently.

It was determined that a positive relationship between nominal returns on common stock and inflation was inconsistent and that the regression results generally tended to be negative. However, Gultekin (1983a) states that the relationship between equity returns and the inflation rate in most countries was not statistically significant and that the explanatory power of all the regressions was low. The sample period used in this study was the period between 1947 and 1979, and included a sample set of 25 different countries. Of the 25 countries included in the sample, only six of the β estimates are reliably different from zero, and four of these six estimates are negative in nature, the UK and Israel being the only two countries with significant positive β estimates. All of the countries examined excluding the UK were determined to have a β value that was reliably different from one and of these 25 countries 18 exhibited a negative β coefficient. Gultekin (1983a) concluded that the relationship is unstable over time and is inconsistent between countries. The lack of a consistent positive relationship between common stock return and inflation would indicate that the Fisher Hypothesis is not accurate and that for the most part common stock returns do not function as an efficient hedge against inflation according to the time series regression results.

3.2.5 Gultekin (1983b)

A separate study undertaken by Gultekin (1983b) made use of the Livingston Survey of Expectations in order to analyse the pure form of the Fisher Hypothesis as a model, which related expected returns on common stock to the expected inflation rate. This Livingston Survey of Expectations was used to model the relationship between the expected rates of return and the expected inflation rate in order to test the Fisher Effect.

Livingston compiled a data set consisting of data from the Dow Jones Industrial Price Index between 1946 and 1951, after which it was replaced by data from S&P 500 index between 1952 and 1979. The data set was compiled through the use of surveys conducted by Livingston who requested forecasts from over fifty business economists of their price expectations six, twelve and in several of the included years, eighteen months in advance, given by the level of indices including the Consumer Price Index (CPI), the Wholesale Price Index (WPI) and various stock price indices (Gultekin, 1983b). Gultekin (1983b) pointed out the possibility of the occurrence of measurement errors during the data collection process due to the fact that is impossible to determine the exact value of the original stock market index each individual source used when making predictions due to inter-temporal variation, which may have influenced the expectations data collected. As such, Gultekin (1983) employed a methodology which avoided all potential statistical errors by using the raw forecast data instead of Livingston's published summaries and used a forecasting model to resolve any issues that may have stemmed from an undefined base period. Additionally, Gultekin (1983b) only used forecasts taken from the S&P 500 index between 1952 and 1979 in order to ensure the utilisation of a consistent data series.

The results obtained by estimating a regression model using the consensus expectations data during the period showed a strong positive relationship between expected stock returns and expected inflation which Gultekin (1983b) states is consistent with the Fisher Effect in general, but since the β estimates consistently exceed unity the results are not consistent with the simple form of the Fisher Hypothesis, which states that the nominal interest rate should equal the sum of the real interest rate and the expected inflation rate (Gultekin, 1983b). Gultekin (1983b) then extended the model to allow for a time varying real interest rate by running a single cross-section time series regression on the collective individual responses and including a dummy variable in each time period, while assuming a time-independent inflation forecast coefficient.

This extension yielded results for the β coefficient which were indistinguishable from unity, which supports the Fisher Equation even in its simple form by proving the existence of a parallel correlation between expected nominal stock returns and the expected inflation rate. Gultekin (1983b) notes that the expected real returns on stocks is subject to variation over time, but maintains a positive aggregate relationship with inflation. Gultekin (1983b) determined that the Fisher model is more accurate when using *ex-ante* expectations than *ex-post* realizations and that the effect of unanticipated inflation on *ex-post* returns is significantly negative. In conclusion Gultekin (1983b) determined that the expected real return on common stocks is subject to inconsistency over time and is positively related to expected inflation.

3.2.6 Day (1984)

Day (1984) developed a model that was used to measure the relationship between expected real returns and the expected inflation rate by examining the simultaneous response of each variable when exposed to additional unexpected economic information. This unexpected economic information was introduced to the model in the form of a change in the random shock variable of the production process. Day (1984) states that if the change in the random shock variable results in an increase (decrease) in the real rate of return along with a decrease (increase) in the expected rate of inflation a negative relationship is implied between the two dependant variables in the model. Alternatively, if the variables experienced shifts in the same direction a positive relationship between the two variables would exist.

Day's (1984) model was developed in a three-step process. During the initial step Day (1984) developed a model of a basic production economy that included a stock market as well as a government sector. The second step in Day's (1984) process was to derive an asset pricing relationship from the inter-temporal decision faced by a typical investor of whether to consume or to invest in the case of excess wealth. In this section the author showed that the *ex-post* real rate of return is negatively related to the *ex-post* inflation rate. In the third step of Day's (1984) modelling process the author showed that, according to his model, there can be a consistent relationship in the case where investors act rationally between the equity returns- inflation relationship and an equilibrium state of the securities market. Day (1984) effectively extended his model in the third step so that it was able to provide an analysis of the *ex-ante* equity returns - inflation relationship and showed that when the relationship between the variables that is consistent with the equilibrium model of investors that have rational expectations is present, the relationship tended to be negative in nature.

Day (1984) found that the expected rate of inflation varied inversely with the direction of the unanticipated random shock, while the expected real rate of returns varied in the same direction. This implies a negative relationship between the expected rate of inflation and the expected real rate of returns in the model. Day (1984) attributed this negative relationship to the fact that an increase in the significance of a positive shock to the production process would increase the expected real return from investment in the firm. This has a positive effect on the expected supply of goods, resulting in a decline in the expected rate of inflation due to the inverse relationship between the supply of goods relative to the expected money supply. To elaborate, if the supply of goods increased while the money supply remained constant the price of the goods would be expected to decrease, resulting in an aggregate decrease in the rate of inflation. Day's (1984) model illustrated that in a market occupied by rational investors, or more specifically investors with rational expectations, that a negative relationship between inflation and real stock returns is expected during a state of economic equilibrium.

3.2.7 Prabhakaran (1989)

Prabhakaran (1989) states that an economy experiences inflation due to either a cost push or demand-pull mechanism and effectively reduces the purchasing power of all commodities. As such, Prabhakaran (1989) argues that the value of any investment must be determined based on its real rate of return as opposed to its absolute return and investors should be able to reconsider their investment should the rate of inflation surpass the rate of return on the investment. Prabhakaran (1989) follows the work of Mayya (1977), who found that in economies that experienced significant rates of inflation, specifically the Indian economy between 1961 and 1973, equities did not function effectively as an inflationary hedge, and extends the analysis to account for the significant market changes that occurred in the decade following Mayya's (1977) publication. These market changes are attributed by the author to increases in the number of listed securities, traded instruments, annual turnover and the community's awareness regarding equity investment.

Since the boom of the mid 1980's however, the Indian markets experienced a measure of investor reluctance which Prabhakaran (1989) attributed to five primary reasons, including the absence of investment returns from companies in the form of dividends along with delayed annual reports, inefficient administrative procedures in listed companies and thirdly a failure to include a variety of agents in the laws of the stock exchange. The fourth issue highlighted by the author is the fact that banks did not have the capacity to meet the increased workload and finally the fact that investors tended to blame brokers for stock market complications was considered. The aggregate effect on investor sentiment that arose from these issues was negative and it drove away many investors while the market experienced a rapid transformation. Due to the development of the market, along with certain operational improvements, the nature of the equity return - inflation relationship between 1970 and 1986 in India was called back into question, with the intention of suggesting certain improvements in stock market operations as well as to satisfy academic interest (Prabhakaran, 1989).

Prabhakaran (1989), like Mayya (1977) used an Indian data set which included annual averages of index values of wholesale prices for all commodities to represent the inflationary variable in the analysis and price indices of equities from all industries which is termed the variable dividend industrial securities index as the equity return variable. The data set consisted of annual data between 1970 and 1986. Both of these measures were compiled and reported by the Reserve Bank. The inflation variable decreased only in 1975 and maintained a constant level in 1978, otherwise it experienced consistent increases in the remaining years. When the abovementioned years are not included in the analysis the wholesale price variation fell between 1.7 percent and 25 percent with an average annual increase of 9.11 percent, 1.3 percent above the inflationary figures reported by Mayya (1977).

Equity prices on the other hand experienced decreases in four of the years included in the data set and price increases in the remaining years. The equity price average annual increase was 9.8 percent when the negative years were excluded from the analysis. The positive range of equity price increases fell between 1.4 percent and 63 percent, which occurred during the boom of 1985. As such the average annual rate of equity growth was greater than the average annual wholesale price increase. However, should the abnormal data obtained during the boom be removed the average annual equity growth would have been significantly lower than the inflation rate, equalling only six percent.

In conclusion, Prabhakaran (1989) states that between 1970 and 1986 equities provided either a partial hedge or no hedge against inflation in 9 out of the 15 years and when the data from the abnormal boom year is removed equity returns were on average significantly less than the rate of inflation in India. Even should this abnormal boom data be included equity prices only slightly surpassed the rate of inflation and would on average have acted as a hedge, although by a very slight margin. Because the equity prices exhibited an increase in 11 out of 15 years as opposed to the results shown by Mayya (1977), in which they exhibited an increase in only

5 of 12 years, the authors concluded that the likelihood of a rise in equity prices has increased during the time period between the studies with the development of the market and so would have provided a hedge against inflation in 6 of the 15 years included in Prabhakaran's (1989) study. The conclusion however remains the same as that of Mayya's (1977) conclusion, being that on aggregate equities are generally unable to provide an effective hedge against inflation.

3.2.8 Claude, Campbell and Viskanta (1995)

This study focuses on expanding the scope of studies of this nature to a significant number of countries in contrast to most studies that had, up until this point in time, focused primarily on the equity returns - inflation relationship in the United States of America (USA) and the United Kingdom (UK) (Claude *et al.* 1995). The authors provide an analysis of the relationships between inflation, expected equity returns and risk in a data set that includes 41 developing economies and found that the evidence supports the findings of Fama (1981), Gultekin (1983a) and Lee (1992) who discovered that a negative relationship existed between equity returns and inflation. Claude *et al*. (1995) used a cross-sectional regression analysis to investigate the long-term relationship between inflation and 'long-horizon' returns on equities and found that a positive relationship between the two variables did not exist, contrary to previous evidence, which suggests that investment in international equities fails to provide a hedge against inflation even when considered over the long-term.

The data set used by Claude *et al*. (1995) included the total return indices from Morgan Stanley Capital International (MSCI) for 21 countries and the total return indices from the International Finance Corporation (IFC) for 20 countries. These indices were constructed as value-weighted portfolios which were based on sets of stocks that were regularly traded in each market. As the inflationary variable the authors used the Consumer Price Index as reported by the International Finance Statistics database formulated by the International Monetary Fund (IMF). The time frame covered by the data set was dependent on the availability of the data which determined the starting point for each country, but included data for each variable up until the end of 1993. When analysing the time series data obtained during the study, Claude *et al*. (1995) focused on the responsiveness of returns on equities to changes in the inflation rate and found that when using a one-month time horizon out of the 41 countries examined the coefficient was negative for 30 of the countries.

When considering the 21 developed markets included in the study, 16 showed evidence of a negative coefficient while the countries which exhibited a positive coefficient tended to be high inflation emerging market countries including Argentina and Brazil (Claude *et al.*, 1995). Claude *et al*. (1995) conducted an analysis of the serial correlation of inflation rates which provided evidence of a negative serial correlation over one, six- and twelve-month time periods in 29 out of the 41 countries with a negative median coefficient of -0.9 in the 21 developed markets and -1.2 in the 20 emerging markets which lends support to the arguments against the Fisher Hypothesis. The results obtained by the authors failed to show a parallel relationship between nominal asset returns and inflation and they therefore state that according to their results which are from the perspective of a local currency, equities are unable to provide a consistent hedge against local inflation.

The authors conclude that their analysis of the interaction between inflation and the time series of expected returns in the sample markets yielded evidence of a negative time series relationship between realized inflation and realized asset returns when countries were individually examined (Claude *et al*., 1995). Based on this finding, the authors concluded that when countries are individually examined equity returns do not act as an effective hedge against inflation.

3.3 The Transition to the Application of Cointegration Techniques

Alongside the development of cointegration techniques, research into the equity returns-inflation relationship shifted to the use of these methods in their analyses. Such studies typically used the Engle Granger method, as developed by Engle and Granger in 1987 or Johansen's methodology which was developed in 1996. Since then, cointegration techniques themselves have developed extensively to account for factors such as threshold effects based on regimes, and the possibility of asymmetric adjustment. Such models in this latter category include the Two-Regime Threshold Vector Error Correction Model (TVECM) developed by Seo (2006), as well as the Autoregressive Distributed Lag Model ARDL, originally developed by Pesaran, Shin and Smith (2001). Extensions to the original ARDL include the Non-linear ARDL (NARDL) developed by Shin, Yu and Greenwood-Nimmo (2014). Several of these models have been applied within the context of the analysis of the equity returns-inflation relationship and are discussed in the following section (which also included a coverage of previous South African literature on this subject).

The cointegration methods applied in these later chapters are discussed in the individual research papers in greater detail, while the sub-sections of this chapter describe the specific models applicable to literature reviewed. The chronological review of the literature is continued, with the emphasis on studies that have used cointegration based methodologies. It is interesting to note the changes in the magnitude of the β coefficients from the predominantly negative empirical findings prior to the use of cointegration techniques, to the generally positive findings afterwards.

3.3.1 Ely and Robinson (1997)

Ely and Robinson (1997) used Vector Error Correction Models (VECM) and modern revisions of cointegration theory with international data samples to examine the relationship between share values and the inflation rate. The authors note that an important attribute of VECMs is that they are able to include the variables that partly determine the nature of the equity returns-inflation relationship, specifically the real output and money supply variables. Ely and Robinson (1997) state that the VECM is able to model the long-term relationship between equity returns and inflation by using error-correction terms to impose any long-run equilibrium conditions between the variables on the system using the results from the cointegration tests. They also used the impulse-response function of the VECM to examine the responses of share and goods prices to changes in the money supply and real output which provided a means to test if stocks are able to maintain their value compared to fluctuations in the goods price. Additionally, this provided a means to test if the hedging capacity of stocks differs if the inflationary shock is dependent on real or monetary factors. Ely and Robinson (1997) pointed out that an important factor that may influence the nature of the inflation-equity returns relationship is the source of the inflationary shock.

The authors used the consumer price index (CPI), producer price index (PPI) and the gross domestic product (GDP) deflator as measures of goods prices within the context of the study. The data set used was in quarterly data during the period between 1957 and 1992 for 16 countries around the world but excluded any African countries. Ely and Robinson (1997) state that because stocks represent claims on real assets they should function as a hedge against inflation which would be consistent with the Fisher Hypothesis. However, they state that much of the empirical evidence historically observed suggests that a negative relationship exists between the two variables when using models that fail to account for a long-run relationship between the prices of stocks and goods. The empirical evidence section of this paper is split into three subsections, the first of which is concerned with unit root testing, the second with cointegration testing and the third with monetary versus nonmonetary sources of inflation. Ely and Robinson (1997) used the Augmented Dickey Fuller Test (ADF) to determine the order of integration of the variables included in the empirical analysis and used the results from an additional test for stationarity in case of the possibility that the ADF test suffered from low power. The additional test used was the KPSS test, which specifies as its null hypothesis that the variable in question is stationary. The common trend between the two tests was the rejection of the KPSS null hypothesis of stationarity and the failure by the ADF test to reject the unit root - generally providing evidence of stationary data (Ely and Robinson, 1997).

Subsequent to the determination of stationarity Ely and Robinson (1997) conducted an analysis of the long-run relationship between the variables included within the framework of the study; these being: stock price, goods price, output and money supply. Additionally, the authors aimed to determine whether cointegration between the variables was present. Several measures were employed in order to improve on the significance of the results for the goods price variable. Two of these measures were used for the output variable, an index of industrial production as well as real GDP, and two for the money supply variable, a narrow monetary aggregate as well as a broad monetary aggregate. The model used in the study was of the same form as that put forward by Johansen and Juselius (1990) which was arranged in an unrestricted error-correction format, of the form:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \cdots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \varepsilon_t$$

in which the rank of Π, which is known as the $(p \ \times p)$ parameter matrix that characterizes the long-run relationship between the $(p \ \times 1)$ vector of the X variables, gives the number of cointegrating vectors in the system (Ely and Robinson, 1997). The null hypothesis used in the modelling process was the hypothesis that the variables are not cointegrated, which could be rejected if the test statistics exceed asymptotic critical values as described in Johansen and Juselius (1990).

Ely and Robinson (1997) rejected the classical notion that a parallel relationship existed between movements in the stock price and goods prices, but note that in the long-run there is evidence that stocks do in fact generally maintain their value relative to the price of goods following external inflationary shocks. As such, stocks were shown to have the capacity to provide an effective long-run hedge against inflation. Ely and Robinson (1997) state that with a few exceptions stocks did offer long-run protection against inflation by maintaining their value subsequent to both real and monetary shocks. These exceptions tend to be single quarter exceptions which occurred soon after the real or monetary shock in most countries except for the US, in which stocks failed to maintain their value relative to the goods price subsequent to real output shocks.

3.3.2 Khil and Lee (2000)

Khil and Lee (2000) conducted a study using data from 10 Pacific Rim countries and the United States intended to identify the nature of the relationship between real stock returns and the rate of inflation. The countries included in this data set were selected as the authors identified a lack of studies of this nature that explored the relationship in emerging Asian economies. As such the 10 Pacific Rim countries included in the sample were primarily comprised of Asian countries which experienced a wide range of inflation rates. The authors noted that it was becoming increasingly important to understand financial markets in Asian countries, especially since the effects on the US economy of the financial crises in a number of Asian countries during 1997 (Khil and Lee, 2000). Khil and Lee (2000: 460) summarised their reasoning for the use of Asian countries as their sample set by stating that "Asian countries' diverse experiences should provide us with a natural laboratory for experimenting with different hypotheses about the stock return-inflation relation and with a better understanding of the forces that influence it."

Khil and Lee (2000) used data over a shorter period than most comparable studies, partly due to the shortage of reliable, long time-series data in the sample countries with regards to stock returns and other important financial variables. Khil and Lee (2000) collected nominal stock returns (and prices) data, which included dividends when they were available. If only share prices were available the authors used the first differences in the log of the stock prices which were not inclusive of dividends in order to measure stock price returns. It was noted in this study that because dividend yields tend to be very small in most Asian countries that the measure of stock prices when dividends were not available should not significantly impact the results. The authors found that out of the countries included in the study that only Malaysia exhibited a positive relationship between stock returns and inflation during the period, while the others showed a negative relationship. In light of this finding the authors developed an empirical framework which attempted to uncover the reasons for the positive and negative relationships and to test whether the observed relationship between equity returns and the inflation rate can be explained by any of the earlier proposed hypotheses in order to help explain the observed nature of the relationship in the US and to help understand why Asian countries typically experience such highly variable inflation rates.

The empirical methodology used by Khil and Lee (2000) followed the theoretical framework proposed by Marshall (1992) which shows that the equity returns - inflation relationship is primarily driven by real (output) shocks and monetary shocks. The model proposed by Marshall is essentially an equilibrium model which incorporates assets in the form of money, bonds and equities where money does not enter the utility function but rather reduces the costs of consumption transactions under the equilibrium framework. The model, which was derived by solving the representative agent's problem (utility maximization under a budget constraint), represents the excess return on an asset i using a single beta (β^m)

The authors state that when changes in inflation are primarily caused by output shocks, an unexpected increase in output has a negative effect on inflation and ultimately increases the chance that β^m will be negative. In contrast, when changes in inflation are primarily caused by monetary shocks β^m is more likely to be positive. This means that real output shocks would contribute negatively to the equity return - inflation relationship while monetary shocks would contribute positively to the relationship. These relationships are justified by the authors, who summarised the implications of the model as a negative correlation between expected asset returns and expected inflation alongside the prediction of a more significantly negative relationship between asset returns and inflation when the source of in inflation is attributed to a change in real economic activity in comparison to monetary fluctuations (Khil and Lee, 2000).

The results of this study showed that out of the 11 sample countries, 10 of the countries exhibited a negative equity return - inflation relationship which obviously provides evidence in contrast to the predictions of the Fisher Hypothesis during the sample period, which was between 1970 and 1997. These 10 countries included Australia, Hong Kong, Indonesia, Japan, South Korea, The Philippines, Singapore, Taiwan, Thailand and the United States. The only country that exhibited a positive equity return - inflation relationship during the period was Malaysia. Khil and Lee (2000) also found that out of the 11 countries, the equity return - inflation relationship could be explained by real and monetary disturbances in nine of the countries and that the relationships predicted by the model were typically consistent with the empirical evidence. The first of these findings is more important within the context of this study, as the evidence of a negative relationship between equity returns and the rate of inflation indicated that equities were ineffective as a hedge against inflation in the sample countries during the period.

3.3.3 Moolman and du Toit (2005)

In 2005 Moolman and du Toit conducted a study that analysed the relationship between share prices and a variety of economic factors which was focused on the development of a structural model of the South African stock market using cointegration techniques and error correction modelling. The purpose of the study was to identify the extent to which various macroeconomic variables influence the stock market.

Moolman and du Toit (2005) state that the stock market is generally regarded as an important indicator of economic activity as it is based on the expectations of investors with regards to future economic conditions. The long-term and short-term stock market behaviours were individually modelled, using a cointegration equation and the error correction model respectively. Quarterly data between 1978 and 2000 for the following variables was used: JSE overall index (JSE), the Gross Domestic Product at current prices (GDP), a discount rate constructed from the economy's risk-free rate; the expected rate of inflation and a risk premium. Additional variables included the Gold Price, the S&P 500 Index prices, the Rand/US$ exchange rate, the short-term interest rate and a risk premium which the authors defined as the difference between the long-term interest rate in South Africa and the United States (Moolman and du Toit, 2005).

Initially Moolman and du Toit (2005) found that in all cases variables were integrated of the first order, or $I(1)$, as expected according to economic theory, using the ADF and PP tests. Moolman and du Toit (2005) state that stock prices are a function of dividends and the discount rate in the constant growth model, although it must be tested empirically whether such models hold in South Africa. The authors proceeded to execute a Johansen cointegration analysis in order to determine the extent to which each variable affects the long-term level of the stock market. Following this step, they constructed an Error Correction Model (ECM) aimed at capturing the short-term stock market variation. Both the trace tests and maximum eigenvalue tests were able to reject the null hypothesis and confirmed the existence of a single cointegrating vector, confirming that a cointegrating relationship existed between the variables. The results of the cointegration analysis are briefly summarised in Table 1 below, although it is interesting to point out that a significant positive relationship exists between stock market returns and GDP, which would function as an indicator of economic activity. This finding is consistent with the theoretical underpinnings of Fama's (1981) Proxy Hypothesis.

Moolman and du Toit (2005) discovered that the long-term value of stock in the South African market is typically consistent with the present value model, indicating that it is determined by fundamental variables in the long-term. Additionally, it was found that the JSE experiences a reaction to variations in international stock markets, although these changes are temporary. The model also evaluated the relationships between the stock market and several macroeconomic variables and discovered that the long-term share price level is determined by discounted expected future dividends and that short-term fluctuations occur as a result of variations in the short-term interest rates, the R/US$ exchange rate, the S&P 500 Index, the gold price and a risk premium. It is interesting to note that although the rate of inflation was not included as a macroeconomic variable, inflation has a direct effect on the real interest rate, the value of gold in real terms and the real value of expected future dividends. The discovery that these factors have a direct effect on share values lends to support to Fama's (1981) theory that the relationship between stock prices and inflation is based on proxy variables.

Table 1: The Error Correction Model Results obtained by Moolman and du Toit (2005).

Dependent variable: Δlog(JSE) **Method: Least squares**				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**p-value**
$\Delta Log(JSE_{t-1})$	0.262	0.067	3.922	0.000
$Residual_{t-1}$	−0.163	0.050	−3.230	0.002
ΔLOG(Gold)	0.250	0.091	2.759	0.007
ΔLOG(SP500)	0.856	0.103	8.321	0.000
ΔRP	−0.045	0.009	−4.834	0.000
ΔRP_{t-1}	0.042	0.010	4.439	0.000
$\Delta Log(R\$_{t-1})$	0.343	0.093	3.711	0.000
Constant	0.001	0.018	0.058	0.954
$\Delta Log(R_{S\ t-1})$	−0.023	0.007	−3.062	0.003
DUM00	−0.124	0.017	−7.509	0.000
DUM94	0.060	0.028	2.121	0.037
R^2 Adjusted R^2 S.E. of regression	0.63 0.58 0.06	F-statistic Prob(F-statistic)		13.54 0.000

Source: Moolman and du Toit (2005)

3.3.4 Kasman, Kasman and Turgutlu (2006)

Kasman *et al*. (2006) took a different approach to testing for a relationship between stock returns and inflation. The authors argued that, because standard cointegration analysis assumes that the variables are integrated of order one $I(1)$, the error correction term is restricted to an $I(0)$ process, which they believed was inconsistent and could explain the lack of an established relationship between stock returns and inflation in previous literature. Kasman *et al.* (2006) believed this may be due to a slower response time of the error-correction term than is assumed in standard cointegration analysis, causing equilibrium errors to behave as fractionally integrated series which would exhibit a slow rate of mean reversion. This would mean that deviations from the equilibrium would tend to be overly persistent and therefore that the error correction term would not necessarily need to be stationary at $I(0)$. If the error-correction term is then seen to be fractionally integrated a fractional cointegration relationship would be present between nominal interest rates and inflation, which would support the Fisher Hypothesis. As such, the paper by Kasman *et al.* (2006) used a fractional cointegration approach to test the relationship between the two variables to allow the error term in the cointegrating regression to be fractionally integrated instead of stationary, represented by the term $I(d)$ instead of $I(0)$.

That is, Kasman *et al.* (2006) extended the general autoregressive integrated moving average (ARIMA) model into an autoregressive fractionally integrated moving average (ARFIMA) process which differs from the standard ARIMA process in that it has a long memory and allows the series to deviate from the mean for long periods.

The data set used by Kasman *et al*. (2006) was in the form of monthly data from 1957 to 2004 With the inflation rate in each country represented by the Consumer Price Index (CPI) and the interest rate variable represented by T-Bill rates. The sample included thirty-three countries, twelve of which were developed countries.

In order to test the Fisher Hypothesis Kasman *et al*. (2006) initially performed the Engle-Granger test for cointegration following which they permitted a fractional differencing parameter which effectively led to the fractional cointegration analysis. The existence of fractional cointegration would imply that the system of economic time series would be able to experience a random walk from the equilibrium for longer time periods and eventually return to the equilibrium level.

The test for fractional cointegration was then conducted following the determination that the variables were integrated of order 1, $I(1)$, using ADF and KPSS tests. The fractional cointegration test initially involved the estimation of the Fisher equation with ordinary least squares after which the residual series was used in order to estimate the differencing parameter, referred to as the spectral regression. The Engle-Granger two-step test was then run to compare the results of the fractional cointegration test with the results of the conventional cointegration test in order to test for the possibility of a long-run relationship between the inflation rate and the interest rate; and it was determined that cointegration between the inflation rate and the interest rate did not hold for most countries in the sample when using conventional cointegration tests (Kasman *et al*., 2006).

It was found that cointegration between nominal interest rates and inflation did not exist in most of the countries examined (only five were cointegrated); however, when fractional integration was allowed it was found that the error term was stationary in the majority of the sample countries and that the residuals were fractionally integrated in all but five of the sample countries (Kasman *et al*., 2006).

The authors state that there was ample evidence that the residuals of the cointegrating regression were stationary or mean reverting, indicating the existence of a stable long-run relationship between nominal interest rates and the rate of inflation, which lends support to the validity of the Fisher Hypothesis and showed that deviations from the long-run equilibrium relationship between nominal interest rates and inflation can take a long time to be corrected (Kasman *et al*., 2006). The evidence, which supported the Fisher Hypothesis in the study, indicated that the cointegrating parameter was either lower than one but different from zero, the partial Fisher effect, or that it did not significantly differ from unity, the full Fisher effect (Kasman *et al.*, 2006). When the partial Fisher effect occurs equity returns tend to act as a partial hedge against inflation, while in the presence of the full Fisher effect equity returns generally provide a full hedge against inflation. Therefore, this study advocated the use of equities as an effective hedge against inflation.

3.3.5 Hancocks (2010)

Hancocks (2010) conducted a similar study to the study by Moolman and du Toit (2005) in which a multivariate analysis was conducted in order to determine the magnitude of the effects on the All-Share, Financial, Mining and Retail sectors of the JSE by a series of macroeconomic variables. The sample period ranged between 1996 and 2008. In order to analyse the various relationships, the author employed Johansen's approach to test for cointegration between the macroeconomic variables and the stock price index in question. The Vector Error Correction

Model (VECM) was used to establish the magnitude of the effects of each cointegrating vector and to determine the speed of adjustment coefficients in each case. The author hypothesized that the different macroeconomic variables would have varying effects on each particular index, and used the example that a change in interest rates would be more likely to have more of an impact on the retail and financial indices than on the resources sector, while a change in the Rand/US$ exchange rate would have the opposite effects.

The macroeconomic variables included in this study, for which the relationship with the All Share Index were analysed are listed as follows: money supply, the Rand/US$ exchange rate, long and short-term interest rates and finally inflation. The most applicable of these relationships to the analysis of the capacity for equities to act as a hedge against inflation is the relationship between the inflation rate and the All Share Index. In the study by Hancocks (2010) inflation was measured by the 12-month rate of change in consumer prices between 07-1995 and 11-2008, using the Consumer Price Index (CPI). Hancocks (2010) notes that between 1995 and 2001 inflation in South Africa exhibited a consistent downward trend until the onset of the US global economic crisis and terror attacks. Post 2001 the inflation rate exhibited a sharp increase due to rising oil prices and a decline in the Rand/US$ exchange rate, which was caused by decreases in foreign investment as a result of increased risks of global economic instability. Following this inflationary spike, the Rand/US$ exchange rate proceeded to strengthen considerably and when combined with the adoption of an inflation targeting framework, resulted in a decline in inflation and stabilised the rate of inflation until mid-2007. At this point inflation rose to well above the 6% inflationary target band, an increase Hancocks (2010) attributes to increasing global inflationary pressures and rising global oil and food prices. This last paragraph highlights the relative volatility of the South African inflation rate and its vulnerability to international economic shocks.

Hancocks (2010) hypothesized that the relationship between inflation and stock returns is dependent on the current level of inflation in the South African economy. The author states that the relationship may exhibit contradictory movements, where in some cases stock returns increase alongside inflation and in others experiences a decrease when inflation increases simultaneously. This finding is explained by stating that if the inflation rate is within the target band and a rise in the money supply resulted in an increase in rate of inflation, but it remained within the target band, an increase in stock returns would occur as interest rates would not be adjusted by the Reserve Bank – leading to increases in stock prices caused by the increase in aggregate demand. On the other hand, should the inflation rate exceed the target band, interest rates would be adjusted in order to reduce inflation to target levels leading to a decrease in share prices (Hancocks, 2010).

Using a standard Johansen's approach to test for cointegration, Hancocks (2010) began by establishing the order of integration of the series. The Johansen's procedure found evidence of the existence of cointegration, due to the potential for the presence of multiple cointegrating vectors. Finding the presence of cointegrating vectors, the Vector Error Correction Model (VECM) was estimated, which allows for the restriction of the long-run behaviour of the endogenous variables in order to allow for convergence on their cointegrating relationships, while measuring the short-run adjustments that occur within the system. Following the VECM test the author conducted impulse response tests, which describe the effect shocks to a variable would have on the variables in a system. Finally, a variance decomposition test shows the effect of each variable on the other variables included in the model.

The ADF and KPSS tests indicating that the variables were integrated of the first order, $I(1)$. In this particular study it was found that the various information criterion indicated the use of different and conflicting lag lengths as being optimal. Hancocks (2010) used the criterion starting from the smallest selected lag order and sequentially increased the lags until cointegration was found with serially uncorrelated residuals. In this case the optimal VAR lag order was found to be 4 lags. Evidence was discovered to support at least one cointegrating relationship between the variables. The VECM results indicated that the money supply and the exchange rate variables had a positive and significant relationship with the All Share Index.

Hancocks (2010) discovered a negative and significant relationship between inflation and the All Share Index and the financial sector index; however, it was discovered that the relationship between inflation and the retail sector was positive. It should be noted at this point that the inflation coefficient was -9.819778, indicating that the relationship between inflation and the All Share Index would be nearly 1:10. This indicates that for a 1% increase in inflation, the All Share Index would decrease by 10%, a level that does not seem possible in reality. For example, should an exogenous shock occur that increases inflation by 3%, a shift that has not been uncommon in the last 30 years in South Africa considering its inflationary volatility, stock returns would decrease by a marked 30%. This relationship therefore seems to be far too high to occur in reality, especially considering that the majority of other studies have determined results between 0 and 2.5% in the extreme case, for a wide range of countries (Alagidede and Panagiotidis, 2010). The error correction term indicated efficient adjustment of the All Share

Index, of 14.4% per year towards the long-run-equilibrium. The findings of the negative relationship over the period between inflation and the All Share Index are consistent with the theory of the Proxy Hypothesis, in that inflation decreases asset prices, although as previously noted, the relationship determined in the study exceeds expectations by too great a factor to be consistent with the previous literature.

3.3.6 Alagidede and Panagiotidis (2010)

Alagidede and Panagiotidis (2010) provided an analysis of the capacity of African stock markets to provide investors with a hedge against inflation. The study included a sample of six African countries, consisting of South Africa, Kenya, Morocco, Nigeria, Tunisia and Egypt and focused on two key areas; the first being the relative applicability of the Fisher Hypothesis in African stock markets as the author's note that African countries continue to become more important to foreign investors as a means to diversify their portfolios. Secondly, the study focused on comparing high inflation countries in Africa that have adopted an inflation targeting regime.

The authors applied Johansen's multivariate method to investigate the long-run relationship between stock prices and goods prices. The stock price variable was represented by a stock price index in each country, while the goods price variable was represented by each country's consumer price index. The system of endogenous variables was then parameterized on a Vector Error Correction Model (VECM), specified as:

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

Where:

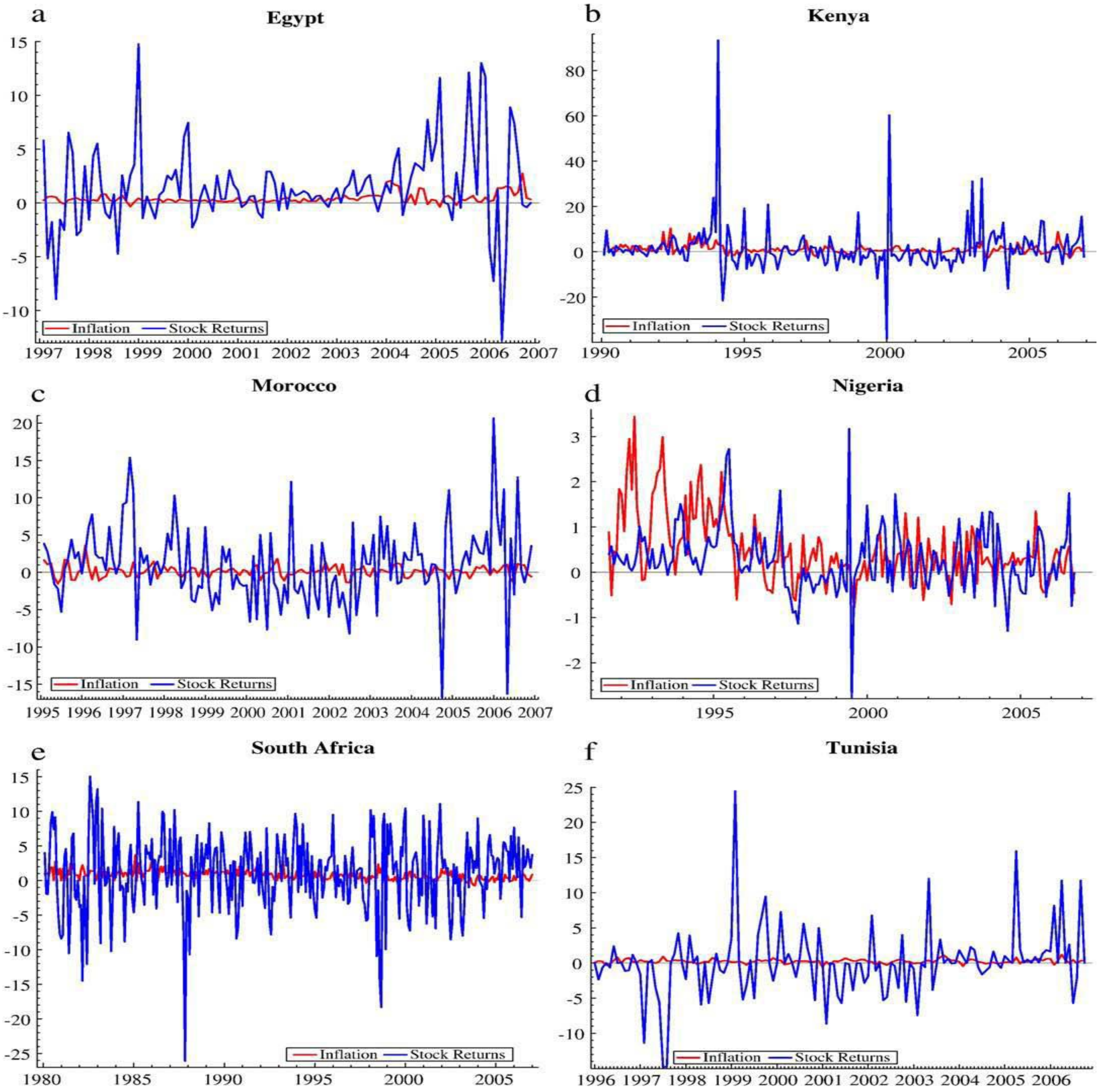
- $y_t = (S_t, P_t)'$ collects the observations of stock and goods prices from each country,
- μ is a (2×1) vector of intercepts
- Γ and Π are (2×2)coefficient matrices.

The test for cointegration considered the rank of the Π by accounting for the number of its non-zero eigenvalues. The number of non-zero eigenvalues specified the number of cointegrating vectors among the variables and were tested for using a trace statistic.

The data set used was based on monthly stock price indices taken from the countries mentioned earlier, with the goods price variable being based on Consumer Price Index (CPI) for each of the countries. Alagidede and Panagiotidis (2010) state that the CPI is the most frequently used indicator of inflation and effectively represents the change in the price of a fixed basket of goods and services. The share price data was sourced from the International Finance Statistics and was based on the various All Share indices in South Africa, Nigeria and Kenya and the indices for the remaining countries were based on the most actively traded stocks in the countries. Monthly data over a period of 10-27 years was used because of the fact that annual data series that cover a sufficiently long period of time were simply unavailable for the sample countries. These monthly intervals were calculated using the individual consumer price indices and stock returns. The average monthly rate of inflation assumed values between 0.16% to 0.81% during the sample period, while average monthly stock returns were between 0.98% and 1.1%. A graph included by the authors is reproduced below (Figure 1) in order to emphasize the highly volatile nature of stock returns as well as inflation in African countries relative to the rates typically experienced in most European countries. The graph showing the monthly average stock returns in South Africa over the period is especially worthy of interest as it shows substantial stock returns volatility when measured using the standard deviation of stock returns.

Alagidede and Panagiotidis (2010) emphasized that there are a significant number of recent studies that reflect poor performance of the stock markets during inflationary periods. Alagidede and Panagiotidis (2010) also pointed out that several of these studies have shown that common stocks perform poorly as a hedge against inflation in the cases of both expected and unexpected inflation. The authors began by estimating the short-term relationship between inflation and stock returns using a simple regression of stock returns on contemporaneous inflation and found that in five of the countries included in the sample there was a positive relationship between stock returns and inflation in contrast to the international data previously observed. However, the generalized Fisher Hypothesis where the β is theoretically equal to one was rejected by the Wald test in the case of five of the countries, showing that according to a regression analysis stocks did not function as an inflationary hedge, although it was noted that the model did not fit the data well based on the observation of low R^2 values (Alagidede and Panagiotidis, 2010).

Figure 1: Inflation Rate and Stock Returns between 1990 and 2007.



Source: Alagidede and Panagiotidis (2010: 94)

The authors then conduct an analysis of the long-run relationship between the variables in which they began by testing for the order of integration and stationarity of the two series. To do this they used two-unit root tests, the Phillips-Perron (PP) and Breitung nonparametric test which tests for the null of a unit root and the KPSS stationarity test which tests for the null of stationarity (Alagidede and Panagiotidis, 2010). The results of the unit root tests indicated that for all of the sample countries (with the exception of Morocco which was consequently excluded) there was at least one unit root.

Subsequently, the authors conducted the Johansen's test in order to test for the presence of cointegration. Four countries showed evidence of one cointegrating vector, including Egypt, Kenya, Nigeria and Tunisia, while South Africa showed evidence of two cointegrating vectors when using Johansen's trace test. They then employed the Breitung and Taylor (2003) test to examine potential deviations from linearity. The Breitung and Taylor nonparametric test showed that only in the case of South Africa cointegration was not rejected. The authors found that the sign of the estimated coefficient was positive and significant in South Africa as well as in several of the other sample countries, but only exceeded unity in South Africa with a value of 2.264. The lower Fisher coefficients for Nigeria, Egypt, Tunisia and Kenya (less than unity) failed to provide evidence in support of the tax-augmented Fisher Hypothesis in these countries, and as such it can be argued that aggregate investment in these markets would only have provided, at best, a partial hedge against inflation.

The Fisher coefficient in South Africa indicated a positive long-run relationship between the variables and the authors provided several reasons why this might have been the case, including the fact that over the period of this study South Africa typically maintained relatively low inflation rates, the market underwent a significant amount of development since the apartheid era after South Africa was once again included in the international community and there were a significant amount of capital inflows subsequent to the lifting of sanctions which would have had a positive effect on equity values. The authors state that although they did not possess a consistent estimate of the tax rate in South Africa, which would be necessary to determine whether investors are fully compensated for taxes as well as inflation as is conditional in the tax-augmented version of the Fisher Hypothesis, that their findings were consistent with the tax-augmented version of the Fisher Hypothesis due to the finding of unit elasticity. They are able to make this conclusion because stock returns in fact exceeded the inflation rate during the sample period, which would theoretically compensate for the loss in real wealth incurred by taxes (Alagidede and Panagiotidis, 2010).

3.3.7 Kim and Ryoo (2011)

In a long-term study done using a data set beginning in the 1900's and ending in 2009 in the United States, Kim and Ryoo (2011) used a two-regime threshold vector error correction model (TVECM) to test for cointegration. This test used the TVECM to allow for asymmetric adjustments of stock return and expected inflation towards the long-run equilibrium which distinguished the results from those of past studies. The need to incorporate asymmetric adjustments between stock return and inflation stems from the independent findings of recent studies (Barnes *et al.*, 1999; Kim, 2003) which ultimately provide a compelling argument for the use of the TVECM model as opposed to the Vector Error Correction Model (VECM) as has been commonly used in previous studies of a similar nature

Kim and Ryoo (2011) used the TVECM to test for the condition of unity of the long-run elasticity between the stock price and the goods price in order to determine whether equities can effectively act as a hedge against inflation. The authors note that this condition of unity stems from the Fisher Hypothesis in which a change in the nominal return on stock occurs subsequently to a change in the expected rate of inflation. The study conducted by Kim and Ryoo (2011) used the TVECM in order to allow for asymmetric adjustment of both the stock return and expected inflation variables toward their long-run equilibrium levels in order to address the disparity in the results obtained by past studies which have failed to account for asymmetric adjustment. The directions of the asymmetric adjustments towards the long-run equilibrium were dependent on whether stocks were overpriced or underpriced relative to the price of goods (Kim and Ryoo, 2011).

The model used in this study was based on Seo's (2006) test for cointegration in which the TVECM was used to test a null hypothesis of linear no cointegration against an alternative hypothesis of threshold cointegration. This test was therefore an extension of common tests for cointegration which were typically limited to testing for an alternative hypothesis of linear cointegration. The TVECM model used in the study by Kim and Ryoo (2011) was specified as:

$$\Phi(L)\text{-}\Delta X_t = \alpha_1 Z_{t-1} I(Z_{t-1} \leq \gamma) + \alpha_2 Z_{t-1} I(Z_{t-1} > \gamma) + \mu + \varepsilon_t$$

where:

- $\Phi(L)$ is the lag of polynomial of order p;
- ΔX_t is the first difference of X_t (Vector of the stock return and inflation);
- α_1 and α_2 are the vectors of speed of adjustment coefficients; $I(\bullet)$ is an indicator function which takes the value 1 if the condition inside the brackets is satisfied
- ε_t is a vector of i.i.d. error terms
- Z_t takes the place of S_t - P_t, which represents the deviation from the long-run equilibrium while γ is its long-run mean. (S_t is the log of the stock price, while P_t is the log of the goods price).

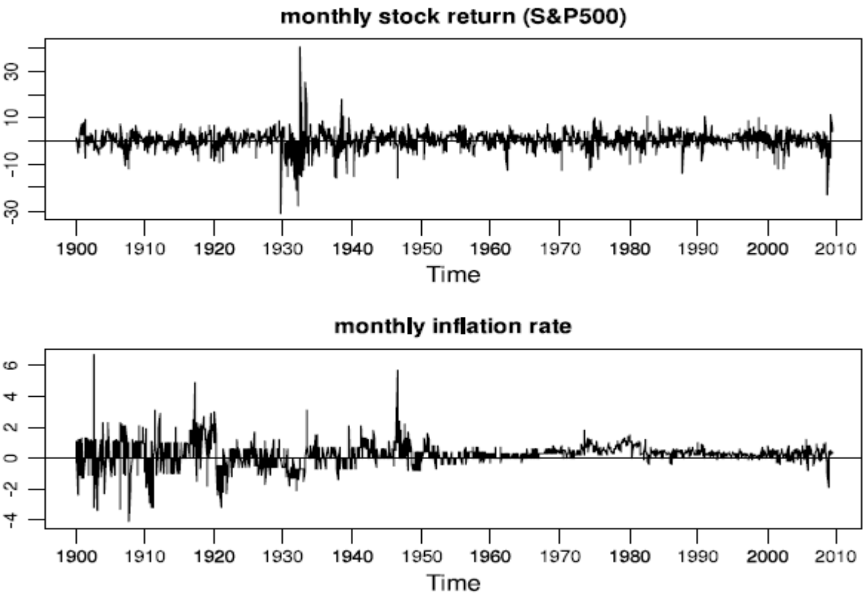
In the above model there are two possible regimes represented by the terms in the brackets. In Regime 1 where $(Z_{t-1} \leq \gamma)$ stocks are underpriced relative to goods and in Regime 2 where $(Z_{t-1} > \gamma)$ stocks are overpriced relative to goods.

Kim and Ryoo (2011) conducted the test for a long-run relationship between the stocks and goods price using moving subsample windows, using monthly data between 1900 and 2009 in the United States. The stock price data was sourced from the S&P 500 and the Dow-Jones Industrial (DJI) indices while the Consumer Price Index (CPI) was used as the inflationary variable. Graphs of the S&P 500 stock return and the Consumer Price Index during the sample period are replicated below (Figure 2) in order to provide a comparison of the volatility of the variables in the United States and those published by Alagidede and Panagiotidis (2010) in Figure 2.

The authors make an important note in that they refuse to distinguish between actual and expected inflation in the context of the study and use actual goods prices as a proxy for expected goods price, which they based on the findings of Madsen (2007) who determined that the testing outcomes in such a context can be biased when incorporating model-based expected inflation values. The moving subsample windows of 30 years were used because the authors have found that this period length ensures that the results are stable, which is consistent with the sample size requirement for this test as specified by Seo (2006). The authors used the ADF test when the moving subsample window covered a period of 30 years, and found that in most cases the time series are integrated of order one, showing that should a standard linear regression test be employed that the long-run relationship between the goods price and the stock's price would be spurious.

The results of the study indicated that the null hypothesis of no linear cointegration was in all cases rejected in favour of the alternate hypothesis of threshold cointegration at the 10% level of significance from 1980 onwards. The study found that a parallel relationship existed between the long-run stock price and the goods price and therefore that US stocks acted as an effective hedge against inflation since the 1950's, which lends support to the Fisher Hypothesis. The study also found the presence of asymmetric error corrections of common stock returns and expected inflation.

Figure 2: Time plots of the S&P500 stock return and the CPI inflation rate between 1900 and 2010 in the US.



Source: Kim and Ryoo (2011).

3.3.8 Eita (2012)

The study undertaken by Eita (2012) focused exclusively on the relationship between stock market returns and the inflation rate in South Africa. Eita (2012) began with a useful description of the history of the South African stock market, which is named the Johannesburg Stock Exchange (JSE). The author described the JSE as one of the most developed international stock exchanges and pointed out low trading costs and high liquidity levels as two of its primary attributes. This study had two objectives, the first being to investigate the historical capacity of equities to act as a hedge against inflation in South Africa and secondly to conduct an investigation into the possibility of a causal relationship between the inflation rate and stock returns.

In order to investigate the possibility of causality between the variables Eita (2012) used a Granger causality test, which determined whether or not past and present values of one variable influence or are influenced by past and present values of an alternate variable. In the current context the Granger causality test was used to determine whether past and present values of inflation and stock returns have had an historical effect on each other. In order to determine the nature of the relationship between stock market returns and the inflation rate Eita (2012) used the Johansen approach and the VECM. In terms of data the sample set spanned the period between 1980 and 2008 and consisted of stock market data compiled from the all-share index

(ALSI) and the gold index (GOLD) in South Africa. The South African Reserve Bank's Repo rate (INT) was used to represent the interest rate variable and the inflationary data was represented by the Consumer Price Index (CPI) in South Africa.

Augmented Dickey Fuller tests indicated stationarity in levels, $I(0)$, and as a result, Eita (2012) states that because the variables are stationary in levels that there was no need for further analysis using cointegration tests and could instead estimation could continue using a VAR approach or an OLS estimation. Using a regression analysis Eita (2012) determined that there was a positive relationship between inflation and stock market returns when the ALSI index was used, which provided evidence supporting the Fisher Hypothesis.

When the gold index was used as a proxy for stock market returns the same results were found, which led to the conclusion that stock market returns are able to act as a hedge against inflation in South Africa. Using the Granger causality test Eita (2012) discovered that when using the ALSI index the causal relationship between past and present values of both inflation and stock market returns are bi-directional which suggested that the two variables have a causal effect on each other. This means that past and present values of stock market returns can be used to predict levels of inflation and vice versa, in the case where the all-share index was used as a proxy for stock market returns (Eita, 2012). This positive relationship between stock market returns and the inflation rate suggested that equities in South Africa acted as an effective hedge against inflation between 1980 and 2008, in line with the Fisher Hypothesis.

However, Eita (2012) discovered that each of the variables in the regression were stationary in level terms and as such did not pursue further cointegration testing. This finding of stationarity is inconsistent with past empirical evidence and financial theory (Moolman and du Toit, 2005; Hancocks, 2010; Alagidede and Panagiotidis, 2010), as both series have shown positive linear trends over the sample period. It is possible that the data used by Eita (2012) was simply the month to month changes in the CPI and All Share Index, instead of the log of the CPI and All Share Index returns over the period established using a base year. This would explain the finding of stationarity in each series, but would mean that the testing procedure was inconsistent with previous studies of this nature and essentially incorrect for the purposes of testing the nature of the relationship between equity returns and inflation. It is therefore noted that either the testing procedure or the data used in this study are inadequate and so the results are viewed as being questionable when considered as a comparable study of the nature of the relationship between equity returns and inflation in South Africa.

3.3.9. Khumalo (2013)

Khumalo (2013) conducted an analysis to test the effect of inflation on stock prices in South Africa over the period 1980 to 2010. Khumalo (2013) investigated the relationship using an Auto-Regressive Distributed Lag Model (ARDL) in order to account for mixed findings of stationarity by the unit root tests employed, these being the conventional ADF and Phillips-Perron tests. Based on the results of the unit root tests Khumalo concludes that stock prices are $I(0)$ while inflation is $I(1)$. This highlights the first disparity with the two previously mentioned South African studies.

Khumalo (2013) adopted a multivariate approach in order to attempt to capture the connection between stock prices and inflation and acknowledges that studies trying to estimate the relationship between the two variables are likely to produce results that are sensitive to the choice of the model being used. The particular linear regression used by Khumalo (2013) took on the form:

$$SP_t = (CPI_t, Ex_t, GDP_t, Ms_t, IR_t, SP_{t-i})$$

Where SP represents the JSE stock price index, Ex is the exchange rate, GDP is the gross domestic product, Ms is the broad money and IR is the interest rate. These are then defined in the forms of multivariate ARDL models for each of the stock price, inflation and the exchange rate. The initial unit root tests find that SP, GDP, IR and Ex are stationary, while CPI and MS are non-stationary. This provides the motivation for the use of the ARDL test, which is able to estimate a regression even when the variables are integrated of different orders.

Prior to the ARDL test, Khumalo (2013) initially ran a Granger Causality analysis and concluded that there is unidirectional causality in the direction of inflation to stock prices. The subsequent ARDL cointegration testing revealed that while there is evidence of a cointegrating relationship, the relationship was negative, with a β coefficient of -0.319. Khumalo (2013) noted that this indicated that an increase in inflation of one percent will lead to a fall in stock prices by about 31 percent, and subsequently concluded that while there is a strong relation between stock prices and inflation, stock prices and inflation are negatively related. Further, Khumalo (2013) notes that the regression results reflect a strong relationship between stock prices and inflation and the other explanatory variables and that stock prices appear to typically exhibit a negative response to inflation rates and interest rates. Khumalo (2013) also found that money supply growth was negatively related to stock prices, contrary to theoretical expectations, as well as a negative relationship between exchange rates and stock prices.

Finally, Khumalo (2013) concluded that stock prices appear to decline during inflationary phases.

3.4. Conclusion to the Literature Review

It has been observed that many of the past studies that form the basis of the literature on this topic have determined conflicting results and conclusions. It is interesting to note however that as the testing methods for the relationship between equities and inflation have developed that more studies have tended to provide evidence of a positive relationship between equities and inflation, lending support to a certain degree to the theory of the Fisher Hypothesis (Alagidede and Panagiotidis, 2010; Kasman *et al.,* 2006; Kim and Ryoo, 2011; Eita, 2012). However, not all of the modern studies reviewed have determined evidence of a positive relationship. Some have still found evidence of the existence of a negative relationship, such as Khil and Lee (2000) who found evidence of a negative relationship in many Pacific Rim Countries, and Ely and Robinson (1997) who found similar evidence in the case of the United States. This suggests that the relatively recently developed cointegration theory is more supportive of the existence of a positive relationship between the variables than the methodologies used to test the relationship prior to the development of cointegration theory. The majority of the studies conducted prior the development of cointegration theory, including those that contributed to the development of the Proxy Hypothesis, as well as those that attempted to build on the theory of the Proxy Hypothesis, determined evidence of a negative relationship (Gultekin, 1983a; Mayya 1977; Day, 1984, Bodie, 1976; Jaffe and Mandelker, 1976; Nelson, 1976; Fama and Schwert, 1977; Hess and Lee, 1999; Kaul, 1990).

It is also important to note that several of the studies reviewed have discovered that the relationship between equity returns and inflation is either country dependent (Claude, Campbell and Viskanta, 1995; Khil and Lee, 2000; Alagidede and Panagiotidis, 2010) or is dependent on the period examined. Long-term studies, such as the study conducted by Kim and Ryoo (2011) tend to find evidence that supports the Fisher Hypothesis if a sufficiently long period is considered. Based on these findings of time and country dependency as factors that play a significant role in the determination of the nature of the equity returns-inflation relationship, it can be seen that it is necessary to specifically test the relationship using South African data in order to provide an accurate indication of the nature of the domestic relationship.

In addition, it has been seen, based on Hancocks (2010) that modelling the relationship alongside a variety of additional macroeconomic variables may provide an inaccurate estimate of the relationship as the results obtained were far greater than the bounds of realistic expectations. Secondly, other studies conducted using South African data have found significantly different results, with Eita (2012) failing to find evidence that the series in question were even non-stationary, while Alagidede and Panagiotidis (2010), as part of a multi-country study that did not specifically focus on South Africa, found evidence of a significant, positive, cointegrating relationship. Khumalo (2013), found that only one of the variables in question was stationary.

Such disparities highlight why the research in South Africa has not been exhausted and emphasize why it is important to test the equity returns-inflation relationship while accounting for these observed differences. Each of the following chapters attempts to address these previous contradictory findings, in order offer a robust conclusion to this issue in the South African context. Possible reasons for the differences are highlighted and are discussed more extensively in an attempt to correct for such errors in order to expand the body of knowledge regarding the capacity for equities to act as a hedge against inflation.

CHAPTER 4: EQUITIES AS A HEDGE AGAINST INFLATION IN SOUTH AFRICA

4.1 Introduction

When one considers the detrimental effects inflation can have on real wealth, following the theoretical discussion in chapter 2 and the preceding studies in the literature, it is evident that inflation is linked to a decrease in purchasing power or the value of currency-based assets in real terms. In light of this it becomes important to identify a hedging mechanism with which to protect against shifts in inflation. Ely and Robinson (1997) present equities as such a hedging mechanism due to the fact that they represent claims to underlying assets, which, under the conventional theory, are thought to maintain a constant value during inflationary periods. Theoretically, this implies a one-to-one relationship between equity returns and inflation. As rapidly became evident when reviewing the literature, this theory does not consistently translate into practice in most cases. An in-depth analysis is required to resolve the disparities in the South African literature, using more modern econometric techniques to more accurately measure the relationship. Identifying whether or not equities have historically acted as an effective long-run inflationary hedge is particularly important in the South African case, given the country's high volatility of inflation as the economy has undergone substantial shocks and developments in the last thirty-five years.

4.2 Original Contribution

First and foremost, it is apparent that the equity returns-inflation relationship differs between countries, and must therefore be assessed on a case-by-case basis (Alagidede and Panagiotidis, 2010). Secondly, the relationship has been shown to differ between time periods, even within the same country – another consideration that must be accounted for (Kim and Ryoo, 2011). A third disparity is identified in that, even when both of the previous statements are common, modelling the relationship using different data sets and statistical methods can provide vastly differing results (Alagidede and Panagiotidis, 2010; Eita, 2012; Khumalo, 2013). This is particularly relevant in the South African case, as the literature does not, to date, provide a clear picture of the nature or magnitude of the equity returns-inflation relationship. This study focuses on identifying any potential prior issues and accounting for these using modern econometric techniques, with a focus on resolving the primary issue in South African studies as to the lack of agreement of the order of integration of between these important time series, a critical underpinning of the now widely used cointegration techniques.

The original contributions of this paper can be summarised as follows:

a) This paper assesses the relationship using the longest data-set available to date, providing improved power and size properties to alternative studies in the literature. This, in and of itself, helps to resolve the disparity between previous studies. This study uses the most up to date data set in the South African literature, to the best of the author's knowledge, and therefore provides updated current assessment of the nature of the domestic equity returns-inflation relationship.
b) This study provides a comparison between the commonly employed vector error correction model (VECM) and the more modern autoregressive distributed lag model (ARDL). The benefit of the latter model is that it is able to account for different orders of integration of the variables (it can assess the magnitude of the relationship regardless of whether the variables are stationary or non-stationary in level terms). This provides a resolution to the conflicting results of prior studies that have found the variables to be integrated of differing orders. Supplementing the VECM approach used previously with the ARDL allows for a comparison of the results of the two models, while endogenously resolving the issue of potentially level stationarity of the variables. Furthermore, the results of the original VECM are more easily comparable with international studies that have used the same technique.

4.3 Paper as *Published* in the African Review of Economics and Finance (AREF)

Section 4.3 presents the paper in its published form. The reference list has been removed, as this thesis provides an amalgamation of all references used in all chapters of this thesis at the end of the thesis as a whole.

Citation

Moores-Pitt, P. and Strydom, S. (2017). Equities as a hedge against inflation in South Africa. *African Review of Economics and Finance*, 9(1) pp: 156-179.

Copyright Permission

Appendix B

Equities as a Hedge against Inflation in South Africa

Peter Moores-Pitt and Barry Stephen Strydom

School of Accounting, Economics & Finance, University of KwaZulu-Natal
Correspondence email: moorespittp@ukzn.ac.za

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].

[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.

This expectation 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 returns and expected economic activity relationship (Ely and Robinson 1997). 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 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 positive relationship exceed unity. 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).

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, *yt* 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 *yt* depends on different combinations of the independent variables up to *k*, and *ut* 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

$$\Pi = \left(\sum_{i=1}^{k} B_i\right) - I_g \text{ and } \Gamma_i = \left(\sum_{j=1}^{i} B_j\right) - I_g \tag{3}$$

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 Δ*y(t-i)* would be zero and if the error terms are assumed to match their expected value of zero, Π*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):

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

and

$$\lambda_{max}(\mathrm{r}, \mathrm{r}+1) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_{i+1})$$

where: r = the number of cointegrating vectors under the null hypothesis, and, $\lambda\,\hat{\imath}$ = 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:

$$LogSP_t = C + \beta LogCPI_t + \varepsilon_t \qquad (3)$$

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 εt 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 *Yt* represents a matrix of the dependent and independent variables. In this case the stock price is represented by *it* and the expected inflation rate is represented by *π(t+1)*. The inflation rate is thus shown simply by *πt*. 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.

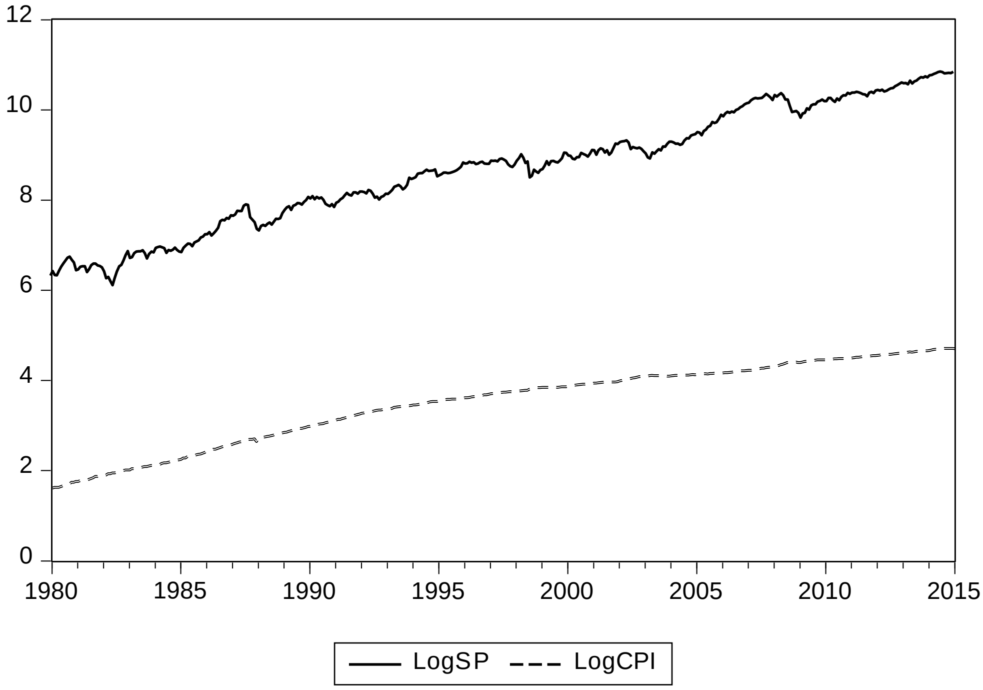
The ARDL*(p,q)* model shown in Equation 5 was estimated using OLS and the F-statistic was calculated for the null and alternative hypotheses. Following Atkins and Coe (2002) we tested the null hypothesis of a stable long-run relationship, using the bounds test approach of Pesaran *et al*. (2001) by comparing 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 THE 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	3.7422	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**	-3.47694	-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 (2012) 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	0.224

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

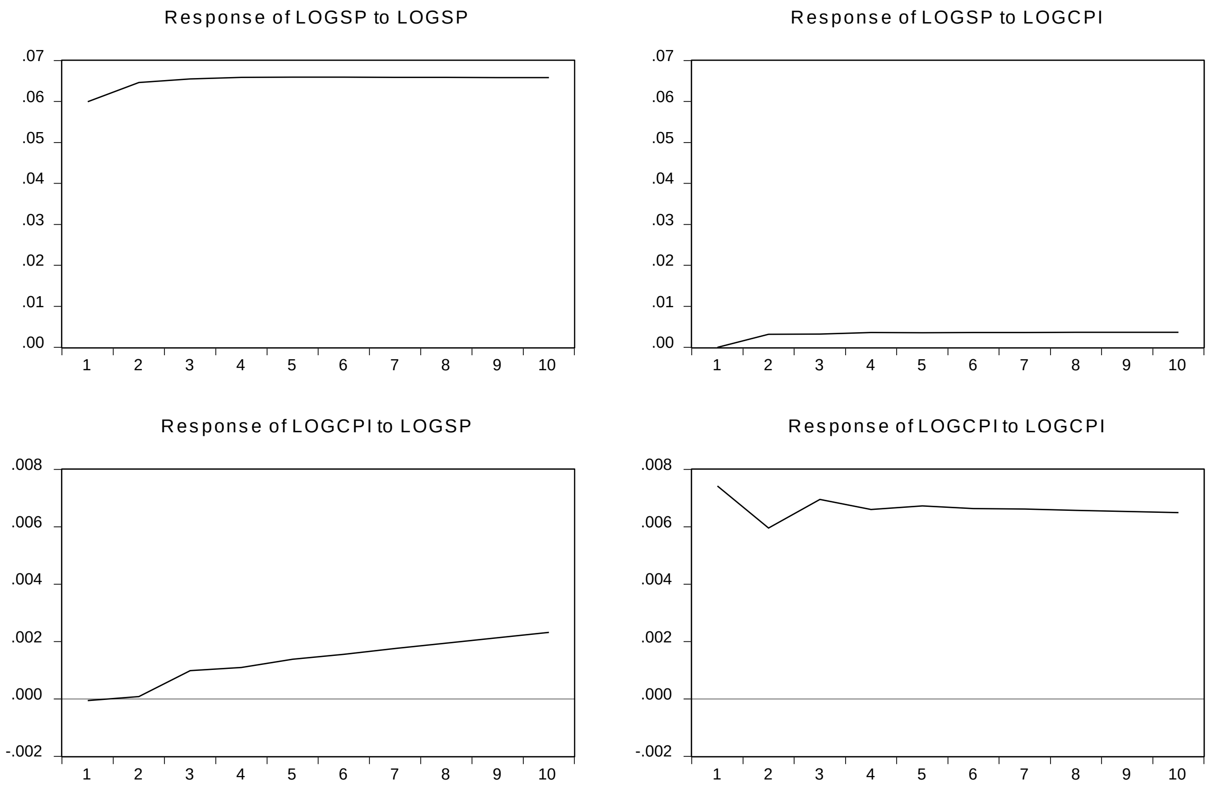
*Results of the ECM using a cointegration equation with LOGCPI normalised, t-stats are shown in [ ]

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 graph 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



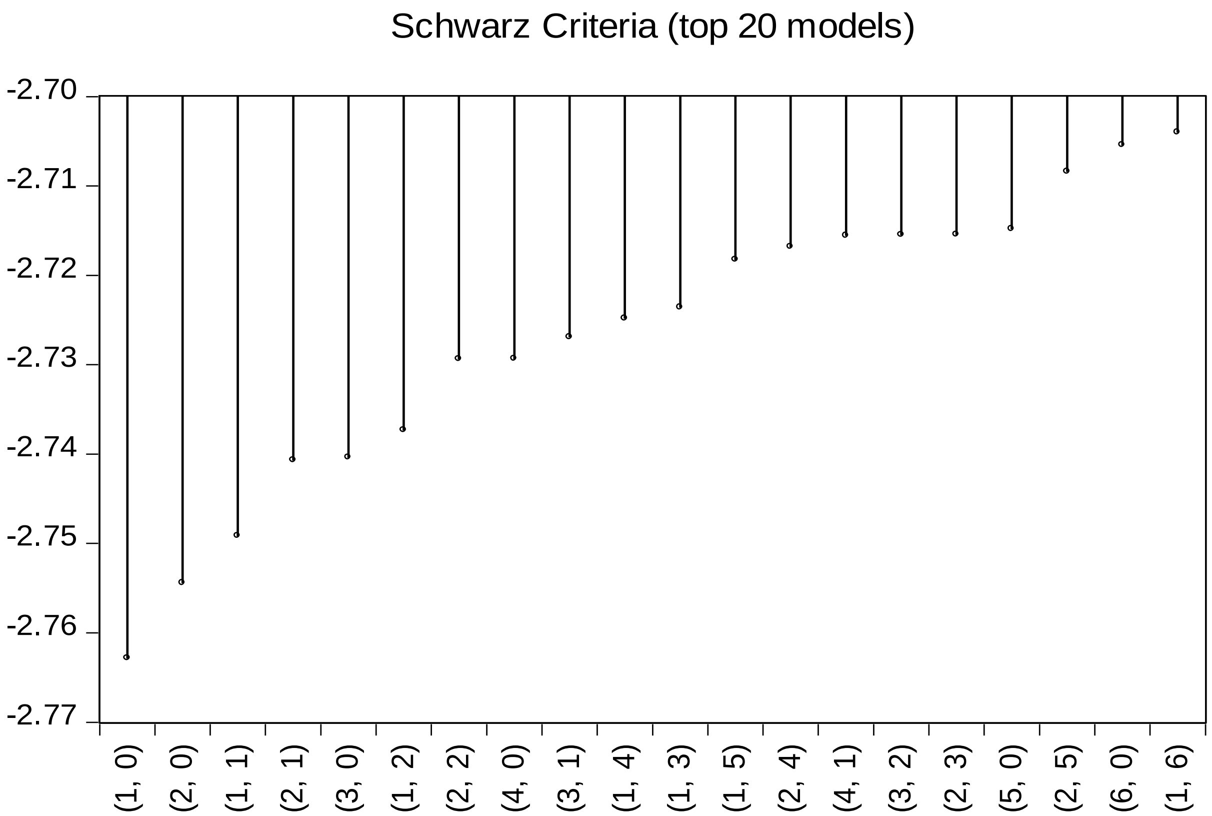
In light of the conflicting evidence presented by other South African studies (Eita, 2012; Hancocks, 2010; and Khumalo, 2013) our results provide strong support for Alagidede and Panagiotidis' (2010) findings and indicate that the South African stock market serves as a highly effective hedge against 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 (2012), 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: ARDLCOINTEGRATION 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.

4.4 Statement of Author Contribution

The University of KwaZulu-Natal College of Law and Management Studies (CLMS) offers a PhD by Publications, in line with international practice. This declaration serves to confirm that the paper presented in Chapter 4 of this thesis "Equities as a hedge against inflation in South Africa" is the doctoral candidate's own original work, as stated in Declaration 2: Publications.

____

Mr. PBD Moores-Pitt

Date:

4.5 Conclusion

This thesis as a whole investigates the nature of the relationship between equity returns and inflation in order to examine whether or not equities have acted as a long-run inflationary hedge in South Africa. The aim of this chapter was to examine the nature of the equity-returns inflation relationship in South Africa in order to resolve the issue of prior disparities in the literature with regards to the order of integration of the variables, as well as to identify issues with prior research. This chapter adds several contributions to the literature.

First and foremost, this study highlights the difference in results between the common VECM and the more modern ARDL model. A specific focus was the capacity for the ARDL model to estimate cointegrating relationships in models that have variables that are integrated of different orders, motivated by the findings that the two variables were stationary, non-stationary or a mix of the two in several of the preceding studies that have considered this relationship in South Africa (Alagidede and Panagiotidis, 2010; Eita, 2012; Khumalo, 2013). Even though the conventional unit root tests indicate that both variables are non-stationary and so would meet the conditions necessary for the use of the VECM, Gregory and Hansen (1996a) note that when there is a break in the intercept and or slope coefficient that the power of the conventional ADF test (that does not allow for a regime shift) falls substantially. As such the conventional unit root tests may not be completely reliable and thus it is safer to employ an ARDL model to account for this issue, as long as it can be confirmed that the variables are not $I(2)$ (Esso, 2016). This idea of low power of the unit root tests is explored and tested extensively in chapter 5, which considers unit root tests in the presence of structural breaks and regime shifts in line with the work of Gregory and Hansen (1996a,b).

Although in this case the results of the VECM and the ARDL do not change the ultimate conclusion regarding the nature of the relationship, the substantially different magnitude determined by the two models points to issues in modelling the relationship which may well have impacted the findings of previous studies that used older cointegration techniques.

In light of this, this study leads to a major contribution in terms of the resolution of the disparity between previous South African studies by producing a fundamental β coefficient that is protected against this disagreement evident in the literature. The baseline relationship determined by the ARDL is more comparable with the expectations of the Fisher hypothesis augmented to account for tax-effects, with the overarching conclusion being that equities have acted as an effective hedge against inflation in South Africa. However, the paper presented in this chapter also identified several limitations to the research, several of which are addressed in subsequent chapters.

As previously mentioned, the major issue to address next is the possibility that conventional unit root tests, and indeed the cointegration tests themselves, are unable to account for structural breaks and regime shifts. In light of this, chapter 5 (paper 2) considers these issues in more detail.

CHAPTER 5: INVESTIGATING TEMPORAL VARIATION IN THE EQUITY RETURNS-INFLATION RELATIONSHIP IN SOUTH AFRICA

5.1 Introduction

The previous chapter presented an analysis of the relationship between equity returns and inflation, based on the theory developed from the original hypothesis of Fisher (1930), that equity returns and inflation should exhibit a unitary relationship in the long term. While this was found to be true for the South African case, one might question why exactly the relationship should be assumed to remain constant over the sample period. Findings of a long-run cointegrating relationship may be somewhat misleading due to the fact that the models utilised inherently fail to account for short-run changes which may have affected the relationship. While previous studies suggest that a cointegrating relationship exists, this relationship may well be time varying and influenced by macroeconomic shocks – a reality which is worth exploring in greater detail.

Given the volatility in the South African economy over the sample period, one might expect that the relationship has exhibited structural changes, making the South African economy a perfect natural experiment to test for breaks in the relationship. Furthermore, the two sets of variables could themselves have exhibited breaks over the period, which may theoretically have contributed to the previous disparity regarding the order of integration of these variables in previous South African studies. Should such structural breaks have occurred in the variables during the sample period, or in the relationship between them, it becomes important to identify these changes and to test whether the relationship is affected. Further to this, if structural breaks have occurred, it is important to assess whether or not the relationship maintains a similar magnitude of cointegration despite such changes. Ultimately, this chapter aims to investigate whether a significant structural change in the South African economy would influence the equity returns-inflation relationship, and if so, if equities are able to maintain the capacity to act as an effective inflationary hedge despite such macroeconomic shocks.

5.2 Original Contribution

While previous studies have considered the long-run relationship between equities and inflation, these studies have neglected to consider changes in the magnitude of the relationship as well as possible breaks while testing for stationarity before testing for cointegration.

Should breaks be shown to exist in the South African data, it is important to test if the cointegrating relationship has been affected. The possibility that the cointegration relationship experienced a change resulting from inflation targeting and structural changes in the market during the apartheid transition is theoretically plausible and would likely have important implications for any conclusions derived from cointegration tests of the relationship.

With this in mind, the paper presented here in Chapter 5 aims to a) identify if the variables have experienced significant structural breaks over the period, b) if a structural break occurred in the relationship between inflation and equity returns in South Africa; and, c) if such a structural break has had a significant effect on the magnitude of the cointegrating relationship before and after the identified break date. If changes in the magnitude of the relationship are evident prior and subsequent to a significant break, this would have important implications for any conclusions derived regarding a long-term relationship. Such breaks might mean that equities have only acted as an effective inflationary hedge in certain periods, or in the long-run, but have failed to act in this capacity during sub-periods within the sample as a result of exogenous shocks.

5.3 Paper as *Published* in the African Journal of Business and Economic Research (AJBER)

Section 5.3 presents the paper in its published form. The reference list has been removed, as the bibliography to this thesis represents an amalgamation of all references used in all chapters of this thesis. The Tables and Figures referred to in the study are presented subsequent to the conclusion, following the original publication in the AJBER.

Citation

Moores-Pitt, P. (2018). Investigating temporal variation in the equity returns-inflation relationship in South Africa. *African Journal of Business and Economic Research*. 13(1), pp: 51-79.

Copyright Permission

Appendix C

Investigating Temporal Variation in the Equity Returns-Inflation Relationship in South Africa

Peter Moores-Pitt

School of Accounting, Economics and Finance, University of KwaZulu-Natal, Pietermaritzburg Campus, South Africa.

Abstract

The relationship between equity returns and inflation has been shown to be conflicting and inconsistent as well as time and country dependent. This is an issue in macroeconomics because equities are commonly regarded as a hedge against inflation. One potential explanation for the inconsistencies in the literature is the failure to account for structural breaks. This paper examines the possibility of structural breaks in both the consumer price index and stock market variables using the Zivot-Andrews (1992) and Gregory-Hansen (1996a, 1996b) procedures, which determined that the relationship exhibited evidence of structural breaks in both the individual series and in the relationship. The Fully-Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimation procedures were employed to investigate changes in the nature of the relationship, divided by the structural break. It was concluded that the relationship is subject to temporal variation and structural breaks should be considered, but that equities have acted as a consistent inflationary hedge in South Africa.

Keywords: *Inflation, equity returns, cointegration, structural breaks, South Africa Investigating temporal variation in the equity returns-inflation relationship in South Africa.*

1. Introduction

The Fisher Hypothesis (1930) predicts a positive relationship between expected real returns and real inflation and has suggested that equities, which act as a claim against real underlying capital assets, should act as an inflationary hedge as their returns should vary positively with actual inflation (Sharpe, 2002: 633). However, the one-to-one relationship between equity returns and inflation expected based on the theory of the Fisher Hypothesis has been shown to be inconsistent with much of the early literature, which typically exhibited evidence of a negative relationship (Fama, 1981; Gultekin, 1983: 50; Mayya, 1997: 61). Arnold and Auer (2015: 188) provide an extensive review of historical findings of the effectiveness of equities as an inflationary hedge and state that 'there is no consensus on whether these assets can hedge against inflation. This is because studies differ in their data sources, sample period and frequency, country coverage and/or econometric methodology.'

More modern studies that have utilised cointegration techniques, which test for a stationary linear combination of variables, have often shown a positive relationship (Alagidede and Panagiotidis, 2010; Kim and Ryoo, 2011; Arnold and Auer, 2015). The literature, however, also shows substantial disparity between studies that analyse different countries or consider varying time periods (Kim and Ryoo, 2011: 142). An underlying premise of the Johansen's (1996) cointegration test, however, is that the relationship is consistent over time. This, in reality, is not necessarily the case and variations in economic conditions can easily lead to a change in the dynamic of the cointegrating relationship in the long-run. As a result, a separate body of literature has developed in order to test for the possibility of a change in the relationship. While recent studies have typically found evidence of the existence of a positive relationship, they often also show temporal variance in the relationship (Ely and Robinson, 1997; Kasman, Kasman and Turgutlu, 2006). Antonakakis, Gupta and Tiwari (2017) show evidence that the relationship evolves over time in the United States, and provide significant evidence that while it may be positive in some periods, it is significantly negative in others. This largely contrasts the results of Kim and Ryoo (2011), who find that US stocks have provided an effective inflationary hedge, and thus a positive relationship, over the last century.

In addition to Antonakakis et al., (2017), studies that have considered potential changes in the relationship over time include those by Prabhakaran (1989) and Lee (2010: 1257) who determined evidence that the relationship is time varying. Furthermore, Boudoukh and Richardson (1993: 1354) discovered that the Fisher effect is stronger over longer time horizons, implying volatility in the relationship in the short-run. This highlights the fact that even if equity returns do act as an inflationary hedge in the long-run, there is no reason to support the assumption that this relationship is necessarily consistent over time.

A combination of structural macroeconomic factors included in the sample set make South Africa a perfect natural experiment for investigating changes in the long-run dynamics of the equity returns-inflation relationship. These include the apartheid transition to democracy in 1994, before which the country was subject to international trade sanctions, the subsequent lifting of these sanctions, the reintroduction of South Africa to the global economy and the relaxation of exchange control mechanisms. The achievement of an investment grade sovereign risk rating and the positive effects on the economy, as well as substantial government-induced volatility in recent years also make it probable that the relationship has experienced a change. An occurrence that may have even more specifically affected the relationship is the introduction of the inflation targeting regime in 2000 (Mitchell-Innes, Aziakpono and Faure, 2007).

From an econometric perspective, such factors may have caused structural breaks in the data series. Esso (2010: 1384) states that previous studies such as that by Gregory and Hansen (1996a) have found evidence that conventional unit root tests, such as those used in the aforementioned studies which included South Africa, may fail to reject the unit root hypothesis in cases where a series that is in fact stationary contains a structural break. Cil Yavuz (2013) notes that the power of conventional unit root tests is reduced when a structural break exists and that they are biased to accept the null of a non-existent long relationship in such cases. This issue of potential structural breaks extends to the relationship itself, which, when considering the assumption typically adopted in the literature that the relationship has remained constant over time, even though there is no empirical basis for this assumption as demonstrated by Prabhakaran (1989) and Lee (2010: 1257); motivation to test for breakpoints in the magnitude of the relationship is provided. Testing for breakpoints in time-series has been previously considered and tests such as those by Gregory and Hansen (1996a,b) allow for an empirical analysis of relationships such as that between equity returns and inflation to determine if the relationship may have experienced breaks within the sample period.

Relatively few studies have examined the relationship between equity returns and inflation in South Africa and these studies do not show any real consensus in their findings. Alagidede and Panagiotidis (2010) discovered that both inflation and the stock price variable were non-stationary, and that they exhibit a significant positive relationship. Eita (2012), on the other hand, finds that both variables were stationary in level terms but still exhibit a positive relationship, albeit of a lesser magnitude than that discovered by Alagidede and Panagiotidis (2010). Khumalo (2013) discovered completely contrasting results, showing that while inflation is non-stationary in level terms, the stock price is stationary and that the magnitude of the relationship is negative and exceptionally strong, but the reasons for these findings remained largely unexplained. Moores-Pitt and Strydom (2017) employed a VECM methodology and found results similar to those of Alagidede and Panagiotidis (2010), but extended the analysis with the use of an ARDL model in order to relax concerns of the order of integration brought about by disparities in the aforementioned studies. This model finds that the relationship is still significant and positive over time, but of a lesser magnitude than suggested by the VECM.

In a multi-country study with six developed and six emerging economies, in which South Africa is included in the latter category, Moazzami (2010: 3) uses a dynamic model to allow for direct estimation of short and long-run impacts on stock prices caused by changes in the goods price. The data sample is larger than those of the other studies, running from 1970 to 2007 and uses an ADF test which rejects the presence of non-stationary residuals (Moazzami, 2010) while the coefficient of adjustment indicates that part of the disequilibrium between goods and stock prices is corrected in each period. The long-run adjustment coefficients do vary significantly between countries, but in the case of South Africa equals 1.0221, supporting the Fisher hypothesis that the coefficient is equal to unity. A potential explanation for these different findings may well be the aforementioned structural changes to the South African economy, or may simply be the use of different data formats as the sample data that is examined is not always clearly described. In fact, Mitchell-Innes et al. (2007) investigates the period following the introduction of inflation targeting between 2000 and 2005 and finds that during the short-run, the Fisher hypothesis does not hold and cannot be confirmed in the long-run while using a Johansen’s (1992) cointegration test. This is in direct contrast to the results obtained when using the same test in the study by Alagidede and Panagiotidis (2010) and suggests that macroeconomic policy changes may well have influenced the nature of the relationship between equities and inflation. However, it is somewhat difficult to compare the two when considering the difference in sample lengths.

Finally, Phiri (2017) introduces a non-linear testing methodology and finds evidence that equities do not function as an effective inflationary hedge, although the author does find evidence that both series are integrated of the first order. This study is limited, however, in that the data set used is relatively short in comparison to alternative studies in the literature, starting in 2003 and ending in 2015, which excludes the introduction of inflation targeting as well as preceding data which may reflect changes caused by other macroeconomic events such as the transition from the apartheid regime.

A major potential issue with these South African studies, aside from their differing results, is that they do not consider that the relationship may not have been consistent over the periods they considered, but rather assume a constant relationship over time. Alagidede and Panagiotidis (2010) conduct stability tests over the sample period for South Africa, by way of an expanding window VECM that adds one observation consecutively and tests for cointegration with the goal of testing for changes over time and the identification of breaks. Alagidede and Panagiotidis (2010: 97) note that in most of the periods that are considered, oil price shocks, emerging market crises and institutional reforms play a role, which 'may induce structural shifts in the long-run relationship.' Furthermore, structural breaks in time series can induce apparent unit roots in the series when in fact they are stationary (Campos, Ericsson and Hendry, 1993). Indeed, Noriega and Ventosa-Santaularia (2006) state that the complication in cointegration tests is the pre-testing problem which arises when identifying the order of integration of the variables. Alagidede and Panagiotidis (2010) find, using the expanding sub-period methodology that they employ, that cointegration has existed over the period for the South African case, but they do not test for changes in the magnitude of the relationship nor do they consider breaks while testing for stationarity before testing for cointegration.

Should breaks be shown to exist in the South African data, it is important to test if the cointegrating relationship has been affected. The possibility that the cointegration relationship experienced a change resulting from inflation targeting and structural changes in the market during the apartheid transition is theoretically plausible and would likely have important monetary policy implications.

In light of this, the research question is developed: has a structural break occurred in the relationship between inflation and equity returns in South Africa and, if so, has this break had a significant effect on the magnitude of the cointegrating relationship before and after the identified break date?

In section 2 the technical econometric framework is presented and the literature on the technical methods employed to investigate the research question is discussed. Section 3 briefly summarises the methodology and the data. The results are presented and discussed in section 4, while section 5 provides a conclusion to the study.

2. Technical econometric framework

2.1. Introduction

The primary problem addressed in this paper is the potential for structural breaks to exist in each series and in the cointegrating relationship in South Africa, which may have affected the capacity for equities to act as an inflationary hedge. We deal with time series data between 1980 and 2015 for both the equity returns and inflation variables. Time series data such as these are typically tested for a unit root prior to testing for a cointegrating relationship using tests such as the Augmented Dickey-Fuller test or the Phillips-Perron test in modern literature. Should these tests find evidence of a unit root, the conventional cointegration testing methodologies of Engle and Granger (1987) and Johansen (1988) are typically employed. Such testing is necessary to provide a baseline with which to build an analysis of the equity returns-inflation relationship in South Africa. These methodologies may however, incur errors by failing to account for structural breaks in the time series and in the relationship and because of the assumption of time-invariance, and as such newer methodologies are employed to account for this. This section discusses these newer methodologies.

2.2. Structural break testing

Previous studies in the literature have illustrated that it is possible for conventional unit root tests to fail to reject the unit root hypothesis in cases where the variable is in fact trend stationary with a structural break (Esso, 2010). Perron (1989) provides an example of the inherent bias of conventional unit root tests towards a false unit root null hypothesis when the data is trend stationary with a structural break. This was demonstrated using the Dickey and Fuller (1979) test when Perron (1989) developed a technique to test a series for a null hypothesis of a unit root with drift when an exogenous structural break occurs at time $1 < T_B < T$. The alternative hypothesis is that a unit root does not exist and that the series is stationary around a deterministic time trend with an exogenous change in the trend function at time T_B. Perron (1989) demonstrates that standard unit root tests are inconsistent when the alternative is a stationary noise component with a break in the slope of the deterministic trend, with the primary argument being that an exogenous shock with a permanent effect will not accept the unit root hypothesis even when it is correct.

Esso (2010: 1384) states that tests such as that by Perron (1989) have less power than conventional tests when there is no break. However, they are consistent irrespective of whether a break is or is not contained in the series and additionally provide results that are independent of the magnitude of the break. Gregory and Hansen (1996a) note that when there is a break in the intercept and or slope coefficient that the power of the conventional ADF test that does not allow for a regime shift falls substantially. In addition, Johansen, Mosconi and Neilsen (2000: 216) point out that during the economic time series analysis it is often required that the model accounts for breaks in the deterministic components. Johansen et al. (2000) mention Perron's (1989) methodology as one that allows for such breaks before they present a test which generalizes one of the three models by Perron (1989) for a case in which the break date is known. The primary controversy surrounding these tests is the assumption that the time of the break is known *a priori*, which can lead to the use of an incorrect break date and results in size distortions and power loss (Esso, 2010). Essentially, Perron's (1989) methodology allows one to test whether a series remains non-stationary even when it exhibits evidence of a structural break.

2.3. The Zivot-Andrews (1992) unit root test

Zivot and Andrews (1992) improve on Perron's (1989) methodology by extending the models to allow them to treat the time of the break as unknown. According to Zivot and Andrews (1992) the variation of Perron's (1989) test allows the breakpoint to be estimated rather than fixed which the authors deem to be more appropriate in order to avoid the problem of data mining. This test has an advantage over conventional unit root testing in that it allows one to test for the presence of a structural break within the series simultaneously. The Zivot-Andrews (1992) test examines the hypothesis of a unit root against the alternative hypothesis of a trend stationary process with a structural break (Zivot and Andrews, 1992: 254). Three regression equations capture this procedure.

Model A allows for a once-off change in the intercept, with a modified null hypothesis of a unit root which is represented as a dummy variable equal to one at the time of the break. Model B accounts for a change in the slope of the trend function without a sudden shift in the process at the time of the break (Perron, 1989: 1364). Model C accounts for a combination of changes in both the intercept and the slope of the trend function of the series, essentially capturing the functions of both Models A and B simultaneously (Zivot and Andrews, 1992: 253). In the case where the unit root captured in Model C is rejected, we revert to testing Model A and B. The null hypothesis of Model A is a structural break with a unit root in the intercept. For Model B the null is a structural break with a unit root in the trend and for Model C the null is a structural break with a unit root in both the intercept and the trend. Drawing on the notation of Esso (2010) these models are presented as follows:

Model A (Intercept)

$$y_t = \mu + \theta DU_t(\tau_b) + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta y_{t-1} + e_t$$

Model B (Trend)

$$y_t = \mu + \gamma DT_t(\tau_b) + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta y_{t-1} + e_t$$

Model C (Intercept and Trend)

$$y_t = \mu + DU_t(\tau_b) + \beta t + \gamma DT_t(\tau_b) + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta y_{t-1} + e_t$$

Where:

- $DU_t(\tau_b)$ =1 if t > τ_b and 0 otherwise, and $\gamma DT_t(\tau_b)$ = t-τ_b if t>τ_b and 0 otherwise.
- Δ is the first difference operator
- e_t is the white noise disturbance term
- DU_t is a sustained dummy variable that captures a shift in the intercept
- DT_t is a shift in the trend occurring at time τ_b
- The breakpoint τ_b is estimated using an OLS methodology for $T = 2,3, \ldots T - 1$
- τ_b is selected by the minimum t-statistic, $t_{\hat{\alpha}}$ on the coefficient of the autoregressive variables. $t_{\hat{\alpha}}$ represents the one-sided t-stat for testing $\alpha = 1$.
- *k* represents the number of lagged first-differences

Including too many extra regressors of lagged first differences does not influence the size of the test but decreases its power while including too few lags may significantly affect the size of the test (Perron, 1989: 1384). Zivot and Andrews (1992: 257) use an ADF approach to determine whether additional lags should be included and note that the number of extra regressors must increase with the sample size at a controlled rate. The same approach is followed in this paper, whereby the maximum lags included in the Zivot-Andrews (1992) test are dependent on optimal lag length endogenously determined during the ADF test. To clarify, prior to the use of the Zivot-Andrews test (1992) the ADF approach is employed in order to determine *k*, based on the Akaike Information Criterion (AIC). This approach in itself follows the approach initially presented by Perron (1989), who presents results of the Dickey-Fuller test for values of *k* ranging from 1 to 12.

2.4. Cointegration testing

The Gregory and Hansen (1996a) tests for cointegration are employed in this paper to investigate the relationship between equity returns and the inflation rate in the form of a two-step error-correction model. The Gregory and Hansen (1996a) tests are able to include a break in the cointegrating relationship, in contrast to the conventional tests of Engle and Granger (1987) and Johansen (1998).

Gregory and Hansen (1996a: 100) state that the model is concerned with a more general type of cointegration in which the cointegrating vector is allowed to exhibit a change at a solitary unknown time within the sample period. They state that they broaden the class of models being considered because their modified alternative hypothesis includes the Engle-Granger model as a distinctive subcase. This alternative hypothesis differs from conventional tests, while the null hypothesis of no cointegration is maintained. This model is spurred by the possibility of regime changes for situations in which several series are cointegrated but that the cointegrating vector has shifted during the sample period, at an unknown time. This differs from standard cointegration tests which assume that the cointegrating vector is time-invariant (Gregory and Hansen, 1996a: 100). For the sake of clarity, the aforementioned Zivot-Andrews (1992) test analyses the independent series for breaks, while the Gregory-Hansen (1996) test examines the relationship for cointegration in addition to a structural break in the relationship.

In line with the recommendations of Gregory and Hansen (1996), tests for parameter instability must be conducted prior to testing for cointegration. To test for this the Hansen (1992) test as well as the Recursive Residuals and Cumulative Sum of Squares (CUSUM) tests are used. The Recursive Residuals test shows a plot around a line at zero along with a positive and negative line at two standard errors from zero. If the residuals exceed the standard error lines the test suggests parameter instability in the equation. The CUSUM is based on the cumulative sum of the recursive residuals and plots the cumulative sum together with 5% critical value bands.

Similar to the Recursive Residuals test the CUSUM test indicates parameter instability if the cumulative sum exceeds either or both of the critical lines.

For the Hansen (1992) instability test the Lc statistic is examined, initially including only a constant and then including a constant and trend variable. According to Esso (2010: 1388) the null of the Lc test is stability of the long-run relationship which is tested against an alternative hypothesis of a change in the long-run equilibrium at some unknown point in the sample. The Lc statistic is particularly useful for testing for a gradual change in the cointegrating vector. The non-stationary estimation method used is the Fully-modified Ordinary Least Squares (FMOLS), discussed further in section 2.5, with default long-run variance parameters.

After finding evidence of parameter instability the Gregory-Hansen (1996a) test can be employed to test for cointegration with a structural break. Gregory and Hansen (1996a) propose tests that allow for cointegration with a regime shift in the intercept or the entire coefficient vector. They state further that the tests are essentially multivariate extensions of the univariate tests of Perron (1989) and Zivot and Andrews (1992), among others, which have been previously discussed. Gregory and Hansen (1992a) calculate critical values for up to four regressors using simulation methods, specifically evaluating the finite-sample performance of the tests using Monte Carlo methods based on the experimental design of Engle and Granger (1987). They discovered that the tests are able to determine cointegrating relationships between variables in the presence of a break in the intercept or slope coefficient, in situations where the power of the conventional ADF test, with no capacity to account for regime shifts, declines. Esso (2010:1385) presents the general long-run relationship used in the Gregory-Hansen (1996a) test that allows for a structural break in the regime and trend shift, shown below:

$$\ln(Y_t) = \mu_1 + \mu_2 D_t(T_b) + \beta_1 t + \beta_2 t D_t(T_b) + \alpha_1 \ln(E_t) + \alpha_2 \ln(E_t)\, D_t(T_b) + \varepsilon_t$$

Where:

- The dummy variable $D_t(T_b) = 1$ if $t > T_b$ and 0 otherwise, where the unknown parameter T_b denotes the timing of the change point.
- Y_t = First Variable (Change to CPI)
- E_t = Second Variable (Change to SP)
- ε_t = white noise disturbance term
- μ_1 represents the intercept before the shift

- μ_2 represents the change in the intercept at the time of the shift
- β_1 = the trend slope before the shift
- β_2 = the change in the trend slope at the time of the shift
- α_1 = the cointegrating slope coefficient before the regime shift
- α_2 = the change in the cointegrating slope coefficient at the time of the regime shift

Esso (2010: 1385) states that the test for the null of no cointegration is residual based, where the above equation is estimated using OLS and a unit root test is applied to the regression errors following the methodology of Gregory and Hansen (1996a). The time break T_b is consistently considered to be unknown and is estimated with a data dependent method, with T representing the sample size (Zivot and Andrews, 1992). The date at which the structural break occurs will be when the unit root test statistics are at a minimum. The test, which is able to simultaneously account for a structural break and cointegration, will provide an indication of the possible effect structural breaks have had on the relationship over time, highlighting the effects of inflation targeting or other exogenous shocks on the equity returns-inflation relationship in South Africa.

2.5. Parameter estimation

The parameters in the long-run model are estimated using the FMOLS method of Phillips and Hansen (1990) and the Dynamic Ordinary Least Square (DOLS) estimator of Stock and Watson (1993), following studies by Eggoh, Bangake and Rault (2011), Gocen, Kalyoncu and Kaplan (2013); Cil Yavuz (2014) and Vogelsang and Wagner (2014). According to Vogelsang and Wagner (2014) the FMOLS approach makes use of a two-part transformation in order to remove the asymptotic bias terms, and allows for the direct estimation of cointegrating regressions. As a robustness check we employ the DOLS estimator alongside the FMOLS based on the work of Eggoh et al. (2011) who note that it is possible for the FMOLS to exhibit small sample bias and that the DOLS estimator appears to outperform the FMOLS in certain cases. The DOLS estimator uses parametric adjustment to the errors by including the past and future values of the $I(1)$ regressors with the intent to correct for endogeneity in the model (Eggoh et al., 2011). Following Cil Yavuz (2014) in the case of a structural break, two sub periods are defined before and after the date of the break for which the parameters are estimated using the aforementioned estimators. This allows one to observe changes in the relationship between the two periods, in order to determine whether or not the relationship has changed or remained consistent over time.

3. Methodology and data

The conflicting evidence in South Africa suggests that structural breaks may have occurred but no study to date has accounted for this possibility. As has been seen in the technical econometric framework the proposed methodology is designed to answer the research question of whether a structural break has occurred in the equity returns-inflation relationship, and if so, what its effect on the magnitude of the cointegrating relationship has been between the two periods. As discussed in section 2, there are established techniques to test for structural breaks in time series data.

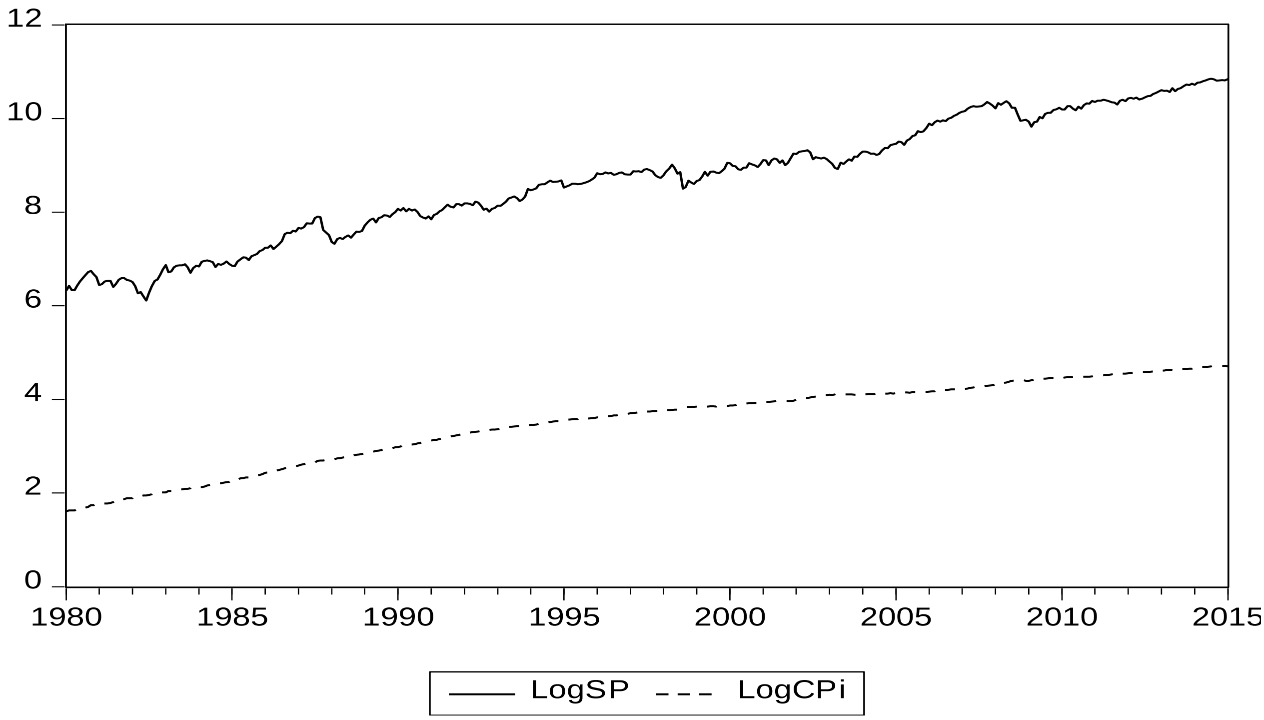
Using the techniques discussed in section 2, a structural break testing methodology was utilised in order to conduct the cointegration analysis. Initially each series was tested individually for a single structural break, then tested for parameter instability in the relationship. The possibility of structural breaks in each variable is examined using the Zivot-Andrews (1992) test, which is able to determine whether either of the series independently contains a structural break and if whether or not the series was stationary before testing the relationship between them for a structural break with the Gregory-Hansen (1996) test. A necessary precondition for further cointegration testing is the finding of non-stationarity in the case of each variable. The Hansen's (1992) Lc test was used alongside a Recursive Residuals test and a CUSUM to determine parameter instability, after which the Gregory Hansen (1996a) test was used to test if the cointegration relationship holds while accounting for the most significant break in the relationship. In the case of cointegration The FMOLS and DOLS were then employed to estimate the cointegrating equation in order to assess whether or it provided evidence of a change in magnitude, or was proven to be time-invariant.

In terms of the sample, monthly data was obtained from the Johannesburg Stock Exchange (JSE) in the form of the All Share Index, which was converted in log form and used as a proxy for equity returns. This was made available upon request directly from the JSE. The monthly inflation data is publicly available from StatsSA in the form of the Consumer Price Index (CPI), which acts as a proxy for inflation. In the case of CPI, headline index numbers were used where December of 2012 was used as the base year and set equal to 100. Both series span the period between 1980 and 2015 and were converted into natural log form prior to use following Kim and Ryoo (2011). Using these data sets as proxy variables is well precedented in the international literature (Ely and Robinson, 1997; Alagidede and Panagiotidis, 2010; Kim and Ryoo, 2011) and it is assumed that the theory that current stock prices reflect future dividend payments holds (Moolman and du Toit, 2005: 88). The sample range covers the international trade sanctions, the apartheid transition period and subsequent reintroduction of South Africa into the global economy, the introduction of the inflation targeting regime and the period in which South Africa gained a positive sovereign investment grade rating, as well as changes to the computation method of the ALSI in 2002. This makes the sample suitable for the consideration of structural economic changes in South Africa's recent history.

4. Results

Section 4 presents the results of the methodologies discussed in section 3. Initially graphs of the logs of SP and CPI are shown in Figure 1.

FIGURE 1: Log of the Stock Price and CPI between 1980 and 2015



4.1 Zivot-Andrews unit root test results

Table 1 shows the results of the Zivot-Andrews test for each variable using each model. The ADF test described earlier is used to determine the maximum lag length to be included for each series. The Zivot-Andrews test then selected optimal lag lengths for each test, these being 1 for LogSP and 12 for LogCPI. LogSP and LogCPI in the table show the Zivot-Andrews test statistic for each case.

TABLE 1: Zivot-Andrews Unit Root Test Results

Variable	Lag Length	Break Date	Model A	Model B	Model C
LogSP	1	1998: 05	-4.552872	-4.064942	-4.633738*
5% crit. val.			-4.93	-4.42	-5.08
LogCPI	12	1990: 08	-2.469797	-4.354663	-4.186123*
5% crit. val.			-4.93	-4.42	-5.08

* indicates the optimal model use in each case, where the null cannot be rejected.

It is evident that for the stock price variable, LogSP, the null cannot be rejected in Model C, showing that a unit root with a structural break exists in both the intercept and the trend. In the case of the inflation variable, LogCPI, the null hypothesis cannot be rejected at the 5% level as indicated by Model C which indicates that a unit root exists with a structural break in both the intercept and trend. Esso (2010: 1386) states that only in the case of significance of Model C where the null is rejected, we revert to the use of Model A or B and otherwise use Model C. In light of this, we do not need to consider the results of Model A or B in either case as the null of a unit root with a structural break in both the intercept and the trend cannot be rejected for either series. The results of Model C, the test with a break in the intercept and trend, are presented in Figures 2 and 3.

FIGURE 2: Graph showing the results of the Zivot-Andrews test on LogSP for Model C

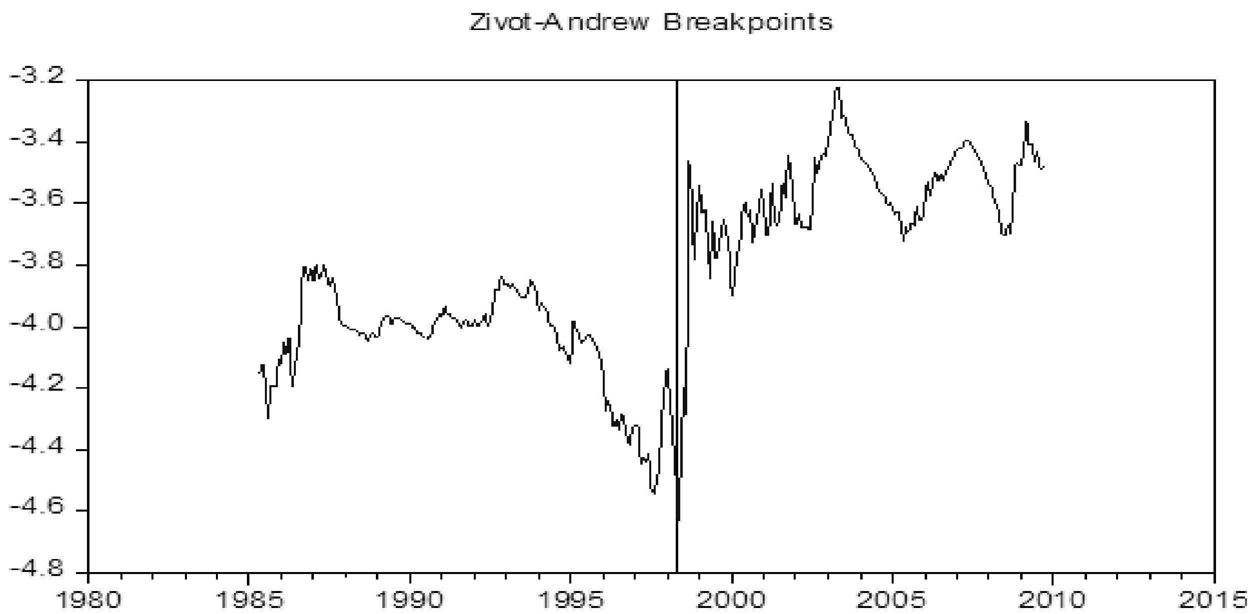
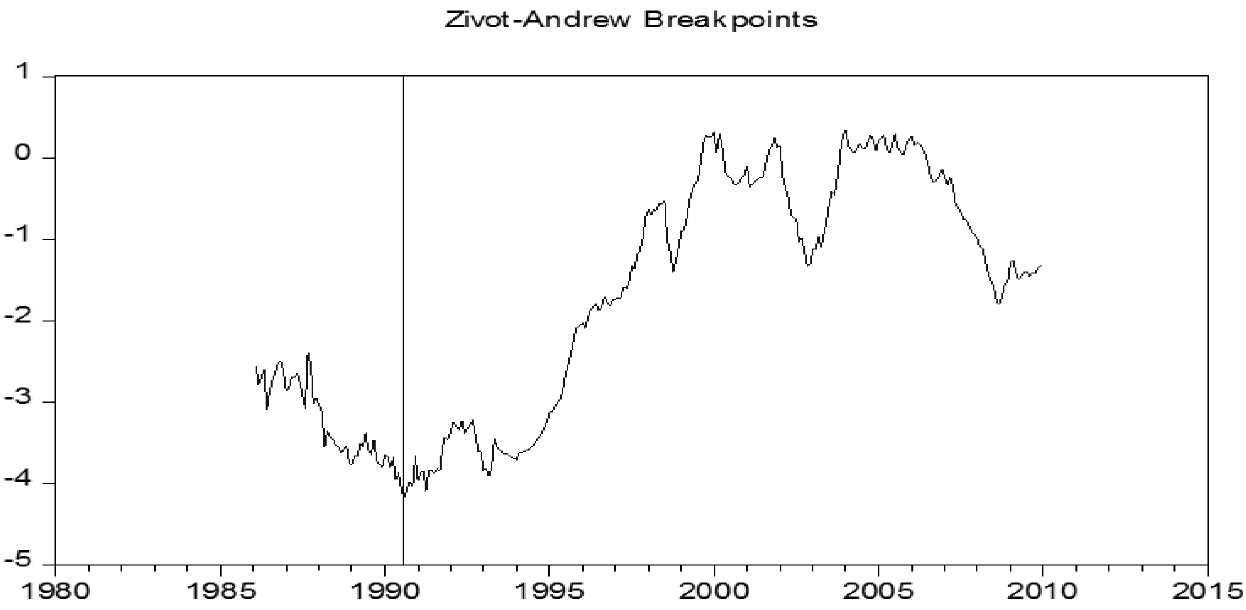


FIGURE 3: Graph of the results of the Zivot-Andrews test on LogCPI for Model C



The largest break for LogSP occurred in 1998: 05, while the largest break for LogCPI occurred in 1990: 08. The break in LogSP is likely linked to decreased investor confidence and trade disruptions caused by the Asian financial crisis of 1997, which Corsetti, Pesenti and Roubini (1999) state may have itself been caused by sudden shifts in market expectations and confidence, especially with key trade partners such as China. The Asian Financial Crisis started with a currency market failure in Thailand after a government decision to no longer peg the Thai Baht to the US Dollar, resulting in currency declines that spread through South Asia leading to stock market declines and reductions in imports. Market declines were subsequently experienced in the United States, Europe and Russia.

A report by the Industrial Development Corporation (IDC) (2013) marks the period around 1998 as a 'dramatic downturn for South Africa, as its economy was concurrently adjusting to its reintegration in the world economy, including substantial trade liberalisation and structural adjustments.' According to Ricci (2006: 191) the inflation rate in South Africa remained high due to a weaker monetary policy stance during the 1980s until the early 1990s. The high inflation rate and volatility was also caused in part by the anti-apartheid sanctions and the disinvestment campaign which was first legislated in 1986 by the United States, leading to massive foreign capital movement out of South Africa and upward pressure on the inflation rate. As part of this disinvestment campaign the majority of US firms with South African holdings left between 1980 and 1991 (Posnikoff, 1997). It was only in the early 1990s that a stronger monetary policy framework was employed which brought about a marked reduction in inflation in comparison to major South African trading partner countries (Ricci, 2006). The structural break detected by the Zivot-Andrews test reflects the relative volatility experienced during the year when headline year-on-year rates dropped to 13.3% from 15.1% in January of 1990 and climbed back to 15.3% by November of the same year. Effective stability and reductions in the inflation rate only really occurred in 1992, where CPI dropped below 10% for the first time in more than ten years, after which it exhibited a relative amount of stability following the end of apartheid and the introduction of the inflation targeting regime in 2000.

4.2. Testing for parameter instability

The results of the Zivot-Andrews (1992) test indicate that each series contains at least one unit root and thus the relationship cannot be tested using a simple OLS framework in case of the possibility of a spurious regression (Gujarati and Porter, 2009). To test the long-run relationship while avoiding this possibility, one would generally employ a conventional cointegration test. However, as noted by Esso (2010: 1385), these tests for the null of cointegration may be subject to reduced testing power in the presence of structural breaks because the residuals from cointegrating regressions capture unaccounted breaks and may as a result exhibit non-stationary behaviour, which the Zivot-Andrews tests do find during the sample.

To avoid the problem of reduced testing power in conventional tests, Esso's (2010) approach is followed where one considers non-linear techniques, specifically the Gregory-Hansen (1996a) cointegration tests which account for a break in the cointegrating relationship. Preceding the Gregory-Hansen (1996) test, one employs parameter instability tests including the Lc statistic, the Recursive Residuals and the CUSUM tests discussed in section 2.5. Beginning with the Lc statistic in Table 2 the null of a stable long-run relationship was tested against the alternative hypothesis of a change in the long-run equilibrium relationship at an unknown point in the sample.

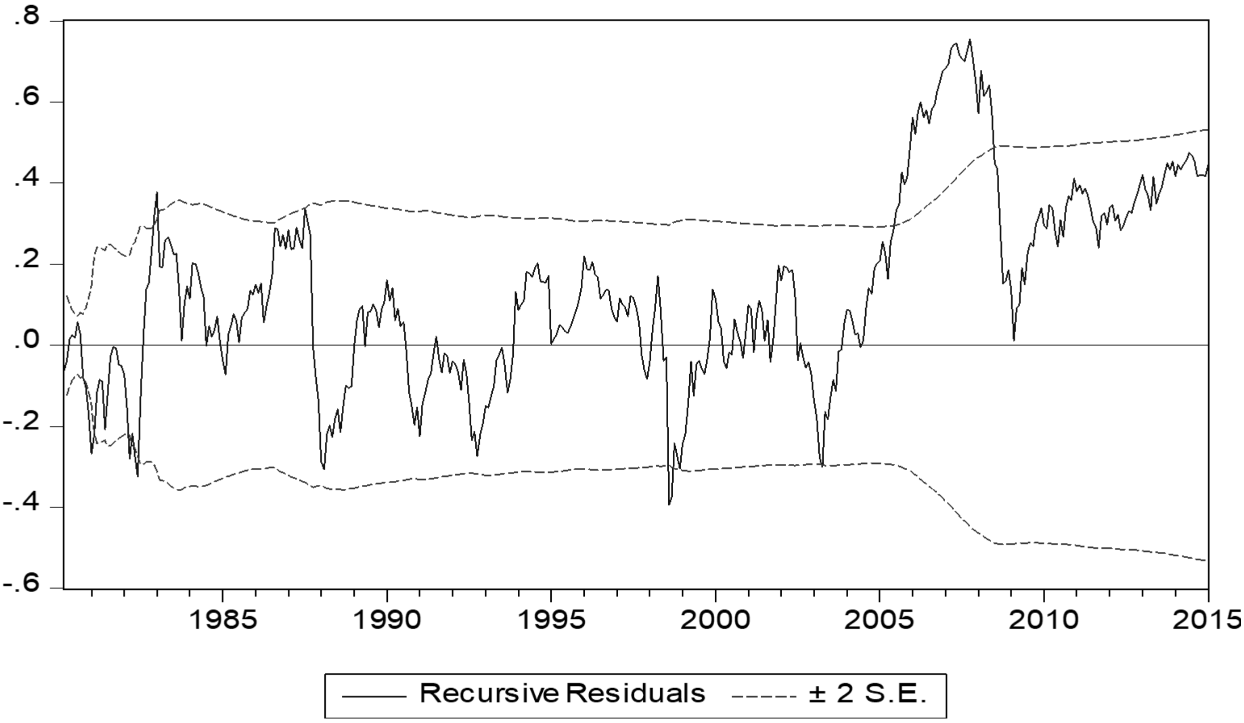
TABLE 2: Hansen Parameter Instability test

	LC statistic	Stochastic Trends (m)	Deterministic Trends (k)	Excluded Trends (p2)	Prob
No Trend Variable	3.90439*	1	0	0	<0.0.1
Trend Variable	0.83872*	1	1	0	0.017

* We can reject the null at the lowest critical value for the Lc statistic (0.470)

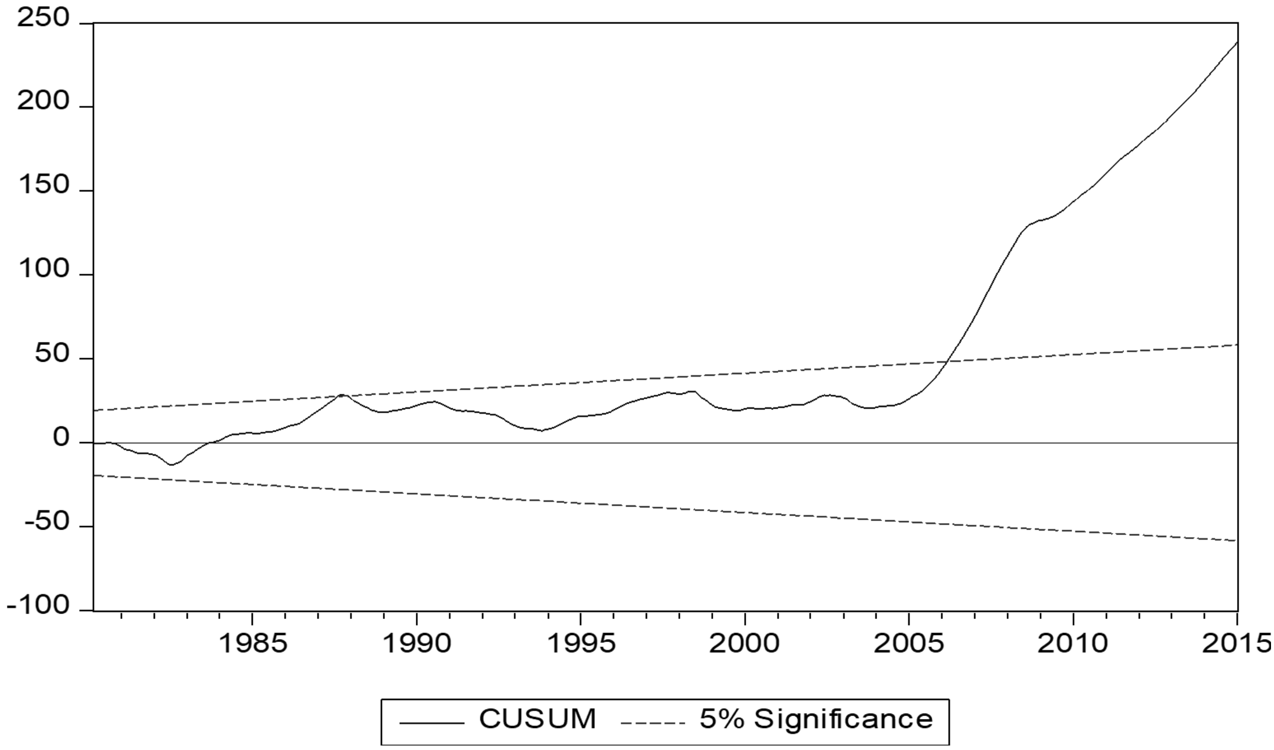
The asymptotic critical values for the Lc statistic are presented by Hansen (1992: 524) according to degrees of freedom (m+1). The relationship was tested with and without a trend variable and in both cases the null hypothesis of a stable long-run relationship can be rejected and the alternative hypothesis that there is a change at an unknown point in the sample can be accepted. Next the Recursive Residuals test was run, shown in Figure 4, which shows a clear breach of the +- 2 standard errors at multiple points in the sample, the most significant being between 2005 and 2009 during the period of the global financial crisis. These points of significance suggest parameter instability in the model.

FIGURE 4: Recursive Residuals Test of the relationship between 1980 and 2015



The CUSUM test, shown in Figure 5, shows two breaches of the 5% significance bands, one in 1988 where it briefly crosses the line after which it returns to within the 5% band and the second in 2007, from which it does not return. Similar to the other tests this indicates parameter instability and motivates the implementation of the cointegration tests proposed by Gregory and Hansen (1996a, b).

FIGURE 5: CUSUM test of the relationship between 1980 and 2015



4.3. Gregory-Hansen (1996) test

Following evidence of parameter instability found in the previous tests, the results of the Gregory-Hansen (1996a) test are presented for the case of a level shift, a level shift with trend and a regime shift, referred to in Table 3 as Model 1, Model 2 and Model 3 respectively. The test statistic presented is the ADF statistic according to the AIC. Presented alongside this are the number of lags included in the model and the estimated date of the break. Critical values for the tests are calculated in Gregory and Hansen (1996a). The null hypothesis in each case is no cointegration, tested against an alternative hypothesis of cointegration.

TABLE 3: Gregory-Hansen test results

	Model 1	Model 2	Model 3
ADF Stat	-5.62168*	-5.41800*	-5.66620*
Break Date	2005:06	2005:06	2005:06
Lags	4	4	4

*Denotes a rejection of the null hypothesis.

As seen in Table 3, one can reject the null hypothesis of no cointegration in each case and therefore, regardless of the model used, accept the alternative hypothesis of cointegration between stock prices and the consumer price index. The lag length selected by each model for unit root testing is uniform irrespective of the model, being 4 lags. The tests each show the important result within the context of this study that each model determines significant evidence of cointegration along with the presence of a structural break.

There are a number of reasons as to why the break may have occurred in mid-2005. A likely reason for the change in the relationship are the relatively low levels of inflation experienced between 2004 and 2005 with year-on-year rates that ranged from 0.2 to 4.4 over the two years (StatsSa, 2016). This is in comparison to a year on year rate of 11.6 early in 2003 and 13.7 in mid-2008. The year-on-year rates in May and June of 2005 were 2.8 and 3.4 respectively. These low inflation rates fit with the goals of the inflation targeting regime which was introduced in South Africa in 2000, aiming to curb inflation below 6%. The inflation targeting regime has typically been fairly successful since its implementation with the marked exception of the period between 2007 and 2009, the same period as the global financial crisis, often considered to be the worst financial crisis since the Great Depression (Goh, Li, Ng, Ow Yong, 2015).

From a stock market standpoint 2005 showed the highest index return by year from 2000 to 2015, falling directly between years of negative return in 2002 and 2008. According to the IDC (2013) the South African economy recorded its highest growth rates since the 1960‘s between 2004 and 2007. Over the 2004 to 2006 period South African interest rates were in one of two remarkably low phases, leading to credit growth and stimulating a housing market boom alongside the increased stock market investment. This massive growth, in conjunction with the low inflation rates over the period, points to a significant structural change in the relationship observed by the Gregory-Hansen (1996a) test in mid-2005. This break date coincides perfectly with adjustments of South Africa’s sovereign credit ratings by Standard and Poors and Fitch, who both adjusted their evaluation of South Africa’s investment grade to BBB+ in 2005. This rating indicates that the rating agencies both deemed South Africa to be worthy of a ‘lower medium grade’ rating, up from BB+, ‘non-investment grade speculative’ following the apartheid transition in 1995. These ratings have a substantial impact on investor confidence and a rating upgrade directly increases the rate of foreign investment.

4.4. FMOLS and DOLS results

Based on the results of the Gregory-Hansen (1996a) test, that being of a long-run cointegrating relationship with a structural break between the variables, the FMOLS and DOLS can be used to estimate the economic model. The break date shown by the Gregory-Hansen (1996a) test is used to separate the two sub-periods and the results are presented in Table 4.

TABLE 4: Results of the FMOLS and DOLS tests around a single break point

		1980-01 to 2005-06		**2005-06 to 2015-01**	
		FMOLS	**DOLS**	**FMOLS**	**DOLS**
LogCPI	**Coefficient**	**1.19287**	**1.22398**	**1.59059**	**1.67211**
	T-Stat	34.89551	37.93687	3.60779	12.00455
	Std. Error	0.03418	0.03226	0.44088	0.13929
	Prob.	0.00000	0.00000	0.00005	0.00000
Constant	**Coefficient**	**4.34814**	**4.15762**	**3.19644**	**2.56375**
	T-Stat	39.23568	29.64636	1.62449	3.84595
	Std. Error	0.11082	0.14024	0.19644	3.84595
	Prob.	0.00000	0.00000	0.10710	0.00030

*critical values for these tests are 1.65, 1.96 and 2.6 at the 10%, 5% and 1% levels respectively.

It is clear from Table 4 that there is a significant difference in the LogCPI coefficient between the two periods, which remains the case regardless of whether the FMOLS or DOLS results are considered. The coefficients in the first period show that for a 1% change in LogCPI, LogSP will change by 1.19% (FMOLS) and 1.22% (DOLS). In the latter period the coefficients show a 1.59% (FMOLS) or 1.67% (DOLS) change in the stock price. All the coefficients are shown to be significant. The results show a far higher coefficient in the post-2005 period, indicating changes that are about 0.45% higher per 1% change in CPI than in the pre-2005 period. From these results, it can be said that equities maintained their function as an inflationary hedge in the 1980 to 2005 period, but performed as a more effective inflationary hedge in the latter period. It can also be seen that the relationship has changed over time, with it being higher following the structural break detected by the Gregory-Hansen (1996) test in 2005.

These tests were then replicated using sample periods based on multiple structural breaks in order to account for the possibility that more than a single shift has occurred in the relationship during South Africa's recent history. When the pre-2005 sub-period was tested for a structural break using the Gregory-Hansen (1996) test, the most significant break in the sub-period was detected in September of 1994. In the post 2005 sub-period, the most significant break was found in June of 2008. While these periods obviously exhibit lesser power and size properties due to the shorter sample lengths, each was still significant for both tests. These results are reported in Table 5. While multiple structural break testing methodologies are available, such as the Bai-Perron (1998) test, the Gregory-Hansen (1996) test was favoured in this study in order to determine the single most significant structural break during each period.

4.5. Multiple structural break results

TABLE 5: Results of the FMOLS and DOLS tests for multiple structural breaks

Period	FMOLS CPI Coefficient	DOLS CPI Coefficient
1980:01 – 1994:09	1.14698	1.16925
1994:09 – 2005:06	1.26308	1.19707
2005:06 - 2008:06	4.35171	3.83714
2008:06 – 2015:01	2.52297	2.58831

As can be seen in Table 5, the cointegrating relationship exhibited changes in magnitude depending on the structural period measured, but remained positive and above unity in each period. From this it can be concluded that the equity returns-inflation relationship has been subject to multiple structural changes over the period and that while structural breaks affect the magnitude of the relationship, equities have in each period acted as an effective hedge against inflation in South Africa.

5. Conclusion

The aim of this study was to investigate changes in the equity returns-inflation relationship over time and to determine if these changes have caused the cointegrating relationship to change, thus questioning the assumption of time invariance. The Zivot-Andrews (1992) test showed that structural breaks have occurred over the sample period in both the stock price and CPI variables, with the most significant changes being in 1998 and 1990 respectively. However, it was still found that the variables are both non-stationary in levels, an important finding in this context given the disparity in the South African literature. Furthermore, it has been seen that the cointegrating relationship has experienced its most significant structural break in mid-2005, but that the cointegrating relationship still exists, based on the finding of cointegration by the Gregory-Hansen (1996a) model. The long-run elasticities were then estimated using the FMOLS and DOLS techniques, which found that there has been a significant change in the relationship coefficient before and after the structural break in mid-2005. The tests were then replicated for multiple structural breaks and found that while the magnitude of the relationship has experienced significant variance, equities have in each period acted as an effective inflationary hedge regardless of structural breaks.

Given this finding, we can address the research problem and state that structural breaks are indeed evident in the relationship and may well be a cause for the different results in the literature, but have no cause to question that the long-term cointegrating relationship has remained significant and positive, a pertinent finding in the South African case. Furthermore, it can be seen that the assumption of temporal invariance in previous South African studies is not necessarily accurate. This may partially explain the variance in results between previous studies in South Africa. These findings show that one should account for structural breaks and temporal variance when analysing the equity returns-inflation relationship and it cannot be assumed that the relationship is consistent over time. Interestingly, it does not appear that the inflation-targeting regime or the anti-apartheid sanctions had particularly significant effects on the relationship, but rather that the equity returns-inflation relationship in South Africa is primarily subject to political factors and global economic performance that affect foreign investment.

While this study has shown that the relationship does not remain consistent over time by providing evidence of a changing cointegrating relationship around a structural break, an analysis including a multiple structural break testing methodology test may provide further insights into the nature of the relationship when the time invariance assumption is relaxed. Furthermore, this study could be extended by the implementation of recent developments in cointegration theory that allow for the consideration of asymmetric adjustment, another factor that has been overlooked in much of the existing literature.

5.4 Statement of Author Contribution

The University of KwaZulu-Natal College of Law and Management Studies (CLMS) offers a PhD by Publications, in line with international practice. This declaration serves to confirm that the paper presented in Chapter 5 of this thesis "Equities as a hedge against inflation in South Africa" is the doctoral candidate's own original work, as stated in Declaration 2: Publications.

____

Mr. PBD Moores-Pitt

Date:

5.5 Conclusion

This chapter aimed to investigate whether the equity-returns relationship has remained a consistent hedge against inflation over time, or whether the capacity for equities to act as an effective inflationary hedge is time-variant in South Africa. Interestingly, it was found that structural breaks exist in both the stock price and inflation variables, but that the variables are both non-stationary in levels consistently over the sample period. Further, it was found that at least one structural break does indeed exist in the overall cointegrating relationship, but that this relationship is maintained even when the structural break is accounted for.

When examining the relationship prior and subsequent to the most significant structural break in the cointegrating relationship, there is evidence of a difference in the magnitude of the β coefficient, and so structural breaks may well be a cause and meaningful explanation for the different results in the literature. Structural breaks often occur as a result of exogenous shocks to a system, which is especially true for South Africa, which has experienced exceptional macroeconomic volatility over the past thirty-five years. This volatility has often occurred during periods of economic change, including the Apartheid transition, the implementation and subsequent removal of trade sanctions as well the international financial crises. Inflation over the period has exhibited exceptional instability, ranging from close to zero to above twenty percent during the period. Due to the fact that certain industries may be affected differently by inflationary variations of such magnitudes, the presence of structural breaks in the overarching relationship would suggest that there is likely to be value in further research that considers a sectoral analysis.

In any case, given the results for the South African case there is no apparent reason to question that the long-term cointegrating relationship between inflation and equity returns has remained significant and positive over time, and that it has in fact increased in magnitude between the first and second sub-periods. This research paper has made a novel contribution in identifying that the magnitude of relationship does in fact vary over time and, while the capacity for equities to act as an effective inflationary hedge remains consistent for the South African case, this would not necessarily be true for the international literature. The results illustrate that the relationship experiences volatility over time, proving that the assumption of time invariance is likely flawed – which may have had a far greater effect on the conclusions derived from the results of international studies.

The long-term relationship could of course be sub-divided further in order to assess the magnitude of the relationship between every set of structural breaks that were discovered. However, eventually the power properties of the models would be adversely affected due to the diminishing sample size resulting in reduced robustness of the results. In any case, the study has served its purpose in illustrating that there is indeed time variance in the relationship and that it is important to account for this when testing the nature of the relationship.

With reason given to question the assumption of time-invariance that is common in conventional cointegration testing, it is posited that the underlying assumption that the relationship is linear in nature is also flawed. Based on the findings of structural breaks, it is likely that asymmetric adjustment will prove to be evident in the adjustment of the cointegration relationship towards its long-run equilibrium. Due to the fact that the relationship has been proven to vary over time it is worthwhile considering that threshold effects may have occurred in the relationship. These conditions are defined, discussed and examined in chapter 6 (paper 3) of this thesis.

CHAPTER 6: ACCOUNTING FOR THRESHOLD EFFECTS AND ASYMMETRIC ADJUSTMENT BETWEEN INFLATION AND EQUITY RETURNS IN SOUTH AFRICA

6.1 Introduction

Given the findings of structural breaks in the relationship obtained in the Chapter 5, which included the introductory consideration of threshold cointegration with the Gregory-Hansen (1996) test, leads to the conclusion that the relationship between equity returns and inflation does not necessarily remain stable over time. As with many economic series, there may be a certain level of inelasticity of response in the relationship up until a certain point where an adjustment would occur. For example, in this context, if inflation is very low and stable, investors would be less compelled to find an investment that has the ability to hedge against inflationary increases. However, if an exogenous shock to the system disrupts the level of stability and causes expectations of inflationary increases to occur, investors would naturally be more inclined to explore hedging options. Following this logic, expectations of a minor increase in inflation would presumably provide less of a motivation to identify a hedging mechanism than expectations of high levels of future inflation and the required return on equity investments would have to be higher to effectively hedge against inflation. This leads to one goal addressed in this study, that being the identification of a certain threshold above or below which the response of equity returns to inflation changes and to investigate whether or not a cointegrating relationship is maintained around such a threshold.

Previously it had been assumed that positive and negative adjustments of equity returns or inflation back to the long-run equilibrium are symmetric, while in reality there is no good reason for such an assumption. Asymmetric adjustment essentially develops the idea that the relationship is not necessarily time-invariant: a common assumption of conventional cointegration techniques. Rather, it may adjust at different rates depending on whether it is above or below certain thresholds. Accounting for asymmetric adjustment between variables in the modelling of this relationship is a consideration that has been gaining popularity in recent literature and has in fact been explored in a recent examination of the relationship by Phiri (2017). The model employed in the study by Phiri (2017) accounts for a threshold effect, as well for the asymmetric adjustment of the variables towards their long-run equilibrium, and finds a negative adjustment coefficient, completely at odds to prior works in the field that have used earlier cointegration approaches. The study is limited by the use of a short data set, and the power properties of the model are consequentially not ideal – however, the findings help to highlight the fact that the issue of asymmetric adjustment may well extend to the relationship between equity returns and inflation.

6.2 Original Contribution

The contributions of this study are two-fold. Initially the Threshold Autoregressive (TAR) and Momentum Threshold Autoregressive (MTAR models), developed by Enders and Siklos (2001), and used in South Africa by Phiri (2017), are employed for comparative purposes. The models however use a longer sample in an attempt to improve on the power properties and provide a more robust analysis. While the TAR model is able to identify a threshold, the power properties remain somewhat limited, and so a superior threshold cointegration methodology is employed, in the form of the Two-Regime Threshold Vector Error Correction Model (TVECM). The limitations of the TAR and MTAR models and subsequent improvements of the TVECM are discussed in further detail in the methodology of the research paper.

The model used is developed by Hansen and Seo (2002) and Seo (2006, 2011) and represents, to the best of the authors knowledge, the first application of the model in the South African context. The TVECM employed in this study:

a) Allows for the identification of a threshold effect and tests for cointegration in light of such a threshold and improves on the power properties of previous studies due to the use of a far longer, more stable, sample.

b) Relaxes the assumption in the previous literature of symmetric adjustment, instead testing and accounting for asymmetric adjustment in the cointegrating relationship. The aim is then to produce a β coefficient while relaxing the assumption of symmetric adjustment, which frees the result from an asymmetric adjustment error and produces a more robust analysis.

The findings obtained are important to gaining an accurate understanding of the equity returns-inflation relationship and ultimately the capacity for equities to act as a hedge against inflation in South Africa. Even in the case where the final β coefficient does not differ substantially from cointegration tests that assume symmetric adjustment for the South African case, evidence of asymmetric adjustment and subsequently taking it into consideration within the model parameters provides a considerably more reliable result than studies that have used older cointegration techniques. Ultimately, by accounting for threshold effects and asymmetric adjustment, this research paper provides a far more robust estimate of the magnitude of relationship between equity returns and inflation, and the subsequent implications for the use of equities as an inflationary hedge than has been produced in the South African context to date.

6.3 Paper Presented as Submitted to Studies in Economics and Econometrics (SEE)

Section 6.3 presents the paper as submitted to Studies in Economics and Econometrics. The reference list has been removed, as the reference list of this thesis represents an amalgamation of all references used in all papers and chapters of this thesis as a whole.

Accounting for Threshold Effects and Asymmetric Adjustment between Inflation and Equity Returns in South Africa

PETER MOORES-PITT.
School of Accounting, Economics and Finance, New Arts Building, Pietermaritzburg Campus, University of KwaZulu-Natal, South Africa.
Email: moorespittp@ukzn.ac.za

BARRY STEPHEN STRYDOM
School of Accounting, Economics and Finance, New Arts Building, Pietermaritzburg Campus, University of KwaZulu-Natal, South Africa.
Email: strydomb@ukzn.ac.za

MICHAEL MURRAY
School of Mathematics, Statistics and Computer Science, Howard College Campus, University of Kwazulu-Natal, South Africa.
Email: murraym@ukzn.ac.za

Abstract

Recent South African empirical tests of the ability of equities to act as a hedge against inflation have generally relied on conventional cointegration tests that assume symmetric adjustment between the variables in the cointegrating relationship, however modern international evidence increasingly indicates that the relationship may not be this straightforward. Using CPI and JSE-ALSI data for the period 1980 – 2015, this study employs a threshold cointegration approach to investigate the long-run relationship between inflation and equity returns allowing for non-linear adjustment. The study finds compelling evidence that the relationship has experienced asymmetric adjustment over the sample period and that the relationship between equity returns and inflation is more appropriately modelled using threshold cointegration. The study confirms the ability of equity returns to protect investors against inflation, even when allowing for asymmetric adjustment, making the results a more robust indicator of the equity returns-inflation relationship.

Keywords: Inflation, equity returns, threshold cointegration, asymmetric adjustment, South Africa

1. Introduction

The relationship between equity returns and inflation is one that has been highly debated over the last several decades, with many studies showing disparate results in both developing and developed countries. The results found in the previous literature considering South Africa provide a particularly good example of this conflict (Alagidede and Panagiotidis, 2010; Eita, 2012; Khumalo, 2013). The importance of the magnitude of the equity returns-inflation relationship lies in the fact that it indicates whether or not equities have acted as an effective long-run inflationary hedge. A positive relationship with a value equal to one indicates that equities have acted as a long-run inflationary hedge in line with the Fisher (1930) hypothesis, while a positive value between zero and one indicates a partial inflationary hedge. Findings of a negative relationship indicate that equities have not acted as even a partial hedge against inflation. However, recent evidence suggests that this relationship may be time varying and may be subject to non-linear adjustment in the case of South Africa, and as such cannot be assumed to time-invariant (Phiri, 2017).

The original theory linking inflation and equity returns stems from Fisher's (1930) hypothesis, who posited that there exists a positive, unitary relationship between inflation and aggregate equity returns due to the fact that equities are essentially based on underlying assets which maintain their real value irrespective of inflation, and is represented in the Fisher equation by a β coefficient for inflation with a value of one. However, subsequent empirical evidence contradicted this theory with findings that the relationship is in fact negative. More modern studies that have employed cointegration techniques have found mixed results and the high variance between international results has led to the idea that the relationship is not necessarily uniform but is rather time and country dependent and therefore should be tested for in country-specific scenarios using relevant historical data.

This idea is consistent with the work of Antonakakis, Gupta and Tiwari (2017) who analyse US data between 1791 and 2015 and find evidence that the correlation between inflation and stock prices "evolve heterogeneously overtime" and "are indeed time varying". Moreover, Antonakakis et al. (2017) find that the relationship is significantly positive in certain years during the sample period and significantly negative in others. Such conflicts are evident in the South African literature, depending on methodologies and data sets used (Geyser and Lowies, 2001; Alagidede and Panagiotidis, 2010; Eita, 2012; Khumalo, 2013; Phiri, 2017). Based on the work of Balke and Fomby (1997), a further concern has arisen in the recent literature, that being that the assumption implicit in conventional cointegration modelling that adjustment is symmetric and that the relationship remains consistent over time may in fact be incorrect, causing disparities in time-series analysis. With the existence of strong evidence that the relationship is not in itself time-invariant, the assumption of symmetric adjustment is questionable.

The concern of an asymmetric adjustment error has been introduced into the question of the nature of the relationship of inflation and equity returns by attempting to account for non-linear adjustment between the variables (Kim and Ryoo, 2011; Phiri, 2017). Asymmetric adjustment essentially develops the idea that the relationship is not necessarily time-invariant- a common assumption of conventional cointegration techniques – but rather that it may adjust at different rates depending on whether it is above or below certain thresholds. This idea of non-linear adjustment is especially important in cases such as the South African market which has shown exceptional historical inflationary volatility and may thus be more susceptible to changes in the nature of the relationship if certain thresholds do exist.

Recent literature highlights the importance of accounting for asymmetric adjustment in the analysis of such an important relationship, based on the fact that changes in the relationship when equities are being utilised as an inflationary hedge could have substantial economic consequences. In this study, the Enders and Siklos (2001) threshold autoregressive (TAR) approach is initially used to analyse the data for comparative purposes, in which the possibility of threshold cointegration is examined. A Two-Regime Threshold Vector Error Correction Model (TVECM) is then constructed following the work of Balke and Fomby (1997), Hansen and Seo (2002), Seo (2006) and Seo (2011) and used to analyse the relationship between equity returns and inflation. We test for a null of no cointegration as well as a null of linear cointegration against alternate hypotheses of threshold cointegration within the TVECM framework, which allows for asymmetric adjustments of both equity returns and inflation towards the long-run equilibrium. A longer data set to meet the minimum sample size requirement of Seo (2006) is used, which is likely to provide more significant results than those of previous studies. The TVECM approach is used partly for comparability with the study by Kim and Ryoo (2011), who utilise the same approach to investigate the relationship in the United States. According to Seo (2006) this test is superior to its precursors, including the aforementioned tests proposed by Balke and Fomby (1997) and Hansen and Seo (2002) (Kim and Ryoo, 2011).

Essentially, this study frames the research question: Is there evidence of asymmetric adjustment in the equity returns – inflation relationship and has it affected the nature of the relationship?

Should this study provide evidence of asymmetric adjustment in this fundamental economic relationship it will highlight an error that may well account for many of the mixed results that have been obtained in the literature, some of which are discussed in the subsequent chapter. Furthermore, it will provide a substantial incentive for the use of threshold cointegration methods over conventional cointegration techniques in order to resolve the error that arises from the assumption inherent in conventional analyses that adjustment is symmetric in nature. The study also provides a magnitude for a β coefficient based on Seo's (2011) TVECM that fits the results into the framework of the Fisher hypothesis, in itself a major contribution that allows for comparisons to be drawn with preceding research in the field which, to the best of the authors knowledge, has not been done while accounting for asymmetric adjustment.

2. Literature Review

Since the introduction of econometric methods for the estimation of statistical relationships the field has typically been dominated by similar linear time series methods, not just in the financial field but also in fields including agriculture and environmental research. According to Enders and Siklos (2001) standard cointegration tests such as the Engle and Granger (1987) and Johansen's (1988) tests implicitly assume that linear adjustment occurs within the testing parameters, although there is no empirically supported reason to assume that the mechanism of adjustment is always linear in nature. Linear models have gained popularity in econometric testing due to their simplicity with regards to estimation and interpretation of their results, but it has been shown that the assumption of a linear mechanism of adjustment tends to conceal important factors that should be considered within the analysis.

As such, the consideration of non-linearity has recently been integrated into models that are used during econometric analyses, which have yielded interesting results and have highlighted the fact that the failure to account for non-linearity has, in the past, produced results contrary to those that are determined when non-linearity is considered. According to Hansen (1999) the consideration of non-linearity is especially important when asymmetric adjustment costs, transaction costs, market uncertainty and liquidity restraints and other forms of rigidities are present in the analysis. According to Enders and Siklos (2001: 166) the standard tests for linear adjustment have shown low power properties in the presence of asymmetric adjustment, but a threshold autoregressive (TAR) test, which is able to account for non-linearity, significantly improves on the power and size properties in comparison to the tests which assume symmetric adjustment.

The results obtained by previous studies that have examined the South African market without accounting for asymmetric adjustment have proved to be inconsistent and often conflicting. Alagidede and Panagiotidis (2010), Eita (2012), Khumalo (2013) and Moores-Pitt and Strydom (2017) found differing orders of integration of the stock returns and inflation variables. The South African literature reflects Eita (2012) finding both variables to be stationary, Khumalo (2013), finding one to be stationary and one to be non-stationary and Alagidede and Panagiotidis (2010) and Moores-Pitt and Strydom (2017) finding both variables to be non-stationary when using conventional unit root testing methods. Phiri (2017), who does consider asymmetric adjustment, uses the Enders and Granger (1998) approach to test a null of a unit root, which he found could not be rejected and thus also concluded that the variables are non-stationary, which he notes acts as evidence of the existence of a cointegrating vector under the Enders and Granger (1998) framework.

Alagidede and Panagiotidis (2010) use Johansen's (1995) multivariate method which they parameterize as a system of endogenous variables in a vector error correction model (VECM). They express the variables in logarithms and as such the estimated equation effectively shows the elasticity of changes in stock prices with respect to corresponding changes in consumer prices, shown by a β coefficient. They use data from 1980 to 2007 for the South African case, with the CPI acting as an inflationary indicator and the All Share Index data for the stock price variable, supplied by the International Monetary Fund (IMF), and find strong evidence of cointegration with a positive β coefficient for inflation of 2.264.

To emphasize the disparity evident in South Africa, several more studies are briefly considered. Eita (2012) considers the period between 1980 and 2008 and finds that all variables are stationary in levels, a direct contrast to the initial findings of Alagidede and Panagiotidis over virtually the same sample period. Subsequent to this finding Eita (2012) uses a VAR in levels to estimate the magnitude of the relationship, and finds what is referred to in this study as a β coefficient of 0.399. This implies that equity returns would only provide a partial hedge against inflation within the framework of the Fisher Hypothesis. In addition, Eita (2012) finds bi-directional causality between stock returns and inflation. Khumalo (2013) investigates the relationship using an Auto-Regressive Distributed Lag Model (ARDL) in order to account for findings that the unit root tests employed indicate that stock prices are I(0) while inflation is

I(1). This highlights the first disparity with the two previously mentioned South African studies. Khumalo (2013) initially runs a Granger Causality analysis and concludes that there is unidirectional causality in the direction of inflation to stock prices, in contrast to the findings of Eita (2012). The subsequent cointegration testing reveals that while there is evidence of a cointegrating relationship, the relationship is negative, with a β coefficient of -0.319. Khumalo (2013) notes that this indicates that an increase in inflation of one percent will lead to a fall in stock prices by about 31 percent, and subsequently concludes that while there is a strong relation between stock prices and inflation, stock prices and inflation are negatively related.

Arjoon, Botes, Chesang and Gupta (2011) apply a structural bivariate vector autoregressive (VAR) methodology originally applied by King and Watson (1997) to investigate the integration and cointegration properties of the two variables. The goal of the study is to determine how real stock prices respond to a permanent inflation shock, and so differs slightly from most other studies that aim to investigate the nature of the cointegrating relationship. The data set examined spans the period between 1980 and 2010, with inflation calculated as the first difference of the natural logarithm of the CPI and the stock price as the natural logarithm of the nominal share price deflated by the CPI. Note the important distinction between the calculation of the stock price by Arjoon et al. (2011) and the raw stock price data used by Alagidede and Panagiotidis (2010) and Moores-Pitt and Strydom (2017), which may well contribute to disparities in the final results. Arjoon et al. (2011) employ a range of conventional root tests and in combination conclude that each variable is integrated of the first order i.e. non-stationary in levels. However, Arjoon et al. (2011) run standard cointegration tests prior to employing the King and Watson (1997) methodology, which requires that the endogenous variables in the VAR should not be integrated and state that if the variables are non-stationary but cointegrated, “a finite VAR process in first differences does not exist for the variables.” Using the Engle-Granger (1987) test and the Shin (1994) two-step procedure. Arjoon et al. (2011) conclude that the variables are not cointegrated, contrary to the existing literature, a necessary precondition for using the King and Watson (1997) methodology. They also find that within the bivariate vector autoregressive (VAR) framework employed, that there is considerable evidence that long-run stock prices are invariant to permanent changes in the rate of inflation. They do however find that the impulse response functions suggest the existence of a real stock price response to a permanent inflation shock in the long-run, which indicates that in the short-run real stock prices will be corrected towards the long-run value. Furthermore, they state that in the long-run stock investments can provide a hedge against inflation in South Africa.

Moores-Pitt and Strydom (2017) point out that the differences in the results between South African studies may have occurred due to the use of differing data sets, specifically in the format of the data used and from where it was sourced. The authors sourced the same stock returns and inflation data directly from the Johannesburg Stock Exchange (JSE) and the inflation data from StatsSA as was used by Alagidede and Panagiotidis (2010), and were able to replicate the results that they obtained using a simple Vector Error Correction Model (VECM) framework. To eliminate the potential error obtained from using an incorrect order of integration, Moores-Pitt and Strydom (2017) then employed an Autoregressive Distributed Lag Model (ARDL). The analysis of Moores-Pitt and Strydom (2017) essentially explores the lack of consensus with regards to the order of integration of the variables, and employs the ARDL model to analyse the relationship between equity returns and inflation free from concerns of stationarity. It was found in this case that a stable cointegrating relationship does exist and that the inflation coefficient was positive and greater than unity, with a β coefficient of 1.3539, allowing the authors to conclude that equities do have the capacity to act as a long-run inflationary hedge in South Africa. However, the authors noted that the relationship may still exhibit threshold effects that are left unaccounted for by the VECM and ARDL models employed in their study, as they only consider linear adjustment. The need to incorporate asymmetric adjustments between stock return and inflation stems from the independent findings of recent studies (Barnes et al., 1999; Kim, 2003; Kim and Ryoo, 2011) which show disparities when failing to account for asymmetric adjustment, and ultimately provide a compelling argument for the use of the TVECM model as opposed to conventional VECM. It is worth accounting for asymmetries in the correction as even if one concludes that equities act as an effective hedge against inflation, more accurate and meaningful estimates are gained and the result itself may be considered to be more robust.

Threshold effects essentially occur when large shocks and small shocks to a variable result in different dynamic responses, which are often non-linear in nature. These shocks will therefore have to be of a sufficiently significant magnitude before a particular response is elicited (Goodwin and Harper, 2000) This consideration could potentially be particularly important in the South African context due to the relative volatility of both inflation and equity returns in recent history, brought about by macroeconomic events such as the apartheid transition, international trade sanctions and inflation targeting. When considering asymmetric linkages between a range of risk factors and stock returns in the BRICS countries, which represent major South African trade partners, Mensi, Hammoudeh, Yoon and Nguyen (2016) found significant evidence of threshold effects in a dynamic panel threshold model.

The concept of threshold cointegration was first introduced by Balke and Fomby (1997) and allows for the conversion of the mechanism of standard linear adjustment towards the long-run equilibrium into a non-linear adjustment mechanism. The authors state that it is assumed in the theory of cointegration that there is an expectation of a tendency for a cointegrated system to move towards its equilibrium state in each period, but it is possible that movement towards the long-run equilibrium will not occur in every period. They attribute this occurrence to the presence of fixed adjustment costs which prevent continuous adjustment via economic agents simply because the gain from adjustment would not be sufficient to offset the costs of adjustment. It is only when the deviation from equilibrium crosses a certain threshold that the profit from adjustment exceeds the costs of adjustment and so economic agents are provided with an incentive to move the system back into equilibrium. The authors examine the situation where there is a cointegrating relationship that is inactive inside a neutral band, which is effectively a specified range of values below the critical threshold level where the benefits of adjustment do not exceed the adjustment costs, but in which cointegration becomes active once the system crosses this critical threshold. Indeed, threshold cointegration itself stems from the existence of a neutral band which may exist due to the presence of transaction costs within a market, in which spatial arbitrage is unprofitable (Goodwin and Piggott, 2001). An important note made by Balke and Fomby (1997) is that the concept of threshold cointegration allows for the integration of the non-linear properties observed in many economic series but allows for use of the tools developed in traditional cointegration models.

Balke and Fomby (1997) proposed a two-step approach in order to address the dual testing issues, the first being the test for cointegration and the second being the test for linearity. In this test the initial step is to test the linear no cointegration null hypothesis against the alternative hypothesis of linear cointegration after which the second step is conducted, specifically a test of the linear no cointegration null hypothesis against an alternative hypothesis of threshold cointegration (Seo, 2006). This testing procedure includes three of the four possible hypotheses included in threshold cointegration testing, the excluded hypothesis being that of threshold no-cointegration which is also excluded in all existing literature as testing for it requires an entirely different distribution theory than is used for testing the null of no linear cointegration and therefore there are no tests which simultaneously examine both null hypotheses. Because of this consideration it is assumed that a rejection of the linear no-cointegration null hypothesis indicates either linear cointegration or threshold cointegration within the testing parameters.

The modelling of threshold effects has developed along two routes, namely the Enders and Siklos (2001) TAR and MTAR approaches and the Hansen and Seo (2002) and Seo (2006, 2011) TVECM approach. Kim and Ryoo (2011) were the first to apply one of these approaches in the equity returns-inflation relationship context in a long-term study done using a data set beginning in the 1900's and ending in 2009 in the United States. Kim and Ryoo (2011) used a two-regime threshold vector error correction model (TVECM) to test for cointegration in the context of the equity returns-inflation relationship. This study used the TVECM developed by Hansen and Seo (2002) and Seo (2006) to allow for asymmetric adjustments of stock return and expected inflation towards the long-run equilibrium which distinguished the results from those of past studies. Using the aforementioned TVECM Kim and Ryoo (2011) were able to find evidence of a threshold effect, but discovered that the relationship maintained a significant unitary relationship and thus that equities acted as an effective inflationary hedge. They also noted, when using the tests over different time periods, that a data set of thirty years provided substantial improvements in power and size properties relative to ten and twenty-year data sets. Kim and Ryoo (2011) conclude that the timing of rapid inflation adjustment has coincided with deflation, suggesting that stock returns and inflation have adjusted in order to cushion shocks and maintain a positive long-run relationship, and find significant evidence of asymmetric error correction.

In a recent South African study over the sample period 2003 to 2015, Phiri (2017) employs The Enders and Siklos (2001) approach to examine the relationship while considering the non-linear adjustment issue. Phiri (2017) used a twelve-year data set from South Africa spanning from 2003 to 2015 and finds contrasting results to much of the literature in the field of cointegration, with the estimation of a negative slope coefficient of -0.16 in South Africa, and also finds evidence of asymmetric adjustment. The results of a negative relationship may have been affected to some extent by their use of a relatively short data set. The sample size required to get reliable results has been examined by Kim and Ryoo (2011), who mention in their study that the results only become stable when a 30-year data set is used, consistent with the sample size requirement suggested by Seo (2006). In order to improve on the potential shortcoming in Phiri (2017) this study uses an extended data set that spans the period 1980-2015, a 35-year sample, in order to ensure compliance with the criterion established by Kim and Ryoo (2011) and Seo (2006). The stock price data used by Phiri (2017) was sourced from the Federal Reserve Economic Data (FRED) and differs from that sourced directly from the JSE. It is thus somewhat limited in its comparability with several of the other South African studies, similar to the situation leading to the difference in results between the studies of Alagidede and Panagiotidis (2010) and Moores-Pitt and Strydom (2017) and those of Eita (2012) and Khumalo (2013). Phiri (2017) found that the South African data exhibited a threshold effect in both the TAR and MTAR models with significant rejections of the null hypothesis of no cointegration, instead accepting the alternative hypothesis of threshold cointegration. Phiri (2017) also found that the equilibrium threshold terms satisfied the conditions of convergence discussed by Enders and Siklos (2001) and interestingly, that the TAR and MTAR models indicated that negative deviations from the equilibrium are eliminated more rapidly than positive deviations. A limitation with the study by Phiri (2017) is that the data set from 2003 to 2015 excludes significant structural changes to the South African economy, such as the apartheid transition, international trade sanctions and the introduction of the inflation targeting regime.

As such, the negative relationship determined by Phiri (2017) does warrant further investigation, both with the use of a longer data set that is consistent with other studies in the domestic literature and with the use of the Hansen and Seo (2002) and Seo (2006, 2011) approach for comparability with the international literature of Kim and Ryoo (2011). This latter test will also, to the best of the authors knowledge, be the first application of Seo's (2006, 2011) approaches to the South African context and will thus provide a somewhat novel contribution to the understanding of the equity returns-inflation relationship in historically volatile markets.

3. Methodology

3.1. Introduction

Prior to cointegration testing we conduct a series of tests for stationarity which are consistent with the existing literature (Kim and Ryoo, 2011). We then employ both extensions of Balke and Fomby's (1997) threshold cointegration testing approaches in this study. Initially we employ the test developed by Enders and Siklos (2001) which extends the Engle-Granger (1987) testing methodology to permit asymmetric adjustment towards the equilibrium, essentially capturing the effects of non-linear adjustment caused by the presence of a threshold. The test developed by Seo (2006), which tests a null of no cointegration against a null of threshold cointegration, is then employed alongside the test developed by Hansen and Seo

(2002) which tests a null of linear cointegration against a null of threshold cointegration and finally the cointegrating relationship is presented in the form of a TVECM following Seo (2011). These tests both have similarities to the cointegration testing methodology of Johansen (1996), except for the added capacity to account for a threshold effect in the error-correction term.

3.2. Unit Root Testing

As mentioned in the literature review, tests for stationarity using South African data have shown conflicting results, with a distinct lack of agreement on the order of integration of the variables. A stationary time series is one which exhibits constant statistical properties over time, including the mean, variance, and autocorrelation. Initially we conduct a graphical inspection of the series following the work of Xu, Sun and Lundtofte (2010) who recommend the inclusion of an intercept and a deterministic trend variable if it is obvious that the series exhibits an upward trend, which is evident in the case of both the inflation and stock price variables.

The Augmented Dickey Fuller (ADF), and the Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS) tests are run to test for the order of integration of the variables. The ADF is the most conventional unit root test, and tests a null of non-stationarity against the alternative hypothesis of stationarity. If non-stationarity is rejected in level terms but not rejected at first differences, we conclude that the series does contain a unit root and is thus non-stationary. The KPSS test performs a similar analysis with opposite null and alternative hypothesis: explicitly a null hypothesis of a stationarity is tested against an alternative hypothesis that the series contains a unit root.

3.3. The Enders and Siklos (2001) TAR and MTAR

The work of Enders and Siklos (2001) essentially generalizes the Enders and Granger (1998) threshold autoregressive (TAR) and momentum-TAR (M-TAR) tests for unit roots in a multivariate framework. They acknowledge the work of Tong (1983) who developed the basic TAR model which enables the degree of autoregressive decay to vary based on the dependent variable, while the M-TAR model developed by Enders and Granger (1998) allows the variable to exhibit varying levels of autoregressive decay based on whether it is increasing or decreasing. Enders and Siklos (2001) note that these important features of the TAR and M-TAR models are what distinguish the analysis they provide from that of the conventional cointegration tests of Engle and Granger (1987) and Johansen (1996) which, as previously discussed, implicitly include the assumption of linear adjustment. Enders and Siklos (2001) begin by specifying the equations used in standard models of cointegration and make the point that cointegration tests based on such regression equations assume symmetric adjustment, implying that there is a misspecification in the tests if adjustment is asymmetric. The Enders and Siklos (2001) approach allows one to test for cointegration with asymmetric error correction, summarised using the following equations below. For a more comprehensive discussion see the original papers by Enders and Siklos (2001) and Enders and Granger (1998). To account for asymmetric adjustment, they specify an alternative to the standard error correction model, the TAR model, in the form:

$$\Delta\mu_t = I_t p_1 \mu_{t-1} + (1 - I_t) p_2 \mu_{t-1} + \varepsilon_t \tag{1}$$

in which I_t is classed as a Heaviside indicator function such that

$$I_t = \begin{cases} 1, & if \quad \mu_{t-1} \geq \tau \\ 0, & if \quad \mu_{t-1} < \tau \end{cases} \tag{2}$$

In this model τ represents the value of the threshold and ε_t is a sequence of zero-mean, constant-variance i.i.d random variables, such that ε_t is independent of $\mu j, j < t$. Enders and Siklos (2001) then augment equation 1 with lagged changes in the μ_t sequence so that it becomes a *p*th order process of the form:

$$\Delta\mu_t = I_t p_1 \mu_{t-1} + (1 - I_t) p_2 \mu_{t-1} + \sum_{i=1}^{p-1} y_i \, \Delta\mu_{t-1} + \varepsilon_t \tag{3}$$

Equation 3 is able to capture the dynamic adjustment of $\Delta\mu_t$ towards its long-run equilibrium value where the errors still approximate a white-noise process. This allows $\Delta\mu_t$ to display asymmetric adjustment with regards to its lagged changes. In this equation, the value of y_i can differ depending on whether $\Delta\mu_t$ is positive or negative and this allows for the asymmetric adjustment factor. By substituting in the alternative Heaviside indicator equation where the threshold is dependent on the variance in the previous period, μ_{t-1}, the Heaviside indicator takes the form

$$M_t = \begin{cases} 1, & if \quad \Delta\mu_{t-1} \geq \tau \\ 0, & if \quad \Delta\mu_{t-1} < \tau \end{cases} \tag{4}$$

This latter class of models are known as the momentum-threshold autoregressive models (M-TAR) where the $\{\mu_t\}$ series has more momentum in one direction than the other, making them especially valuable when attempting to smooth out large shocks to a series (Enders and Siklos, 2001). Each specification of the model requires a unique Monte Carlo simulation in order to test the null hypothesis of no cointegration against the alternative hypothesis of cointegration with a threshold (Ocakverdi, 2012). Both the results of the TAR and the M-TAR are presented, with the lags being endogenously determined according to the SIC and the threshold value (tau) being determined by the data. Critical values are calculated by the model in each case, using 10000 simulations at the 10% level of significance. We can use both the sample value of Φ and the T-max statistic to reject the null hypothesis of no cointegration should they exceed their absolute critical values. It must be noted however, that Enders and Siklos (2001) state that the t-Max test suffers from low power properties in the case of the M-TAR (referred to as the t-max(M) test. Thus, we rely on the Φ value to analyze the results more so than the t-max(M) test.

3.4. The Hansen and Seo (2002) test

The study by Hansen and Seo (2002) developed a maximum likelihood-based estimation theory for a TVECM with an unknown cointegrating vector following the work of Lo and Zivot (2001) who found that multivariate threshold cointegration procedures have higher power than univariate procedures. Considering the notation of Hansen and Seo (2002), the test originally specifies a conventional linear VECM as:

$$\Delta P_t = A' X_{t-1}(\beta) + u_t \tag{5}$$

Where X_{t-1} acts as the regressor and is a $k \times 1$ function; $A\ is\ k \times p$ where $k = pl + 2$ and u_t is an error function assumed to be a Gaussian sequence with a covariance matrix Σ. The parameters are estimated by maximum likelihood (MLE) under this assumption.

Hansen and Seo (2002) extend model one into a two-regime threshold cointegration model of the form:

$$\Delta x_t = \begin{cases} A'_1 X_{t-1}(\beta) + u_t & if\ \ w_{t-1}(\beta) \leq y \\ A'_2 X_{t-1}(\beta) + u_t & if\ \ w_{t-1}(\beta) > y \end{cases} \tag{6}$$

Where y represents the threshold parameter. The threshold model shows two regimes governed by the value of the error correction terms. The model allows all coefficients with the exception of the cointegrating vector (β) to switch between the two regimes. The cointegrating value is initially estimated from the linear VECM. Then, depending on the value estimated by the linear VECM, the LM test is run for a range of different threshold values, of which the maximum LM test value is reported.

4.5) The Seo (2006) TVECM

The TVECM model developed by Seo (2006) used by Kim and Ryoo (2011) is specified as:

$$\Phi(L)\text{-}\Delta X_t = \alpha_1 Z_{t-1} I(Z_{t-1} \leq \gamma) + \alpha_2 Z_{t-1} I(Z_{t-1} > \gamma) + \mu + \varepsilon_t \quad (7)$$

where $\Phi(L)$ is the lag of polynomial of order p; ΔX_t is the first difference of X_t (Vector of the stock return and inflation); α_1 and α_2 are the vectors of speed of adjustment coefficients; $I(\bullet)$ is an indicator function which takes the value 1 if the condition inside the brackets is satisfied; ε_t is a vector of i.i.d. error terms; Z_t takes the place of S_t - P_t, which represents the deviation from the long-run equilibrium while γ is its long-run mean (S_t is the log of the stock price, while P_t is the log of the goods price).

In the above model there are two possible regimes represented by the terms in the brackets. In Regime 1 where $(Z_{t-1} \leq \gamma)$ stocks are underpriced relative to goods and in Regime 2 where $(Z_{t-1} > \gamma)$ stocks are overpriced relative to goods. Seo (2006) presents a band TVECM where the γ function is presented as γ_1 in the first regime and γ_2 in the second, but Seo (2006) notes that in the two-regime TVECM, $\gamma_1 = \gamma_2$. To differentiate between the Hansen and Seo (2002) test and the Seo (2006) test, in the former the hypothesis is tested under the restriction that α_1 and α_2 are both non-zero and that $\gamma_1 = \gamma_2$ in order to examine the null of linear cointegration against threshold cointegration, where as in the latter the linear no cointegration null hypothesis is defined as $H_0\colon \alpha_1 = \alpha_2 = 0$, indicating that both α_1 and α_2 take on a value of zero under the null hypothesis (Seo, 2006: 132).

Following the methodology of Seo (2006) in the same framework as Kim and Ryoo (2011: 168) the cointegrating relationship between the log of the stock price, specified as S_t, and the log of the goods price, specified as P_t is initially considered in the following cointegrating equation:

$$S_t = y + \beta P_t + u_t \quad (8)$$

Where u_t is considered to be a stationary time series. The cointegrating parameter is imposed by setting β, which we use to represent the Fisher coefficient, equal to 1. This is representative of unit elasticity between the stocks and goods price. The deviation from the long-run equilibrium is then specified as:

$$z_t \equiv S_t - P_t = y + u_t \quad (9)$$

When y is the long-run-mean of the series. As stated above, the two regimes are then developed according to the specifications, $(Z_{t-1} \leq \gamma)$ when stocks are under-priced relative to goods and $(Z_{t-1} > \gamma)$ when stocks are overpriced relative to goods.

The null hypothesis of Seo's (2006) TVECM test is that no linear cointegration exists, tested against the alternative hypothesis of the existence of threshold cointegration. The test statistic used is the supremum of the Wald test statistic for the null hypothesis which is calculated using a grid of γ values over its parameter space (Kim and Ryoo, 2011). The lag order is estimated using the various information criterion, similar to Johansen's cointegration test. Throughout this study we utilise the SIC criterion to determine the lag length, following Kim and Ryoo (2011). The Seo (2006) approach uses a sup-Wald test statistic with critical values that are determined using a residual boot-strap, where as in the case of the Hansen and Seo (2002) test the null hypothesis of linear cointegration is tested against an alternative hypothesis of threshold cointegration, using a SupLM test to examine whether a threshold exists. Mann (2012) notes that the primary disadvantage of the Seo (2006) approach is that the cointegrating vector must be known *a priori,* which is relaxed in the case of Seo's (2011) approach. In the case of this study we set the cointegrating vector equal to unity, in line with the research question of whether equities are able to act as an inflationary hedge. If threshold cointegration is found using a unitary cointegrating vector it is indicative that equities exhibit at least a one-to-one relationship with inflation and are thus able to act as an inflationary hedge.

Seo (2011) proposes a methodology to account for non-linear adjustment when the cointegrating vector is unknown, and simulates a sample of results using a smoothed indicator approach. The proofs of theorems and assumptions included in this approach are extensive and are comprehensively described in Seo (2011), and as such we do not discuss this approach in great detail in this study, suffice it to say that it builds on the aforementioned distribution theories. The paper focuses on regime-switching VECM's in which each regime exhibits differing short-run characteristics, which includes threshold cointegration (Seo, 2011). Simulation samples are generated by Seo (2011) using the following process, similar to that described by Hansen and Seo (2002) but presented using the following notation:

$$\Delta x_t = \binom{-1}{0}(x_{1t-1} - \beta_0 x_{2t-1}) + \binom{-2}{0} 1\{x_{1t-1} - \beta_0 x_{2t-1} \leq y_0\} \qquad (10)$$

$$+ \binom{-0.5}{0}(x_{1t-1} - \beta_0 x_{2t-1}) 1\{x_{1t-1} - \beta_0 x_{2t-1} > y_0\} + u_t$$

Where y_0 and β_0 perform similar functions to those mentioned in the Hansen and Seo (2002) test. u_t is a standard $iidN(0, I_2)$ function, $t = 0, \dots, n,$ and $\Delta x_0 = u_0$. Unlike the Hansen and Seo (2002) test, β_0 is fixed at a value equal to unity, while y_0 is fixed equal to zero. Following Seo (2011) the grid search sizes for β, the cointegrating parameter, was set to 100, while the size for y, the threshold parameter was set to 500. The results of the tests are presented in the following section.

4. Results

4.1. Stationarity Tests

We initially present the two stationarity tests that we employ in this study alongside a graph showing the variation in inflation and stock returns independently as a function of time. Based on the graph in Figure 1 the upward trend in both series is evident, justifying the inclusion of an intercept and a deterministic trend following Xu, *et al.* (2010). The results of the stationarity test are shown in Table 1.

Figure 1: Graph showing the log of stock prices and inflation between 1980 and 2015

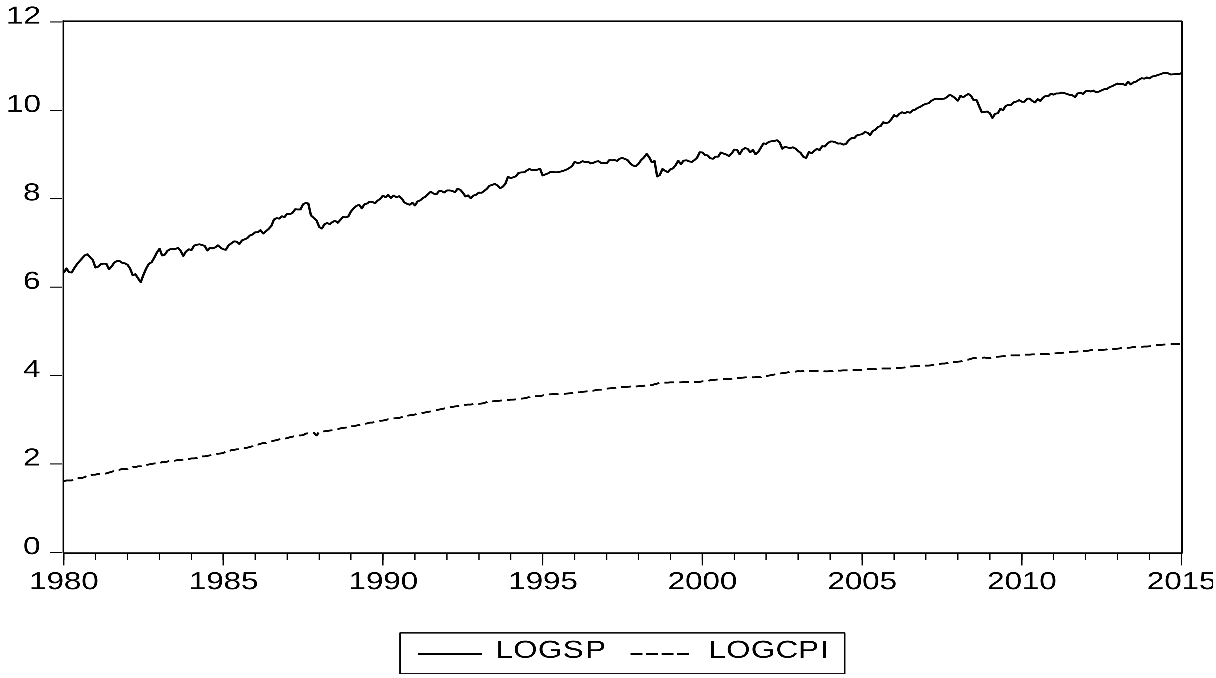


Table 1: Stationarity Test Results

Test	ADF Test		KPSS Test	
Null	Unit Root		Stationarity	
statistic	t-stat		LM-Stat	
Ord. of Int	Levels	1st Diff	Levels	1st Diff
Stock Price	3.25882	-19.00924**	0.189233*	0.02285
CPI	-1.8307	-13.97783**	0.61593**	0.19531*

**Significant at the 1% level, *Significant at the 5% level

According to the results of the ADF test presented in Table 1 we cannot reject the null of a unit root for both the stock price and the CPI in levels, meaning that the series are both non-stationary. The null can however be rejected in first differences at the 1% level of significance, meaning that the ADF test indicates that both series are integrated of the first order, or are $I(1)$ processes. In the case of the KPSS test the null of stationarity can be rejected in level terms for both series in level terms, indicating that they are not stationarity, the null of stationarity fails to be rejected for the stock price at the 5% level, while for CPI it is only rejected at the 1% significance level. We can however conclude that the variables are non-stationary at the 5% level of significance and can progress with cointegration testing.

4.2. TAR and MTAR Results

In this section the results of the TAR and M-TAR tests by Enders and Siklos (2001) are presented. Both the LogSP and LogCPI variables are set as endogenous variables, and the lag length is endogenously determined by the data according to the SIC criterion. The results of the TAR and MTAR test are presented as follows:

Table 2: TAR and M-TAR results with LogSP as the dependent variable

Method	**Threshold (TAR)**		**Momentum (M-TAR)**	
Lags	1		1	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Above Threshold	-0.00958	0.01377	-0.01884	0.01205
Below Threshold	-0.06012	0.01848	-0.07572	0.02820
Differenced Residuals (t-1)	0.09326	0.09326	0.10871	0.05002
	Test statistic	Critical value	Test statistic	Critical value

Threshold Value (tau)	-0.26565		-0.04533	
F-Equal	4.84154	4.98310	3.44904	6.86237
T-Max Value	-0.69573	-1.58889	-1.56355*	-1.47012
F-Joint Φ	5.51628	6.02137	4.80979	7.07750

indicates significance at the 10 level

According to the results presented in Table 2 for the case of the Threshold (TAR) test the value of the Φ test statistic is somewhat lower than the critical value computed by the Monte Carlo Simulation. Furthermore, the t-max test statistic is also lower than its respective critical value. Contrary to expectations, this result indicates that even at the 10 percent level of significance we cannot reject the null of no cointegration. Enders and Siklos (2001) found a similar result in their example and as such resorted to the use of the M-TAR test to derive their conclusions, which showed evidence of cointegration.

However, in this case the Φ value of the M-TAR test also falls well short of the critical value computed during the Monte Carlo simulation, which would indicate a failure to reject the null of no cointegration. The t-max(M) statistic on the other hand, does slightly exceed its critical value at the 10% level of significance. However, as noted earlier, Enders and Siklos (2001) state that this statistic does not exhibit strong power and disregard its result in their analysis in favour of the Φ value. Based on this finding, the Enders and Siklos (2001) analysis would indicate no evidence of a long-term relationship when accounting for asymmetric adjustment. If the t-max(M) statistic is considered sufficient evidence of cointegration in any case, the threshold value would be negative, with a value of -0.04533. The coefficient of adjustment above this threshold is -0.01884, while the coefficient below the threshold is -0.07572. These coefficients would then indicate a weak negative relationship between inflation and stock returns in both cases, however it can be seen that the coefficient below the threshold is significantly greater in absolute terms than the coefficient above the threshold. The conflicting results of the two tests do not provide a strong argument for or against the existence of cointegrating relationship for the sample set and as such, this study extends the analysis using Seo’s (2006) TVECM.

While Phiri (2017) finds evidence that some form of cointegrating relationship does exist, the study also rejects the hypothesis of asymmetric cointegration when stock market returns are treated as the dependent variable, as is the case in this study. Phiri’s (2017) study continues with an analysis treating inflation as endogenous to stock market returns i.e. with inflation as the dependent variable, which seems to find a level of significance, and then conducts OLS estimates to determine a slope coefficient. This is an odd finding in itself as one might expect the results obtained when using one of the variables as the dependent variable to be the inverse of the case when using the other variable in a bivariate model. For comparative purposes the results of this study are presented with inflation as the dependent variable.

Table 3: TAR and M-TAR results with inflation as the dependent variable

Method	**Threshold (TAR)**		**Momentum (M-TAR)**	
Lags	1		1	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Above Threshold	-0.05018	0.01768	-0.07360	0.02687
Below Threshold	-0.01631	0.01369	-0.02043	0.01183
Differenced Residuals (t-1)	0.08927	0.04861	0.10211	0.04928
	Test statistic	Critical value	Test statistic	Critical value
Threshold Value (tau)	0.19358		0.03123	
F-Equal	2.30702	4.99515	3.29274	6.90360
T-Max Value	-1.19095	-1.60538	-1.72747*	-1.44629
F-Joint Φ	4.71720	6.02870	5.21845	7.00612

Contrary to Phiri (2017), the use of the inflation variable as a dependent variable does not provide results that are significant at the 10% level for the TAR model, and in the case of the M-TAR produces results very similar to that of that of the M-TAR when stock prices act as the dependent variable, in that the Φ value still indicates a non-rejection of the null and the t-max(M) also slightly exceeds its respective critical value. A reversal of the coefficients does not in this case change the conclusions we can make concerning the relationship, and the inferences from the latter set of results mirror those of the model when stock prices are used as the dependent variable. The difference in the results to those of Phiri (2017) may well be due to the significantly longer data set used or format of the data.

Based on this result it can be seen that the model does not ascertain substantial evidence for a cointegrating relationship with asymmetric adjustment, providing motivation for the use of a superior threshold cointegration test following Kim and Ryoo (2011). What is noteworthy from the TAR and MTAR tests results however is that both tests do find evidence of thresholds, which suggests that the relationship may well prove to be non-linear in the South African case. To further the investigation, we present the results of the Hansen and Seo (2002) and Seo (2006) tests for threshold cointegration and finally construct the TVECM following Seo (2011). The TVECM has been developed in the literature as an alternate path to the TAR and MTAR tests and is also consistent with the study by Kim and Ryoo (2011) in the same field and as a consequence is appropriate threshold modelling option in this context.

4.3. TVECM results

As discussed earlier this test is run using two distinct partitions. The Hansen and Seo (2002) test analyses a null of linear cointegration against an alternative hypothesis of threshold cointegration, while what we refer to as the Seo (2006) methodology tests a null of linear cointegration against an alternative hypothesis of threshold cointegration. In the case of the Hansen and Seo (2002) test the threshold value is endogenously determined, while the lag length is set to 1 according to the SIC criterion, tested independently of the model using a VAR model. We include an intercept based on graphical inspection of the data set as discussed previously, and set the number of boot strap replications to 1000. The test output is presented as follows:

Table 4: Hansen and Seo (2002) Test Results

Null: Test of linear cointegration null versus threshold cointegration			
Cointegrating value (estimated under restricted linear model): -2.37420			
Test Statistic	Threshold Value	P value	1% critical value
35.6488***	-0.28167	0	23.93303

The Hansen and Seo (2002) test rejects the null of linear cointegration in favour of the alternative hypothesis of threshold cointegration at the 1% level of significance. The test endogenously determines a threshold value of -0.28167, for which the test statistic of 35.6488 is maximized. From Table 4 it can be seen that the linear cointegration null is rejected at the 1% level of significance as the test statistic exceeds the 1% critical value of 23.93303.

Bearing in mind that in the case of the Seo (2006) test it is assumed that the cointegrating vector is known *a priori* and, in this study, β is assumed to equal one, to be consistent with the Fisher hypothesis. The null of no cointegration is tested against the alternative hypothesis of threshold cointegration. For the other parameters a lag length of one is used as indicated by the SIC, consistent with the Hansen and Seo (2002) test. A trimming region was set to 0.1 and the number of boot strap tests to be run was set to 1000. The results of the Seo (2006) test are as follows:

Table 5: The Seo (2006) threshold cointegration test Results

Null: Test of a null of no cointegration versus threshold cointegration				
Cointegrating Value	Test statistic	P Value	10% critical value	5% critical value
1	51.89514*	0.057	49.03090	52.28880

indicates significance at the 10 level

As can be seen from table 5 the test statistic is greater than the 10% bootstrap critical value that was estimated in the equation, but less than the 5% value. Thus, the null hypothesis of no cointegration can be rejected, with acceptance of the alternative hypothesis of threshold cointegration. We can infer from this result that evidence of threshold cointegration does exist between the variables with a pre-specified cointegrating value of one, lending support to the theory of the Fisher Hypothesis. To avoid the limitation inherent in the previous model where the cointegrating vector must be pre-specified however, we next employ Seo's (2011) TVECM, which is able to determine the cointegrating vector endogenously. The Error Correction Models (ECM) shown in Table 6 include results from above the threshold and from below the threshold.

Table 6: Two-Regime Threshold Vector Error Correction (TVECM) Results

Cointegrating Vector:		(1, - 2.42286)		
Threshold Value:		-0.28167		
Percentage of Observations in each regime		Regime 1		Regime 2
		41.3%		58.7%
Threshold	ECT	Constant	$LogSP_{t-1}$	$LogCPI_{t-1}$
Under				
Equation LogSP	-0.0781*	-0.0305	-0.0222	-1.4322
Equation LogCPI	0.0085*	0.0081***	-0.0170*	0.2678**
Over				
Equation LogSP	-0.0036	0.0067	0.1458*	0.5941
Equation LogCPI	0.0025***	0.0087***	0.0119	-0.1259*

Beginning with the cointegrating vector, we normalize the coefficients in the equation on the LogSP variable in order to reformulate the cointegrating vector as a long-run equation, with a β coefficient of 2.417752. Notice that the negative sign presented in the cointegrating vector becomes positive when presented as a long-run equation, following the popular methodology of Johansen (2002). The long-run equation is presented in terms of the Fisher equation to illustrate the relationship between equity returns and inflation as:

$$LogSP = C + 2.42286 LogCPI$$

It can be seen from the cointegrating vector that the β coefficient is positive and far exceeds the unitary relationship necessary for equities to act as a long-run inflationary hedge. The result is similar to that of the VECM constructed by both Alagidede and Panagiotidis (2010) who calculated a β coefficient of 2.264 and Moores-Pitt and Strydom (2017) who calculated a β coefficient of 2.49, even when considering the effects of the threshold. Therefore, it is evident that the VECM used in these previous studies does not provide substantially different outputs from the TVECM used in this study, allowing us to conclude that in terms of the overarching research question regarding the magnitude of the relationship, accounting for a threshold does not significantly impact the β coefficient and that equities do act as an effective inflationary hedge. Such findings allow one to speak more confidently to the use of equities as an inflationary hedge in South Africa. A three regime-TVECM was also run which, while showing evidence of a second threshold that splits the first regime at 23.9%, does not influence the magnitude of the cointegrating relationship.

It can be observed in Table 6 that the rate of change in each regime differs somewhat between regimes. However, in both cases the TVECM results imply that it is the LogSP variable that converges towards the equilibrium in each period to correct for disturbances, while LogCPI actually moves away from the equilibrium level. These results imply that it is the log of the stock price that corrects for any disequilibrium in the relationship. It can be seen that the threshold splits the regimes, with the first regime containing 41.3% of the observations and the second regime containing 58.7% of the observations. The rates of adjustment, as seen in Table 6, imply that when below the threshold, LogSP corrects for 7.8% of the disequilibrium in each period, while LogCPI moves away from the equilibrium level at about 0.85% each period. When above the threshold the converging adjustment of LogSP drops to 3.6% in each period while the adjustment away from the equilibrium of LogCPI drops to about 0.25%. Two conclusions can be taken from this; the first being that the rates of adjustment of both variables differ substantially depending on whether the relationship is above or below the threshold, and secondly that it is the LogSP variable that adjusts to correct the disequilibrium in each period. This correction by the LogSP variable is consistent with the findings of Arjoon *et al.* (2012), who note that there is a positive response by stock prices to a permanent inflation shock in the long-run.

5. Conclusion

The aim of this study was to investigate the nature of the relationship between equity returns and inflation in a South African context while accounting for an asymmetric adjustment error and potential thresholds in the relationship. Additionally, this study provides a β coefficient that allows the results to fit the framework of the Fisher hypothesis and uses a sufficiently long data set to be comparable with previous work in the field. The motivation for the study lies in the fact that the evidence presented by previous South African studies has been exceptionally inconsistent, without much commentary on the reasons for these differing results. Furthermore, international studies have also found conflicting results on the nature of the relationship and it has been shown previously to be time and country dependent.

In light of this more modern threshold cointegration approaches were employed to examine the possibility of the existence of thresholds in the relationship. This approach addressed the potential error that may have occurred in many previous studies in the literature caused by the inherent assumption in conventional cointegration techniques that the relationship remains consistent over time and is not subject to differing rates of adjustment.

Subsequent to testing for stationarity, from which the results provided evidence that the data series are both significantly non-stationary, the TAR and MTAR tests developed by Enders and Siklos (2001) were employed to test for the presence of a threshold in the relationship. While relatively weak evidence was found that the null of no cointegration could be rejected using the t-max(M) statistic in the M-TAR test, it was noted that it would be imprudent to make conclusions based on these mixed results. It was also noted that Enders and Siklos (2001) state that the test statistic does not exhibit strong power and disregard its result in their analysis in favour of the Φ value, but should the t-max(M) statistic be taken as sufficient evidence of cointegration in any case, the threshold value would be negative, with a value of -0.045329, fairly consistent with the result obtained by Phiri (2017).

The alternative methodologies developed by Hansen and Seo (2002) and Seo (2006; 2011) were then employed to provide a magnitude for the threshold cointegration relationship. The

Hansen and Seo (2002) methodology tested a null of linear cointegration against an alternative hypothesis of threshold cointegration, and provided evidence strongly rejecting the null hypothesis in favour of threshold cointegration. The Seo (2006) model was then employed to test for a null of no cointegration against an alternative hypothesis of threshold cointegration and rejected the null hypothesis in favour of the alternative at the 10% level of significance, with a prespecified cointegrating value of one, which lends support to the theory of the Fisher hypothesis. A TVECM based on Seo's (2011) model, which is able to endogenously determine the cointegrating value, was then constructed and which showed the existence of a threshold at -0.259742 and a positive cointegrating relationship with a β coefficient of 2.417752. Furthermore, it was shown that the adjustment coefficients differ substantially depending on whether they are above or below the threshold, and thus that the assumption of linear adjustment is flawed and the relationship exhibits asymmetric adjustment in reality.

When using solely the Enders and Siklos (2001) approach, Phiri (2017) discovered a negative relationship of -0.16 in contrast to the majority of previous South African studies. The use of a longer data set highlights the fact that the Enders and Siklos (2001) approach does not find highly significant results, but the significance of the results show a marked improvement when Seo's (2006, 2011) TVECM is used instead. This allows one to reconsider the findings of a negative relationship and to conclude that the superior results of the TVECM combined with a larger sample size in fact shows a positive relationship, suggesting that equities are in fact able to act as an effective inflationary hedge. The results do however confirm Phiri's (2017) finding that evidence of asymmetric adjustment is apparent in the relationship.

This finding of asymmetric adjustment suggests that threshold effects should be accounted for when considering the relationship between equity returns and inflation internationally. In the South African context, the magnitude of the β coefficient suggests that equities have historically acted as an effective hedge against inflation, and is fairly similar to the VECM results obtained by Alagidede and Panagiotidis (2010) and Moores-Pitt and Strydom (2017), although there is a slight degree of differentiation when the threshold is taken into account. Even though the cointegrating coefficient is similar and does not affect our conclusions in the context, the evidence of a threshold, and differing rates of adjustment around it, highlight the importance of accounting for asymmetric adjustment which may well have influenced the relationship coefficients to a far greater extent in other studies that examined different sample periods or other countries and emphasizes the superiority of the TVECM in relation to the conventional VECM methodology, and thus may partly explain the conflicting results in the literature. This is especially important given the contrasting results of Alagidede and Panagiotidis (2010) who found a β coefficient greater than one, Eita (2012) who found a β coefficient between one and zero, and Khumalo (2013) who found a negative β coefficient in South Africa. This study provides a superior analysis of the equity returns-inflation relationship in South Africa in comparison to these preceding studies based on the more modern methodologies employed as well as the longer data set that has been incorporated, but the conclusions obtained regarding the equity returns-inflation relationship indicate that equities remain an effective hedge against inflation in South Africa even when considering asymmetric adjustment and accounting for the presence of a threshold.

Although this study uses the longest data set that includes South Africa to the best of the author's knowledge, it could be further improved by the use of a longer data set, as has been done in several U.S. studies such as that by Kim and Ryoo (2011) which use sample sizes of over a century. This idea is limited to some extent in the South African market due to data availability as well as changes in index calculation methodologies. Furthermore, a sectoral break down of the data might yield interesting results because of differing relationships to inflation, instead of looking at the All Share Index exclusively, which is lent support by the findings of Geyser and Lowies (2001), where a negative correlation is discovered between the mining sector and inflation.

A further interesting avenue for research would be to apply the TVECM analysis in a multi-country setting, similar to the work of Alagidede and Panagiotidis (2010) with the VECM methodology. This would allow for a comparison of the results and would show whether threshold cointegration techniques find a greater level of variance in comparison to conventional cointegration techniques in other markets than in the South African case.

Finally, stepping away from the bounds of cointegration testing altogether by completing a study using signal decomposition techniques based on a wavelet analysis in order to further study the lead/lag relationship between the equity returns and inflation may represent an interesting contribution to the field. Similar analyses have been conducted by Gallegati (2008), who considers the relationship between the stock market and economic activity, and by Kim and In (2003) who apply a wavelet approach in the context of various financial variables and real economic activity.

6.4 Statement of Author Contribution

The University of KwaZulu-Natal College of Law and Management Studies (CLMS) offers a PhD by Publications, in line with international practice. This declaration serves to confirm that the paper presented in Chapter 6 of this thesis "Equities as a hedge against inflation in South Africa" is the doctoral candidate's own original work, as stated in Declaration 2: Publications.

____

Mr. PBD Moores-Pitt

Date:

6.5 Conclusion

The aims of this research were to establish whether a threshold effect exists in the relationship between equity returns and inflation in South Africa, and to model the long-run cointegrating relationship while testing and accounting for asymmetric adjustment. Applying Seo's (2006, 2011) two-regime TVECM approach produced a more significant result than previous studies that have accounted for asymmetric adjustment and allowed for the more robust conclusion that equities are able to act as an effective inflationary hedge in South Africa, even in the presence of a threshold effect and asymmetric adjustment.

The findings of asymmetric adjustment at a significant level indicate that even though the cointegrating coefficient is similar and does not affect our overall conclusions in the context, the evidence of a threshold, and differing rates of adjustment around it, may well have influenced the relationship coefficients to a far greater extent in other studies that have examined different sample periods or other countries. This emphasizes the superiority of the TVECM in relation to the conventional VECM methodology, and may partly explain the conflicting results in the literature.

Given the results of this study it is established that asymmetric adjustment must be accounted for when analysing such relationships. What has not yet been determined is if the adjustment coefficient remains similar regardless of the whether the adjustment is positive or negative, or if the two adjustments may have substantially different magnitudes. This question is addressed in Chapter 7 (paper 4) of this doctoral thesis.

CHAPTER 7. AN ANALYSIS OF THE NON-LINEAR DYNAMICS OF THE EQUITY RETURNS-INFLATION RELATIONSHIP IN SOUTH AFRICA: AN NARDL APPROACH

7.1 Introduction

Chapter 4 provided a fundamental analysis of the equity returns – inflation relationship and addressed the issue of the disparity in the previous South African literature as to the order of integration of the two variables with the use of the VECM and ARDL models. The relationship between equity returns and inflation had been assumed to be time-invariant, an assumption that was investigated in Chapter 5 with the identification of structural breaks in the relationship. Chapter 6 introduced the possibility that the relationship may have been subject to asymmetric adjustment effects, which was proven to be true with the finding of significant evidence of such effects in the relationship. The final paper to this doctoral dissertation (paper 4 presented in Chapter 7) brings together the benefits of the previous models with the implementation of a non-linear ARDL (NARDL) model, which is simultaneously able to address the issue of the order of integration as well as account for asymmetric adjustment effects. More importantly, this chapter aims to estimate the magnitude of the asymmetric adjustment coefficients for positive and negative adjustments independently.

When one considers the nature of inflation, and the negative effects of inflation on real wealth, one is typically concerned with positive inflationary increases, as a decrease in inflation would typically provide a lesser incentive to hedge against inflation. Therefore, it is important to be able to consider the relationship between equities and inflation in two parts: one where inflationary expectations are negative and one where inflationary expectations are positive (as opposed to only considering the aggregate adjustment coefficient). The latter category, where inflation is expected to increase, would presumably provide a greater incentive to identify and make use of an inflationary hedge, for which purpose equities are assessed. However, the opposite may in fact be true, because interest rates may decline alongside inflation, increasing the motivation to invest in equities during periods of negative inflationary variations. If the negative adjustment coefficient is far higher than the positive adjustment coefficient, this would skew the aggregate coefficient and potentially lead to a scenario where equity returns adjust at a greater than one-to-one rate with inflation when inflation decreases, but fail to do so when inflation increases. This in turn, would compromise the capacity for equities to act as an inflationary hedge during periods of increasing inflation.

Based on the limitations identified in chapter 6 this study aims to address two primary research questions for the South African case. The first of these is to identify if asymmetric adjustment has had an effect on the cointegrating relationship. The second goal, if the relationship is shown to exhibit evidence of asymmetric adjustment, is to identify the magnitudes of the positive and negative coefficients of adjustment. By disaggregating the β coefficient, which has been the focus of the previous studies in the literature, one is able to far more effectively deal with shifts in the rate of inflation, especially in cases where the positive and negative adjustment coefficients differ substantially. Such a disaggregation, to the best of the author's knowledge, is the first application of its kind in the context of the analysis of the capacity for equities to act as an inflationary hedge, both domestically and internationally.

7.2 Original Contribution

The primary aim of this study is to examine the disaggregated adjustment effects by separating and individually quantifying the positive and negative coefficients of adjustment which, to the best of the author's knowledge, represents a novel and potentially critical contribution to the literature. While the estimation of an aggregate β coefficient is theoretically useful in certain contexts, far more accurate assessments and subsequent adjustments will be possible with the knowledge of disaggregated positive and negative coefficients. Such adjustments would be based on expectations of positive and negative inflationary variations, which has the potential to make a substantial difference to equity investment decisions based on the magnitude of the difference between the adjustment of the equity market to positive versus negative changes in inflation. To expand on this point, there may be substantially different reactions from investors to positive inflationary variations as there are to negative inflationary variations. When investors are only able to base their decisions on a single, aggregate relationship, such decisions are likely to be sub-optimal if positive and negative inflationary variations have substantially different effects.

This study represents the first contribution of its kind in the context of assessing the capacity for equities to acts an inflationary hedge. With this contribution, investors and policy makers will be able to more accurately assess the impact of inflation on equity returns as well as the capacity for equity returns to hedge against inflation when inflation independently increases or decreases, instead of having to make use of an aggregate adjustment coefficient. Given that increases in inflation presumably provide a far greater incentive to identify an inflationary hedge than decreases, the importance of such a disaggregation is evident. Furthermore, separating the positive and negative adjustment coefficients removes potential influences on the relationship that may skew the inferences made and actions taken when using an aggregate adjustment coefficient as an indicator. To the best of the author’s knowledge, no such study has been conducted in this context to date.

7.3 Paper Presented as Prepared for Submission to the Investment Analysts Journal (IAJ).

Section 7.3 presents the paper in the form that is being prepared for submission to the Investment Analysts Journal. The reference list has been removed, as the bibliography to this thesis represents an amalgamation of all references used in all papers and chapters of this thesis.

An Analysis of the Non-linear Dynamics of the Equity Returns-Inflation Relationship in South Africa: an NARDL Approach

PETER MOORES-PITT.
School of Accounting, Economics and Finance, New Arts Building, Pietermaritzburg Campus, University of KwaZulu-Natal, South Africa.
Email: moorespittp@ukzn.ac.za

Abstract

Recent investigations assessing the capacity for equities to act as an inflationary hedge have identified a range of limitations with previous employed models, and disparities between results in the existing literature. One such limitation is that the previous literature generally ignores the effects of asymmetric adjustment. The previous literature offers widely differing conclusions with regards to the magnitude of the relationship and the order of integration of the variables. This study employs the NARDL model to address both issues simultaneously, while disaggregating the standard adjustment coefficient into both its positive and negative components in order to assess the impact on equity returns of inflationary increases and decreases.

Using South African data between 1980 and 2015, a positive adjustment coefficient of 1.08, and a negative adjustment coefficient of -16.60 were found. The absolute values are greater than one (meeting the criteria for the Fisher Hypothesis) and confirming the capacity for equities to act as an inflationary hedge in the case of positive inflationary variations. However, the negative coefficient indicates that co-movement of the series does not occur in response to negative variations. Instead, equity returns increase in response to negative inflationary variations at a far greater magnitude than the response to positive variations. It is evident from these results that the negative coefficient typically skews the overall relationship. This emphasizes the importance of individually assessing the adjustment coefficients in similar studies, as increases and decreases in inflation may have vastly different effects on equity returns.

Keywords: Inflation, equity returns, nonlinear ARDL, asymmetric adjustment, South Africa

1. Introduction

The early work of Fisher (1930) led to the development of what is now commonly known as the Fisher Hypothesis – the theory which maintains that the real returns of equities are not affected by inflation. The Fisher hypothesis posits that the nominal return earned by an investment is a function of both the expected inflation rate and the real interest rate (Zulfiqar, Shah, Nasir and Naeem, 2012). The Fisher effect, which stems from this theory, essentially states that the nominal interest rate is able to fully capture all available information related to expected future values of inflation (Jaffe and Mandelker, 1975).

As nominal returns on equities are assumed to move with inflation, and inflation assumed to be fully accounted for in the nominal value, the consequence is that real asset value is maintained during inflationary periods (Nelson, 1976; Sharpe, 2002). The Fisher Hypothesis relies on the notion that nominal returns are a combination of real returns and an expected inflation rate, and thus any changes in inflation will be counteracted by changes in nominal returns, essentially maintaining a set real rate of return. The effect of this is that real wealth and purchasing power are protected in the face of inflationary increases (Ouma and Muriu, 2014).

Negative impacts of inflation extend from personal finance right through to country-wide macroeconomic effects. From a personal finance perspective decreases in real wealth occur if nominal wealth does not increase at the same rate of inflation, in accordance with the theory of Fisher (1930). This is especially prevalent in cases where cash holdings or low-interest bearing accounts constitute a substantial portion of an individual's portfolio – a situation common in low income households in developing countries. It is also widely accepted that inflation has a negative impact on economic growth, including specific thresholds above which inflation is shown to impede economic growth (Sarel, 1996; Thanh, 2015). Due to these negative effects of inflation, many mechanisms that may provide a hedge against inflation have been tested for their capacity to offset a loss in real wealth caused by inflation. The literature on inflation hedging has focused primarily on three asset classes in this regard. The first of the asset classes which have been considered as a potentially effective hedge, and are which are the focus of this study, are common stocks and equity returns (Kim and Ryoo, 2011; Alagidede and Panagiotidis, 2010). Minerals, specifically gold and silver, comprise the second category that has been considered (Van Hoang, Lahiani and Heller, 2016; Bampinas and Panagiotidis, 2015). The third includes property, housing and real estate investments (Yeap and Lean, 2017; Bahram, Arjun and Kamiz, 2004).

The relationship between nominal equity returns and inflation is of considerable importance because it indicates whether or not equities are able to act as an effective inflationary hedge. A positive relationship is indicative that nominal equity returns have acted at least as a partial hedge against inflation, while a negative relationship indicates that negative returns on equities further contribute to negative inflationary effects in terms of a loss in real wealth. Valcarcel (2012) states that the theory predicts a strong positive relationship between equity returns and inflation, but that it is difficult to find consistent empirical evidence to substantiate this prediction. To further complicate the issue, there are substantial disparities in the literature depending on which country is being used as the sample even when the testing methodology is the same (Alagidede and Panagiotidis, 2010; Khil and Lee, 2000) as well as variance in a specific country over differing time periods (Kim and Ryoo, 2011). As a result, relevant time periods within a specific country must be investigated to properly understand the specific dynamics of the equity returns-inflation relationship within that country.

In the more recent literature that deals with inflation hedging, the potential for asymmetric adjustments of variables towards a long-run equilibrium offer valuable insights that have been considered in particular cases (Seo, 2006; Phiri, 2017). Such adjustment mechanisms improve on common cointegration techniques in that the previously inherent assumption that adjustments which maintain the long-run relationship between two or more variables is linear and symmetric has been relaxed. Instead of assuming the adjustment is linear and symmetric, this paper considers the possibility that adjustments are non-linear and asymmetric.

Although studies on the equity-returns inflation relationship are limited, the modification to allow for asymmetric adjustment has been shown to be consistently important in recent literature (Seo, 2011; Shin, Yu and Greenwood-Nimmo, 2014). Such studies employ models such as the Threshold Vector Error Correction Model (TVECM) (Kim and Ryoo, 2011), as well as modern developments of the Autoregressive Distributed Lag Model (ARDL), similar to the Non-Linear ARDL (NARDL) - which is employed in this study to investigate the non-linear dynamics of the relationship. Specifically, this study aims to examine disaggregated adjustment effects by separating and individually assessing positive and negative coefficients of adjustment which, to the best of the authors knowledge, represents a novel and potentially critical contribution to the literature.

2. Literature Review

There is a substantial disparity in both the domestic and international literature regarding the nature of the relationship between nominal equity returns and inflation. From a theoretical standpoint the Fisher (1930) hypothesis and subsequent studies predicted that the relationship should be positive, and equal to unity, due to the fact that equity values are based on underlying assets which maintain their real value under inflationary conditions. This theory held until studies such as those by Fama (1981), who proposed what is known as the Proxy hypothesis, and Feldstein (1980), who developed a tax-based hypothesis, were conducted in an attempt to explain empirical evidence of a negative relationship in the literature (Modigliani and Cohn, 1979; Geske and Roll, 1983; Kaul, 1990). A particularly notable extension of the Fisher hypothesis, discussed by Luintel and Paudyal (2006), known as the tax-augmented Fisher hypothesis proposes that nominal returns on stocks must in fact exceed the unitary relationship initially proposed by Fisher, in order to compensate for the loss that tax-paying investors experience during inflationary periods in real wealth. Conflicting evidence has been reflected in the literature, with many studies finding differing results, including a negative relationship, a positive but less than unitary relationship and a relationship in excess of unity. The last of these is consistent with the tax-augmented Fisher hypothesis, which postulates that investors must be compensated for costs incurred by taxes (Darby, 1975).

The findings of conflicting results are particularly evident in the South African literature, with disparities in both the direction and magnitude of the relationship (Khumalo, 2013; Eita, 2012; Alagidede and Panagiotidis, 2010). Furthermore, the studies that cover the topic in the South African context find differing results as to the nature of the variables themselves. While much of the international data points explicitly to the fact that the data comprising nominal equity returns and inflation (usually represented by CPI) is non-stationary when using conventional unit root testing to examine the order of integration of the variables, this has not consistently been the case in South Africa, discussed in detail by Arnold and Auer (2015). As the authors state “there is no consensus in the literature on whether inflation rates are non-stationary or stationary” and also note that studies on inflation hedging can differ when either CPI growth rates or CPI levels are employed when using the cointegration methodology (Arnold and Auer; 2015: 196). In the South African case, Eita (2012) found that both variables are stationary in level terms, $I(0)$; Khumalo (2013) found that while the stock prices are stationary, inflation is non-stationary and Alagidede and Panagiotidis (2010) found that both variables are in fact non-stationary. Due to the nature of the testing methodologies commonly employed for cointegration testing, such disparities make an important difference to the type of study that is conducted.

In an attempt to resolve this issue Moores-Pitt and Strydom (2017) applied both a Vector Error Correction Model (VECM) and an Autoregressive Distributed Lag (ARDL) model, after finding evidence that both variables were $I(1)$, a necessary precondition for the VECM. The magnitude of the relationship determined by the VECM was similar to that of Alagidede and Panagiotidis (2010). The authors then extended the analysis using the ARDL model developed by Pesaran, Shin and Smith (2001), which improves on the VECM in this context as it allows for variables to be integrated of either the first order I(1) or to be stationary I(0), removing the issue of stationarity from the analysis. However, the model is still subject to potential sources of error involving the issue of non-linearity, recently considered to some extent by Phiri (2017) which suggests that the relationship may indeed be subject to nonlinear adjustment and as such one cannot rely on the assumption that the relationship is time-invariant.

To the best of the authors knowledge, the first study to jointly consider the issues of non-stationarity and nonlinearity was that by Balke and Fomby (1997), who presented a threshold error correction model (threshold ECM). An extension of this theory was later applied in the context of the equity returns and inflation relationship by Kim and Ryoo (2011) who considered that the relationship may have been affected by asymmetric adjustment of stock returns and inflation to the long-run equilibrium. The authors attempted to account for the issue using an extension of the classic VECM, known as a two-regime Threshold Vector Error Correction Model (TVECM). The study used century-long data from the United States and considered the relationship over rolling window periods, finding that the relationship remained significant and positive overall, but that evidence of asymmetric adjustment around a certain threshold does indeed exist. Moores-Pitt, Murray and Strydom (2019) considered such a model in the South African case and found results consistent with those of Kim and Ryoo (2011), namely: that a certain threshold exists and that there is evidence of asymmetric adjustment between equity returns and inflation in South Africa.

While the TVECM model is able to account for asymmetric adjustment it is still limited by the condition that both variables are non-stationary. This has particular relevance in South Africa given the aforementioned conflicting results of Khumalo (2013), Eita (2012) and Alagidede and Panagiotidis (2010). Further, while this model is able to account for asymmetric adjustment, it does not endogenously calculate specific values for positive and negative adjustments. This paper aims to address this issue by employing a version of the ARDL model that is not subject to the condition that the variables are both non-stationary, while still accounting for the possibility of non-linearity in the relationship between the variables.

The non-linear ARDL (NARDL) model was developed relatively recently, compared to others in the field of cointegration, in a paper by Shin, Yu and Greenwood-Nimmo (2014). The model allows one to split the rates of adjustment into both positive and negative components, in order to determine a magnitude for each of the positive and negative adjustment coefficients. If the magnitude of these adjustment coefficients differs in absolute terms at a significant level, it is indicative that the rates of adjustment in the equity returns-inflation relationship are asymmetric, and as such it can be concluded that the relationship is nonlinear. This represents the main advantage of the NARDL over the conventional ARDL in the context of this study, and indeed the primary contribution of the study, that being that the model is able to simultaneously permit linear and nonlinear cointegration (Van Hoang *et al.*, 2016). Testing for significant differences in the adjustment coefficients is done using a Wald-test, following the study by Shin, Yu and Greenwood-Nimmo (2014).

As such, this paper considers the following two research questions, namely: (1) when both the order of integration and the linearity assumptions common in cointegration theory are removed simultaneously, is there evidence of asymmetric adjustment; and, (2) if the relationship is non-linear, what are the magnitudes of the positive and negative adjustment coefficients? The NARDL has not yet been applied in this context, and so this application offers an original contribution to the empirical work around equities as an inflation hedge. This application of the NARDL in identifying the magnitude of the negative and positive coefficients is imperative for accurate decision making regarding both investment and policy decisions, given inflationary expectations at any point in time. For example, assuming a case where the positive and negative coefficients differ substantially, an investor may wish to adjust an asset portfolio between currency-based assets and equities depending on future inflationary expectations. If adjustment is assumed to be symmetric, such considerations may be less important. In turn, government policy decisions may be affected by such findings especially in countries that have adopted inflation targeting regimes, as the magnitude of the effect on equity returns resulting from positive or negative inflationary adjustments may be vastly different.

3. Data and Methodology

3.1 Data and Descriptive Statistics

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 data used in the study is comparable with similar studies in the field such as those by Alagidede and Panagiotis (2012) and Phiri (2017). While the sample size is greater than other South African studies, it cannot match that of certain international studies such as that by Kim and Ryoo (2010) who analyzed the relationship in the United States; however, this potential limitation is negated somewhat by the findings of Kim and Ryoo (2010), who used rolling window periods over a century long sample and found that the results become stable when a window length of 30 years or longer is used. Thus the 35-year sample spanning from 1980 to 2015 that is used in this study is considered adequate and suitable for estimation purposes. The descriptive statistics for LogSP and LogCPI are presented in Table 1 below, followed by a discussion of the unit root tests conducted in this study:

Table 1: Descriptive Statistics

	Mean	Std. Dev.	Skewness	Kurtosis
LogSP	8.6893	1.285	-0.1385	1.9947
LogCPI	3.5014	0.8881	-0.5610	2.1244

3.2 Unit Root Tests

While both the ARDL test and NARDL models are designed to allow for the inclusion of variables that are integrated of different order, the models are limited to $I(0)$ or $I(1)$ variables. While the ARDL model allows data that is either stationary $I(0)$ or integrated of the first order $I(1)$ to be included in the cointegrating equation, it cannot account for $I(2)$ data in the initial VAR (Ahmad, 2010). This does not represent a substantial limitation in the case of this study as the stationarity tests employed have found both variables to be either $I(1)$, $I(0)$ or a combination of the two (Eita, 2011; Khumalo, 2013; Alagidede and Panagiotis, 2010). To the best of the author's knowledge, there are no studies in this context that have determined the variables to be $I(2)$.

In this study the Zivot-Andrews (1992) unit root test is employed, which is able to test for a unit root in a series free of concerns that occur with the use of conventional unit root testing, where a bias toward a false unit root when the data are trend stationary with a structural break generally occurs (Zivot and Andrews, 1992). This model is an extension of the work of Perron, (1989), which itself exhibits higher power than conventional unit root tests (Shrestha and Chowdury, 2007) and has greater power properties when the break-date is unknown. The Zivot-Andrews (1992) test can be divided into three models, referred to as A, B and C. As stated by Esso (2010) only in the case of significance of Model C (where the null is rejected) would we revert to the use of Model A or B. This is due to the fact that Model C accounts for a combination of changes in both the intercept and the slope of the trend function of the series, capturing the functions of both Models A and B simultaneously (Zivot and Andrews, 1992). The reader is referred to the works of Zivot and Andrews (1992), Esso (2010) and Moores-Pitt (2017) for a detailed discussion of the unit root tests, while the models are briefly described as follows:

The null hypothesis of Model A is a structural break with a unit root in the intercept. For Model B the null is a structural break with a unit root in the trend and for Model C the null is a structural break with a unit root in both the intercept and the trend. Drawing on the notation of Esso (2010) these models are presented as follows:

Model A (Intercept)

$$y_t = \mu + \theta DU_t(\tau_b) + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta y_{t-1} + e_t$$

Model B (Trend)

$$y_t = \mu + \gamma DT_t(\tau_b) + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta y_{t-1} + e_t$$

Model C (Intercept and Trend)

$$y_t = \mu + DU_t(\tau_b) + \beta t + \gamma DT_t(\tau_b) + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta y_{t-1} + e_t$$

Where $DU_t(\tau_b)$ =1 if t > τ_b and 0 otherwise, and $\gamma DT_t(\tau_b)$ = t-τ_b if t>τ_b and 0 otherwise, Δ is the first difference operator, e_t is the white noise disturbance term, DU_t is a sustained dummy variable that captures a shift in the intercept, DT_t is a shift in the trend occurring at time τ_b, k represents the number of lagged first-differences

3.3 The Cointegrating Relationship

The cointegrating relationship between the log of the stock price (LogSP) and the log of the consumer price index (LogCPI) forms the basis of the analysis. 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. LogSP, the log of the stock price, acts as a proxy for nominal equity returns while LogCPI, the log of the consumer price index acts as a proxy for expected inflation in line with much of the related literature (Kim and Ryoo, 2011; Alagidede and Panagiotidis, 2010; Arnold and Auer (2015). The linear cointegrating relationship can then be presented using the following equation:

$$\Delta LogSP_t = C + \beta\Delta LogCPI_t + \varepsilon_t$$

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: 290). The β coefficient acts as an indicator of the magnitude of the relationship between equities and inflation and indicates whether or not equities are able to act as an effective inflationary hedge.

The interpretation of the β coefficient is adapted from Arnold and Auer (2015) who discuss that there are three possible definitions of inflation hedging. Firstly, an asset can be called an inflation hedge if it prevents or reduces the likelihood that the real return on the asset will fall below zero. A partial inflationary hedge takes on a β coefficient between zero and one in the above equation hedge, indicating that equities at least adjust to counteract inflation to a certain extent. In the case where the β coefficient is less than zero, equities would not act as an inflationary hedge at all. A perfect inflationary hedge correlates with the theory of the Fisher hypothesis, where the β coefficient takes on a value of exactly one. The final scenario is where the β coefficient can exceed unity, consistent with the tax-augmented Fisher hypothesis, indicating that equities can an effective hedge against inflation even when accounting for tax-effects.

As previously discussed, the ARDL model is limited by the assumption that the relationship exhibits linear adjustment properties. As such, the NARDL model is considered in order to allow for a potential distinction between positive and negative coefficients of adjustment. In the context of this study, this essentially splits the β coefficient into positive and negative components. This will result in the following model, presented in a simplified form, as:

$$\Delta LogSP_t = C + \beta^{+} \Delta LogCPI_t \, Pos - \beta^{-} \Delta LogCPI_t \, Neg + \varepsilon_t \qquad (1)$$

Here the β^{+} and β^{-} coefficients represent the magnitude of the positive and negative coefficients of adjustment respectively. Should these coefficients be equal it proves that the relationship is symmetric. However, if there is a statistically significant difference in absolute terms this would be interpreted as evidence of asymmetric adjustment. This is tested using a Wald test, following Shin, Yu and Greenwood-Nimmo (2014). Such a finding will indicate that the assumption of linearity as commonly utilised in cointegration theory is in fact flawed and as such that, in the context of the equity returns-inflation relationship, non-linear adjustment must be considered.

3.4 The Autoregressive Lag Model (ARDL)

The derivation of the ARDL model is discussed by Pesaran and Shin (1999) and Pesaran (2001) in detail, but is often defined differently depending on the study's requirements, in accordance with a study specific VAR model. In this study, the initial VAR is presented following the work of Ahmed (2010) to ensure consistency with the prior work of Moores-Pitt and Strydom (2017). The VAR is presented as follows:

$$\Delta Y_t = C + \alpha Y_{t-1} + \sum_{j=1}^{p-1} \beta_j \Delta Y_{t-j} + u_t \qquad (2)$$

Where: Y_t represents a matrix of the dependent and independent variables, $Y_t = [i_t \ \ \pi_{t+1}]$. i_t represents the stock price variable and π_{t+1} represents the expected inflation rate and so the actual inflation rate is shown by π_t.

The model is then extended into the ARDL(*p,q)* form, as follows (Ahmad, 2010; Atkins and Coe, 2002; Atkins and Chan, 2004):

$$\Delta i_t = \tau + p i_{t-1} + \delta \pi_t + \sum_{j=1}^{p-1} \omega_{i,j} \Delta i_{t-j} + \sum_{j=1}^{q-1} \omega_{\pi,j} \Delta \pi_{t+1-j} + \sigma \Delta \pi_{t+1} + v_t \qquad (3)$$

In the ARDL(*p,q)* both the stock price and the inflation rate are allowed to exhibit different lag lengths. p represents the lag length of the first difference of the stock price and q the lag length for the first difference of the inflation rate. Ahmad (2010) defines the null hypothesis as a state where $p = \delta = 0$ and the alternative hypothesis where p and δ are both non-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 of each variable need to be the same and so the possibility of varying lag lengths is considered.

The ARDL(p,q) model estimation was implemented using OLS and the F-statistic was used to determine which of the null or alternative hypotheses to accept. Following Atkins and Coe (2002) the null hypothesis of a stable long-run relationship was subsequently tested, using the bounds test approach of Pesaran *et al.* (2001). This approach compares the regression's F-statistic to the asymptotic critical values determined by Pesaran *et al.* (2001) Pesaran *et al*. provide certain bounds on critical values for the F-statistic used in the F-test which establish lower and upper bonds. Upper bounds are predicated on the assumption that all variables are $I(1)$, while lower bounds correspond with the assumption that all variables are $I(0)$. With regards to interpretation of the bounds test results, an F-statistic below the lower bound is indicative of a finding of no-cointegration, if the F-statistic falls between the upper and lower bounds the test is inconclusive; and finally, if the F-statistic exceeds the upper bound the null of the bounds test, that being no cointegration, can be rejected in favour of cointegration.

3.5 The Nonlinear Autoregressive Distributed Lag (NARDL) Model

The NARDL model was originally adapted by Shin, Yu and Greenwood-Nimmo (2014), developing on from the symmetric ARDL by Pesaran (2001). The methodology applied in this study is consistent with a similar NARDL application by Hoang, Lahiani and Heller (2016) that considered the capacity for gold to act as an inflationary hedge.

Van Hoang *et al.* (2016) convert the VAR into a linear ECM shown in equation 4, equivalent to that specified to that of Ahmed (2010) in equation 3 with a slight notational variation. Essentially this represents the ECM specification without asymmetry.

$$\Delta y_t = \mu + p_y y_{t-1} + p_x x_{t-1} + \sum_{i=1}^{r} a_i \Delta y_{t-i} + \sum_{i=0}^{s} \beta_i \Delta x_{t-1} + \epsilon_t \tag{4}$$

In equation 4 y_t is used to represent the share price variable, while x_t represents inflation. Price variations are shown by the symbol Δ (Van Hoang *et al.*, 2016). Van Hoang *et al.* (2016) then extend this model into the NARDL model in equation 4 to incorporate short-run and long-run asymmetries and which decomposes the variable x_t into its positive and negative partial sums shown respectively by Δx_t^+, for increases, and Δx_t^-, for decreases.

$$\Delta y_t = \mu + p_y y_{t-1} + p_{x^+} x_{t^+-1} + p_{x^-} x_{t^--1} + \sum_{i=1}^{r} a_i \Delta y_{t-i} + \sum_{i=0}^{s} (\beta_{i^+} \Delta x_{t^+-i} + \beta_{i^-} \Delta x_{t^--i}) + \epsilon_t \tag{5}$$

Van Hoang *et al.* (2016) note that the (+) and (-) superscripts refer to the positive and negative partial sum decompositions, while the long-run asymmetry is captured by the terms p^{+} and p^{-}. Short-run variations of x_t are captured by the β^{+} and β^{-}parameters. Non-rejection of either short-run asymmetry or long-run asymmetry are shown by equations 6 and 7 respectively.

$$\Delta y_t = \mu + p_y y_{t-1} + p_x x_{t-1} + \sum_{i=1}^{r} a_i \Delta y_{t-i} + \sum_{i=0}^{s} \beta_{i^+} \Delta x_{t^+-i} + \beta_{i^-} \Delta x_{t^--i} + \epsilon_t \qquad (6)$$

Considering equation 7, which considers long-run asymmetry specifically, with the relevant β coefficient, which is this focus of this study, yields the NARDL equation used to assess the long-run relationship between inflation and equity returns. This long-run asymmetry is then tested using a Wald test which, according to Shin, Yu and Greenwood-Nimmo (2014), can be used to determine whether or not the null of symmetric adjustment ($p^{+} = p^{-}$) can be rejected. Equation 7 is presented as follows:

$$\Delta y_t = \mu + p_y y_{t-1} + p_{x^+} x_{t^+-1} + p_{x^-} x_{t^--1} + \sum_{i=1}^{r} a_i \Delta y_{t-i} + \sum_{i=0}^{s} \beta_i \Delta x_{t-i} + \epsilon_t \qquad (7)$$

The positive and negative dynamic multipliers capture the asymmetric responses of the dependent variable, in this case the LogSP, to positive and negative variations of the independent variable, the LogCPI variable. These are reflected as unit changes in $x^{+}$and x^{-} (Van Hoang *et al.*, 2016).

4. Results

4.1 The Unit Root Test Results

Table 2: Zivot-Andrews Unit Root Test Results

Variable	Lag Length	Break Date	Model A	Model B	Model C
LogSP	1	1998: 05	-4.5529	-4.0649	-4.6337*
5% crit. val.			-4.93	-4.42	-5.08
LogCPI	12	1990: 08	-2.4698	-4.3547	-4.1861*
5% crit. val.			-4.93	-4.42	-5.08

* indicates the optimal model use in each case, where the null cannot be rejected.

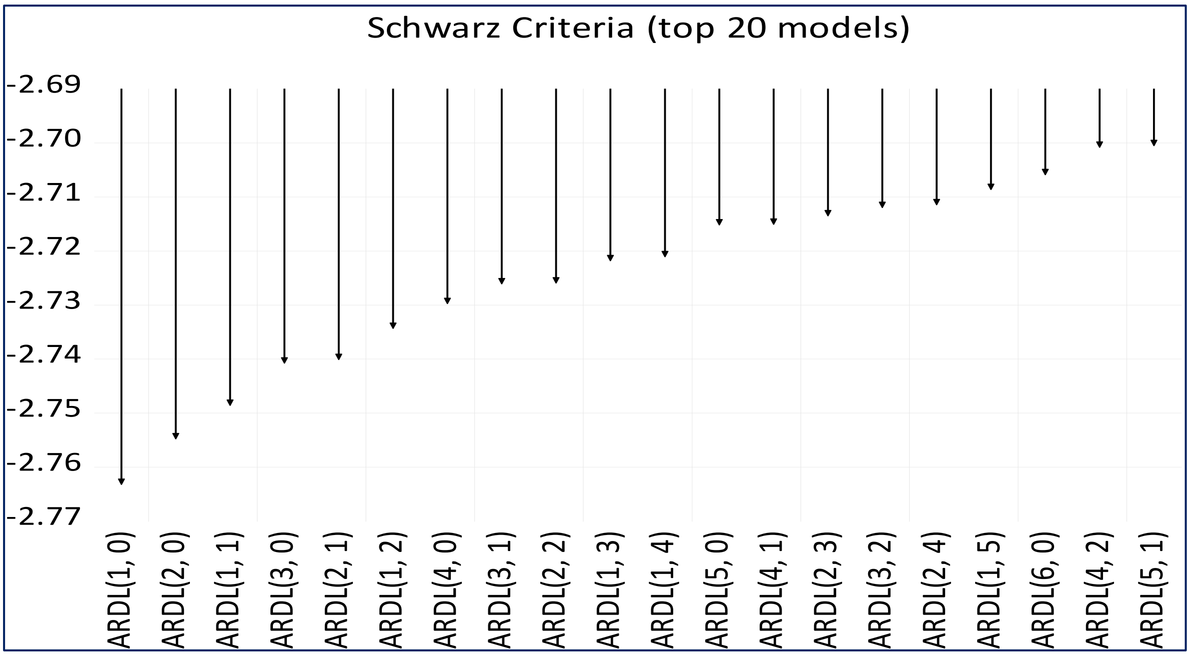
Table 2 shows the results of the Zivot-Andrews test for each variable using each model. The ADF test described earlier is used to determine the maximum lag length to be included for each series. The Zivot-Andrews test then selected optimal lag lengths for each test, these being 1 for LogSP and 12 for LogCPI. LogSP and LogCPI in the table show the Zivot-Andrews test statistic for each case. Breaks are identified by the Zivot-Andrews test in each of the series, dated 1998: 05 for the stock price data and 1990: 08 for the inflation data.

It is evident that for the stock price variable, LogSP, the null cannot be rejected in Model C, showing that a unit root with a structural break exists in both the intercept and the trend. In the case of the inflation variable, LogCPI, the null hypothesis cannot be rejected at the 5% level as indicated by Model C which indicates that a unit root exists with a structural break in both the intercept and trend. The above results that indicate that the variables are integrated of the first order allow for the progression to the ARDL and NARDL cointegration tests.

4.2 The Autoregressive Distributed Lag (ARDL) Model Results

The SIC was used as the information criterion of choice, consistent with the work of Xu, Sun and Lundofte (2010). The estimator evaluated 156 models comprising combinations of p and q across the range to select the best 20, presented in Figure 1 below. To ensure results are not sensitive to lag length, the selection of the best ARDL (x.y) model was checked using multiple lag lengths, however, as can be seen in figure 1 below, only a single lag for the dependent variable, LogSP (x) and zero lags for the regressor, LogCPI (y) are required. Figure 1 and Figure 2 allow for a visual representation of the model that is selected by the ARDL and NARDL models respectively against alternative models. The selection of the optimal model is based on their prediction power versus the prediction power of alternative models

<u>Figure 1: The top 20 ARDL (X,Y) models according to the SIC</u>



As can be seen by Figure 1, the selected ARDL model is ARDL(1,0), indicative of the single lag of the dependent variable and zero lags of the independent variable. The estimation output, bounds test and ARDL cointegration and long-run form are presented in Tables, 3 and 4 and 5 respectively. Table 3 begins with the estimation output of the ARDL model, using 420 observations after adjusting for the appropriate number of lags.

<u>Table 3: The ARDL Estimation Output</u>

Dependent Variable	**Dependent Lags**	**Selected Model**	**Models evaluated**	
LogSP	12	ARDL (1,0)	156	
Variable	**Coefficient**	**Std. Error**	**T-Stat**	**Prob**
LogSP (-1)	0.9799	0.0110	88.5383	0.0000
LogCPI	0.0271	0.0161	1.6847	0.0928
C	0.0897	0.0427	2.1009	0.0362

Table 3 reflects the single lagged variable of LogSP and the LogCPI in accordance with the model selected that minimized the SIC, the ARDL(1,0). The results of the bounds test of the ARDL are presented in Table 4. The null hypothesis of the bounds test indicates that no level relationship exists. Differing numbers of variables are represented by the k term in the test output. As can be seen by the results presented in Table 4, the F-statistic of 5.65 allows for the rejection of the null hypothesis for the $I(0)$ at the 1% level of significance and for the $I(1)$ bound at the 2.5% level of significance. As such we can conclude that a significant cointegrating relationship exists.

<u>Table 4: Results of the Bounds Test</u>

Test Statistic	**Value**	**K**
F-Statistic	5.64986	1
Critical Value Bounds		
Significance	**I(0) bound**	**I(1) bound**
5%	3.62	4.16
2.5%	4.18	4.79
1%	4.94	5.58

Table 5 presents the results of the ARDL test and the long-run form of the model. LogSP(-1) reflects the short-run adjustment coefficient, in this case indicating around a 2% adjustment by the LogSP variable towards the equilibrium in a period subsequent to a disequilibrium. The focus of this study however, is on the long-run relationship, presented in the second half of the table and discussed below. The long-run cointegrating equation (seen in part two of Table 5) shows that the coefficient for LogCPI (the β coefficient in the standard linear cointegrating equation) under the conditions of the Fisher hypothesis is 1.35. This coefficient is positive and greater than unity, consistent with the conditions necessary to meet the tax-augmented Fisher hypothesis.

Table 5: ARDL Cointegration and Long-run Form

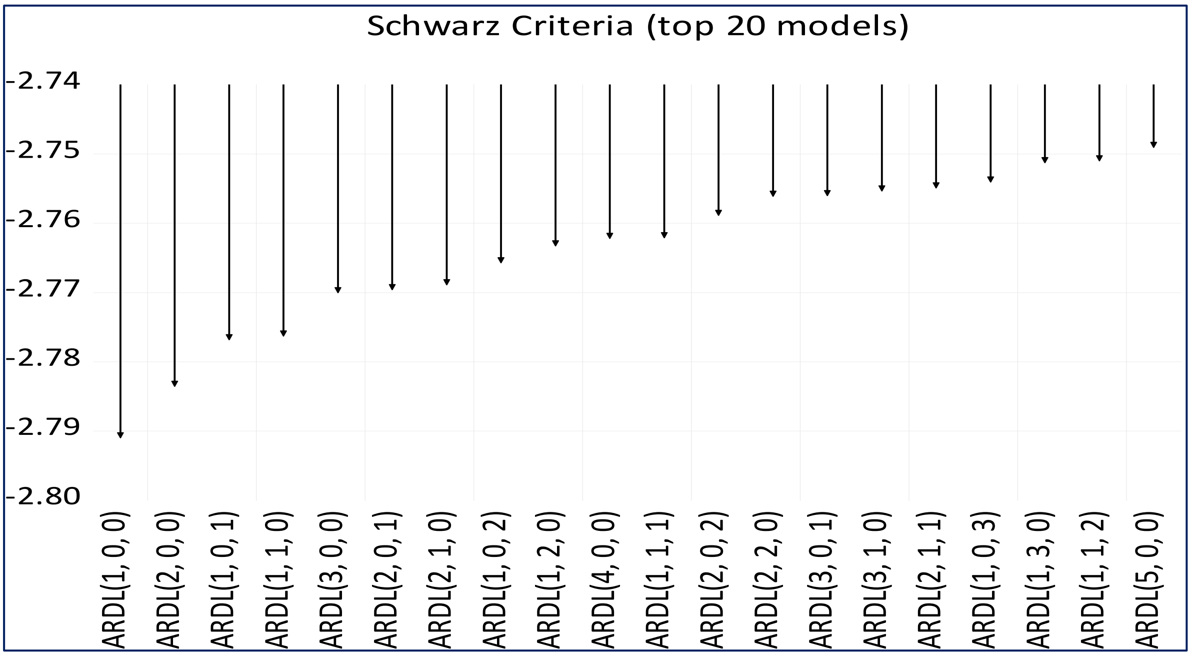
Conditional Error Correction Regression				
Variable	**Coefficient**	**Standard Error**	**T-Statistic**	**Prob**
C	0.08970	0.04270	2.10094	0.03620
LogSP(-1)	-0.02002	0.01107	-1.80915	0.07110
LogCPI	0.02709	0.01608	1.68466	0.09280
Long-Run Coefficients				
Variable	**Coefficient**	**Standard Error**	**T-Statistic**	**Prob**
LogCPI	1.35269	0.17016	7.94960	0.00000
C	4.47902	0.73783	6.07057	0.00000

Thus, according to the ARDL model, equities are able to act as a long-run hedge against inflation. The respective cointegrating equation in the form of the Fisher equation for the ARDL model is presented as follows:

$$LogSP_t = 4.4692 + 1.3539 LogCPI_t + \varepsilon_t$$

4.3 The Nonlinear Autoregressive Distributed Lag (NARDL) Model (Results)

Figure 2: The top 20 NARDL (X,Y,Z) models according to the SIC



Similar to the standard ARDL model, the estimator of the NARDL selected the top 20 models according to the SIC criterion. As can be seen the selected NARDL model is NARDL(1,0,0), indicative of the single lag of the dependent variable and zero lags for each of the positive and negative adjustments of the independent variable. This finding is consistent with the standard ARDL model. The estimation output is shown in table 6 below. As can be seen the estimator evaluates substantially more models than the standard ARDL and splits the LogCPI variable into positive and negative adjustment components.

Table 6: The NARDL Estimation Output

Dependent Variable	**Dependent Lags**	**Selected Model**	**Models evaluated**
LogSP	12	ARDL (1,0,0)	2028

Variable	**Coefficient**	**Std. Error**	**T-Stat**	**Prob**
LogSP (-1)	0.9412	0.0161	58.1031	0.0000
LogCPI_POS	0.0633	0.0194	3.2594	0.00112
LogCPI_NEG	-0.9760	0.3093	-3.1556	0.0017
C	0.3850	0.0102	3.7842	0.0002

Table 7 presents the bounds test for the NARDL model. The asymptotic critical values are initially presented, with the critical values of a finite sample based on the actual sample size presented in parenthesis afterwards. The asymptotic critical values used an n of 1000, suitable for greater sample sizes, while the finite sample used an n of 80, based on the actual sample size of 420. Due to the fact that the sample is fairly large the two sets of critical values show a relatively low level of differentiation and do not affect the conclusion of the bounds test (critical values were only calculated in the case of the finite sample for the 1%, 2.5% and 5% levels of significance.

Table 7: Results of the NARDL Model Bounds Test

Test Statistic	**Value**	**K**
F-Statistic	6.97101	2
Critical Value Bounds		
Significance	**I(0) bound**	**I(1) bound**
5%	3.1 (3.235)	3.87 (4.053)
2.5%	3.55	4.38
1%	4.13 (4.358)	5 (5.393)

The null hypothesis of the bounds test is the same as that of the standard ARDL, that being that there is no levels relationship. Due to the fact that the F-Statistic of 6.97101 far exceeds even the critical values at the 1% level, the null hypothesis can be rejected. It can thus be concluded that when nonlinearity is accounted for, there is still evidence of a significant cointegrating relationship between the two variables, which is consistent with modern cointegration studies of the relationship (Kim and Ryoo, 2011; Phiri, 2017).

Following the findings of the bounds test the respective NARDL form was computed. The results of this test are presented in Table 8. As with the ARDL model the short-run adjustment of LogSP is captured by the LogSP(-1) coefficient, and in this case indicates a 5% adjustment towards the equilibrium following a period of disequilibrium. The LogCPI_POS and LogCPI_NEG variables display the short-run effects in the first half of the table, but once again the primary focus of this study is on the long-run values of the variables shown in the latter half.

Table 8: The NARDL Cointegration and Long-run Form

Conditional Error Correction Regression				
Variable	**Coefficient**	**Standard Error**	**T-Statistic**	**Prob**
C	0.3850	0.10173	3.78420	0.0002
LogSP(-1)	-0.0588	0.01612	-3.63047	0.0003
LogCPI_POS	0.0633	0.01942	3.25942	0.0012
LogCPI_NEG	-0.9760	0.30927	-3.15565	0.0017
Long-Run Coefficients				
Variable	**Coefficient**	**Standard Error**	**T-Statistic**	**Prob**
LogCPI_POS	1.0761	0.0899	11.9662	0.0000
LogCPI_NEG	-16.5953	3.8452	-4.3159	0.0000
C	6.5457	0.1566	41.8057	0.0000

The results presented in Table 8 can be interpreted in a manner similar to that of the results presented for the standard ARDL in Table 5. The major difference however, is the split of what the β coefficient of LogCPI into positive and negative components, referred to as β^+ and β^- respectively. the case of LogCPI_POS, the positive adjustment coefficient, β^+, is 1.08, while the negative adjustment coefficient under LogCPI_NEG, β^-, is -16.60. Both are highly statistically significant.

From these results it can be shown that any positive adjustment of LogCPI (inflation increases) will have a positive effect on the stock price of a magnitude slightly higher than unity, (there is a positive relationship between the variables). Negative adjustments of LogCPI (inflation decreases) will have a far greater effect on LogSP in terms of magnitude, essentially showing that for each negative percentage change in CPI, LogSP will exhibit a 16.6% positive change. That is, in the face of declining inflation, stock market returns increase. The negative coefficient shows an inverse relationship where decreases in inflation are linked to rising equity returns, of a greater magnitude than that of positive inflationary variations. This finding suggests that when inflation is expected to exhibit negative inflationary variations, investors should in fact increase investment in the equity markets.

Based on the direction of the changes and the fact that the absolute values for the response coefficients are significant and greater than unity, it can be seen that equities act as an effective inflationary hedge against positive inflationary variations, while equity returns still exhibit a positive increase in response to negative inflation variations. Thus, any change in inflation would be matched by a positive percentage change in equity returns of at least the same magnitude.

Importantly, these results highlight the fact that the positive and negative adjustment coefficients are vastly different, providing an indication that that while cointegration is evident between equity returns and inflation, the relationship is in fact asymmetric. Following Shin, Yu and Greenwood-Nimmo (2014), a Wald test can then be used to determine whether or not the null of symmetric adjustment can be rejected. The results of a Wald test with a null of symmetric adjustment are presented in Table 9.

Table 9: Wald Test for the NARDL results

Equation: NARDL		**Null Hypothesis: Symmetry**	
Test Statistic	**Value**	**Df**	**Probability**
T-Statistic	3.24753	416	0.0013
F-Statistic	10.54643	(1, 416)	0.0013
Chi Square	10.54643	1	0.0012
Null Hypothesis c(2)=c(3)			
Normalized restriction (=0)		**Value**	**Std. Error**
C(2) – C(3)		1.03923	0.32001

As is observed, the null hypothesis of symmetry is rejected, leading to the conclusion that long-run adjustment is asymmetric. The results can then be presented in a cointegrating equation of the form:

$$LogSP_t = 6.54574 + 1.07609LogCPI_tPOS - 16.69527LLogCPI_tNEg + \varepsilon_t$$

5. Conclusion

Much literature over the past century has considered the relationship between equity returns and inflation (Arnold and Auer, 2015). However, there has been a general disagreement as to the nature of the relationship. As the limits of statistical analysis have been extended, the theory regarding the capacity for equities to act as an inflationary hedge has seen several variations, with two major changes being evident. The first was the shift from Fisher's (1930) original hypothesis that the relationship is positive and thus equities are an effective inflationary hedge to the theories of Feldstein (1980) and Fama (1981) in response to empirical evidence of a negative relationship. The second occurred with the development of cointegration theory by Engle and Granger (1987) and Johansen (1988), which allowed researchers to investigate the relationship using $I(1)$ non-stationary data, which constitutes much of the data used in the related literature. This latter shift has led to much conflicting evidence regarding the nature of the relationship, with no clear consensus as to whether or not equities actually act as an inflationary hedge, but rather that the relationship is either time or country-dependent.

In the last decade the consideration of asymmetric adjustment has come into play, with the challenge to the conventional thinking that the relationship is linear in nature. Naturally, this has been integrated in several models in order to test the capacity for equities to act as an inflationary hedge. None, to the best of the authors knowledge, have employed a model with the power properties of the non-linear autoregressive lag model or determined magnitudes for each of the positive and negative coefficients of adjustment in a long-run model.

This study aimed to address two primary research questions for the South African case. The first of these aims was to identify if asymmetric adjustment has had an effect on the cointegrating relationship, when removing the common assumptions or disparities common in the past literature. Specifically, this referred to the linearity assumption as well as the general disagreement as to whether or not the variables are non-stationary. The second aim was then, if the relationship was shown to exhibit evidence of asymmetric adjustment, to identify the magnitudes of the positive and negative coefficients of adjustment.

Initially, this study showed that there is a positive and significant absolute relationship between equity returns and inflation. During positive inflationary periods the relationship was shown to exhibit a positive coefficient, or β^{+} of 1.08, similar to what was originally predicted by the Fisher (1930) hypothesis, but allowing for a small adjustment margin that would make it consistent with the tax-augmented theory. This β^{+} coefficient magnitude allows for the conclusion that during positive inflationary periods equities have acted as an effective long-run inflationary hedge.

During negative inflationary periods, however, the relationship was shown to exhibit a substantially larger β^{-} coefficient of -16.60, indicating that for each 1% negative adjustment in inflation equity returns have increased by a markedly higher 16.60%. It is posited that such a finding may be the result of possible decreases in the nominal interest rate when inflation decreases, making equities a more attractive alternative investment proposition. Lower inflation rates may also be indicative of an improvement in macroeconomic conditions, leading to improved foreign investor sentiment and increased investment in the domestic equity market. While this result does contradict the classical conditions necessary to classify equities as an effective inflationary hedge because of the negative β^- coefficient, it in fact improves the motivation to invest in equities regardless of inflationary expectations, especially during periods of expected negative inflationary variations. The importance of such a finding is critical for analysts involved in generating consistent positive returns from the equity market.

The magnitude of the difference between the β^+ coefficient β^- coefficient is somewhat surprising, simply due to the exceptionally different values. When one considers that the β^- coefficient is so high, which raises the average magnitude of the overall β coefficient in absolute terms, it becomes worrying that such considerations have not been made in preceding studies. For example, in alternate time periods or countries where the overall β coefficient has been found to be unitary and therefore consistent with the Fisher Hypothesis making equities a hedge against inflation, may well be inaccurate for either the positive or negative adjustment scenario. Situations may exist where an overall β coefficient may be greater than one, but the β^+ coefficient may in fact be less than one. This is likely to have led to incorrect recommendations both to investors and policy makers, who would previously have used the overall β coefficient as an indicator to preemptively hedge against inflationary increases, whereas the actual β^+ coefficient would have indicated that equities are not an effective inflationary hedge during positive inflationary periods. In any case, this situation is mitigated in the South African case to a certain extent, with the findings that both coefficients are independently greater than one in absolute terms.

Based on this finding of this study several recommendations are made. To begin with, it is crucial that studies of a similar nature consider the potential for asymmetric adjustment, as it is obvious from a comparison of the results of the linear ARDL and NARDL models that a failure to do so can lead to exceptionally misleading conclusions. From a practical asset management perspective, investors would be wise to consider investment in the equity market when inflation is anticipated to decrease. In such situation's currency-based assets may represent superior investment options due to their relative increase in purchasing power if nominal returns remain constant. During positive inflationary periods the equity market in South Africa is likely to act as an effective inflationary hedge, while in periods of negative inflationary variation it is expected that equity returns will increase substantially.

7.4 Statement of Author Contribution

The University of KwaZulu-Natal College of Law and Management Studies (CLMS) offers a PhD by Publications, in line with international practice. This declaration serves to confirm that the paper presented in Chapter 7 of this thesis "Equities as a hedge against inflation in South Africa" is the doctoral candidate's own original work, as stated in Declaration 2: Publications.

____

Mr. PBD Moores-Pitt

Date:

7.5 Conclusion

This thesis as a whole aimed to examine the capacity for equities to act as a long-run hedge against inflation. The conventional theory based on the work of Fisher (1930) and the majority of previous studies in the literature have calculated an 'all-important' β coefficient in order to assess the capacity for equities to act an effective hedge against inflation. However, given the nature of inflation and the relative incentive for investors and policy makers to limit the negative impacts of inflationary increases, an aggregate β coefficient is somewhat limited in this particular context. To expand on this point, there may be substantially different reactions from investors to positive inflationary variations as there are to negative inflationary variations.

It is posited that positive variations in expected inflation would lead to increased investment in the equity market in order to maintain the real value of an investment, based on the unitary relationship between the two variables in accordance with the Fisher (1930) equation. This scenario remains robust for the situation of positive inflationary variations, but it does lead to the implication that any negative inflationary variations would then result in a decrease in equity returns, at the same magnitude as the response to positive variations. Given the flaws in the underlying assumptions of conventional cointegration tests and the conventional theories in the previous chapters, alongside the findings of asymmetric adjustments in chapter 6, this idea warranted further investigation.

Chapter 7 thus employed and presented the results of a non-linear autoregressive distributed lag model (NARDL) in order to disaggregate the β coefficient into its positive and negative components and to identify whether the significant asymmetric adjustments that were previously identified are of a substantial magnitude, or if they are negligible for the purposes of inflation hedging. It was found that there is a surprisingly large difference between the positive and negative adjustment coefficients and, given the nature of the effects of inflation on real wealth, that the adjustment coefficients need to be assessed independently in order to accurately identify whether or not equities are able to act as an effective inflationary hedge.

While the relationship was positive in the case of the positive adjustment coefficient, indicating that equities act effectively as a hedge against positive inflation variations, the results indicated that negative inflationary variations have a far more positive effect on equity returns. Such a finding directly contrasts the assumption in the literature that negative adjustments are equal to positive adjustments, and has important implications for the management of equity investments to hedge against inflation. The two coefficients indicate that while investing in equities to hedge against positive inflationary variations is viable and effective, it is in fact probably even more important to make such investments when inflation is expected to decrease to realize the profit from expected increases in equity returns. To reiterate this critical point, instead of disinvesting in the equity market when inflation is expected to decrease as is effectively suggested by the aggregate coefficients presented in the majority of the literature, investors should look to hold equities as they are likely to exhibit a substantial increase in value.

A major contribution of this paper is the identification of the fact that the results of cointegration tests that consider a single adjustment coefficient can be immensely misleading, based on a comparison of the results of the linear ARDL and the NARDL models. It is suggested that in the case of future research that the disaggregated components be examined, instead of the aggregate adjustment coefficient, in order to better understand the dynamics of the cointegrating relationship.

CHAPTER 8: CONCLUSIONS

"As long as inflation doesn't ramp up to the double-digit levels of the 1970s and early 1980s — a scenario I consider extremely unlikely — stocks will act as an excellent hedge. The reason is simple: Stocks are claims on real assets, such as land and plant and equipment, which appreciate as overall prices increase" – Jeremy Siegel

8.1 Summary of Findings

The overarching aim of this body of research was to determine the nature and magnitude of the relationship between equity returns and inflation in South Africa. Initially this thesis presented a review of the underlying theory, including a description of the Fisher Hypothesis and the Proxy Hypothesis, as well as describing the shift in thinking since the development of cointegration theory. Previous empirical research was presented and discussed in the form of chronological review, set out in a manner designed to illustrate the changes over time that came about subsequent to the development of cointegration techniques.

As was evident from the literature review, the conclusions drawn as to the nature of this relationship are time variant and country dependent – as a result, it was concluded that the relationship must be estimated on a country-by-country basis for the relevant time period. In seeking to deeply understand this relationship in South Africa, several aspects were identified as requiring further investigation. In order to accurately determine which (if any) of these were relevant to the South African case, a PhD by Publications approach was taken whereby a series of papers considered various aspects of this issue.

With this in mind, the first research paper was aimed at examining the relationship in South Africa in order to help resolve the issues that have arisen in previous South African studies that were likely the result of differing findings of orders of integration of the data. The previous results of conflicting evidence with regards to the order of integration of the data advocates the use of a cointegration modelling approach that is able to endogenously account for issues in conventional unit root testing. At the same time, it is useful to model the relationship using a conventional cointegration techniques in order to see if this might partly explain previous disparities in the literature. To do this, both a VECM and an ARDL model were applied, the former which can only estimate data that is non-stationary in levels and the latter which can also model data that is stationary in levels. The foremost finding was that when using either cointegration framework we find strong evidence of cointegration between equity returns and inflation. The VECM 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, a high value relative to previous studies.

Under the ARDL framework the β coefficient was found to be 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. From these results the conclusion could be made that when using linear cointegration tests, equities are indeed 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 issue with the reliance on a single long-run estimate however is that it assumes, or at least implies, a certain amount of constancy over time. This is limited in reality due to the fact that exogenous shocks such as global financial crises or domestic political factors may mean that a single long-run measure does not provide the nuance needed for a long-term expression. As a result, it necessary to consider the more realistic idea that the relationship may have been affected to a certain extent by changes in the relationship, or structural breaks, during the sample period as there is in fact no sound theoretical reason that dictates why the relationship would be time-invariant.

In order to address this concern, the assumption of time invariance common in previous studies was relaxed in the second research paper, with the aim of determining whether structural breaks may have affected the cointegrating relationship, if indeed the relationship has been maintained when considering structural breaks. Aside from this issue, the second research paper aimed to analyse how the relationship has varied over time. In order to achieve these goals, the Zivot-Andrews (1992) and Gregory-Hansen (1996) procedures were applied. It was found that in both the individual series as well as the overall relationship that structural breaks had occurred. The most significant structural break was then taken and the cointegration tests conducted on either side of the break, in order to see whether the relationship had remained consistent or had varied over time. Findings of differing magnitudes of the respective β coefficients on either side of the break indicated that structural breaks do have an effect on the relationship and that the relationship is subject to temporal variation. This would help to explain some of the differing results in the previous literature that considered different time periods. It was concluded however, that in the South African case, equities have still maintained their capacity as an effective inflationary hedge over the entire period, but that in studies of a similar nature structural breaks should be considered.

An issue that has arisen in some of the more modern cointegration analyses is the issue of asymmetric adjustment as well as possible threshold effects. Such threshold effects were defined in chapter 5 as being a state where there is a cointegrating relationship that is inactive inside a neutral band. This neutral band essentially represents a specified range of values below the critical threshold level where the benefits of adjustment do not exceed the adjustment costs, but in which cointegration becomes active once the system crosses this critical threshold. It was stated that threshold cointegration itself stems from the existence of a neutral band which may exist due to the presence of transaction costs within a market, in which spatial arbitrage is unprofitable.

The general failure to account for such effects in the previous literature may well also be a source of the disparities evidenced. Theoretically speaking, there is no clear reason why positive changes and negative changes in inflation should affect equity returns in the same manner. Several factors may influence such adjustments; the fact that investors are likely to react more strongly to increases in inflation as it erodes the real wealth of currency investments and in such cases would have a greater incentive to consider alternative investments, such as equities, that are able to act as a hedge against inflation. This suggests that there may be some threshold at which investors would be more likely to diversify into equity investments instead of standard currency holdings. An interlinked extension of this thinking is that stocks may be mispriced relative to goods, which would lead to asymmetric adjustments depending on whether they are overpriced or under-priced. An alternative idea, addressed in chapter 7, was that the incentive to invest in the equity markets during periods of negative inflation may also be the case, due to the link between decreasing inflation and decreasing interest rates, motivating increased investment in equities as an alternative to currency-based assets. In either case, asymmetric adjustment would be evident in the relationship and should thus be accounted for in the econometric approach.

Following a study based on a similar line of thought by Kim and Ryoo (2011), Seo's (2006, 2011) two-regime VECM was employed to test for threshold cointegration. This model allowed for the estimation of the relationship between equity returns and inflation while allowing for asymmetric adjustments of each of the variables towards the long-run equilibrium. The significant evidence of asymmetric adjustment suggests that threshold effects should be accounted for when considering the relationship between equity returns and inflation internationally. In the South African context, the magnitude of the β coefficient does not contradict the findings of the previous research, that equities have historically acted as an effective hedge against inflation, although there is a slight degree of differentiation in the magnitude of the β coefficient when the threshold is accounted for. Essentially, this can be interpreted in a manner that while the overarching conclusion that equities are able to act as a sound inflationary hedge remains true, the significant evidence of threshold effects does impact the relationship. Thus, the slight difference in the magnitude of the β coefficient indicates that when accounting for threshold effects we can more accurately model the relationship, and the research represents a contribution in terms of providing this more accurate estimate.

The evidence of a threshold, and differing rates of adjustment around it, highlight the importance of accounting for asymmetric adjustment which may well have influenced the relationship coefficients to a far greater extent in other studies that examined different sample periods or other countries. Such findings emphasize the superiority of models which are able to account for asymmetric adjustment and may contribute to an understanding of previous discrepancies in the literature.

The primary aim of the final research paper included in this thesis was to disaggregate the asymmetric adjustment effects by separating and individually quantifying the positive and negative coefficients of adjustment. This allows one to adjust equity portfolios based on expectations of positive or negative inflation, instead of assuming that the adjustment coefficient would remain constant for both cases.

The fourth research paper further improved on the previous research into the effects of asymmetric adjustment with the use of the non-linear ARDL model of Shin *et al.* (2014) in order to simultaneously account for the issues of asymmetric adjustment and the disagreement regarding the order of integration of the variables which could have critical modelling consequences. The findings of this final study are the both the most important and the most novel of all the findings included in this body of research, as by disaggregating the long-run relationship into positive and negative components it becomes clear that the positive and negative adjustment coefficients are vastly different.

While the Fisher Hypothesis still technically holds for the case positive inflationary variations, allowing for the conclusion that equities have acted as an effective long-run inflationary hedge against positive inflation to remain true, this is not accurate for the case of negative inflationary variations. Rather, equities and inflation do not exhibit the necessary co-movement during periods of negative inflationary variations required to deem equities a hedge under conditions of the classical theory, but rather implies that equities in fact exhibit increased returns during periods of negative inflation variations. The difference in the magnitude of the coefficients has important ramifications for policy makers and investors alike. The critical finding is that when one may have advocated for disinvestment from the equity market during periods of expected negative inflationary variations, based on the aggregate findings of a positive long-term β coefficient, this would in fact be a mistake. Rather, the disaggregated coefficients imply that investors can hold equities to hedge effectively against inflation during positive inflationary periods, but then would also realize increased returns on their investments during negative inflationary periods, and thus are able to protect real returns against inflation.

8.2 Limitations of Study and Areas of Future Research

Possibly the most productive area for future research that has been identified is the consideration of differences in the relationship between individual sectors of the economy, as it is likely that when the relationship is so evidently time and country dependent, that different sectors may exhibit inter-sectoral variation – especially considering that macroeconomic shocks would affect individual sectors differently. An important consideration here is that reactions to inflation itself would likely have varying impacts on equity returns between sectors, given the finding in chapter 6 that it is equity returns, not inflation, that adjusts towards the equilibrium level. A sectoral analysis conducted using modern techniques such as the TVECM and the NARDL would contribute substantially to our understanding of the relationship between specific equity classes and inflation. A related extension would be to investigate the relationships between the alternative asset classes that have been considered as an inflationary hedge, namely minerals such as gold and silver, and real estate investments while considering the effects of thresholds and asymmetric adjustment. Such a study would allow for the identification of which asset classes, or which sectors, are most responsive to inflation and might provide the most effective inflationary hedge.

Although this study uses the longest data set that includes South Africa, to the best of the authors knowledge, it could be further improved by the use of a longer data set, as has been done in several international studies which have been able to use sample sizes of over a century. This idea, however, is limited to a certain extent in the South African market due to data availability as well as changes in index calculation methodologies which currently make using a longer data set outside of the scope of this thesis. Data availability is also a potential limitation in relation to the frequency of the data. This is due to the fact that monthly data can have a greater tendency to be normally distributed and to be stationary in levels, compared to higher frequency data such as daily data (van Heerden, 2015).

A potential limitation in the early studies could be the effect of over-differencing of the series when rendering it stationary. However, as discussed in the literature review, the use of fractional integration by Kasman *et al*. (2006) found the error term to be stationary in most countries, but could be incorporated into future analysis for robustness.

A further interesting avenue for research would be to apply the TVECM and NARDL analysis in a multi-country setting, in order to see if accounting for threshold effects and asymmetric adjustment have had different effects in on an international level. This would allow for a comparison of the results and would show whether threshold cointegration techniques find a greater level of variance in comparison to conventional cointegration techniques in other markets than South Africa. It would also allow for some insight to be gained as to the extent that the equity markets in certain countries are affected by variations in inflation, which may have important implications for hedging the international component of a portfolio investment, especially in times of global financial turmoil.

In terms of modelling extensions, there a several approaches that would provide an interesting look at the dynamics of the relationship. The recently developed Quantile ARDL of Cho, Kim and Shin (2015) is one such model, although whether or not it would differ substantially from the results of the NARDL is unclear. One might also move away from the bounds of cointegration testing altogether using signal decomposition techniques based on a wavelet analysis in order to further study the lead/lag relationship between the equity returns and inflation, which may represent an interesting contribution to the field. Similar analyses have been conducted by Gallegati (2008), who considers the relationship between the stock market and economic activity, and by Kim and In (2003) who apply a wavelet approach in the context of various financial variables and real economic activity. The stock returns and inflation relationship has recently been examined for the case of India using a wavelet approach (Bhanja and Dar, 2018), who found evidence to suggest that the two variables are independent across time horizons and which lends support the use of stocks as an inflationary hedge. However, if the disparities evident across countries in the previous literature is anything to go by, this is an extension that would need to be investigated in a South African context in order to apply it domestically.

8.3 Conclusions and Summary of Original Contributions

This thesis aimed to investigate the dynamics of the relationship between equity returns and inflation in South Africa, in order to assess whether equities have historically acted as an effective hedge against inflation. This was reflected in the broad research question, stated as "Have equities acted as an effective long-run hedge against inflation in South Africa?" The motivation for the study was drawn from the vastly conflicting results regarding the nature and magnitude of the relationship both nationally and internationally. The conflict in the previous literature was illustrated during the literature review of Chapter 3, which helped show how disparate the results of previous studies actually are. Further, the review of previous studies highlighted the fact that the magnitude of the relationship is both time and country dependent, and that the results of international studies may not provide an accurate representation of the domestic South African relationship. The lack of consensus as to the nature of such a potentially important macroeconomic relationship is surprising, given the implications the relationship has with regards to investment decisions in terms of optimising returns as well as the macroeconomic policy considerations.

A resolution to this disparity for the South African case is therefore of particular importance, as there has been no agreement as to the capacity for equities to function as an effective inflationary hedge on a domestic level. This thesis sought, first and foremost, to resolve this conflict for the South African case. Prior to the presentation of the first research paper the dominant schools of thought in the historical literature, the Fisher Hypothesis and the Proxy Hypothesis were considered alongside their fundamental underpinning assumptions and theories. The initial research paper then interrogated the lack of consistency in the order of integration of the variables and focused on establishing a certain degree of uniformity once resolving the aforementioned issue with other similar studies. To this end the ARDL approach was employed in order to address the concerns regarding the order of integration of variables, alongside conventional stationarity tests and provided the conclusion that equities have acted as an effective inflationary hedge in accordance with the theory of the Fisher Hypothesis. Among other research issues, it was posited that the common assumption in previous studies that the relationship is time-invariant may in fact be incorrect and may therefore account for much of the conflicting results of previous studies.

In order to interrogate this issue, the relationship as well as the independent series were tested for structural breaks, an original contribution in South Africa. The occurrence of such breaks would theoretically be unsurprising given the volatility in the South African economy over the past thirty-five years with the transition from the apartheid regime, international sanctions, vast fluctuations in macroeconomic factors such as inflation, GDP and inflation, as well the global financial crises that have occurred over the period. The implications of such issues would be that while the cointegrating relationship may have been positive in the long-run, allowing equities to act as an inflationary hedge, economic shocks may have fundamentally influenced the nature of the relationship on a domestic level. This was proven with the use of the Zivot-Andrews (1992) and Gregory-Hansen (1996) tests, which found that structural breaks have indeed occurred in the relationship between the variables in South Africa, and that the relationship is substantially different when tested prior and subsequent to the most significant of these breaks. This allows for the conclusion that the relationship is not time-invariant and that much of the conflicting evidence in preceding literature may be based on the consideration of different samples.

The major gap in the research, and opportunity for a novel contribution to the field, that was identified during the course of the second research paper was that measurement of the relationship in prior studies has been inherently based on a potentially inaccurate set of underlying assumptions. The question that arose as a result was that if the relationship shows temporal variance, it may have at certain points during the sample period, been subject to certain threshold effects which may have influenced the relationship. Further, tests of the relationship have not previously allowed for the possibility of asymmetric adjustment within the measurement of the relationship. Chapter 6 of this thesis sought to remedy this issue for the South African case, both to test if evidence for threshold effects exists and to test if asymmetric adjustment has occurred. It was concluded that a certain threshold does exist and that the adjustment coefficients differ substantially depending on whether they are above or below the threshold. Thus, the conclusion was made that the assumption of linear adjustment is flawed and the relationship exhibits asymmetric adjustment in reality. The important implication of this conclusion was that the relationship is significantly affected by asymmetric adjustment and it is critical that future research integrates such factors into the analysis in order to accurately model the relationship, and by extension, optimise the efficiency as to how equities are employed as an inflationary hedge.

This study was the first of its kind in South Africa to employ a sufficiently long data set and testing methodology to avoid issues of low power that are evident in previous studies, and contradicted the results of a negative relationship found by such studies. The superior analysis allowed for the conclusion that asymmetric adjustment in indeed evident in the relationship and must be accounted for in order to accurately assess the magnitude and nature of the relationship. Further, it was concluded that even in the presence of asymmetric adjustment and threshold effects, equities have maintained their capacity to act as an effective hedge against inflation in South Africa.

Subsequent to the findings of the research paper in Chapter 6 the core research question of this thesis was effectively answered, however the question remained that if the asymmetric adjustment does in fact influence the relationship, what would the extent of such an influence be in reality? This is an important consideration due to the fact that if the positive and negative coefficients of adjustments differ drastically, decisions based on inflationary expectations should be tailored accordingly.

In a study that was, to the best of the authors knowledge, the first of its kind, this question was addressed in the research paper in chapter 7. In order to disaggregate the adjustment coefficients into their positive and negative components an NARDL model was employed which allowed for the independent estimation of the positive and negative adjustment coefficients and found that the coefficients do indeed differ substantially. As described in chapter 7, both policy and investment recommendations may have been skewed based on the essentially inaccurate use of the single, aggregate β coefficient, where in fact the disaggregated adjustment coefficients provide a far superior reflection of the nature of the relationship.

Overall it was concluded that equities have historically acted as an effective long-run hedge against positive inflation in South Africa, in accordance with the theory of the Fisher Hypothesis, and are able to protect real returns against both positive and negative inflationary variations. Based on the different components of this thesis, the recommendation is made that investors can effectively utilise an aggregate portfolio in order to mitigate the detrimental effects of inflation in South Africa in the long-run. Investors should however, be cautioned that the relationship can be expected to fluctuate over time and is likely to differ substantially in terms of its absolute magnitude depending on whether the adjustment is positive or negative. In fact, these findings would indicate that future research needs to look at developing the hedge decision making process into one which builds in these sorts of real-world data considerations. Further, those conducting studies of a similar nature in the future are advised to consider that the results of models that assume time-invariance or asymmetric adjustment are likely to be misleading and such factors may heavily influence the integrity of their results.

REFERENCES

ADUSEI, M. (2014). The Inflation-Stock market returns Nexus: Evidence from the Ghana Stock Exchange. *Journal of Economics and International Finance*, 6(2): pp. 38-46.

AHMAD, S. (2010). The long-run Fisher effect in developing economies. *Studies in Economics and Finance*, 27: pp. 268-275.

AKMAL, M.S. (2007). Stock Returns and Inflation: An ARDL Econometric Investigation Utilizing Pakistani Data. *Pakistan Economic and Social Review*, 45(1): pp. 89-105.

AL NASSAR, N.S. and BHATTI, R.H. (2018). Are common stocks a hedge against inflation in emerging markets? *Journal of Economics and Finance.* [Online]. Available: https://doi.org/10.1007/s12197-018-9447-9.

ALAGIDEDE, P. and PANAGIOTIDIS, T. (2010). Can common stocks provide a hedge against inflation? Evidence from African Countries. *Review of Financial Economics*, 19: pp. 91-100.

ALAGIDEDE, P. and PANAGIOTIDIS, T. (2012). Stock returns and Inflation: Evidence from Quantile Regression. *Economics Letters*, 117: pp. 283-286.

ALEXANDER, C. (1999). Optimal Hedging Using Cointegration. *Philosophical Transaction of the Royal Society, London. Series A*, 357: 2039-2058.

ANARI, A. and KOLARI, J. (2001). Stock Prices and Inflation. *The Journal of Financial Research*, 24(4): pp. 587-602.

ANDREWS, D.W.K. (1992). Test for parameter stability and structure change with unknown change points. *Econometrica,* 61. pp. 821-856.

ANTONAKAKIS, N., GUPTA, R. and TIWARI, A.K. (2017). Has the correlation of inflation and stock prices changed in the United States over the last two centuries? *Research in International Business and Finance,* 42: pp 1-8.

ARJOON, R., BOTES, M., CHESANG, L.K. and GUPTA, R. (2011). The Long-Run Relationship Between Inflation and Real Stock Prices: Empirical Evidence from South Africa. *Journal of Business Economics and Management*, 13: 600-613.

ARNOLD, S. and AUER, B.R. (2015). What do scientists know about inflation hedging? *North American Journal of Economics and Finance*. 34: pp. 187-214.

ATKINS, F. J. and CHAN, F.J. (2004). Trend breaks and the Fisher hypothesis in Canada and the United States. *Applied Economics,* 36: pp. 1907-1903.

ATKINS, F.J. and COE, P.J. (2002). An ARDL bounds test of the long-run Fisher effect in the United States and Canada. *Journal of Macroeconomics*, 24: pp 255-266.

BAHRAM, A., ARJUN, C. and KAMIZ, R. (2004). REIT Investments and Hedging Against Inflation. *Journal of Real Estate and Portfolio Management,* 10(2): pp. 97-112.

BAI, J. and PERRON, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica*, 66: pp 47-78.

BALDUZZI, P. (1995). Stock returns, inflation, and the "Proxy Hypothesis:" A new look at the data. *Economics Letters*, 48: 47-53

BALKE, N.S. and FOMBY, T.B. (1997). Threshold Cointegration. *International Economic Review,* 28: 627-645.

BAMPINAS, G. and PANAGIOTIDIS, T. (2015). Are gold and silver a hedge against inflation? A two century perspective. *International Review of Financial Analysis*, 41: pp. 287-276.

BARSKY, R.B. (1987). The Fisher Hypothesis and the Forecastability and Persistence of Inflation. *Journal of Monetary Economics,* 19: 3-24.

BERUMENT, H. and JELASSI, M. M. (2002). The Fisher Hypothesis: a multi-country analysis. *Applied Economics*, 34: pp. 1645-1655.

BHANJA, N. and DAR, A.B. (2018). Stock returns and inflation: a tale of two periods in India. *Economic Change and Restructuring.* [Online]. Available: https://doi.org/10.1007/s10644-018-9231-z.

BODIE, Z. (1976). Common Stocks as a Hedge Against Inflation. *Journal of Finance*, 21: pp. 459-470.

BODIE, Z., KANE, A. and MARCUS, A.J. (2010). Essentials of Investment. Published by Mcgraw-Hill/Irwin, New York.

BOUDOUKH, J. and RICHARDSON, M. (1993). Stock Returns and Inflation: A Long-Horizon Perspective. *The American Economic Review,* 83: pp. 1346-1355.

BRADLEY, M. and JARREL, G.A. (2008). Expected Inflation and the Constant-Growth Valuation Model. *Journal of Applied and Corporate Finance,* 20: pp. 66-78.

BRANCH, B. (1974). Common Stock Performance and Inflation: An International Comparison. *Journal of Business,* 47: pp 48-52.

BREALEY, R.A., MYERS, S.C. AND ALLEN, F. Principles of Corporate Finance. Mcgraw-Hill/Irwin, New York.

BROOKS, C. (2008). Introductory Econometrics for Finance. Cambridge University Press: New York.

CAMPOS, J., ERICSSON, N.R. and HENDRY, D.F. (1993). Cointegration tests in the presence of structural breaks. *International Finance Discussion Papers,* 440: pp. 1-28.

CHAVES, C.S. and SILVA, A.C. (2018). Inflation and Stock Returns at B3. [Online]. Available: http://dx.doi.org/10.2139/ssrn.3178972.

CHO, J.S., KIM, T.H. and SHIN, Y. (2015). Quantile Cointegration in the Autoregressive Distributed-Lag Modelling Framework. Journal of Econometrics, 188 pp. 281-300.

CIL YAVUZ, N. (2014). CO_2 Emission, Energy Consumption and Economic Growth for Turkey: Evidence from a Cointegration Test with a Structural Break. *Energy Sources, Part B: Economics, Planning and Policy,* 9: 3 pp 229-235.

CLAUDE, B.E., CAMPBELL, R.H. and VISKANTA, T.E. (1995). Inflation and World Equity Selection. *Financial Analysts Journal,* 51: pp. 28-42.

COOLEY, P.L. ROENFELDT, R.L. and CHEW, I.K. (1975). Capital Budgeting Procedures under Inflation. *Financial Management,* 4: 18-27.

COORAY, A. (2002). The Fisher Effect: A Review of the Literature. Macquarie University Research Papers, 206: pp. 1-25.

CORSETTI, G., PESENTI, P. and ROUBINI, N. (1999). What caused the Asian currency and financial crisis? *Japan and the World Economy,* pp 1-92.

DAMODARAN, A. (2002a). Investment Valuation: Tools and Techniques for Determining the Value of Any Asset. 2nd edition. John Wiley & Sons, Inc, New York.

DAMODARAN, A. (2002b). Estimating Risk free Rates. *Working Paper, Stern Business school, New York University.* [Online]. Available: http://people.stern.nyu.edu/adamodar/pdfiles/papers/riskfree.pdf. (Accessed 22/10/2013).

DAMODARAN, A. (2012). Investment Valuation: Tools and Techniques for Determining the Value of Any Asset. 3rd edition. John Wiley & Sons, Inc, New York.

DANTHINE, J.P. and DONALDSON, J.B. (1986). Inflation and Asset Prices in an Exchange Economy. *Econometrica*, 54: 585-605.

DARBY, M. (1975). The Financial and Tax Effects of Monetary Policy on Interest Rates. *Economic Inquiry*, 13(2): pp. 266-276.

DAY, T. E. (1984). Real Stock Returns and Inflation. *The Journal of Finance,* 39: pp. 493-502.

DICKEY, D.A. and FULLER, W.A. (1979). Distribution of estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association,* 74: pp. 427-431.

DRAKE, P.P., (2006). What is free cash flow and how do I calculate it? [Online] Available: http://educ.jmu.edu/~drakepp/general/FCF.pdf. (Accessed 04/06/2013).

EGGOH, J.C., BANGAKE, C. and RAULT. (2011). Energy consumption and economic growth revisited in African countries. *Energy Policy,* 39: pp 7408-7421.

EITA, J.H. (2012). Inflation and Stock Market Returns in South Africa. *International Business and Economics Research Journal*, 11: pp. 677-686.

ELY, D. P. and ROBINSON, K. J. (1997). Are stocks a hedge against inflation? International evidence using a long-run approach. *Journal of International Money and Finance*, 16: pp. 141-167.

ENDERS, W. (2010). Applied Econometric Time Series 3rd Ed. Wiley: Hoboken.

ENDERS, W. and GRANGER, C. (1998). Unit root tests and asymmetric adjustment with an example using the term structure of interest rates. *Journal of Business and Economic Statistics*, 16: 304-311.

ENDERS, W. and SIKLOS, P.L. (2001). Cointegration and Threshold Adjustment. *Journal of Business and Economic Statistics,* 19: 166-176.

ENGLE, R.F. and GRANGER, C.W.F. (1987). Cointegration and Error Correction: Representation, estimation and testing. *Econometrica,* 55: pp. 251-276.

EHRHARDT, M.C. and BRIGHAM, E.F. (2010). Corporate Finance. Cengage Learning, USA.

ESSO, L.J. (2010). Threshold cointegration and causality relationship between energy use and growth in seven African countries. *Energy Economics,* 32: pp. 1383-1391.

ESSO, L.J. (2016). Energy consumption, economic growth and carbon emissions: Cointegration and causality evidence from selected African countries. *Energy,* 114: pp. 492-497.

EZZELL, J.R. and KELLY, W.A. (1984). An APV Analysis of Capital Budgeting under Inflation. *Financial Management,* 13. No. 3: 49-54.

FAMA, E.F. (1981). Stock returns, real activity, inflation and money. *American Economic Review*, 71: pp. 545–565.

FAMA, E.F. (1983). Stock returns, real activity, inflation and money: Reply. *American Economic Review,* 73: pp. 471–472.

FAMA, E.F. and MACBETH, J.D. (1974). Tests of the Multiperiod Two-parameter Model. *Journal of Financial Economics,* 1: 43-66.

FAMA, E.F. and SCHWERT. G.W. (1977). Asset Returns and Inflation. *Journal of Financial Economic*s, 5: pp. 115-146.

FARSIO, F. and FAZEL, S. (2008). Can Investors Use Inflation Data to Predict Stock Prices? [Online]. Available: http://kastoria.teikoz.gr/icoae2/wordpress/wp-content/uploads/articles/2011/10/037-2008. pdf. (Accessed 14/11/2013).

FELDSTEIN, M. (1980). Inflation and the stock market. *American Economic Review*, 70: pp. 839–847.

FINANCIAL TIMES. (2018). *Equities back on the menu.* [Online]. Available: www.ft.com/content/b56dd766-1559-11e8-9c33-02f893d608c2. (Accessed 30/01/2019).

FIRTH, M. (1979). The Relationship Between Stock Market Returns and Rates of Inflation. *The Journal of Finance*, 34: pp. 743-749.

FISHER, I. (1930). The Theory of Interest. Macmillan: New York.

GALLEGATI, M. (2008). Wavelet analysis of stock returns and aggregate economic activity. *Computational Statistics and Data Analysis*, 52: 3061-3074.

GESKE, R. and ROLL, R. (1983). The monetary and fiscal linkage between stock returns and inflation. *The Journal of Finance*, 38: pp. 1-33.

GEYSER, J.M. and LOWIES, G.A. (2001). The Impact of Inflation on Stock Prices in Two SADC Countries. *Meditari: Research Journal of the School of Accounting Sciences.* 9: 109-122.

GOCEN, H., KALYONCU, H. and KAPLAN, M. (2013). Do Private Savings Offset Public Savings in Turkey? *Journal of Economic and Social Studies*, 3: pp 5-14.

GOH, B.W., LI, D., NG, J. and OW YONG, K.K. (2015). Market pricing of banks' fair value assets reported under SFAS157 since the 2008 financial crisis. *Journal of Accounting and Public Policy,* 34: pp 129-145.

GOODWIN, B.K. and HARPER, D.C. (2000). Price Transmission, Threshold behaviour, and Asymmetric Adjustment in the U.S. Pork Sector. *Journal of Agricultural and Applied Economics*, 32: 543-553.

GOODWIN, B.K. and PIGGOTT, N. (2001). Spatial Market Integration in the Presence of Threshold Effects. *American Journal of Agricultural Economics,* 83: 302-317.

GREGORIOU, A. and KONTONIKAS, A. (2010). The long-run relationship between stock prices and goods prices: New evidence from panel cointegration. *Journal of International Financial Markets, Institutions & Money,* 20: pp. 166-176.

GREGORY, A.W. and HANSEN, B.E. (1996a). Residual-Based tests for Cointegration in Models with Regime Shifts. *Journal of Econometrics,* 70: pp. 99-126.

GREGORY, A.W. and HANSEN, B.E, (1996b). Tests for cointegration in models with regime and trend shifts. *Oxford Bulletin of Economics and Statistics,* 58: pp 555-560.

GUJARATI, D.N. and PORTER, D.C. (2009). *Basic Econometrics*. McGraw-Hill: New York.

GULTEKIN, N. B. (1983a). Stock Market Returns and Inflation: Evidence from Other Countries. *The Journal of Finance*, 38: pp. 49-65.

GULTEKIN, N. B. (1983b). Stock Market Returns and Inflation Forecasts. *The Journal of Finance*, 1: pp. 663-673.

HANCOCKS, R.L. (2010). An Analysis of the Influence of Domestic Macroeconomic Variables on the Performance of South African Stock Market Sectoral Indices. Unpublished Masters Thesis, Rhodes University, Grahamstown.

HANSEN, B. E. (1992). Testing for Parameter Instability in regressions with I(1) processes. *Journal of Business and Economic Statistics*, 10: pp. 321-335.

HANSEN, B.E. (1999). Testing for Linearity, *Journal of Economic Surveys*. 13: 551-576.

HANSEN, B.E. and SEO, B. (2002). Testing for two-regime threshold cointegration in vector error-correction models. *Journal of Econometrics,* 110: 293-318.

HARRIS, R.S. (1986). Using Analysts' Growth Forecasts to Estimate Shareholder Required Rates of Return. *Financial Management*, 15: 68-75.

HASSAN, K., HOQUE, A. and RAO, A. (2015). Revisiting the link between stock prices and goods prices in OECD countries. *Australian Economic Papers*. 54(3): pp. 135-150.

HESS, P.J. and LEE, B. (1999). Stock returns and Inflation with Supply and Demand Disturbances. *Review of Financial Studies*, 12: pp. 1203-1218.

HILL, S. and GOUGH, J. (1981). Discounting Inflation – A Note. *Managerial and Decision Economics*, 2: 121-123.

HILLIER, D., ROSS, S., WESTERFIELD, R., JAFFE, J. and JORDAN, B. (2010). Corporate Finance. Mcgraw-Hill Education, Berkshire England.

HOWELLS, P. and BAIN, K. (2008). The Economics of Money, Banking and Finance. Prentice-Hall, Harlow England.

INDUSTRIAL DEVELOPMENT CORPORATION (2013). South African economy: An overview of key trends since 1994. [Online]. Available: http://www.idc.co.za/reports/IDC%20R&I%2 0publication%20%20Overview%20of%20key %20trends%20in%20SA%20economy%20since%201994.pdf. (Accessed 02/03/2017).

INGLESI-LOTZ, R. and GUPTA, R. (2013). The long-run relationship between house prices and inflation in South Africa: an ARDL approach. *International Journal of Strategic Management*. 17(2): pp. 188-198.

JAFFE, J. and MANDELKER, G. (1976). The 'Fisher Effect' for Risky Assets: An Empirical Investigation. *Journal of Finance*, 31: 447-458.

JOHANSEN, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control,* 12: pp. 231-254.

JOHANSEN, S. (2000). Modelling of cointegration in the vector autoregressive model. *Economic Modelling*, 17: pp 359-373.

JOHANSEN, S. and JUSELIUS, K. (1990). Maximum likelihood estimation and inference on cointegration - with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52: 169-210.

JOHANSEN, S., MOSCONI, R. and NEILSEN, B. (2000). Cointegration analysis in the presence of structural breaks in the deterministic trend. *Econometrics Journal,* 3: 216-249.

JORGENSEN, J.J., and TERRA, P.R.S. (2006). Revisiting the Causality between Stock Returns and Inflation: Evidence from Advanced and Emerging Markets. Retrieved February 12, 2013, from http://papers.ssrn.com/sol3/papers. cfm?abstract_id=889961.

KASMAN, S., KASMAN, A. and TURGUTLU, E. (2006). Fisher Hypothesis Revisited: A Fractional Cointegration Analysis. *Emerging Markets Finance and Trade*, 42: pp. 59-76.

KATSUR, T. and SPIERDIJK, L. (2010). Stock Returns and Inflation Risk: implications for portfolio selection. *University of Groningen* Working Paper.

KAUL, G. (1990). Monetary regimes and the relation between stock returns and inflationary expectations. *Journal of Financial and Quantitative Analysis*, 25: pp. 307-321.

KENNON, J. (2013). The Five Components of an Investors Required Rate of Return. [Online]. Available: http://beginnersinvest.about.com/od/investing101/a/aa040407a.htm. (Accessed 22/10/2013).

KHIL, J. and LEE, B.S. (2000). Are common stocks a good hedge against inflation? Evidence from the Pacific-rim countries. *Pacific-Basin Finance Journal,* 8: pp. 457-482.

KHUMALO, J. (2013). Inflation and Stock Prices Interactions in South Africa: VAR Analysis. *International Journal of Economics and Finance Studies*, 5(2): pp. 23-34.

KIECHLE, D. and LAMPENIUS, N. (2012). Inflation and the Constant Growth Model: Reconciling the Literature. *Abacus,* 48: 518-538.

KIM, J.H. and RYOO, H.H. (2011). Common stocks as a hedge against inflation: Evidence from century-long US data. *Economics Letters*, 113: pp. 168–171.

KIM, S. and IN, F.H. (2003). The Relationship Between Financial Variables and Real Economic Activity: Evidence from Spectral and Wavelet Analyses. *Studies in Nonlinear Dynamics & Econometrics,* 7: -. Retrieved 14 Nov. 2017, from doi:10.2202/1558-3708.1183

KING, R.G. and WATSON, M.W. (1997). Testing long-run neutrality. *Federal Reserve Bank of Richmond Economic Quarterly*. 82: 69-101.

KUHLEMEYER, G.A. (2004). Required Returns and the Cost of Capital. [Online]. Available: https://www.*wps.pearsoned.co.uk/wps/media/objects/1670/.../0273685988_ch15.ppt*. (Accessed 22/10/2013).

KWIATKOWSKI, D., PHILLIPS, P.C.B., SCHMIDT, P. and SHIN, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics*, 54: pp. 159-178.

LEE, B.S. (1992). Causal Relations Among Stock Returns, Interest Rates, Real Activity and Inflation. *The Journal of Finance*, 47: pp. 1591-1603.

LEE, B.S. (2010). Stock returns and inflation revisited: An evaluation of the inflation illusion hypothesis. *Journal of Banking & Finance*, 34: pp. 1257- 1273.

LI, L., NARAYAN, P.K. and ZHENG, X. (2010). An analysis of inflation and stock returns for the UK. *Journal of International Financial Markets, Institutions & Money*, 20: pp. 519-532.

LINTNER, J. (1975). Inflation and Security Returns. *The Journal of Finance*, 2: pp. 259-280.

LO, M. and ZIVOT, E. (2001). Threshold cointegration and nonlinear adjustment to the law of one price. *Macroeconomic Dynamics,* 5: 533-576.

LUINTEL, K.B. and PAUDYAL, K. (2006). Are Common Stocks A Hedge Against Inflation? *Journal of Financial Research*, 29(1): pp. 1-19.

LUNAR CAPITAL. (2018). *Inflation and its impact on stock prices.* [Online]. Available: https://www.lunarcapital.co.za/inflation-and-its-impact-on-stock-prices/. (Accessed 29/01/2019).

MADSEN, J.B., (2007). Pitfalls in estimates of the relationship between stock returns and inflation. *Empirical Economics*, 33: pp. 1-21.

MAHADEVA, L. and ROBINSON, P. (2004). Unit Root Testing to Help Model Building. *Handbooks in Central Banking*, 22: pp. 1-53.

MANN, J.M. (2012). Threshold cointegration with applications to the oil and gasoline industry. Doctor of Philosophy Thesis. *Queen's University,* Ontario, Canada.

MAYYA M.R. (1977). Do Equities Act as a Hedge against Inflation? *Economic and Political Weekly*, 12: pp. 61-71.

MEHTA, D.R., CURLEY, M.D. and FUNG, H.G. (1984). Inflation, Cost of Capital, and Capital Budgeting Procedures. *Financial Management,* 13, No. 4: 48-54.

MENSI, W., HAMMOUDEH, S., YOON, S. and NGUYEN, D.C. (2016). Asymmetric Linkages between BRICS Stock Returns and Country Risk Ratings: Evidence from Dynamic Panel Threshold Models. *Review of International Economics*, 24(1): 1-19.

MICHAUD, R.O. and DAVIS, P.L. (1982). Valuation Model Bias and the Scale Structure of Dividend Discount Returns. *The Journal of Finance*, 37: 563-573.

MISHKIN, F. (1992). Is the Fisher effect for real?: A re-examination of the relationship between inflation and interest rates. *Journal of Monetary Economics*, 30: pp. 195-215.

MITCHELL-INNES, H.A., AZIAKPONO, M.J. and FAURE, A.P. (2007). Inflation targeting and the Fisher effect in South Africa: An empirical investigation. *South African Journal of Economics*, 75: 693-707.

MOAZZAMI, B. (2010). Stock Prices and Inflation: Evidence from 12 Developed and Emerging Economies. *International Business and Economics Research Journal*, 9(11): pp 1-4.

MODIGLIANI, F. and COHN, R.A. (1979). Inflations, Rational Valuation and the Market. *Financial Analysts Journal*, 35(2): pp. 24-44.

MOOLMAN, E. and DU TOIT. (2005). An Econometric Model of the South African Stock Market. *South African Journal of Economic and Management Sciences*, 8: pp 77-91.

MOORE, M.A., BOARDMAN, A.E., VINING, A.R., WEIMER, D.L. and GREENBERG, D.H. (2004). *Journal of Policy Analysis and Management*, 23: 789-812.

MOORES-PITT, MURRAY, M and STRYDOM, B.S. (2019). Accounting for threshold effects and asymmetric adjustment between inflation and equity returns in South Africa. Working Paper Under Review with the Journal for Studies in Economics and Econometrics.

MOORES-PITT, P. and STRYDOM, B.S. (2017). Equities as a hedge against inflation in South Africa. *African Review of Economics and Finance,* 9: 156-179.

MOORES-PITT, P. Investigating temporal variation in the equity returns-inflation relationship in South Africa. *African Journal of Business and Economic Research*. 13(1), pp: 51-79.

NELSON, C.R. (1976). Inflation and Rates of Return on Common Stocks. *Journal of Financ*e, 31: pp. 471-483.

NORIEGA, A.E. and VENTOSA-SANTAULARIA, D. (2006). Spurious Cointegration: The Engle-Granger Test in the Presence of Structural Breaks. *Banco de Mexico Working Papers,* 12: pp 1-12.

OCAKVERDI, E. and TANG, C.F. (2009). Gregory-Hansen Cointegration Test EViews Source Code. [Online]. Available: http://forums.eviews.com/viewtopic.php ?f=15&t=976#p3427. (Accessed 05/07/2017).

OUDET, B.A. (1973). The Variation of the Returns on Stocks in Periods of Inflation. *Journal of Financial and Quantitative Analysis,* 8: 247-258.

OUMA, W.N. and MURIU, P. (2014). The Impact of Macroeconomic Variables on Stock Market Returns in Kenya. *International Journal of Business and Commerce*, 3(11): pp. 1-31.

PELGRIN, F. (2010). Unit Root Tests. [Online]. Available: https://hec.unil.ch/docs/ files/46/991/chapter_6_2012_2013.pdf. (Accessed 24/06/2013).

PERRON, P. (1989). The Great Crash, the Oil Price Shock and the Unit Root Hypothesis. *Econometrica,* 55: pp. 277-301.

PESARAN, M.H. and SHIN, Y. (1999). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. *Econometrics and Economics in the 20th Century: The Ragnar Frisch Centennial Symposium*, Strom, S. (ed). Cambridge University Press.

PESARAN, M.H., SHIN, Y. and SMITH, R. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics*, 16: pp. 189-326.

PHILLIPS, P.C.B. and HANSEN, B.E. (1990). Statistical inference in instrumental variables regression with *I*(1) processes. *The Review of Economic Studies,*57: pp. 99-125.

PHIRI, A. (2017). Long-run equilibrium adjustment between inflation and stock market returns in South Africa: a nonlinear perspective. *International Journal of Sustainable Economy*, 9: 19-33.

PRABHAKARAN, M. (1989). Do Equities Act as a Hedge against Inflation? *Economic and Political Weekly*, 24: pp. 24-26.

REILLY, F.K., JOHNSON, G.L. and SMITH, R.E. (1971). Individual Common Stocks as Inflation Hedges. *Journal of Financial and Quantitative Analysis,* 6: 1015-1024.

RICCI, L.A. (2006). Part IV. Monetary Developments. In: Nowak, M. and L.A. Ricci, ed. *Post-Apartheid South Africa: The First Ten Years*. Washington, D.C: International Monetary Fund, 189-210.

RUSHDI, M., KIM, J.H. and SILVAPULLE, P. (2012). ARDL bounds tests and robust inference for the long relationship between real stock returns and inflation in Australia. *Economic Modelling*, 29: pp. 535-543.

SAREL, M. (1996). Non-linear Effects of Inflation on Economic Growth. *IMF Staff Papers*, 43: pp. 199-215.

SEO, M. (2006). Bootstrap Testing for the Null of No Cointegration in a Threshold Vector Error Correction Model. *Journal of Econometrics*, 134: pp. 129-150

SEO, M.H. (2011). Estimation of nonlinear error correction models. *Econometric Theory*, 27: 201-234.

SHARPE, S. A. (2000). Reexamining Stock Valuation and Inflation: The Implications of Analysts' Earnings Forecasts. [Online]. Available: http:// www.federalreserve.gov/pubs/feds/1999/199902/199902pap.pdf.

SHARPE, S. A. (2002). Reexamining Stock Valuation and Inflation: The Implications of Analysts' Earnings Forecasts. The *Review of Economics and Statistics*, 84(4), pp: 632-648.

SHEMER, N. (2013). Required Rate of Return. [Online]. Available: http://strategiccfo.com/wikicfo/required-rate-of-return/. (Accessed 22/10/2013).

SHIN, Y., YU, B., and GREENWOOD-NIMMO, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a Nonlinear ARDL Framework. *Festschrift in Honor of Peter Schmidt* pp. 281-314.

SHRESTHA, M.B. and CHOWDHURY, K. (2007). Testing financial liberalization hypothesis with ARDL modelling approach. *Applied Financial Economics*, 17(18) pp: 1529-1540.

SIEGEL, J.J. (2011). Stocks: The Best Inflation Hedge. [Online]. Available at: http://www.kiplinger.com/article/investing/T052-C019-S001-stocks-the-best-inflation-hedge.html.

SORENSON, B.E. (1997). Cointegration. [Online] Available: http://www.uh.edu/~bsorense/coint.pdf. (Accessed 14/08/2013)

STIGLER, M. (2012). Threshold cointegration: overview and implementation in R. [Online]. Available: http://cran.r-project.org/web/packages/tsDyn/vignettes/ThCointOverview.pdf. (Accessed 27/3/2013).

STOCK, J.H. and WATSON, M.W. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica,* 6: pp 783-820.

THANH, S.D. (2015). Threshold effects of inflation on growth in the ASEAN-5 countries: A Panel Smooth Transition Regression Approach. *Journal of Economics, Finance and Administrative Science*, 38: pp. 41-48.

TSAY, R. S. (2014). Multivariate Time Series Analysis with R and Financial Applications. Wiley: New York.

VALCARCEL, V.J. (2012). The dynamic adjustments of stock prices to inflation disturbances. *Journal of Economics and Business*, 64: pp. 117-144.

VAN HEERDEN, C. (2015). The Influence of Higher Moments and Non-Normality on the Sharpe Ratio: A South African Perspective. *The Journal of Applied Business Research*, 31: pp 197- 220.

VAN HOANG, T.H., LAHIANI, A. and HELLER, D. (2016). Is gold a hedge against inflation? New evidence from a nonlinear ARDL approach. *Economic Modelling*, 54: pp. 54-66.

VAN ROOYEN, J.H, and JONES, D.L. (2018). The inflation-hedging ability of individual shares: Evidence from the Johannesburg Stock Exchange (JSE). *Investment Analysts Journal* [Online]. Available: https://doi.org/10.1080/10293523.2018.1525210.

VOGELSANG, T.J. and WAGNER, M. (2014). Integrated modified OLS estimation and fixed – *b* inference for cointegration regressions. *Journal of Econometrics*, 178: pp. 741-760.

WILKINSON, J. (2013). Capital Budgeting Methods. [Online]. Available: https://strategiccfo.com/capital-budgeting-methods-2/. Accessed 16/06/2019)

XU, Y., SUN, Y. and LUNDTOFTE, F. (2010). Dynamic linkages between China and US equity markets under two recent financial crises. [Online]. Available: http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=1613235&fileOId=1613239. (Accessed 11/06/2013).

YEAP, G.P. and LEAN, H.H. (2017). Asymmetric inflation hedge properties of housing in Malaysia: New evidence from nonlinear ARDL approach. *Habitat International*, 62: pp. 11-21.

ZIVOT, E. and ANDREWS, D.W.K. (1992). Further Evidence on the Great Crash, the Oil-Price Shock and the Unit-Root Hypothesis. *Journal of Business and Economic Statistics*, 10: pp. 251-270

ZULFIQAR, S., SHAH, A., NASIR, Z.M. and NAEEM, M. (2012). Can Common Stocks Provide Hedge Against Inflation? Evidence from SAARC Countries. *The Pakistan Development Review*, 51(4): pp. 435-477.

APPENDIX B: COPYRIGHT PERMISSION – AFRICAN REVIEW OF ECONOMICS AND FINANCE

Permission to use Copyright Material

1. For inclusion in the examiners copy of this Doctoral Thesis

As copyright holder/licensor/publisher of the following article:

Moores-Pitt, P. and Strydom, B.S. (2017) Equities as a hedge against inflation in South Africa. African Review of Economics and Finance, 9(1): pp 156-179

I **grant permission** for this article to be included verbatim as a section of Peter Moores-Pitt's Doctoral Thesis by Publication ***for the purpose of a printed hard-copy being sent to each examiner to the thesis***.

I **do not** grant permission for this article to be included verbatim as a section of Peter Moores-Pitt's Doctoral Thesis by Publication for the purpose of a single printed hard-copy being sent to each examiner to the thesis.

2. For inclusion in the digital version of this Doctoral Thesis

As copyright holder/licensor/publisher of the following article:

Moores-Pitt, P. and Strydom, B.S. (2017) Equities as a hedge against inflation in South Africa. African Review of Economics and Finance, 9(1): pp 156-179

I **grant permission** for this article to be included verbatim as a section of Peter Moores-Pitt's Doctoral Thesis by Publication ***for the purpose of offering an online version at http://researchspace.ukzn.ac.za/xmlui***

I **do not** grant permission for this article to be included verbatim as a section of Peter Moores-Pitt's Doctoral Thesis by Publication ***for the purpose of offering an online version at http://researchspace.ukzn.ac.za/xmlui, and request that the URL http://reference.sabinet.co.za/document/EJC158218, be used in the online UKZN publication of this thesis.***

Name:	Signed:	Date:
Prof. Paul Alagidede		03 SEPT 2018

APPENDIX C: COPYRIGHT PERMISSION – AFRICAN JOURNAL OF BUSINESS AND ECONOMICS RESEARCH

Permission to use Copyright Material

1. **For inclusion in the examiners copy of this Doctoral Thesis**

As copyright holder/licensor/publisher of the following article:

Moores-Pitt, P. (2018). Investigating temporal variance in the equity returns-inflation relationship in South Africa. African Journal of Business and Economics Research, 13: pp 51-79.

I **grant permission** for this article to be included verbatim as a section of Peter Moores-Pitt's Doctoral Thesis by Publication ***for the purpose of a printed hard-copy being sent to each examiner to the thesis***.

I **do not** grant permission for this article to be included verbatim as a section of Peter Moores-Pitt's Doctoral Thesis by Publication for the purpose of a single printed hard-copy being sent to each examiner to the thesis.

2. **For inclusion in the digital version of this Doctoral Thesis**

As copyright holder/licensor/publisher of the following article:

Moores-Pitt, P. (2018). Investigating temporal variance in the equity returns-inflation relationship in South Africa. African Journal of Business and Economics Research, 13: pp 51-79

I **grant permission** for this article to be included verbatim as a section of Peter Moores-Pitt's Doctoral Thesis by Publication ***for the purpose of offering an online version at http://researchspace.ukzn.ac.za/xmlui***

I **do not** grant permission for this article to be included verbatim as a section of Peter Moores-Pitt's Doctoral Thesis by Publication ***for the purpose of offering an online version at http://researchspace.ukzn.ac.za/xmlui, and request that the URL http://reference.sabinet.co.za/document/EJC158218, be used in the online UKZN publication of this thesis.***

Name:	Signed:	Date:
PHOCENAH NYATANGA		5/8/2018

APPENDIX A: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

01 August 2017

Mr Peter Moores-Pitt (212556668)
School of Accounting, Economics & Finance
Pietermaritzburg Campus

Dear Mr Moores-Pitt,

Protocol reference number: HSS/1237/017D
Project title: An Econometric Analysis of the Equity Returns-Inflation relationship in South Africa

Approval Notification – No Risk / Exempt Application

In response to your application received on 11 July 2017, the Humanities & Social Sciences Research Ethics Committee **has** considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

……………………………………………………………………
Dr Shenuka Singh (Chair)

/ms

Cc Supervisor: Mr Barry Strydom and Dr Michael Murray
Cc Academic Leader Research: Dr Harold Ngalawa
Cc School Administrator: Ms Jerusha Singh

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 Facsimile: +27 (0) 31 260 4609 Email: ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: Edgewood | Howard College | Medical School | Pietermaritzburg | Westville