

**THE RELATIONSHIP BETWEEN INTEREST RATES AND
INFLATION IN SOUTH AFRICA:
REVISITING FISHER'S HYPOTHESIS**

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ABSTRACT

This thesis investigates the relationship between expected inflation and nominal interest rates in South Africa and the extent to which the Fisher effect hypothesis holds. The hypothesis, proposed by Fisher (1930), that the nominal rate of interest should reflect movements in the expected rate of inflation has been the subject of much empirical research in many industrialised countries. This wealth of literature can be attributed to various factors including the pivotal role that the nominal rate of interest and, perhaps more importantly, the real rate of interest plays in the economy. The validity of the Fisher effect also has important implications for monetary policy and needs to be considered by central banks. Few studies have been conducted in South Africa to validate this important hypothesis.

The analysis uses the 3-month bankers' acceptance rate and the 10-year government bond rate to proxy both short- and long-term interest rates. The existence of a long-run unit proportional relationship between nominal interest rates and expected inflation is tested using Johansen's cointegration test. The data is analysed for the period April 2000 to July 2005 as the research aims to establish whether the Fisher relationship holds within an inflation targeting monetary policy framework.

The short-run Fisher effect is not empirically verified. This is due to the effects of the monetary policy transmission mechanism and implies that short-term nominal interest rates are a good indication of the stance of monetary policy. A long-run cointegrating relationship is established between long-term interest rates and expected inflation. The long-run adjustment is less than unity, which can be attributed to the credibility of the inflation-targeting framework.

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CONTENTS

Abstract.....	ii
List of contents.....	iii
List of figures.....	vi
List of tables.....	vii
List of appendices.....	vii
Acknowledgements.....	viii

CHAPTER 1

INTRODUCTION

1.1 Context of the study.....	1
1.2 Objectives of the study.....	2
1.3 Document structure.....	4

CHAPTER 2

THEORY AND LITERATURE REVIEW

2.1 Introduction.....	5
2.2 Fishers (1930).....	6
2.3 Empirical studies in developed countries.....	7
2.4 Empirical studies in developing countries.....	10
2.5 Explanations for the deviations from the Fisher hypothesis.....	12
2.5.1 Introduction.....	12

2.5.2 Mundell-Tobin effect.....	13
2.5.3 Darby-Feldstein effect.....	14
2.5.4 The inverted Fisher effect.....	15
2.5.5 The risk aversion effect.....	15
2.5.6 Modelling assumptions and considerations.....	16
2.5.7 Influence of monetary policy.....	17
2.6 Summary.....	17

CHAPTER 3

MONETARY POLICY AND THE FISHER EFFECT

3.1 Introduction.....	19
3.2 The South African Reserve Bank.....	20
3.3 Formal inflation-targeting.....	21
3.3.1 Introduction.....	21
3.3.2 Reasons for inflation-targeting.....	22
3.3.3 Inflation 2000-2005.....	24
3.4 Short-term interest rates as the main variable of monetary policy.....	25
3.4.1 Introduction.....	25
3.4.2 Accommodation policy of the South African Reserve Bank.....	26
3.4.3 The repo rate and other money market rates.....	27
3.5 Monetary policy transmission mechanism.....	30
3.5.1 Introduction.....	30
3.5.2 Interest rate channel.....	31
3.5.3 Exchange rate channel.....	32
3.5.4 Credit channel.....	32
3.5.5 The transmission mechanism and the Fisher effect.....	33
3.6 Inflation-targeting, credibility and the long-term real interest rate	35
3.7 Summary.....	38

CHAPTER 4

METHODOLOGY

4.1 Introduction.....	40
4.2 Inflation expectations – Step 1.....	41
4.2.1 Introduction.....	41
4.2.2 Model to estimate inflation predictions.....	42
4.2.3 The break-even inflation rate.....	42
4.2.4 Survey method.....	43
4.2.5 Rational expectations model.....	44
4.2.6 ARIMA and smoothing.....	45
4.3 Unit root test - Step 2.....	46
4.3.1 Introduction.....	46
4.3.2 Augmented Dickey and Fuller (1979).....	46
4.3.3 Phillips and Peron (1988).....	48
4.4 Cointegration analysis - Step 3.....	49
4.4.1 Introduction.....	49
4.4.2 Lag length and deterministic trend specification	52
4.4.2.1 Likelihood ratio (LR) test.....	52
4.4.2.2 The Akaike information criterion and Schwartz criterion.....	53
4.5 Weak exogeneity - Step 4.....	54
4.6 Summary.....	54

CHAPTER 5

EMPIRICAL ANALYSIS

5.1 Data.....	56
5.2 Results.....	58
5.2.1 Data generating process.....	58
5.2.1.1 Visual inspection.....	58

5.2.1.2 Unit root test.....	60
5.2.2 Lag length selection.....	61
5.2.3 Deterministic trend assumption.....	62
5.2.3.1 Short-term interest rate.....	62
5.2.3.2 Long-term interest rate.....	63
5.2.4 Johansen cointegration analysis.....	63
5.2.5 Vector error correction model-long-term interest rates.....	64
5.2.6 Weak exogeneity test.....	65
5.3 Interpretation of the results.....	66
5.3.1 Short-term interest rate results.....	66
5.3.2 Long-term interest rate results.....	67
5.4 Summary.....	68

CHAPTER 6

CONCLUSION

6.1 Summary of findings.....	70
6.2 Conclusions and policy implication.....	72
6.2.1 Short-run Fisher effect.....	72
6.2.2 Long-run Fisher effect.....	72
6.3 Limitations and future research.....	74

REFERENCES

List of references.....	83
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LIST OF FIGURES

Figure 1: Consumer price index 2000-2005.....	24
Figure 2: The monetary policy implementation framework of the Reserve Bank.....	27

Figure 3: Money market rates 2000-2005.....	28
Figure 4: 3-Month bankers' acceptance and the repurchase rate 2000-2005.....	29
Figure 5: The monetary policy transmission mechanism in South Africa.....	30
Figure 6: Graphic representation of variables in levels.....	58
Figure 7: Graphic representation of variables in first difference	59

LIST OF TABLES

Table 1: Money supply growth and inflation outcomes from 1986 to 2000.....	22
Table 2: Summary of variables.....	57
Table 3: ADF-unit Root Test 2000-2005.....	60
Table 4: Phillips and Perron-unit root test 2000-2005.....	60
Table 5: Lag length selection.....	61
Table 6: Cointegration analysis.....	64
Table 7: VECM results for G10&C5MA	65
Table 8: Weak exogeneity results.....	66
Table A Literature review.....	75
Table B1 E-Views cointegration results- BA & C5.....	78
Table B2 E-Views cointegration results G10 & C5.....	79
Table C1 E-Views VEC results G10 & C5.....	81

LIST OF APPENDICES

Appendix A: Literature summary.....	75
Appendix B: Johansen cointegration analysis.....	78
Appendix C: Vector error correction model.....	81

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CHAPTER 1

INTRODUCTION

1.1 CONTEXT OF THE STUDY

The Fisher hypothesis states that nominal interest rates move one-for-one with expected inflation, leaving the real rate of interest unaffected. This simple hypothesis has enjoyed widespread empirical research and remains one of the cornerstones of monetary economics. Whether monetary policy is able to influence the real rate of interest is one of the most important questions facing monetary authorities. However, there has been little empirical research conducted to verify Fisher's hypothesis using South African data, especially within the South African Reserve Bank's current inflation-targeting monetary policy framework.

There are a number of reasons, according to Hawtrey (1997:337), as to why the Fisher hypothesis has maintained such a key position in economic literature. Firstly, the real rate of interest plays a pivotal role in any economy's economic growth, savings and investments, while also affecting trade and capital flows through its influence on the exchange rate. Secondly, there is a large amount of evidence, as proposed by Fama (1975), to suggest that nominal interest rates can be used to determine future inflation expectations. Thirdly, the Fisher hypothesis is an important factor of consideration for central banks. Should a long-run Fisherian link be established between interest rates and expected inflation, this would suggest that the real interest rate is not affected by monetary policy, but instead determined by real economic factors alone (Payne and Ewing 1997:683).

A significant amount of research has been conducted in developed countries to prove and establish this hypothesis: among the most prominent papers are those

by Fama (1975), Mishkin (1992), Yuhn (1996), Crowder and Hoffman (1996), Dutt and Ghosh (1995), Hawtrey (1997), Koustas and Serletis (1999) and Mishkin and Simon (1995). However, explorative research into this relationship within developing countries has been sparse. Garcia (1993) tests for the Fisher effect using Brazilian interest rate data and finds that, even though the inflation data used was extremely high and volatile and *ex post* real interest rates varied greatly, there is sufficient evidence to validate the Fisher model. Two studies by Carneiro, Divino and Rocha (2002) and Phylaktis and Blake (1993) both investigate the Fisher hypothesis for three high inflation countries: Brazil, Mexico and Argentina. Phylaktis and Blake (1993) find strong evidence in favour of the Fisher effect for all three economies. Carneiro, Divino and Rocha (2002) only verify the hypothesis for Argentina and Brazil.

No research has been conducted to empirically investigate the Fisher hypothesis within the South African Reserve Bank's (SARB) inflation-targeting monetary policy framework. Wesso (2000) examines the relationship between expected inflation and the nominal bond yield using South African data for the period January 1985 to February 1999. This corresponds with the SARB's monetary policy framework that targeted the growth in the broad money supply (M3). Using cointegration and error-correction modeling techniques, Wesso (2000:81-82) finds that long-term bond yields are largely driven by expected inflation in South Africa.

1.2 OBJECTIVES OF THE STUDY

South Africa introduced an inflation-targeting monetary framework in April of 2000. One of the primary motivations behind the shift away from the previous "eclectic" approach of monetary policy management was the increased importance placed on policy credibility in the "eyes of the public" and the influential impact this has on inflation expectations. The Fisher equation is therefore able to make a significant contribution to understanding the dynamics

between nominal interest rates, real interest rates and expected inflation within an inflation-targeting framework.

Consequently, the thesis aims to ascertain whether or not a Fisherian link exists between nominal interest rates and expected inflation in South Africa within an inflation-targeting monetary policy regime. The validation of the Fisher hypothesis has two interesting implications. Firstly, it would simply suggest that nominal interest rates include an inflation premium above the real rate of interest. Secondly, it would advocate that the real rate of interest has not been affected by monetary policy since the inception of inflation-targeting.

In terms of methodology employed, the thesis utilises Johansen's cointegration analysis. This is an ideal analysis technique to validate the Fisher hypothesis, as it is able to verify a long-term unit proportionate relationship between nominal interest rates and expected inflation. However, a cointegrating relationship between nominal interest rates and expected inflation only partially validates the Fisher hypothesis. In order to fully confirm the hypothesis it is important to ensure that the causality runs from the expected inflation rate to nominal interest rates. This is achieved through a weak exogeneity test. The analysis uses the 3-month bankers' acceptance rate and the 10-year government bond rate to proxy short-term interest rates and long-term interest rates, respectively. The data is analysed for the period April 2000 to July 2005, which corresponds to the South African Reserve Bank's inflation-targeting monetary policy framework.

The empirical results find no evidence to support either the long or short-run Fisher effect. The lack of any statistically significant relationship between short-term nominal interest rates and expected inflation is largely due to the impact of the monetary transmission mechanism on short-term real interest rates. The results for the long-run Fisher effect, however, suggest that there is a long-run cointegrating relationship between long-term interest rates and expected

inflation, but causality cannot be confirmed to run from expected inflation to long-term nominal interest rates.

1.3 DOCUMENT STRUCTURE

This thesis is structured as follows.

Chapter 2 outlines Fisher's own research and reviews empirical literature from both developed and developing countries. The chapter then examines alternative explanations put forward by researchers in an attempt to explain why Fisher's hypothesis lacks empirical consistency.

Chapter 3 examines monetary policy and its effect on the strength of the Fisher hypothesis. The chapter begins by briefly describing the role of the South African Reserve Bank within the South African economy, outlining its responsibilities, legislative and governing structure. This is followed by a detailed description of the South African Reserve Bank's inflation-targeting monetary policy framework, including an outline of the rate of inflation and the role that monetary policy plays in determining interest rates. The various channels of the monetary transmission mechanism are then explored. The chapter concludes by analysing the dynamics between inflation-targeting, credibility and the long-run real rate of interest.

Chapter 4 describes the econometric methodology used in the study.

In chapter 5, the data and the results are presented.

Chapter 6 provides a summary of the findings, policy implications, limitations and future research.

CHAPTER 2

THEORY AND LITERATURE REVIEW¹

2.1 INTRODUCTION

Fisher (1930:451) hypothesised that the nominal rate of interest is made up of two components: the expected rate of inflation (π_t^e) and the real rate of interest (r_t):

$$i_t = r_t + \pi_t^e \quad (2.1)$$

This simple equation is founded on the premise that rational economic agents, be they investors or savers, require compensation for any purchasing power lost on their nominal money due to price level increases. What has come to be known as the *Fisher effect* postulates a one-for-one relationship between expected inflation and nominal interest rates and the *ex ante* real rate of interest that is approximately constant over the long-run. The implication is that there is no correlation between expected inflation and the *ex ante* real interest rate². This also suggests that if monetary authorities desire stable nominal interest rates in the long-run, then they must ensure that the expected inflation premium embedded in the Fisher equation also remains stable over the long-run.

This section commences by outlining Fisher's own research. Then the chapter gives a review of the literature from both developed and developing countries³.

¹ See Coraay (2003:135-150) for an excellent survey of the literature.

² The Fisher equation is formally written as

$$i_t = r_t + \pi_t^e + r_t \times \pi_t^e.$$

The cross-effect term ($r_t \times \pi_t^e$) compensates the lender for loss on the interest element of the loan and is generally considered to have negligible if any effect (Mishkin 2004:80).

³ Appendix A presents a summary of the all major Fisher effect literature.

The bulk of Fisherian research has been carried out in first world economies. The extent to which the hypothesis can be confirmed in developing economies has not been extensively examined. There has also been no previous research investigating this fundamental hypothesis using data from an inflation-targeting monetary policy regime in either developed or developing countries. Finally the chapter explores various alternative interpretations put forward in an attempt to explain why Fisher's hypothesis lacks empirical consistency.

2.2 FISHER (1930)

In his analysis of price changes and nominal interest rate data from Great Britain and the United States for the periods 1820-1924 and 1890-1927 respectively, Fisher (1930:417) found "no apparent relationship" between price changes and interest rates in these countries in the short-run, where a correlation coefficient of -0.459 was obtained for the British data and -0.289 for the United States data without lagging the data. In contrast, when a distributed lag of past inflation was used as a proxy of expected inflation, the correlation coefficients increased substantially. Here Fisher (1930:423) obtained correlation coefficients of 0.98 and 0.857 for Great Britain and the United States, when price changes were spread over 28 years and 20 years respectively. From these findings Fisher (1930:451) concluded:

We have found evidence general and specific, from correlating P' with both bond yields and short term interest rates, that price changes do, generally and perceptibly affect the interest rate in the direction indicated by *a priori* theory. But since forethought is imperfect, the effects are smaller than the theory requires and lagged behind price movements, in some periods, very greatly. When the effects of price changes upon interest rates are distributed over several years, we have found remarkably high coefficients of correlation, thus

indicating that interest rates follow price changes closely in degree, though rather distantly in time.

Fisher concluded that though nominal interest rates do follow expected inflation, they did so less than his initial hypothesis suggested and only over the long-run. Since Fisher's work, there has been a significant amount of empirical research done to confirm the hypothesis, especially in developed countries, all with modest consistency. The next two sections review the empirical literature, first starting with studies in developed countries, then developing countries.

2.3 EMPIRICAL STUDIES IN DEVELOPED COUNTRIES

The Fisher effect has been extensively investigated in the USA. Fama (1975) studies the United States Government Treasury bill market to find evidence to support his efficient market hypothesis. Fama (1975:269) concludes that, during the period 1953-1971, nominal interest rates correctly incorporated "all information about future inflation rates, that is, in time series of past inflation rates". He also finds evidence to support the hypothesis that the expected real returns on one- to six- months' bills are constant for the period under study. Various authors including Carlson (1977:1), Joines (1977:1-2), Tanzi (1980:20) and Nelson and Schwert (1977:485) all find evidence against Fama's joint hypothesis, while Levi and Makin (1979:36) argue that the level of anticipated inflation is a function of various factors including changes in employment, output and the amount of uncertainty about future inflation movements. This could result in the real rate of interest not being constant, explaining why these aforementioned authors find contradictory results to Fama (1975).

Mishkin (1992) explains why there is a high correlation between the level of interest rates and inflation in certain periods and not in others. Using monthly data from January 1953 to December 1990, he finds no support for a short-run

Fisher effect, but did find evidence in support of a long-run Fisher effect. The study makes a distinction between a short-run Fisher effect, where a change in expected inflation is associated with an immediate change in short term interest rate, and a long-run Fisher effect, where inflation and interest rates trend together in the long-run. The study concludes that the Fisher relationship would only hold in periods when inflation and interest rates display stochastic trends.

Later studies of the Fisher effect in the United States generally concluded in favour of the proposed relationship. Crowder and Hoffman (1996:108-115) find evidence of nominal interest rates adjusting by more than one-for-one to changes expected inflation, using quarterly United States data from 1952:1 to 1991:4, and find that a 1 percent increase in inflation caused the nominal interest rate to increase by 1.34 percent. Fahmy and Kandil (2003:459-461), using United States data from the 1980s and early 1990s, cannot reject the cointegration relationship between nominal interest rates and inflation in the long-run. Tillmann (2004:6-7), taking into account regime shifts, also finds evidence of the Fisher relation using post-war data.

Canadian results are mixed, with Crowder (1997:1138) finding evidence to support the Fisher equation from 1960:1 to 1991:4, whilst Dutt and Ghosh (1995:1026-1030) find no evidence to support the Fisher hypothesis under both fixed and floating exchange rate regimes in Canada.

Empirical studies using Australian data done in the late 1990s have been to some extent supportive of the Fisher effect. For instance, Mishkin and Simon (1995:225) find support for a long-run Fisher effect, but not a short-run Fisher effect, prompting the conclusion that short-run changes in interest rates indicate the stance of monetary policy, while longer-term levels are primarily driven by inflation expectations. Two later studies, one by Hawtrey (1997:444) and the other by Olekalns (1996:855), both find evidence of the Fisher effect only in the period 1984-1994, the period after full deregulation of the financial system in

Australia. Olekalns (1996:855) is only able to establish a partial adjustment of nominal interest rates to expected inflation when he studies data from both before and after financial deregulation (1969:4 to 1993:3). Inder and Silvapulle's (1993:842) results disagreed with the other Australian studies. Investigating the period from 1964-1990, they rejected the hypothesis that nominal interest rates adjusted to changes in expected inflation.

Empirical studies conducted in Finland, the United Kingdom and Italy have had limited success in verifying the Fisher effect. Junttila (2001:596) finds no substantial evidence of the Fisher effect in Finland. Evans (1998:216) cannot prove that a Fisherian link existed between expected inflation and interest rates for the United Kingdom. Muscatelli and Spinelli (2000:155-157) use Italian data for the period 1948-1990 and find that expected inflation and nominal interest rates trended together in the long-run. Esteve, Bajo-Rubio and Diaz-Roldan (2004:2), using Spanish data for the period 1962-1996, find evidence that suggests that nominal interest rates only partially adjust to shifts in expected inflation.

Atkins and Serletis (2002:2-7) use the Pesaran, Shin and Smith (2001) autoregressive distributed lag (ARDL) bounds testing methodology to test for the Fisher effect in six countries: Norway, Sweden, Italy, Canada, the United Kingdom, and the United States. Their findings suggest little evidence in support of the Fisher effect. Atkins and Coe (2002:10), using the same methodology on post-war United States and Canadian data, find evidence of a long-run relationship of interest rates and inflation. However they, find no evidence supporting the tax-adjusted Fisher effect for Canada. The results for the United States were also inconclusive. An empirical study by Atkins and Sun (2003:24) find similar results, for Canada and the United States, using data from 1959 to 2002. This study applies a discrete wavelet transformation (DWT) to the series of data as an alternative for the more commonly used differencing approach. Like Mishkin (1992:213), they only find evidence of a long-run relationship between

nominal interest rates and inflation but no short-run relationship. An empirical study by Koustas and Serletis (1999:106) reveals little in support of the Fisher effect using post war data from Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Japan, the Netherlands, the United Kingdom and the United States. Miyagawa and Morita (2003:6) also reject the presence of a one-for-one relationship between nominal interest rates and expected inflation for Japan, Sweden and Italy. Yuhn (1996:43) was able to verify the existence of the Fisher effect in the United States, Germany and Japan, but could not find enough evidence to validate the Fisher effect for Canada and the United Kingdom for the period 1973:09 to 1993:06. Lardic and Mignon (2003:8) are able to positively validate the Fisher effect for all the G7 countries except for Germany for the period 1970:01 to 2001:03.

As is evident from the above, there has been a large amount of empirical research done in developed countries, all with modest consistency. However, little has been done to explore this relationship in developing countries that, in contrast to the developed countries studied, tend to have high and more volatile levels of inflation. The next section explores the empirical studies in developing countries including South Africa.

2.4 EMPIRICAL STUDIES IN DEVELOPING COUNTRIES

Garcia (1993:90-91) tests for the Fisher effect using Brazilian interest rate data on non-indexed certificates of deposit for the period 1973 to 1990 and finds that, even though the inflation data used was extremely high and volatile and *ex post* real interest rates varied greatly, there is sufficient evidence to validate the Fisher model. Two studies, one by Carneiro, Divino and Rocha (2002:95) and the other by Phylaktis and Blake (1993:591), investigate the Fisher hypothesis for three high inflation countries: Brazil, Mexico and Argentina. Phylaktis and Blake (1993:598) find for all three economies, “strong evidence for a long-run unit proportional relationship between nominal interest rates and anticipated inflation”.

Carneiro, Divino and Rocha (2002:96), on the other hand, only confirm the Fisher hypothesis for Argentina and Brazil. Their Mexican results show that the inflation rate adjusts to changes in interest rates. Thornton (1996:256) finds strong evidence of the Fisher hypothesis between post-tax nominal interest rates on 91-day treasury bills and quarterly inflation between 1978 and 1974 in Mexico. Jorgensen and Terra (2003:9) use a four-variable VAR model to test for the Fisherian link between interest rates and inflation in seven major Latin American economies (Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela). They only confirm the relationship in Mexico and Argentina.

Cooray (2002-2003:29-36) examines the Fisher hypothesis using Sri Lankan data for the period 1952 to 1998. Sri Lanka, like South Africa, experienced high inflation during the 1970s and 1980s, reaching a high of 26.1 percent by 1980. Using 3-month Treasury bill rates and an inflation-forecasting model that follows the monetarist view of inflation, he finds that interest rates reacted slowly to inflation expectation in Sri Lanka, and concludes that monetary policy could have an impact on real interest rates over the short-term.

There has been very little empirical research that investigates the Fisher hypothesis using South African data. The relationship between expected inflation and nominal bond yields for the period January 1985 to February 1999 is examined by Wesso (2000). Wesso (2000:77) uses cointegration and error-correction modelling techniques and finds that bond yields are cointegrated with expected inflation for the period studied. The author therefore concludes that long-term bond yields are largely driven by expected inflation in South Africa.

Whereas Wesso (2000:77) focused on whether interest rates are good predictors of future inflation, this thesis aims to use the Fisher equation to primarily ascertain whether the real rate of interest has been affected by monetary policy since the inception of inflation-targeting. Wesso's (2000:73) study suffered from two major limitations. Firstly, it used lagged inflation rates as a proxy for inflation

expectations. Secondly, it did not test the direction of causality between expected inflation and interest rates.

Empirical studies conducted in both developing and developed countries have yielded inconsistent results. Although the many of the studies find a positive long-run relationship between nominal interest rates and expected inflation, very few have been able to establish the one-for-one relationship hypothesised by Fisher (1930). Subsequently, some empirical Fisherian studies distinguish between two forms of the Fisher effect⁴. The weak form or partial Fisher effect portrays a less than unity long-run coefficient. This form is the most prevalent in the literature and is the relationship Fisher was able to empirically verify. The second form, referred to as the strong form Fisher effect, is characterised by a long-run coefficient that equals one or greater than one, suggesting a full adjustment (one-for-one) or over adjustment of nominal interest rates to changes in expected inflation.

Various authors offer alternative explanations as to why so few empirical studies are able to find the theoretical one-for-one relationship proposed by Fisher (1930). These alternative interpretations are briefly reviewed in the following section.

2.5 EXPLANATIONS FOR THE DEVIATION FROM THE FISHER HYPOTHESIS

2.5.1 Introduction

Alternative explanations have been proposed by empirical researchers in an attempt to explain why Fisher's economically intuitive hypothesis has not held in its strictest form. Mundell (1963) and Tobin (1965) argue that nominal interest rates should adjust by less than one-for-one due to the impact of inflation on

⁴ See Lungu (1998:6).

wealth and subsequently savings. Darby (1975) and Feldstein (1976) point out that the effects of tax would result in a more than one-for-one adjustment to expected inflation, while Shome, Smith and Pinkerton (1988:1123) suggest a premium needs to be incorporated in nominal interest rates to account for covariance risk. The section also examines the inverted Fisher effect proposed by Carmichael and Stebbing (1983) and highlights the likely implications that different econometric methodology and assumption have on the strength of the Fisher effect. Finally, the influence of monetary policy on the Fisher effect will be explored. Though a number of researchers find that shifts in monetary policy have influenced the magnitude of the long-run relationship between nominal interest rate and expected inflation, very little explorative research has been conducted to explain why.

2.5.2 Mundell-Tobin effect

While Fisher (1930) proposed that nominal interest rates should be directly related to expected inflation, he did not empirically prove a one-for-one relationship; instead, he found a less than one-for-one relationship. Mundell (1963: 280-283), in an attempt to explain Fisher's (1930) empirical results, argues that inflationary pressures cause the real rate of interest to decrease. This is because inflation reduces real money balance and consequently wealth. A decline in wealth therefore stimulates savings, which Mundell suggested could take various forms including equities and bonds. Tobin (1965:680-682) similarly argues that inflation causes people to increase their holding of real capital. Mundell and Tobin's shared view of the lagging relationship between interest rates and expected inflation is known as the Mundell-Tobin effect, or the so-called wealth effect.

2.5.3 Darby-Feldstein effect

Darby (1975) and Feldstein (1976) both argue that the tax structure influences the Fisher relationship. According to Darby (1975:274): “nominal interest rates must rise by $1/(1-\tau)$ basis point for each basis point increase in the expected rate of inflation, where τ is the marginal income tax rate, in order to leave borrowers’ and lenders’ expected payments and receipts unaffected in real terms.” Thus the Fisher equation becomes:

$$(1-\tau) i_t = r_t + \pi_t^e, \quad (2.2)$$

This suggests that nominal interest rates will adjust more than one-for-one to changes in expected inflation. Carr, Pesando and Smith (1976:264-268) test the relationship between expected inflation, income tax and nominal rates of interest in Canada from 1959-1971. Applying various interest rate models, they fail to find conclusive results as to whether income tax would cause nominal interest rates to rise more than the rise in expected inflation. Cargill (1977:134) likewise cannot verify the existence of such a relationship. Engsted (1996:886, however, finds support for the tax-adjusted long-term Fisher effect for thirteen OECD countries. Crowder and Hoffman (1996:108-115) also find evidence in support of the “tax-adjusted” Fisher equation, using quarterly United States data from 1952:1 to 1991:4.

Tanzi (1980:20) suggests in contrast that analysis of the rise in nominal interest rates must take into consideration the “fiscal illusion” suffered by economic agents, that is, the effect that income tax has on the profits of a particular asset, resulting in a less than one-for-one adjustment of nominal interest rates to inflation expectations. However, Crowder and Wohar (1999:316) argue that Tanzi’s theory does not accurately explain why the Fisher effect does not hold empirically, saying it represents a “bizarre violation of rational expectations”.

2.5.4 The inverted Fisher effect

Carmichael and Stebbing (1983:619) suggest a different relationship between inflation, nominal interest rates and real interest rates to that of Fisher (1930). Assuming money and financial assets to be substitutable, they hypothesize that nominal interest rates on financial assets can be considered constant over time and that the real rate of interest moves inversely with inflation. They argue that this is the reason for many empirical studies failing to find evidence for the Fisher effect in its strictest form. This so-called inverted Fisher effect, or Fisher paradox, has had little empirical support. Testing the same dataset as used by Carmichael and Stebbing (1983:16), Moazzami (1991:131-133) cannot find the same long-run inverse relationship between the real rate of interest and expected inflation. Likewise both Choudhry (1997:258), using data from Belgium, France and Germany from 1955-1994, and Woodward (1992:319), studying British data from 1982-1990, are unable to find evidence of the inverted Fisher effect.

2.5.5 Risk aversion effect

Shome, Smith and Pinkerton (1988:1123) argue that when investors are risk averse they will require a premium to compensate them for any risks involved in holding the assets. According to them, the strong form Fisher hypothesis has not held empirically because expected inflation measures used in the literature only capture total variability in prices and do not consider the covariance of real output and future prices. They develop a model of the Fisher equation that incorporates this additional covariance risk by assuming that investors have power utility functions and that consumption and the price index are jointly lognormally distributed. Thus in an uncertain environment they show that the long-run coefficient between nominal interest rates and expected inflation is unlikely to be unity.

2.5.6 Modelling assumptions and considerations

Sahu, Jha and Meyer (1990:113) demonstrate that the magnitude of the adjustment of nominal interest rates to expected inflation is primarily dependent on the assumptions that researchers have had to make about the underlying parameter values. In empirical econometric studies of any nature assumptions generally need to be made, however, because expected inflation is not directly observable researchers have had to employ a variety of stringent assumptions in order to derive a testable proxy. Hsing (1997:1057) finds, by contrasting three different expected inflation proxies - the Livingston survey, rational expectations hypothesis and the adaptive expectations model - that the strength of the Fisher effect changes. His results show that the coefficient capturing the adjustment of nominal interest rates to changes in expected inflation varies depending on what assumption is used to measure inflation expectations, for example a coefficient of 1.070 is obtained between AAA bond yields and an expected inflation proxy derived from the adaptive expectations model. However, when an expected inflation measure derived from Livingston survey data is utilised the coefficient is substantially lower, at only 0.016.

Once expected inflation has been estimated, an econometric technique is needed to measure the strength of the relationship between expected inflation and nominal interest rates. There have been a number of econometric time series developments since Fisher first proposed the hypothesis in 1930. Consequently, empirical researchers have utilised a wide variety of econometric models to test the hypothesis. Weidmann (1997:3) argues that the majority of these models are unable to properly analyse the stochastic properties of inflation and interest rates and therefore incorrectly reject the strong form Fisher hypothesis. Ghazali and Ramlee (2003:763-769) find support for this argument by implementing an Autoregressive Fractionally Integrated Moving Average (ARFIMA) model. This ARFIMA model allows fractional differencing to be employed and is therefore able to capture a long-memory process. Conventional unit root tests that utilise

the standard ARIMA equation are only able capture a short memory process. They find no evidence of a long-run relationship between inflation and nominal interest rates for all the G7 countries when using the ARFIMA model. This prompted them to conclude that the Fisher relationship is “not robust to choice of statistical test employed” (Ghazali and Ramlee 2003:768).

2.5.7 Influence of monetary policy

Söderlind (2001) uses a dynamic rational expectations model with staggered price setting to study the affects of monetary policy on the relation between nominal interest rates, inflation expectations, and real interest rates. Söderlind (2001:494) finds that stricter inflation-targeting and a more active monetary policy decrease the strength of adjustment of nominal interest rates to changes in expected inflation.

Studies by Huizinga and Mishkin (1984:714), Mishkin (1992:213) and Hawtrey (1997:337) have also shown that different monetary regimes have had varying impacts on the strength of the Fisher effect. This may be expected considering that interest rates form the central tool used in many monetary policy regimes and inflation, the main target variable. However, though these studies find that monetary policy does influence the Fisher effect, there is no research available that presents reasons as to why monetary policy affects the strength of the Fisher equation.

2.6 SUMMARY

In 1930 Irwin Fisher argued that lenders would demand an inflation premium above the real rate of interest so as to be compensated for an inflationary induced erosion of their nominal money balances. This idea is formally known as the Fisher hypothesis/effect, which asserts that nominal interest rates adjust on a one-for-one basis to expected changes in the inflation rate. The Fisher

hypothesis has been extensively researched in developed countries but very little research has been done to prove it empirically in developing countries. There has only been one study testing its validity using South African data. Wesso (2000) finds nominal long-term yields and expected inflation to be cointegrated for the period 1985:1 to 1999:2.

Though theoretically sound, the hypothesis in its strictest form has shown very little consistency. Empirically, a positive long-run relationship is generally verified; however, studies either find nominal interest rates to adjust by less than one-for-one to expected inflation or, alternatively, by more than one-for-one. This has prompted researchers to put forward a variety of explanations to justify why the one-for-one relationship proposed by Fisher (1930) has not held. Mundel (1963) and Tobin (1965) both argue that inflation reduces wealth and therefore prompts economic agents to increase their holdings of real capital, bonds and equity, resulting in a less than one-for-one adjustment of nominal interest rates to expected inflation. Darby (1975) and Feldstein (1976) suggest that a premium needs to be incorporated in the adjustment of nominal interest rates to more accurately capture taxation. Similarly, Shome, Smith and Pinkerton (1988:1123) propose a premium for the covariance between real output and future prices. Carmichael and Stebbing (1983:619) argue that it is the nominal interest rate that is constant over time and that the real rate of interest moves inversely with inflation.

The inconsistencies in the literature can partly be attributed to the wide variety of econometric assumptions and models used to test the hypothesis. Finally, because short-term interest and inflation are largely controlled by the central bank as part of a monetary policy framework, monetary policy is also likely to have some influence on the strength of adjustment. This observation is examined in detail in the next chapter and remains the central theme of this thesis.

CHAPTER 3

MONETARY POLICY AND THE FISHER EFFECT

3.1 INTRODUCTION

Monetary authorities throughout the world have become increasingly aware of the importance of creating and maintaining price stability. Consequently, many countries, including South Africa, have adopted an inflation-targeting monetary policy framework. This brings an interesting dynamic to conventional Fisherian studies, that is, how does an inflation-targeting monetary policy regime affect the strength of the Fisher relationship? This chapter attempts to find answers to this question by examining the relationship between monetary policy and the Fisher effect since the inception of inflation-targeting in South Africa.

This chapter is organised as follows: firstly it briefly explores the role that the South African Reserve Bank occupies within the South African economy, outlining its responsibilities, legislative and governing structure. This is followed by a detailed description of the South African Reserve Bank's inflation-targeting monetary policy framework, including a brief outline of the rate of inflation since the formal adoption of the target.

A distinction is made between a short-run Fisher effect, where changes in expected inflation are reflected in short-term interest rates, and a long-run Fisher effect, where movements in inflationary expectations are reflected in long-term interest rates⁵. In the short-run analysis the role of monetary policy and more specifically the repo rates are explored. This is done to illustrate that short-term interest rates are not determined by market forces but are controlled by the South African Reserve Bank. The short-run Fisher effect is therefore unlikely to

⁵ Mishkin (1992:196) uses a similar categorization.

hold empirically. A more appropriate framework consistent with the monetary transmission mechanism is then presented to more accurately describe the relationship between expected inflation and short-term interest rates.

Finally, the Fisher equation is used to examine the link between long-term real- and nominal rates of interest and inflation expectations within an inflation-targeting environment. This analysis has fascinating implications for the conventional Fisher relationship as it shows that as an inflation-targeting framework gains credibility the expected rate of inflation will become increasingly locked into the target range, suggesting a relatively stable expected inflation premium over the long-run, rather than the stable long-term real rate of interest as hypothesised by Fisher (1930).

3.2 THE SOUTH AFRICAN RESERVE BANK

The South African Reserve Bank (SARB) is South Africa's central bank. It was established in 1921 in terms of the Currency and Banking Act of 1920 (Act No 31 of 1920). It was the fourth central bank to be established outside Europe and came into existence primarily due to the abnormal monetary and financial conditions that arose during and immediately after World War I. The Currency and Banking Act of 1920 was replaced by two subsequent Acts: the South African Reserve Bank Act of 1944 and the South African Reserve Bank Act of 1989 (Act No 90 of 1989). The Act of 1989 was promulgated in order to "...consolidate the laws relating to the South Africa Reserve Bank and the monetary system of the Republic; and to provide for matters connected therewith." This Act has a broad scope that encompasses all the functions and operations of the bank. In terms of Section 3 of the Act, the primary objective of the Bank is to protect the currency of the republic so as to attain balanced and sustainable growth. The composition of the Board of directors is stated in Section 4 of the Act. The powers and duties of the Bank are given in Section 10, which also details the cash reserve requirement and the powers the bank has to

change the requirement. Section 31 of the Act outlines the reporting procedures of the bank and states, “The governor shall annually submit to the minister a report relating to the implementation by the Bank of monetary policy.”

Since 1996 the Bank’s operations are also governed by section 223 and 225 of the Constitution of the Republic of South Africa (Act No 108 of 1996). The Constitution states (1996:Section 224): “The primary object of the South African Reserve Bank is to protect the value of the currency in the interests of balanced and sustainable economic growth in the Republic. The South African Reserve Bank, in pursuit of its primary object, must perform its functions independently and without fear, favour or prejudice, but there must be regular consultation between the bank and the cabinet member responsible for national finance matters.” It is clear that this legislative framework affords the Bank a large degree of independence to pursue its goals. According to the South African Reserve Bank (2005) it regards its primary goal in the South African economic system as “the achievement and maintenance of price stability”.

The pursuit of price stability prompted the South African authorities to implement an inflation-targeting monetary framework in April 2000, and this framework is examined in the next section.

3.3 FORMAL INFLATION -TARGETING

3.3.1 Introduction

The Minister of Finance announced in the budget speech on 23 February 2000 that the government had decided to set an inflation target range of 3 to 6 percent for the year 2002. The Reserve bank formally adopted an inflation target monetary framework in April 2000. This meant that the monetary authorities had shifted from the “eclectic” monetary policy approach to a monetary framework that targets inflation directly (Van der Merwe 2004:1).

3.3.2 Reasons for inflation-targeting

According to Van der Merwe (2004:1) there were four reasons why the South African Reserve Bank decided to shift its policy towards a formal inflation-targeting framework. With an informal inflation target in place the public was at times unable to accurately judge the SARB's monetary policy stance. During the "eclectic" monetary policy approach followed by the SARB, the growth in money supply and bank credit remained above the guidelines set out by the authorities for an extended period. The public therefore anticipated an increase in short-term interest rates. But the SARB did not tighten monetary policy as it viewed the growth in both money supply and bank credit to have resulted from structural changes in the financial system. These structural changes "weakened the more stable relationship that had previously prevailed between changes in the money supply and in bank credit extensions, on the one hand, and in nominal spending on goods and services and in prices on the other hand" (Casteleijn 2001:5-6).

Table 1: Money supply (M3) and inflation outcomes from 1986 to 2000					
Year	Lower limit	Upper limit	Money growth actual	Inflation CPI	Inflation CPIX
1986	16	20	9.3	18.6	
1987	14	18	17.6	16.1	
1988	12	16	27.3	12.9	
1989	14	18	22.3	14.7	
1990	11	15	12.0	14.4	
1991	8	12	12.3	15.3	
1992	7	10	8.0	13.9	
1993	6	9	7.0	9.7	
1994	6	9	15.7	9.0	
1995	6	10	15.2	8.7	
1996	6	10	13.6	7.4	
1997	6	10	17.2	8.6	
1998	6	10	14.6	6.9	7.1
1999	6	10	10.2	5.2	6.9
2000	6	10	7.5	5.3	7.8
Source: (Casteleijn 2001:5)					

It is clear from Table 1 that even though the consumer price index continued to decrease from 1994 to 1998, money supply (M3) increased at rates higher than the pre-announced target range in the same years. Therefore, the SARB felt that there needed to be more transparency in its monetary policy approach.

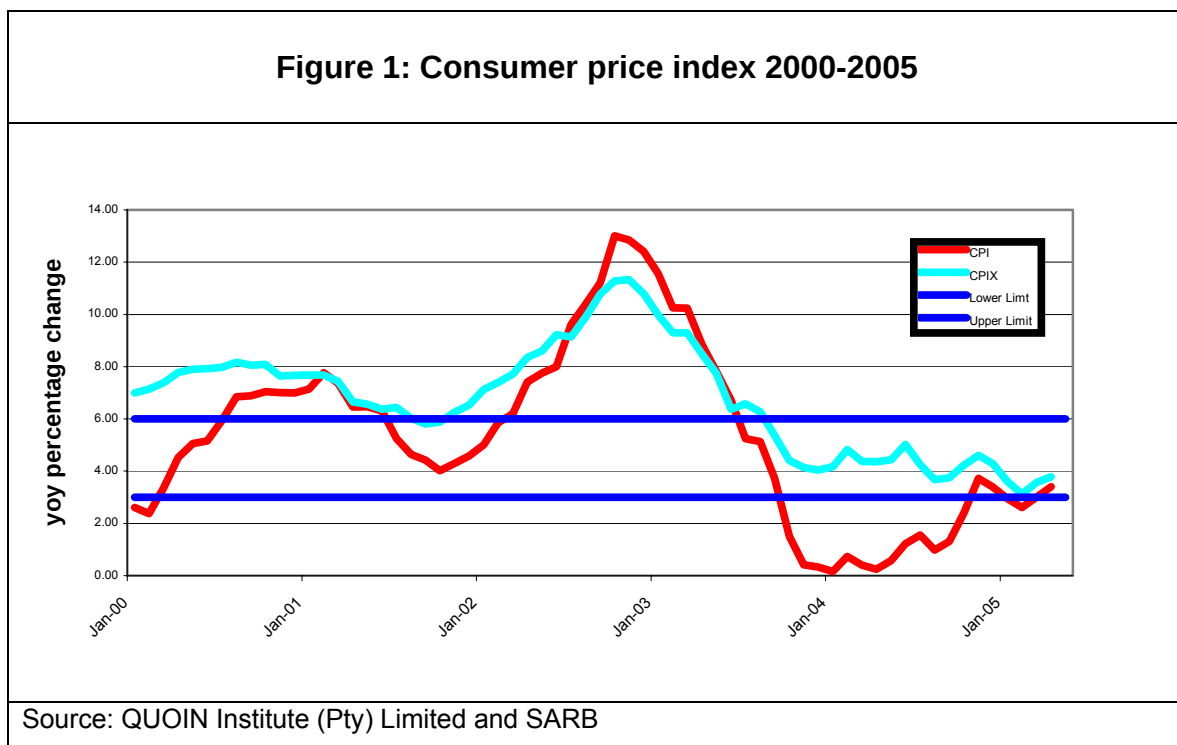
The second reason put forward by Van der Merwe (2004:1-2) is that an inflation-targeting framework allows for better co-ordination between monetary policy and other economic policies. Thirdly, it increases the accountability of the SARB with regard to monetary policy, as it is the bank's direct responsibility to ensure that inflation remains within the target range.

Lastly, if the public believes that the inflation-targeting framework is credible, it should influence inflationary expectations and serve to reduce actual inflation. It is this final point put forward by Van der Merwe (2004:1-2) that is most relevant to this study. If the Fisher effect is found to hold then a decrease in inflation expectations will result in an equal one-for-one decrease in nominal interest rates. In addition, credible policy should anchor inflation expectations within the target range. This then would result in a stable inflation expectation over the long-run.

The level of actual inflation becomes the central target variable within an inflation-targeting monetary policy regime and therefore can be used to directly gauge the success of monetary policy. The inflation rate since the adoption of the target is examined in the following section.

3.3.3 Inflation 2000-2005⁶

In April 2000, South Africa followed the world-wide push towards greater price stability, and through its conservative monetary and fiscal policy it was largely able to curtail inflation. CPIX accelerated during the first eight months of 2000, from 7.0 percent in January to 8.2 percent in August. This acceleration was caused by a rise in the domestic price of petrol and diesel and higher food prices due to flood damage to crops in the early months of 2000. It is also a typical characteristic of the South Africa economy that inflation accelerates during an upswing of the business cycle. CPIX inflation, illustrated in Figure 1, slowed down to 6.6 percent in 2001, compared to 7.8 percent in 2000. CPI inflation, illustrated in Figure 1, slowed down to 6.6 percent in 2001, compared to 7.8 percent in 2000.



The most noticeable feature in both the CPI and CPIX, as shown in Figure 1, is the peak during 2002. This acceleration of inflation was caused primarily by the sharp depreciation in the external value of the rand in the second half of 2001.

⁶ This section was compiled using the following SARB annual economic reports (2000:26-31; 2001:31-34; 2002:29-35, 63; 2003:27-28; 2004:23-29).

Other factors, including a drought in Southern Africa, high international food prices, increases in international crude oil prices and administered prices, also contributed to spike in inflation experience during 2002. The target range of between 3 and 6 percent in CPIX for 2002 could not be achieved. The monetary authorities increased the repo rate on four occasions from January 2002 to September 2002⁷. This, coupled with a recovery in the exchange value of the rand and lower food prices, pushed inflation down towards the end of 2002 and to historically low levels in 2003 and the beginning of 2004. The strong rand was able to counter the effect of rising crude oil prices, which increased by US\$18 per barrel from January 2002 to May 2004. Figure 1 clearly illustrates how successful the inflation-targeting framework has been at combating inflation. CPIX has remained within the target range from September 2003 till the end of the period under study.

The inflation-targeting monetary policy regime has important implications for the Fisher relationship. In this regime short-term nominal interest rates are controlled directly, and expected inflation is influenced indirectly, through the monetary transmission mechanism and the perceived credibility of monetary policy. The next section describes how SARB manages short-term interest rates and its role as monopoly supplier of liquidity.

3.4 SHORT-TERM INTEREST RATES AS THE MAIN VARIABLE OF MONETARY POLICY

3.4.1 Introduction

The South African Reserve Bank's key operational variable within its monetary policy framework is the level of short-term interest rates. South African monetary authorities therefore largely determine the level of short-term interest rates. The

⁷ The repo rate was increased by 1 percent in January, March, June and September.

Bank is able to influence these rates through its control over the bank rate/repo rate i.e. the lowest rate at which banks that are experiencing shortfalls are able to acquire funds from the Reserve Bank. This has interesting implications for the relationship between short-term interest rates and expected inflation. Short-term rates are not formed by market forces in South Africa but are directly controlled by the Reserve Bank. Mishkin and Simon (1995:225), as well as Esteve, Bajo-Rubio and Diaz-Roldan (2003:1) argue that short-term nominal interest rates become a poor indicator of the stance of monetary policy if the Fisher effect is confirmed. This is because verification of the Fisher effect suggests that nominal short-term interest rates movements are primarily caused by inflation expectations and are not due to changes in monetary policy.

The following section argues that due to the effectiveness of the accommodation policy in South Africa, market forces do not influence short-term nominal interest rates and therefore the short-run Fisher effect is unlikely to transpire empirically.

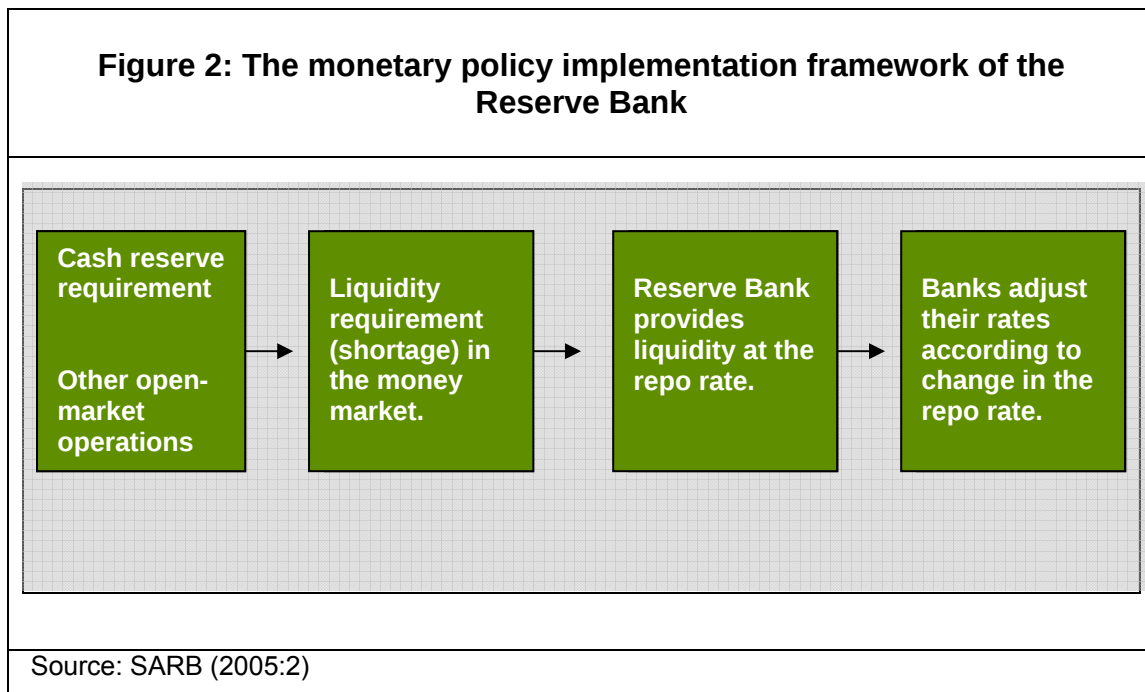
3.4.2 Accommodation policy of the South African Reserve Bank

Accommodation offered by the Reserve Bank is the credit offered to commercial banks at the accommodation facility of the central bank. The operational framework used by the Reserve Bank involves reliance upon the accommodation instrument known as the repo rate. This framework is illustrated in Figure 2 and is known as a cash reserve system of monetary control. Under this system, banks are compelled to utilise the Reserve Bank's accommodation facility through the repo system, which enables them to meet their daily liquidity requirements. Liquidity refers to the commercial banks' balances at the central bank that are available to settle their transactions with one and another, over and above the minimum statutory level of reserves required by law (SARB 2005:2).

The Reserve Bank's monetary policy framework involves creating a liquidity requirement (or shortage) in the money market, it then refinances this shortage at

the repurchase (or repo) rate. The bank is able to manipulate the size and nature of its balance sheet in order to maintain the shortage at a level that it believes is appropriate to meet its objectives (SARB 2005:2).

In addition to the cash reserve requirement the Reserve Bank conducts open-market operations to drain any excess liquidity so as to ensure an appropriate liquidity requirement or shortage in the markets. The Bank uses various types of open-market instruments, including Reserve Bank debentures, longer-term reverse repos and foreign exchange swaps (SARB 2005:2-3).

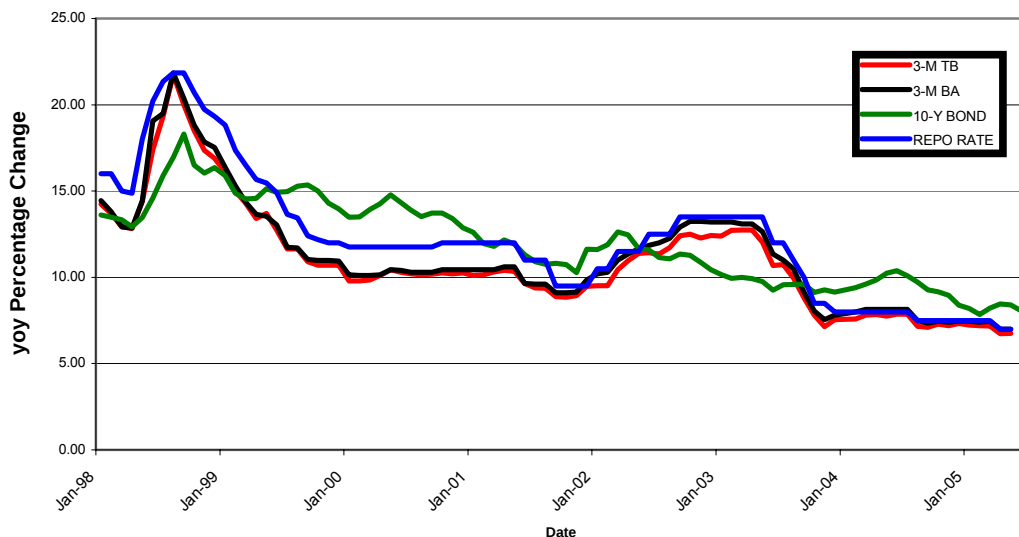


3.4.3 The repo rate and other money market rates

To make the repo rate effective, the Reserve Bank intervenes in the money market to create a shortage, that is, it drains excess liquidity. By ensuring that a money market shortage exists at all times, it means that commercial banks are always indebted to the Reserve Bank and within its financial grip. The monetary policy committee determines the repo rate, which represents the marginal cost of money for the banks. Commercial banks can obtain funding from the interbank

market at a rate just below the repo rate and this interbank rate plays a major role in influencing the call rate the banks are prepared to pay to large depositors, and call rates in turn influence all other deposit rates. Banks place and maintain a margin between the cost of their deposits (liabilities) and their loans and advances. This means that the repo rate has an almost direct influence on bank lending rates. This has a ripple effect on all other interest rates in the economy, which in turn affects other economic aggregates such as money supply, bank credit extension and ultimately the rate of inflation (SARB 2005:2; Faure 2003:144-162).

Figure 3: Money market rates 2000-2005

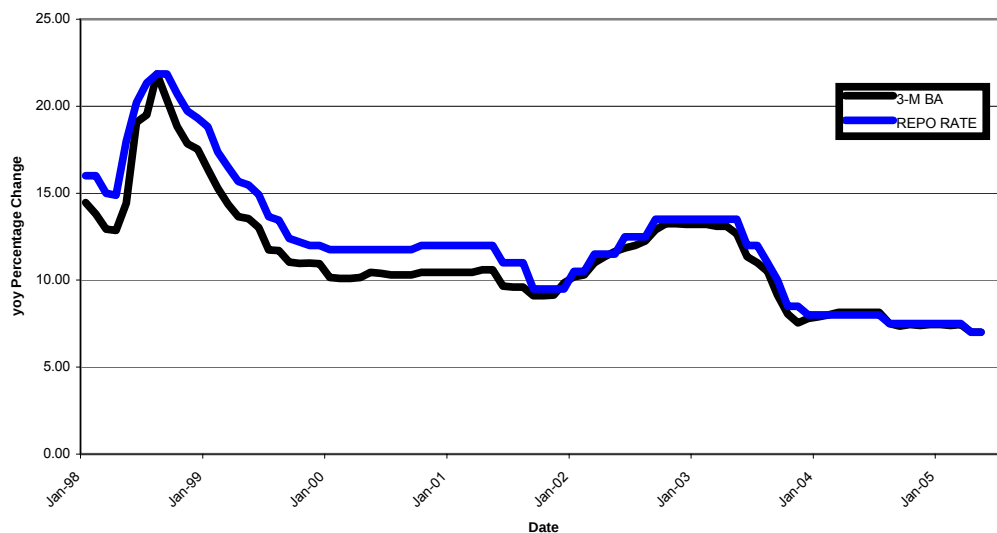


Source: QUOIN Institute (Pty) Limited and SARB

The repo rate also gives the market a good indication of the Bank's stance on monetary policy. Even banks that do not directly participate in the repo auction adjust their interest rates when the repo rate is increased or decreased. Within this monetary framework it is clearly evident that money market rates are vastly determined by the repo rate (see Figures 3 and 4). De Angelis, Aziakpono and

Faure (2005:668) explore the econometric link between the repo rate and three other money market interest rates for the period September 2001 and November 2004, and find that all three rates respond almost one-for-one to changes in the repo rate. The relationship is unity for the prime lending rate, 0.91 for the prime interbank rate and 0.99 for the 3-months NCD rate. This illustrates that market forces play an incredibly small role in the formation of short-term interest rates. Fluctuations in supply and demand of liquidity and the extent to which the market anticipates changes in the repo rate only have a minimal impact (SARB 2005:2).

Figure 4: 3-Month bankers' acceptance and the repurchase rate 2000-2005



Source: QUOIN Institute (Pty) Limited and SARB

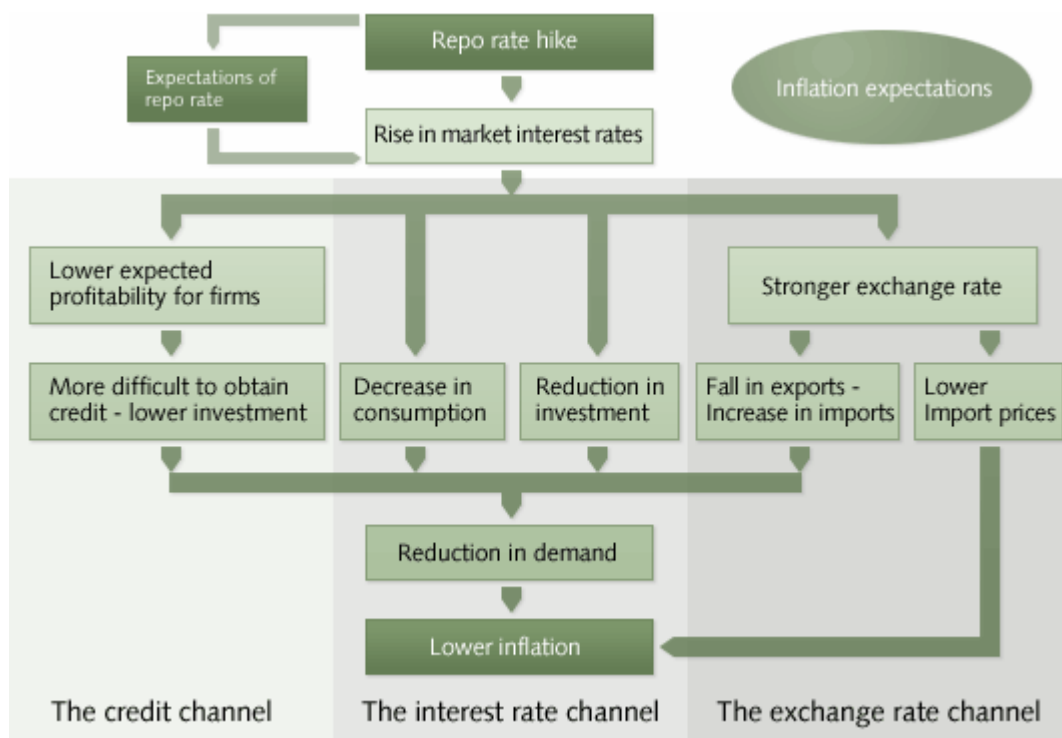
The repo rate not only influences short-term nominal interest rates but it also directly affects other economic variables. The process through which these changes occur is formally referred to as the transmission mechanism, and is explained in the following section.

3.5 MONETARY POLICY TRANSMISSION MECHANISM

3.5.1 Introduction

The transmission mechanism (illustrated in Figure 5) refers to the chain of economic events set in motion by an increase or decrease in the repo rate, which is implemented to affect the economy in general and inflation in particular.

Figure 5: Monetary policy transmission mechanism in South Africa



Source: Riksbank (2004:1)

Monetary policy induced changes to the repo rate have a direct impact on various economic variables including the exchange rate, money and credit, asset prices and decisions on spending and investment. These variables subsequently

control the demand and supply dynamics of goods and services markets, and essentially it is the relationship between supply and demand in these markets which causes inflationary pressures to emerge in the economy (Smal and De Jager 2001:5). Aron and Muellbauer (2000:15) find empirical support for both the interest rate channel and the exchange rate channel in South Africa. This section explores these two transmission channels and the credit channel, drawing predominantly from Mishkin (2004:617-625), Smal and De Jager (2001:5-9) and the Riksbank (2004:1).

3.5.2 Interest rate channel

The interest channel uses the real rate of interest to influence aggregate demand and finally inflation. If the SARB increases the repo rate, then the short-term real interest (r_t) rate will subsequently increase. This will prompt both firms and individuals to alter their investment and spending behaviour. Higher real interest rates stifle consumer spending (C) and investment spending (I) and ultimately lead to lower real output (y) (Mishkin 2004:617).

$$\text{Repo} \uparrow \Rightarrow r_t \uparrow \Rightarrow (I \downarrow, C \downarrow) \Rightarrow y \downarrow \quad (3.1)$$

Mishkin (2004:617) highlights that an important feature of the interest rate transmission mechanism is that it is the real rate of interest rather than nominal interest rates that affects general economic activity. He argues that the real long-term interest rate has a more potent impact on consumer and investment spending than changes in short-term nominal interest rates. The SARB can artificially decrease the short-term real rate of interest through its influence over short-term interest rates, but this will only have a long-run positive impact on the economy if the induced decrease in short-term real rates filters through to long-term real rates of interest. This emphasises the importance of establishing the validity of the Fisher effect. If the Fisher effect is verified when long-term interest

rates are analysed, it would suggest that monetary policy has not been able to influence the long-term real rate of interest downward over the long-run.

3.5.3 Exchange rate channel

The exchange rate channel influences inflation through its effect on net exports (NX). When the SARB increases the repo rate, short-term real rates also increase causing the rand to strengthen. This is because rand denominated deposits become more attractive compared to foreign currency deposits. This results in capital inflows and increased demand for the rand causing the rand to strengthen. The stronger rand makes domestic goods relatively more expensive to foreigners and foreign goods relatively cheaper for domestic importers, resulting in a decrease in net exports (NX) and consequently aggregate demand (Mishkin 2004:618).

$$\text{repo} \uparrow \Rightarrow r_t \uparrow \Rightarrow (\text{Rand} \uparrow) \Rightarrow \text{NX} \downarrow \Rightarrow y \downarrow \quad (3.2)$$

The effects of this channel are illustrated graphically in Figure 2, where inflation accelerated drastically in South Africa during 2002 due to a depreciation of the rand.

3.5.4 Credit channel

The credit channel refers to the transmission mechanism that affects aggregate demand through influencing credit issued by institutions. Mishkin (2004:621) outlines two separate channels through which bank credit is affected, the bank lending channel and the balance sheet channel.

The bank lending channel is illustrated in equation 3.3. Restrictive monetary policy causes bank reserves and bank deposits to decrease, resulting in a

decrease in the quantity of bank loans available to economic agents. This subsequently curtails both consumer and investment spending.

$$\text{repo}\uparrow \Rightarrow \text{Bank deposits}\downarrow \Rightarrow \text{bank loans}\downarrow \Rightarrow (I\downarrow, C\downarrow) \Rightarrow y\downarrow \quad (3.3)$$

The balance sheet channel, depicted in equation 3.4, is made effective due to imperfect information inherent in credit institutions. Restrictive monetary policy causes stock prices (P^s) to decline because the public have less money available to invest in stocks. This results in a decline in the net worth of firms, which increases the risk of adverse selection and moral hazard when lending to these firms. Therefore, less lending occurs and in turn investment spending decreases.

$$\begin{aligned} \text{repo}\uparrow \Rightarrow P^s\downarrow \Rightarrow \text{adverse selection}\uparrow \text{ and moral hazard}\uparrow \Rightarrow \text{Lending}\downarrow \\ \Rightarrow I\downarrow \Rightarrow y\downarrow \end{aligned} \quad (3.4)$$

The transmission mechanism combined with the forward-looking nature of inflation-targeting has interesting impact on the short-run Fisher effect, which are analysed in the next section.

3.5.5 The transmission mechanism and the Fisher effect

Smal and de Jager (2001:1-6) point out that due to the forward looking nature of an inflation-targeting regime it is imperative that monetary authorities be acutely aware of the time lags between policy action and the impact of this action on the real economy and eventually inflation. They suggest that the monetary policy transmission mechanism can take between 12 to 24 months to impact on inflation in South Africa. Therefore for inflation-targeting to be successful the SARB must make monetary policy decisions based on inflationary pressures between 1 and 2 years in the future.

In South Africa a short-run Fisher effect is not likely to hold empirically because short-term interest rates are not formed by market forces but are directly controlled by the SARB. The decision making process of the SARB artificially induces nominal interest rates and expected inflation to move in the same direction. However, once SARB changes the repo rate it sets in motion the transmission mechanism, which then overwhelms the Fisher effect. Therefore in an inflation-targeting environment the relationship between expected inflation and nominal interest rates is more likely to follow the analysis presented in equation 3.5.

$$\begin{aligned}
 \text{SARB } \pi^e \text{ forecasts (12-24 months ahead)} \uparrow &\Rightarrow \text{repo rate } \uparrow \Rightarrow r_t \uparrow \\
 &\Rightarrow \text{Transmission mechanism} \Rightarrow \pi_{t+(12-24)} \downarrow \Rightarrow \\
 &\pi^e_{t+(12-24)} \downarrow
 \end{aligned} \tag{3.5}$$

Equation 3.5 can be decomposed into two phases: the decision phase, before policy action is taken, and the transmission mechanism phase, after policy action is taken. Van der Merwe (2004:1) states that within inflation-targeting monetary policy regime “Policy changes depend on expected development in inflation”. In the decision phase monetary authorities attempt to predict if inflation will remain in the target range. If the SARB’s inflation forecasts show that inflation is likely to breach the target in 12 to 24 months, they will be prompted to increase the repo rate, which in turn will cause other short-term nominal interest rates to increase. This ensures that monetary authorities artificially cause interest rates to move in the same direction as expected inflation during the decision phase. However because of the transmission mechanism, expected inflation before policy actions is different from expected inflation (12-24 months ahead) after policy action is taken. This makes this first phase very difficult to empirically test without the SARB’s actual inflation forecasts. When the policy decision is implemented the transmission mechanism is set in motion. This then causes nominal interest rates and expected inflation to move in opposite directions.

This transmission mechanism analysis illustrates that output decreases if the repo rate is increased. A reduction in real output will subsequently lead to a reduction in inflation, and because economic agents base their short-term inflation expectations on actual inflation, expected inflation will also decrease. In the decision phase causality runs from expected inflation to interest rates consistent with the Fisher hypothesis, during the transmission mechanism phase causality runs from interest rates to expected inflation.

The SARB is able to influence the short-term real interest rate through its influence over short-term nominal interest rates. What is more important to monetary authorities is whether this influence is carried through to long-term real interest rates. The following section presents an examination of the relationship between credibility and the long-term real rate of interest within an inflation-targeting monetary policy regime.

3.6 INFLATION-TARGETING, CREDIBILITY AND THE LONG-TERM REAL INTEREST RATE

The SARB considers its primary goal to be “the achievement and maintenance of price stability”. The introduction of an inflation-targeting monetary policy framework marked a major shift towards securing greater price stability and obtaining inflation fighting credibility. Through a clearly defined target and a genuine commitment to achieve this target, the SARB is able to guide the public’s inflation expectations. The Fisher equation can be used to establish whether inflation expectations have been sufficiently anchored to enable the SARB to influence the long-term real rate of interest.

Wesso and Kock (2004:12) show that as the SARB’s inflation-targeting monetary policy becomes more credible and successfully maintains actual inflation within the target range, expectations of future inflation subsequently decline. Söderlind

(2001:493-494) argues that in an inflation-targeting environment, the central bank will attempt to use the real interest rate to shift output in order to stabilise inflation. This, in turn, ensures that the volatility of inflation decreases, but the volatility of the real interest rate increases since it takes large movements in output to keep inflation within the target range. Movements in the nominal interest rate will therefore primarily reflect movements in the real interest rate. Pfaendler (2006:3) finds similar results also suggesting that when a central bank has achieved price stability the real rate of interest will steer nominal interest rates and the expected rate of inflation will remain stable. Analysing data from three highly credible monetary policy regimes - the United States, United Kingdom and Eurozone - he concludes that as these regimes gain credibility volatility of break-even, inflation declines and the real rate of interest becomes the major driver of nominal yields. This implies that as inflation-targeting regimes become more credible, inflation expectations become increasingly firmly anchored within the target range.

This has interesting implications for the dynamics of the Fisher equation. Whereas Fisher (1930) hypothesised a constant real rate of interest, in a credible monetary policy regime it will be the expected rate of inflation that will remain relatively constant, allowing the real interest rate to drive nominal interest rates. Based on the findings of both Wesso and Kock (2004) and Söderlind (2001:493-494), and by analysing long-term nominal interest rates, it could be theoretically argued that an inflation-targeting monetary policy framework would consist of two evolutionary stages. The first stage would represent the early part of an inflation-targeting framework; in this stage the central bank would fight towards greater long-term price stability and attempt to stabilise inflation expectations. As the policy gains credibility and inflation expectations become increasingly less volatile, until inflation expectations will become constant over the long-run, signalling the second evolutionary stage. In this stage it would be the long-term real rate of interest that would drive nominal yields.

Stage 1:

In the preliminary stages of an inflation-targeting framework, long-term nominal interest rates movements should follow the Fisher equation, if expected inflation decreases:

$$i_t = r_t + \pi_t^e \downarrow \quad (3.6)$$

and the long-term real rate of interest is constant over time, then a decrease in expected inflation will result in an equal decrease in long-term nominal interest rates:

$$i_t \downarrow = r_t + \pi_t^e \downarrow \quad (3.7)$$

Before the central bank is able to achieve this level of stability, it would be the expected rate of inflation that principally drives long-term nominal interest rates, as illustrated in equation 3.7.

Stage 2:

In this second stage the dynamics of the Fisher equation change. Now it is the expected rate of inflation that will remain relatively constant:

$$i_t = r_t \downarrow + \pi_t^e \quad (3.8)$$

This will allow the central bank to target the real rate of interest, as it will be the principal driver of long-term nominal interest rates movements:

$$i_t \downarrow = r_t \downarrow + \pi_t^e \quad (3.9)$$

Once price stability is achieved and inflation expectations are constant over the long-run, it will be the long-term real interest rate that will be primarily responsible for changes in nominal interest rates.

The above analysis illustrates two interesting points. Firstly, if monetary authorities require low nominal interest rates in the long-run, then this is most effectively achieved through a credible and successful monetary policy management framework. Credible policy is able to anchor inflation expectations at low levels and inflation expectations are included as a premium in long-term nominal interest rates. Secondly, once the SARB is able to secure long-run price stability and achieve a level of inflation expectations that is relatively constant over the longer run, it will be the real rate of interest that will drive nominal interest rates. This will enable the SARB to target the long-term real interest rate directly in order to achieve 'real' economic benefits.

3.7 SUMMARY

The SARB formally adopted an inflation-targeting monetary framework in April 2000. There were four key reasons that contributed to the SARB's decision to shift from the previous "eclectic" monetary policy approach to a monetary framework that targeted inflation directly:

- Greater transparency.
- Better co-ordination between monetary policy and other economic policies.
- Increased accountability of the SARB with regard to monetary policy.
- Greater credibility of monetary policy in the eyes of the public.

Since the inception of the inflation-targeting framework the SARB has controlled inflation and has managed to keep CPIX within the target range from September

2003 till the end of the period under study. This, in turn, has helped anchor inflation expectations into the target range.

Short-term nominal interest rates are a function of the repo rate and therefore are directly controlled by the SARB. The adjustment of the repo rate by the SARB also makes up the first step in the monetary transmission mechanism. Three channels through which the transmission mechanism operates, namely the interest rate channel, the exchange rate channel and the credit channel, were schematically illustrated. The SARB's direct control over the repo rate and the effectiveness of the monetary transmission mechanism both have implications for the relationship between expected inflation and short-term interest rates. In order to simplify these implications the entire monetary policy process is decomposed into two parts: the decision phase, before policy action is taken, and the transmission mechanism phase, after policy action is taken. In the decision phase, policy action aimed at containing future inflation will artificially induce short-term nominal interest rates to move with expected inflation (12-24 months ahead), broadly consistent with the Fisher equation. In the post policy action phase the relationship between expected inflation and short-term nominal interest rates follows the transmission mechanism and therefore overshadows the Fisher effect.

Long-term nominal interest rates are analysed within an inflation-targeting monetary policy framework consisting of two evolutionary stages. In the first stage the central bank strives for greater long-run price stability and inflation expectations are the principal driver of nominal interest rates. Once the policy gains credibility, both inflation and expected inflation become increasingly locked into the target range. The second stage is therefore characterised by stable inflation expectation and the long-term real rate of interest becomes the primary driver of nominal interest rates.

CHAPTER 4

METHODOLOGY

4.1 INTRODUCTION

The econometric technique used in the research is similar to that used by both Phylaktis and Blake (1993:592-593) and Carneiro, Divino and Rocha (2002:95-96), where the Fisher equation is represented in the form⁸:

$$i_t = r_t + \pi_t^e \quad (4.1)$$

where i_t is the nominal interest rate, r_t is the *ex ante* real interest rate, and π_t^e is the expected inflation rate. Assuming Fama (1975) expected and actual inflation differ by a white noise stationary term and the *ex ante* real interest rate is stationary, we can empirically test the Fisher equation in the following form:

$$i_t = \alpha + \beta \pi_t + \mu_t \quad (4.2)$$

where α is the long-run real interest rate, π_t is the actual inflation rate and μ_t is the sum of the stationary components. The strong form Fisher hypothesis is validated if a long-run unit proportional relationship exists between inflation (π_t) and nominal interest rates (i_t) and $\beta=1$, if $\beta<1$ this would be consistent with a weak form Fisher hypothesis.

This study will ascertain the existence of such a relationship by implementing the following four-step procedure:

⁸ Atkins (1989:1614) finds the effective difference between Fisher's equation with or without incorporating tax to be minimal. Therefore, this study has decided not to include income taxes in the empirical investigation.

Step 1: The first challenge facing any empirical Fisherian study is to derive an inflation expectations proxy. The first step of the methodology comprehensively explores the various proxies available to researchers within the South African context.

Step 2: The order of integration of both π_t^e and i_t will be determined by employing tests devised by Dickey and Fuller (1979) and Phillips and Perron (1988).

Step 3: If both variables are integrated as of the same order, a maximum likelihood method of cointegration, proposed by Johansen (1991) and later improved in Johansen (1995), will be applied in order to determine the number of cointegrating vectors. If one or more cointegration vectors are found to exist, any short-run disequilibrium will be corrected with an error correction model.

Step 4: To determine whether causality runs from inflation to interest rates, a weakly exogeneity test suggested by Johansen (1992:389) will be carried out.

4.2 INFLATION EXPECTATIONS⁹ - STEP 1

4.2.1 Introduction

Since Fisher's (1930) study, obtaining an accurate proxy for inflation expectations has remained one of the primary problems faced by researchers. Although there are various approaches available, not all are applicable to South African. This section will outline the most recognised approaches and explain why this study has opted for a moving average model of actual inflation assuming rational expectations in line with Muth (1961) to proxy its expected inflation variable. While it is noted that many authors, including Hsing (1997:1057), find that using different proxies for inflation expectations (Livingston

⁹ See Kahn and Farrell (2002:6-9) for good discussion on different measures of inflation expectations.

Survey data, rational expectations hypothesis, adaptive expectations model) yield different results, the sensitivity of results based on different inflation forecasts would be an interesting area for future research.

4.2.2 Model to estimate inflation predictions

Cooray (2002-2003:29-36) employs an inflation-forecasting model to proxy inflation expectations. The model follows the monetarist view of inflation and is extended to include the effects of import prices and the exchange rate. It assumes that inflation forecasts are made using the following variables: money supply, real Gross National Product, the import price index, and the exchange rate. Aron and Muellbauer (2000) have developed a single equation, multi-step forecasting model for South Africa. The model forecasts inflation four quarters ahead. Woodward (1992:316) argues that using an equation estimated on past inflation to proxy expected inflation is prone to inaccuracy, as various assumptions have to be made with regard to how economic units go about making inflation forecasts and these models do not account for once-off events such as supply shocks or terrorist attacks.

4.2.3 The break-even inflation rate

Expected inflation data can be directly obtained by comparing the yield on index-linked and non-indexed government bonds. Both Barr and Campbell (1997:361) and Evans (1998:187) have developed methods which use United Kingdom government nominal and index linked bonds to estimate *ex ante* real interest rates and inflation rates. Chu, Pittman and Yu (2003:190) use the Evans (1998:187) methodology to derive the United States *ex ante* real rate from Treasury Inflation-Indexed Securities (TIIS). Woodward (1992:316-319) finds evidence to support the Fisher hypothesis using inflation expectation data derived from the United Kingdom market for indexed securities. Inflation-linked government bonds do exist in South Africa, and Wesso and Kock (2003:4-7)

employ the break-even inflation rate as a proxy for expected inflation for South Africa. They calculated it as the difference between the nominal yield on conventional bonds (R153) and real yield on inflation linked-bonds (the R189).

However, Orr, Edey and Kennedy (1995:77) argue that the difference between the yields on index-linked and non-indexed government bonds may also reflect factors other than inflation expectations, including differences in tax treatment, inflation uncertainty and liquidity premiums. Inflation-linked bonds were only introduced in South Africa in 2000, making any series derived by this methodology too short to be used in this research.

4.2.4 Survey method

Zilberfarb (1989:536) uses the survey method to approximate expected inflation in Israel. Questionnaires are sent to various market participants every quarter asking them to predict the next quarter's inflation. Each of the responses is then averaged to produce a variable representing expected inflation. According to Woodward (1992:316), however, there are various problems associated with this method. Firstly, surveys do not replicate market forces very accurately: often the respondents are not financially linked to their inflation predictions and thus have no incentive to respond accurately. Secondly, the responses are not weighted according to how large or how influential the respondents are in the market.

Inflation expectations derived from the survey method are available in South Africa, such as the Bureau of Economic Research (BER) survey. However, this time series only dates back to 16 November 2000 and again would not be appropriate for this particular study.

4.2.5 Rational expectations model¹⁰

The manner in which expectations are modelled changed substantially when Muth (1961), in an attempt to explain how expectations are formed, proposed the rational expectations hypothesis: “Expectations, since they are informed predications of future events, are essentially the same as the prediction of the relevant economic theory” (Muth 1961:361). Fama (1975) extended the rational expectations theory when he proposed the efficient market hypothesis. The rational expectations theory assumes that inflationary forecasts of individuals in the economy tend to be fully “rational”, that is, they are unbiased forecasts of future inflation.

Using the rational expectations model to estimate inflation expectations¹¹ would mean that the difference between realised inflation (π_t) and expected inflation (π_t^e) is captured by an error term (ε_t):

$$\pi_t^e - \pi_t = \varepsilon_t \quad (4.3)$$

where

$$E(\varepsilon_t) = 0 \quad (4.4)$$

If this were not the case, then there would be a systematic component in the forecast error, which would need to be corrected by forecasters. The rational expectations model also requires that this prediction error be uncorrelated to all the variables in the information set at the time of the prediction (Maddala 2001:397). This rational expectations model for inflation expectations can be incorporated into the Fisher equation as follows.

$$\dot{i}_t = r_t + \pi_t \quad (4.5)$$

¹⁰ See Peng (1995:4).

¹¹ See Hawtrey (1997:338), Carneiro, Divino and Rocha (2002:96) and Mishkin (1995:197).

Assuming nominal interest rates on contracts are set at the start of a given period and that actual inflation follows the rational expectations model, we can rearrange equation 4.3:

$$\pi_t = \pi_t^e + \varepsilon_t \quad (4.6)$$

where ε_t is a white noise error term. If we assume that the real interest rate is also generated under a stationary process, where r_t^e is the *ex ante* real interest rate and v_t is the stationary component, we obtain:

$$r_t = r_t^e + v_t \quad (4.7)$$

Now by substituting equation 4.7 in equation 4.5:

$$i_t = r_t^e + \pi_t^e + \mu_t \quad (4.8)$$

where μ_t is the sum of the two stationary error terms, r_t^e is the *ex ante* real interest rate and π_t^e is the expected rate of inflation.

4.2.6 ARIMA and smoothing

Time series modelling techniques are becoming an increasingly popular method of estimating inflation expectations. These techniques include models such as a Moving Average (MA), sometimes referred to as smoothing, the Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average (ARIMA). Junttila (2001:580) uses a univariate time series ARIMA modelling method to estimate inflation expectations in his study to verify the Fisher hypothesis in Finland. Pain and Thomas (1997), Yuhn (1996) and Carneiro, Divino and Rocha (2002) all utilise a simple moving average modelling procedure to generate the required expected inflation time series.

The expected inflation proxy adopted by this thesis is one suggested by Yuhn (1996:42)¹², who utilises a five quarter moving average (with two leads and two lags) of actual inflation and incorporates it into the rational expectations model outlined in the previous section. Yuhn (1996:42) motivates this methodology by pointing out that economic agents make their inflation forecast based on a finite information set that does not span too far into the future. This approach also allows both past and future data to be included in the final estimation, making it a more accurate representation of how economic agents make their inflation forecasts.

4.3 UNIT ROOT TESTS - STEP 2

4.3.1 Introduction

In order to determine whether the interest rate and expected inflation series contain unit roots, the study employs tests devised by Dickey and Fuller (1979) and Phillips and Peron (1988). These approaches are described below.

4.3.2 Augmented Dickey and Fuller (1979)

The respective time series will first be tested utilising a unit root test developed by Dickey and Fuller (1979). This test requires both the data generating process of the series under study as well as the appropriate lag length be chosen.

Eviews 5, using the Schwartz Information Criteria from a maximum lag length of 6 months, automatically chooses the lag length. Since the data generating process of the series is unknown, both visual inspection and the testing procedure outlined in Seddighi, Lawler and Katos (2000:264-278) are used to identify the Data Generating Process (DGP). Three different data generating processes can be chosen within the Augmented Dickey-Fuller test.

¹² Also implemented by Carneiro, Divino and Rocha (2002:96).

A pure random walk is given as:

$$\Delta X_t = \delta X_{t-1} + \sum_{j=2}^q \delta_j \Delta X_{t-j+1} + \varepsilon_t \quad (4.9)$$

A random walk with drift can be represented as:

$$\Delta X_t = \alpha + \delta X_{t-1} + \sum_{j=2}^q \delta_j \Delta X_{t-j+1} + \varepsilon_t \quad (4.10)$$

A random walk with drift and trend is represented as:

$$\Delta X_t = \alpha + \beta t + \delta X_{t-1} + \sum_{j=2}^q \delta_j \Delta X_{t-j+1} + \varepsilon_t \quad (4.11)$$

where Δ is the difference operator, α is the constant term (drift term), β is the linear deterministic trend (time trend), t is time, and ε is a white noise error term. The null hypothesis is that the times series X_t is nonstationary, that is if $\delta = 0$ and the series is therefore stationary if $\delta < 0$, using the τ statistic. The conditional hypothesis testing procedure requires that the significance of both α and/or β be tested. Dickey and Fuller (1981:1063-1064) provide three symmetric critical τ_{ij}^{13} values, called $\tau_{\alpha\tau}$, $\tau_{\beta\tau}$ and $\tau_{\alpha\mu}$, for testing the drift parameter α and the linear trend β conditionally upon $\delta = 0$. These conditional hypotheses are as follows:

1) Using Dickey and Fuller regression equation of the form 4.11:

$$H_0: \alpha = 0 \text{ given that } \delta = 0 \text{ if } |t| < |\tau_{\alpha\tau}|$$

$$H_1: \alpha \neq 0 \text{ given that } \delta = 0 \text{ if } |t| > |\tau_{\alpha\tau}|$$

¹³ The table of these critical values is reported in Seddighi, Lawler and Katos (2000:272).

2) Using Dickey and Fuller regression equation of the form 4.11:

$$H_0: \beta = 0 \text{ given that } \delta = 0 \text{ if } |t| < |\tau_{\beta\tau}|$$

$$H_1: \beta \neq 0 \text{ given that } \delta = 0 \text{ if } |t| > |\tau_{\beta\tau}|$$

3) Using Dickey and Fuller regression equation of the form 4.10:

$$H_0: \alpha = 0 \text{ given that } \delta = 0 \text{ if } |t| < |\tau_{\alpha\mu}|$$

$$H_1: \alpha \neq 0 \text{ given that } \delta = 0 \text{ if } |t| > |\tau_{\alpha\mu}|$$

(Seddighi, Lawler and Katos, 2000:273)

4.3.3 Phillips and Perron (1988)

In order to ensure that the unit root results are accurate, this research employs a second unit root test, developed by Phillips and Perron (1988:335). This method utilises a nonparametric approach to control serial correlation in the error term. Eviews 5 (2003) uses the following statistic when carrying out the Phillips and Perron test:

$$\tilde{t}_\alpha = t_\alpha \left(\frac{\gamma_0}{f_0} \right)^{1/2} - \frac{T(f_0 - \gamma_0)(se(\tilde{\alpha}))}{2f_0^{1/2}s} \quad (4.12)$$

Here $\tilde{\alpha}$ is the estimate, t_α the t -ratio of α , $se(\tilde{\alpha})$ is the coefficient standard error, and s is the standard error of the test regression. In addition, γ_0 is a consistent estimate of the error variance in:

$$\Delta y_t = \alpha y_{t-1} + x_t' \delta + \varepsilon_t \quad (4.13)$$

calculated as $(T-k) s^2 / T$, where k is the number of regressors. The remaining term, f_0 , is an estimator of the residual spectrum at frequency zero.

Assumptions regarding the data generating process of the times series under study also need to be made. The choices are the same as those outlined in the Augmented Dickey and Fuller test. Therefore, whichever assumption is used in the Augmented Dickey and Fuller test will also be used for the Phillips and Perron test. Eviews 5 (2003) uses a Kernel (Bartlett) sum-of-covariances estimator to estimate f_0 , while the Newey-West (1994:631) data-based automatic bandwidth parameter method is used in selecting the bandwidth parameter for the kernel-based estimator.

King and Watson (1997:69) and Koustas and Serletis (1999:106) both argue that cointegration techniques should only be applied if the underlying variables are integrated of the same order. Therefore if both series are found to be of the same order, they can be tested to verify whether a stable long-run relationship exists between them.

4.4 COINTEGRATION ANALYSIS - STEP 3

4.4.1 Introduction

Macroeconomic time series are typically non-stationary, as established by Nelson and Plosser (1982:139). When traditional regression analysis is used on two non-stationary time series, a spurious regression may result (Granger and Newbold 1974:111). The non-stationary nature of the majority of macroeconomic time series has prompted the development of various non-stationary time series analysis techniques, the most prominent being cointegration analysis. This concept of cointegration, introduced by Granger (1981:128) and later extended by Engle and Granger (1987:253), is built on the premise that the linear combination of two non-stationary series results in a stationary series.

Cointegration can be defined simply as the long-term, or equilibrium, relationship between two series. This makes cointegration an ideal analysis technique to

validate the Fisher hypothesis: by ascertaining the existence of a long-term unit proportionate relationship between nominal interest rates and expected inflation, cointegration analysis can thereby establish if nominal interest rates are cointegrated with expected inflation. The cointegration method by Johansen (1991; 1995) has become the most cited cointegration technique used in Fisherian literature, and is used in this study.

The Vector Autoregression (VAR) based cointegration test methodology developed by Johansen (1991; 1995)¹⁴ is described here.

The procedure is based on a VAR of order p:

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + Bz_t + \varepsilon_t \quad (4.14)$$

where y_t is a vector of non-stationary I(1) variables (interest rate and expected inflation), z_t is a vector of deterministic variables and ε_t is a vector of innovations. The VAR may be reformulated as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bz_t + \varepsilon_t \quad (4.15)$$

where

$$\Pi = \sum_{i=1}^p A_i - I \quad (4.16)$$

and

$$\Gamma_i = - \sum_{j=i+1}^p A_j \quad (4.17)$$

¹⁴ The procedure is outlined in Eviews 5 (2003).

Estimates of Γ_i contain information on the short-run adjustments, while estimates of Π contain information on the long-run adjustments, in changes in y_t . The number of linearly dependent cointegrating vectors that exist in the system is referred to as the cointegrating rank of the system. This cointegrating rank may range from 1 to $n-1$ (Greene 2000:791). There are three possible cases in which $\Pi y_{t-1} \sim I(0)$ will hold. Firstly, if all the variables in y_t are $I(0)$, this means that the coefficient matrix Π has $r = n$ linearly independent columns and is referred to as full rank. The rank of Π could alternatively be zero: this would imply that there are no cointegrating relationships. The most common case is that the matrix Π has a reduced rank and there are $r < (n-1)$ cointegrating vectors present in β . This particular case can be represented by:

$$\Pi = \alpha\beta' \quad (4.18)$$

where α and β are matrices with dimensions $n \times r$ and each column of matrix α contains coefficients that represent the speed of adjustment to disequilibrium, while matrix β contains the long-run coefficients of the cointegrating relationships. In this case, testing for cointegration entails testing how many linearly independent columns there are in Π , effectively testing for the rank of Matrix Π (Harris, 1995:78-79). Johansen's approach uses both the trace and maximum Eigenvalue tests to identify the rank of Π ; in effect this tests for the number of nonzero characteristic roots (or *eigenvalues*) (Kennedy 2003:337).

4.4.2 Lag length and deterministic trend specification

This Johansen procedure requires that the appropriate lag length for the VAR be estimated.¹⁵ This study employs three different criteria: the Schwarz and Akaike information criteria and the Likelihood Ratio (LR) test.

4.4.2.1 Likelihood ratio (LR) test

$$LR = 2[\ln \ell_u - \ln \ell_r] \sim \chi^2(v) \quad (4.19)$$

where,

$\ln \ell_u$ = Log of likelihood of the complete in coefficient (unrestricted) equation

$\ln \ell_r$ = Log of likelihood of the smaller in coefficient (restricted) equation

v = number of restrictions imposed

Given VAR(k) model with coefficients corresponding to the lagged variables of the matrix $A = [A_1, A_2, \dots, A_k]$, the test involves testing the following hypotheses in a sequence starting with the largest lag length k.

$$H_0 : A_k = 0 \text{ vs. } H_a : A_k \neq 0$$

$$H_0 : A_{k-1} = 0 \text{ vs. } H_a : A_{k-1} \neq 0 \text{ given that } A_k = 0$$

$$H_0 : A_{k-2} = 0 \text{ vs. } H_a : A_{k-2} \neq 0 \text{ given that } A_k = A_{k-1} = 0$$

....

$$H_0 : A_k = 0 \text{ vs. } H_a : A_k \neq 0 \text{ given } A_k = A_{k-1} = \dots = 0$$

The test terminates when the null hypothesis is rejected using the LR statistic, following which the VAR order q , for $k \geq q \geq 1$, is selected. ((Holden and Perman 1994) in Seddighi, Lawler and Katos 300:2000).

¹⁵ Gonzalo (1994:220), Hawtrey (1997:344) and Yuhn (1996:42) all report that the Johansen procedure produces results that are sensitive to the lag length chosen.

4.4.2.2 The Akaike information criterion (AIC) and Schwartz criterion (SC)

EvIEWS 5 (2003) reports Akaike's information criterion as:

$$-2(l/T) + (k/T) \quad (4.20)$$

and the Schwartz criterion as:

$$-2(l/T) + k \log(T)/T \quad (4.21)$$

where l is the value of the log of the likelihood function with the k parameters estimated using T observations. The various information criteria are all based on -2 times the average log likelihood function, adjusted by a penalty function.

It is likely that the different criteria mentioned may yield different optimal lag lengths. In this event the criteria yielding the highest lag length will be chosen. As Gonzalo (1994:220) has shown, the cost of over-parameterising by including more lag lengths in the ECM is small in terms of loss of efficiency. If the largest lag length produces results that show signs of serial correlation, however, the next largest lag length will be used until serial correlation is removed.

Johansen (1995:80-84) outlines five deterministic trend assumptions available to the researcher. Unfortunately, there is very little research available that offers a formal fixed procedure to ascertain which deterministic trend assumption is most appropriate. Wesso (2000:77)¹⁶ suggests that the final decision should be guided by both economic theory and statistical criteria.

¹⁶ Wesso (2000:76) also uses South African data.

4.5 WEAK EXOGENEITY¹⁷ - STEP 4

Cointegration between nominal interest rates and expected inflation partially validates the Fisher hypothesis. To fully confirm the hypothesis, causality must run from the expected inflation rate to interest rates. This implies that weak exogeneity needs to be rejected for the interest rate variables, and accepted for expected inflation.¹⁸

To test whether expected inflation is weakly exogenous, a test proposed by Johansen (1992:389) is utilised. This test imposes a zero-restriction on the error correction mechanism obtained from the cointegration analysis; the null hypothesis is given by $\alpha_i = 0$. Therefore the non-rejection of the null hypothesis for expected inflation and the rejection of the null hypothesis in the cases of the interest rate variables would verify the Fisher equation.

4.6 SUMMARY

This chapter describes the four-step econometric procedure that will be utilised to ascertain the existence of long-run unit proportional relationship between expected inflation (π_t^e) and nominal interest rates (i_t). The first step of the procedure reviews the various expected inflation proxies available to researchers and outlines the rationale for implementing a moving average model representation of actual inflation assuming rational expectations.

The remaining three steps outline the cointegration framework used in this thesis. Cointegration can simply be defined as a long-term, or equilibrium, relationship between two series. This makes cointegration an ideal analysis technique to

¹⁷ Proposed by Richard (1980) and formally defined by Engle, Hendry and Richard (1983:277).

¹⁸ Both Hawtrey (1997:342) and Carneiro, Divino and Rocha (2002:96) have successfully implemented weak exogeneity tests to validate the Fisher hypothesis.

validate the Fisher hypothesis, as cointegration analysis is able to establish whether nominal interest rates move one-for-one with expected inflation.

The first step in the cointegration framework involves determining the order of integration of both π_t and i_t by employing tests devised by Dickey and Fuller (1979) and Phillips and Perron (1988). Then a maximum likelihood method of cointegration, proposed by Johansen (1991; 1995), is described. If cointegration is established the short-run dynamics of this relationship will be modelled with an error correction framework. The final step is a weak exogeneity test suggested by Johansen (1992), and this test will be used to determine whether causality runs from expected inflation to nominal interest rates.

CHAPTER 5

EMPIRICAL ANALYSIS

5.1 DATA

The empirical analysis uses monthly nominal interest and expected inflation rates for the period April 2000 to July 2005, this coincides with the SARB formal adoption of an inflation-targeting monetary policy framework. Short-term interest rates are captured using the three-month bankers' acceptance rate (BA). The BA time series utilised in this thesis has been compiled by QUOIN Institute (Pty) Limited from various money market participants, while yields on government bonds ten-years and greater obtained from the SARB are used to proxy long-term nominal interest rates (G10).

Inflation expectations are estimated utilising a five-month moving average (with two leads and two lags) of actual inflation (C5) as suggested by Yuhn (1996:42)¹⁹. This measure of inflation expectations embodies the use of both backward and forward looking information in the formation of inflation forecasts. The study also assumes economic agents to be rational in line with Muth (1961) forecasts to be efficient following Fama (1975).

South Africa has three measures of consumer price inflation: the headline consumer price index, the core consumer price index, and the overall index excluding the effects of changes in mortgage costs (the CPIX). The indexes are captured within certain geographic regions, for example metropolitan areas, other urban areas and rural areas. These are then aggregated to represent the consumer price index for the country as a whole (Van der Merwe 2004:4).

¹⁹ This procedure is similar to the procedure outlined in Mishkin (1992:197) and Mishkin and Simons (1995:218) and is also used by Carneiro, Divino and Rocha (2002:96).

The headline consumer price index is directly linked to changes in the Reserve Bank's repurchase rate. If the Reserve Bank tightens (relaxes) their monetary policy stance it will cause an immediate increase (decrease) in the overall consumer price index as mortgage interest payments, which are included in the index, will decrease. Core inflation overcomes this monetary policy problem as it excludes the cost of mortgage bonds as well as excluding certain food products and certain indirect taxes. These additional exclusions mean that this measure is not as severely affected by exogenous shocks, which are not under the control of monetary policy. This measure is however difficult for the general public to accurately comprehend and is also considered less credible than headline inflation. CPIX in metropolitan and other areas is the variable targeted by the SARB. This broad measure of inflation was chosen because it is perceived to be a more understandable for the general public. It also does not include the direct impact of repo rate adjustments (Van der Merwe 2004:4-5). The study therefore uses a monthly percentage change CPIX series obtained from the QUOIN Institute (Pty) Limited to derive the expected inflation measure²⁰.

Table 2 Summary of variables		
C5	Expected Inflation proxy	5-month moving average of CPIX
BA	Short-term interest rates	3-month bankers' acceptance rate
G10	Long-term Interest rates	Government bonds 10-years+
DC5	Expected Inflation proxy in first difference	
DBA	Short-term interest rates in first difference	
DG10	Long-term Interest rates in first difference	

All the variables and abbreviations are summarised in Table 2. The empirical results are presented in the following section.

²⁰ Any econometric study of the Fisher effect using CPI would be misleading. If interest rates and inflation were found to be cointegrated it would be impossible to separate whether the relationship was due to the Fisher effect or was the direct link between mortgage rates and CPI outlined above.

5.2 RESULTS

5.2.1 Data generating process

Since the data generating process of the three time series is unknown, both visual inspection and the testing procedure outlined in Seddighi, Lawler and Katos (2000) are used to identify the data generating process (DGP).

5.2.1.1 Visual inspection

Figure 6: Graphic representation of the variables in levels

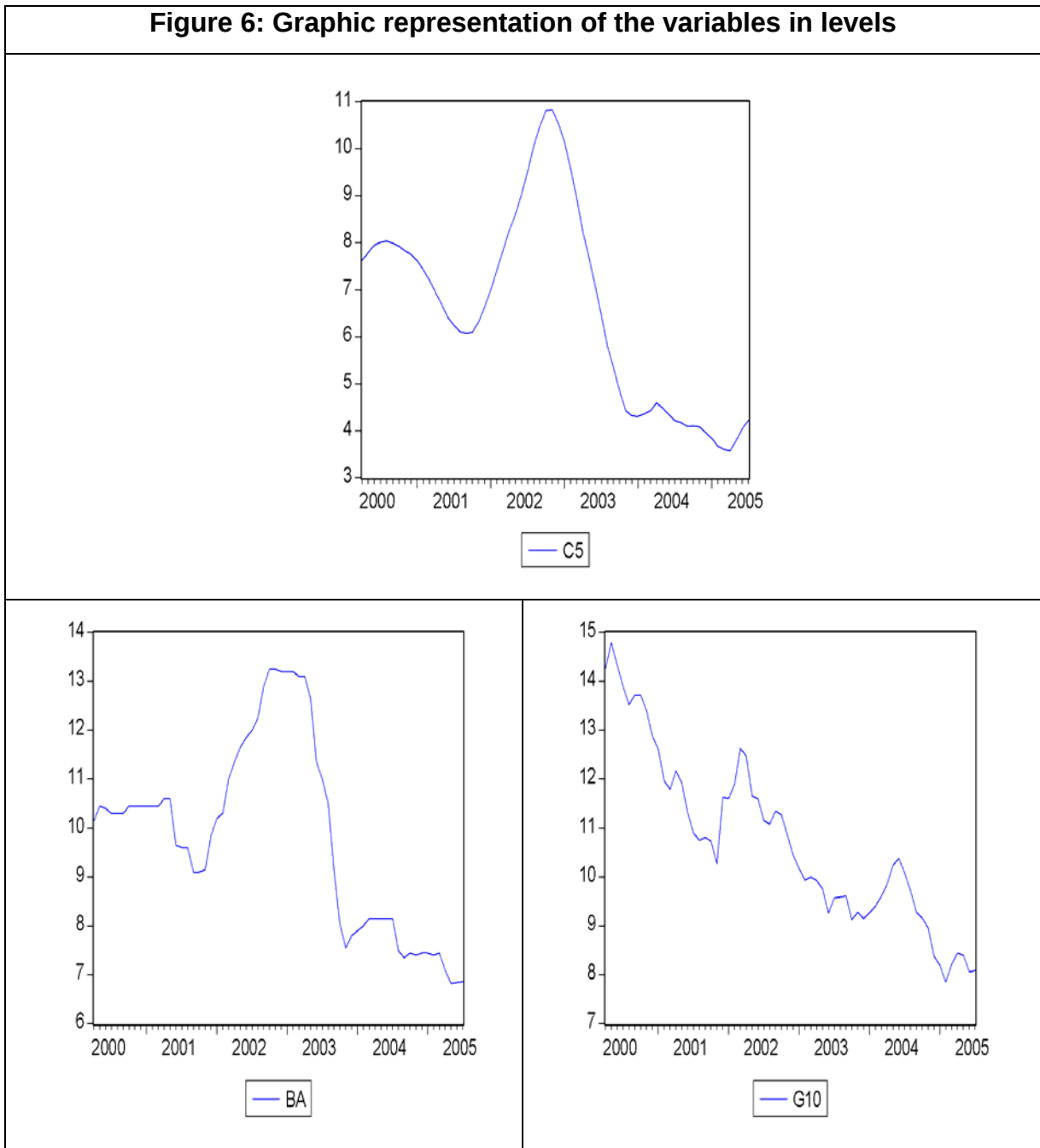
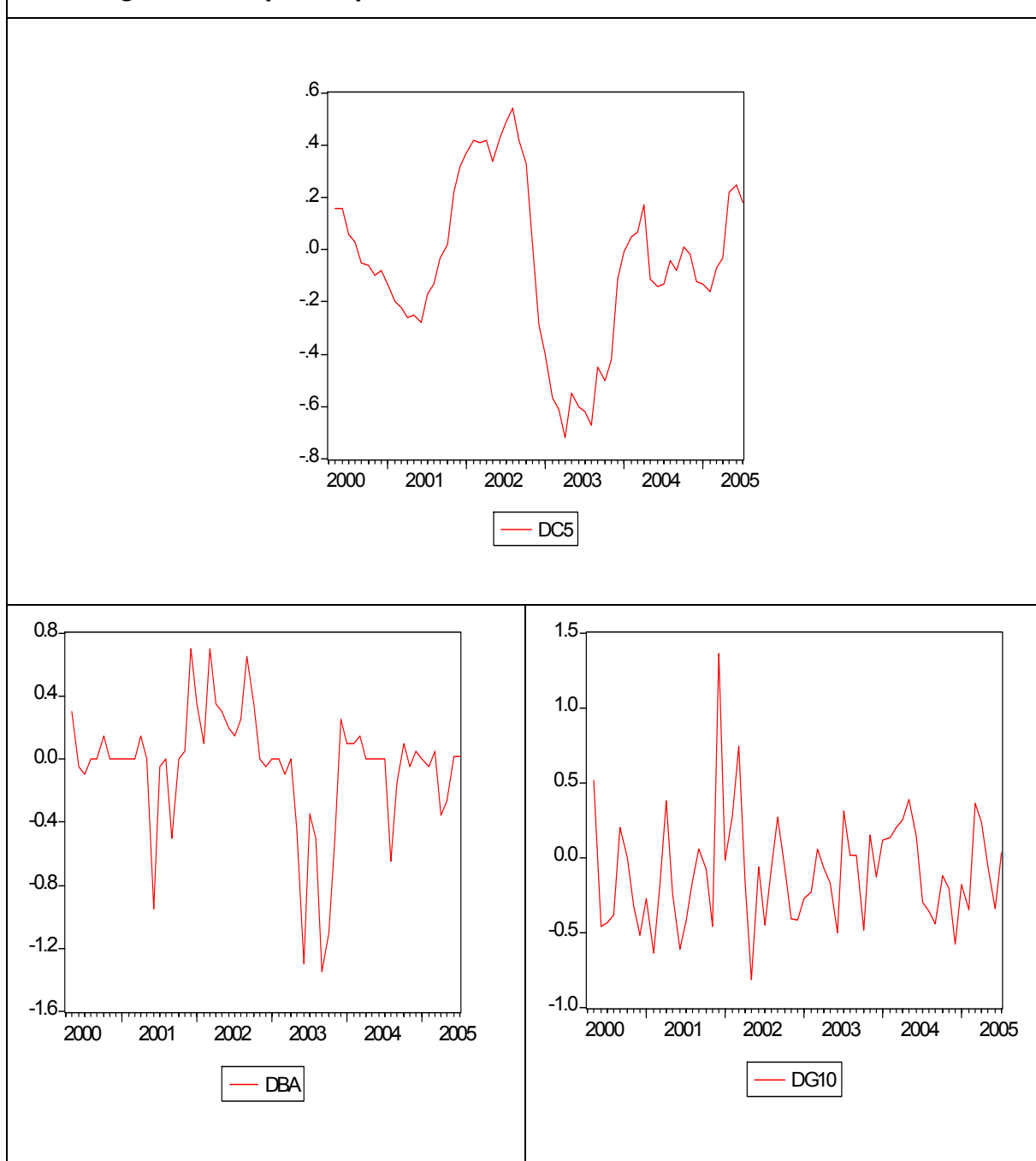


Figure 7: Graphic representation of the variables in first difference



The three variables G10, BA and C5 are presented graphically in level form in Figure 6 and in first difference form in Figure 7. The most noticeable feature on the levels graphs is the peak towards the end of 2001. This peak was primarily due to exchange rate developments that caused inflation to accelerate. It is interesting to observe that both BA and G10 also reflect this acceleration, which

would suggest that nominal interest rates do follow inflation expectations as suggested by Fisher's hypothesis.

Visually BA and C5 both exhibit similar shapes when graphed in levels and do not contain a trend or drift. G10, however, displays a clear downward trend in levels. DG10 and DBA demonstrate typical mean reverting stationary shapes. The DC5 time series would also seem to show signs of mean reversion, but not as clearly as the other two time series. The visual analysis therefore tentatively suggests that all the variables are first-difference stationary, with C5 displaying the only doubtful results. The next step is to verify this conclusion using two formal unit root procedures, the augmented Dickey and Fuller (1979) (ADF) and Phillips and Perron (1988) (PP) tests.

5.2.1.2 Unit root tests

Table 3: ADF - unit root test 2000-2005						
	Trend	Drift	ADF-Statistic 1st Difference	ADF-Statistic levels	Lag Lengths	Order
BA	No	No	-4.243761***	-0.883806	0	I(1)
G10	Yes	Yes	-7.135328***	-2.340651	0	I(1)
C5	No	No	-4.596905***	-1.130321	7	I(1)
*** Indicates significant at 1% Based on SIC						

Table 4: Phillips and Perron - unit root test 2000-2005						
	Trend	Drift	ADF-Statistic 1st Difference	ADF-Statistic levels	Lag Lengths	Order
BA	No	No	-4.224988***	-0.789583	3	I(1)
G10	Yes	Yes	-7.145118***	-2.505814	1	I(1)
C5	No	No	-2.041725**	-0.917321	4	I(1)
*** Indicates significant at 1% ** Indicates significant at 5% Based on the Newey-West using Barlett Kernel						

Tables 3 and 4 report the results of both the augmented Dickey and Fuller (1979) (ADF) and Phillips and Perron (1988) (PP) tests respectively. Using the ADF statistic, the null hypothesis of a unit root is not rejected in all cases for the levels series. Given the existence of a unit root in the interest rate and inflation variables, the next step is to establish the significance of the trend and constant. This is done following the critical hypothesis testing procedure outlined in Chapter 4 and utilising the three symmetric critical τ_{ij} values provided in Dickey and Fuller (1981:1063-1064). Neither the trend nor the drift coefficients were found to be statistically significant for any of the variables. The drift and trend coefficient of the G10 variable though not statistically significant are quite high. Combining this with the visual inspection of the time series suggests that the variable does contain a drift and trend, therefore a drift and trend parameter was included in both the ADF test and PP tests.

The hypothesis of a unit root in the first difference data is rejected at a 1 percent level of significance for all the variables tested for both the ADF and PP tests, indicating that all the variables are $I(1)$. Since all the variables are integrated to the same order we can test whether a long-run relationship exists through cointegration analysis.

5.2.2 Lag length selection

Table 5: Lag length selection			
	LR	AIC	SC
BA & C5	2	2	2
G10 & C5	2	2	2

Table 5 reports the optimal lag length out of a maximum of 6 lag lengths as selected by three different criteria: the Schwarz and Akaike information criteria as well as the Likelihood Ratio (LR) test. Johansen's cointegration approach has

been criticised for being sensitive to the lag length chosen²¹: it is therefore essential that the lag length for both the cointegration analysis and the error-correction model are chosen according to a consistent procedure. When the lag lengths chosen by all three information criteria are the same, this lag length will be used for both the cointegration analysis and error correction model. The lag that produces the most well-behaved model in terms of diagnostic test will be chosen for the error correction model. Therefore the VAR that exhibits normal distributed, homoscedastic and non-serially correlated errors will be chosen.

5.2.3 Deterministic trend assumptions

This Johansen procedure requires that one of five deterministic trend assumptions be chosen for the analysis. The final choice is outlined below and is guided by both economic theory and statistical criteria.

5.2.3.1 Short-term interest rate

The unit root analysis concluded that neither BA nor C5 contain a drift and trend parameter in levels. Economically the equilibrium condition between expected inflation and short-term nominal interest rates is not likely to exhibit trends. This is because short-term interest rates are directly administered by the SARB as part of the monetary policy framework in order to control inflation. The repo rate becomes the primary tool in the framework and is a function of the SARB future inflation forecasts, which at times could be affected by short-run shocks either up or down. However, once the policy action has been implemented the strength and direction of the influence of short-term interest rates on expected inflation through the monetary transmission mechanism is subject to lengthy and sometimes unpredictable lags. The combination of statistical criteria and economic theory suggests that neither the levels data nor the cointegrating

²¹ See Gonzalo (1994:220), Hawtrey (1997:344) and Yuhn (1996:42).

equation display trends. Deterministic trend assumption two is therefore most appropriate for the short-run Fisher effect analysis.

5.2.3.2 Long-term interest rate

The data used in this research corresponds to the early stage of an inflation-targeting framework. In this stage economic theory would suggest that should a cointegration vector exist between long-term interest rates and expected inflation it would trend downwards. This observation is based on the argument presented earlier that as an inflation-targeting monetary policy regimes gains credibility, both actual and expected inflation should decrease, allowing nominal interest rates to also decrease through the Fisher equation. Statistically G10 contains a drift and trend parameter in levels. The long-run Fisher analysis results are therefore based on deterministic trend assumptions that both the time series and the cointegrating equation have linear trends.

5.2.4 Johansen cointegration analysis²²

Table 6 reports the results of the trace test and the maximum eigenvalue test, as well as, the lag length chosen in each case. The trace and maximum eigenvalue tests utilise a sequential testing procedure. If the null hypothesis of at most zero cointegrating relationships is rejected in favour of at most one cointegrating relationship, then in the next step the null hypothesis of at most one cointegrating relationship is tested against the alternative of at most two cointegrating relationships, and so on. Therefore if p is the number of variables (interest rate and expected inflation) and r is the rank (number of cointegrating equations), then the trace test tests the hypothesis that $r \leq p$ against the alternative. The null hypothesis fails to be rejected when the test statistic is smaller than the trace test's critical values. The maximum eigenvalue test tests the null of r cointegrating equation against the alternative of $r+1$ cointegrating equations. The

²² See Appendix B for Eviews results.

null hypothesis fails to be rejected when the test statistic is smaller than the maximum eigenvalue test's critical values (Hawtrey 1997:341).

Table 6: Cointegration analysis			
	Null Hypothesis	G10 & C5	BA & C5
Lags		2	2
Trace	$r = 0$	26.759**	15.548
	$r \leq 1$	5.779	3.866
λ_{max}	$r = 0$	20.980**	11.681
	$r \leq 1$	5.779	3.866
Trace	No. of vectors	1	0
λ_{max}	No. of vectors	1	0
Note: ** Indicates significant at 5%			

The hypothesis of the existence of at most one cointegrating equation ($H_0: r \leq 1$) is not rejected in all cases, whilst the hypothesis of no cointegration ($H_0: r = 0$) is rejected at a 5% level of significance for G10 & C5, and is not rejected in the case of BA & C5. Therefore the analysis concludes that a long-run cointegrating relationship exists between long-term nominal interest rates and expected inflation. Conversely, the existence of a cointegrating relationship is rejected for short-term nominal interest rates and expected inflation.

Since the existence of a long-run relationship has been established between long-term interest rates and expected inflation, the short-run dynamics of the model can be established within an error correction model.

5.2.5 Vector error correction model - long-term interest rate²³

The results from the vector error correction model for long-term interest rates are reported in Table 7. The magnitude and the signs of the adjustment coefficients

²³ See Appendix C for Eviews results.

prove to be plausible. The $\alpha * \beta$ forms the error correction mechanism, α is the term which reflects the speed at which the interest rate shifts to eliminate shocks in inflation within one month. Therefore, the α coefficient indicates how quickly the system re-establishes its long-run equilibrium position (Harris 1995:77-79). The vector error correction model shows the long-term interest rate moving 23 percent in the same month to eliminate the long-run disequilibrium. Therefore it takes just over four months for long-term interest rates to reach full adjustment. The β coefficient is 0.275 and is statistically significant, suggesting that expected inflation and long-term interest rates move in the same direction but less than unity in line with a weak form Fisher hypothesis.

Table 7: VECM results for G10 & C5				
Lags 2	β	α	Adj. R²	R²
G10	1	-0.230531 [-3.37980]	0.141062	0.21264
C5	0.274546 [2.97634]	-0.067345 [-3.27186]	0.898605	0.907055
Residual diagnostic test	Test	Test statistic	d.f	P-Value
Normality test	Doornik-Hansen	2.505258	Jarque-Bera $\chi^2(4)$	0.6437
Serial correlation	Breusch-Godfrey	1.108538	$\chi^2(4)$	0.8929
Heteroskedasticity	White	34.42444	$\chi^2(30)$	0.2642

The vector error correction model is very robust as all the diagnostic tests are insignificant, indicating that the error are normally distributed, homoskedastic, and not serially correlated.

5.2.6 Weak exogeneity test

Since a cointegrating relationship between both nominal long-term interest rates and expected inflation has been established, the final step required to validate the Fisher hypothesis is to verify if inflation is weakly exogenous. If weak exogeneity is accepted for inflation and rejected for interest rates, then it can be

concluded that it is nominal interest rates that respond to movements in inflation expectations. The results of the weak exogeneity test are reported in Table 9.

Table 8: Weak exogeneity results			
Weak exogeneity test on restricted system χ^2	LR test	P-value	Weakly exogenous
Long-term interest rates			
G10 weakly exogenous to system A(1,1)	8.519	0.004	No
C5 weakly exogenous to system A(2,1)	8.040	0.005	No

The weak exogeneity results for long-term interest rates suggest neither C5 nor G10 are weakly exogenous. Therefore, though a long-run relationship exists between both variables, causality does not strictly run from expected inflation to nominal interest rates as suggested by the Fisher hypothesis, instead a two-way causality between the variables is found.

5.3 INTERPRETATION OF THE RESULTS

5.3.1 Short-term interest rate results

The short-run Fisher hypothesis does not hold empirically using South African data during the inflation-targeting monetary policy framework. The most likely explanation for the lack of short-run Fisher effect is because short-term interest rates are not formed by market forces but are artificially determined by monetary authorities as part of the monetary policy framework. Once policy action has been implemented, the short-term real rate of interest is affected either up or down and as a result does not remain constant. Therefore the monetary transmission mechanism causes the short-term real rate of interest to fluctuate contrary to the hypotheses put forward by Fisher.

In Chapter three a more appropriate framework was schematically presented which incorporated the decision making process as well as the transmission

mechanism of monetary policy. This relationship is outlined below, as described in section 3.5.4.

$$\begin{aligned}
 \text{SARB } \pi^e \text{ forecasts (12-24 months ahead)} \uparrow &\Rightarrow \text{repo rate } \uparrow \Rightarrow r_t \uparrow \\
 &\Rightarrow \text{Transmission mechanism } \Rightarrow \pi_{t+(12-24)} \downarrow \Rightarrow \\
 &\pi_{t+(12-24)}^e \downarrow
 \end{aligned} \tag{5.1}$$

This equation can be interpreted in two phases: the decision phase, before policy action is taken, and the transmission mechanism phase, after policy action is taken. In the decision phase (illustrated in 5.2) monetary authorities artificially cause interest rates to move in the same direction as expected inflation, which would be consistent with the causality described by Fisher (1930).

$$\begin{aligned}
 \text{SARB } \pi^e \text{ forecasts (12-24 months ahead)} \uparrow &\Rightarrow \text{repo rate } \uparrow \\
 &\Rightarrow r_t \uparrow
 \end{aligned} \tag{5.2}$$

When policy is actually implemented then the transmission mechanism phase comes into play and causes nominal interest rates and expected inflation to move in opposite directions.

$$r_t \uparrow \Rightarrow \text{Transmission mechanism } \Rightarrow \pi_{t+(12-24)} \downarrow \Rightarrow \pi_{t+(12-24)}^e \downarrow \tag{5.3}$$

Therefore it is the combination of the SARB control over short-term interest rates and the effects of the monetary transmission mechanism which cause the short-run Fisher effect not to hold in South Africa.

5.3.2 Long-term interest rate results

The analysis of long-term interest rates and the expected inflation proxy suggests that a long-run cointegrating relationship exists between the two variables. The long-run coefficient is less than unity, implying that long-term nominal interest

rates adjust less than one-for-one to changes in expected inflation, consistent with a weak form Fisher effect. The weak exogeneity showed that neither of the variables were weakly exogenous, thus both inflation and nominal interest rates respond to changes in each other.

This result is not altogether unanticipated for two reasons. Firstly, the weak exogenous results may simply reflect the complex relationship between expected inflation and nominal interest rates. Movements in expected inflation result in economic agents requiring higher nominal interest rates in compensation for purchasing power losses, which is described by the Fisher hypothesis. Conversely, nominal interest rates cause changes in expected inflation through the transmission mechanism. Equation 5.1 can therefore also be used to illustrate this bi-directional relationship between expected inflation and nominal interest rates. Expectations of future inflation prompt monetary authorities to either increase or decrease the repo rate. However, after policy action is implemented it is interest rates that make up the first part of the monetary transmission mechanism, and which eventually cause actual inflation to increase or decrease and subsequently impact on expected inflation. Secondly, the weak exogeneity results could imply that the real rate of interest is starting to play a more influential role in nominal interest rate movements than inflation expectations. Therefore, as the inflation-targeting framework continues to gain credibility and successfully anchor inflation expectations, it allows the real rate of interest to drive nominal interest rates.

5.4 SUMMARY

All three variables are non-stationary in levels and stationary in first difference according to a combination of visual inspection and two formal unit root tests (ADF and PP). Utilising Johansen cointegration analysis, short-term interest rates and expected inflation provide no evidence of a long-run relationship. However, a long-run cointegrating relationship does exist between long-term

nominal interest rates and both expected inflation measures. The long-run coefficient is less than unity. To determine whether that causality runs from expected inflation to interest rates, a weak exogeneity test was conducted. Weak exogeneity is rejected for the long-run nominal interest rate and inflation rate. Therefore the long-run Fisher hypothesis could not be confirmed in its strictest form.

CHAPTER 6

CONCLUSION

6.1 SUMMARY OF FINDINGS

This thesis presents an empirical investigation into the strength and validity of the Fisher hypothesis using South African data during the SARB's inflation-targeting monetary policy regime. A significant amount of research has been conducted in developed countries to prove and establish this hypothesis, yielding conflicting results. However little has been done to explore this relationship in developing countries which, in contrast to the developed countries studied, tend to have higher and more volatile levels of inflation. The sparse empirical research conducted using data from developing countries is also inconsistent. Three prominent interpretations have emerged in the literature in an attempt to reconcile these inconsistencies. The Mundell-Tobin effect suggests that nominal interest rates should adjust by less than one-for-one to expected inflation, whereas the Darby-Feldstein effect and risk aversion effect proposes a greater than one-for-one movement. Finally, the inverted Fisher effect postulates that it is nominal interest rates that remain constant over time and it is the real interest rate that moves inversely to inflation.

Despite these alternative interpretations, the Fisher hypothesis, in its strictest form, still attracts a significant amount of empirical research. This is largely attributed to the Fisher equation's ability to analyse whether the real rate of interest has remained constant over a given period of time. Due to the infancy of most inflation-targeting monetary regimes, very few previous studies have empirically investigated the Fisher effect using data from an inflation-targeting monetary policy framework. This thesis is therefore an attempt to fill this gap and uncovers a variety of interesting relationships specific to an inflation-targeting regime.

In April 2000 South Africa adopted an inflation-targeting monetary policy framework. One of the main reasons that the SARB shifted from the previous “eclectic” monetary policy approach to a monetary framework that targeted inflation directly was to achieve greater credibility of monetary policy in the “eyes of the public”. The inflation-targeting framework has enjoyed widespread credibility and has made promising steps towards successfully containing inflation.

Against this backdrop the crucial question addressed is the extent to which monetary authorities have been able to affect both the long- and short-term real rates of interest through policy action in an environment where inflation expectations are becoming increasingly firmly anchored. The Fisher equation is therefore used as a behavioural equation to analyse the relationship between expected inflation and both short- and long-term nominal interest rates.

The analysis distinguishes between a short-run Fisher effect and a long-run Fisher effect. The short-run Fisher effect is unlikely to hold empirically, given the effects of the transmission mechanism. This is confirmed by the empirical results, which show no statistically significant long-run relationship between expected inflation and short-term nominal interest rates. This is consistent with the transmission mechanism’s influence on the short-term real rate of interest (see 6.1).

$$\begin{aligned}
 \text{SARB } \pi^e \text{ forecasts (12-24 months ahead)} \uparrow &\Rightarrow \text{repo rate } \uparrow \Rightarrow r_t \uparrow \\
 &\Rightarrow \text{Transmission mechanism} \Rightarrow \pi_{t+(12-24)} \downarrow \Rightarrow \\
 &\pi^e_{t+(12-24)} \downarrow
 \end{aligned} \tag{6.1}$$

The long-run Fisher effect analysis is able to identify whether monetary policy has been able to reduce the long-run real rate of interest. This information is

important to monetary authorities because a reduction in the long-term real rate of interest enables the economy to achieve long-run increases in economic output. Utilising Johansen's maximum likelihood cointegration framework, the results suggest a weak long-run cointegrating relationship between expected inflation and long-term nominal interest rates. This would indicate that the long-term real rate of interest has not remained constant since the inception of inflation-targeting and that monetary policy has actually influenced the long-term real rate of interest. This also implies that changes in inflation expectations do move in the same direction as the long-term nominal interest rate; however the movement is less than unity.

6.2 CONCLUSIONS AND POLICY IMPLICATION

6.2.1 Short-run Fisher effect

Economic agents will only place their long-run faith in monetary policy if the short-run dynamics of the monetary framework work efficiently and in a timely manner. The analysis of short-term interest rates presents an encouraging testament to the effectiveness of the SARB's inflation-targeting framework, and more especially the monetary transmission mechanism in South Africa. It also implies that short-term interest rates are not driven by inflation expectation and are therefore a good indication of the stance of monetary policy in South Africa.

6.2.2 Long-run Fisher effect

The thesis concludes that long-term nominal interest rates are cointegrated with expected inflation. The long-run adjustment is, however, less than unity. This can primarily be attributed to the credibility of the inflation-targeting framework and the success it has achieved in locking inflation expectations into the target range, thereby ensuring that the expected inflation premium required by economic agents to compensate them for the inflationary erosion of nominal money

balances remain relatively low and stable. Economic agents do not require nominal interest rate movements to fully adjust to changes in expected inflation because inflation is not perceived to remain at abnormally high or low levels. If, for example, an acceleration of the currency causes inflation expectations to increase beyond the mid-point of the target range, economic agents would feel confident that this impact would only be transitory due to the effectiveness of monetary policy.

Applying a similar argument, the weak long-run Fisherian relationship may be indicative of the increasingly influential role that the long-term real rate of interest is having on nominal interest rates. This scenario is even more compelling given the length and success of South Africa's inflation-targeting regime. The results may therefore advocate that the SARB is beginning to evolve into the second evolutionary stage of an inflation-targeting regime. This stage is characterised by nominal interest rates that primarily reflect movements in the long-term real rate of interest rather than the relatively constant expected rate of inflation (see 6.2).

$$i_t \downarrow = r_t \downarrow + \pi_t^e \quad (6.2)$$

The Mundell-Tobin effect postulates that due to the impact of inflation on real money balances, economic agents would rather hold other assets and this reduction in money balances causes a less than unity adjustment of nominal interest rates. Rather than concluding in favour of this hypothesis put forward by Mundell (1963) and Tobin (1965), this thesis has credited the weak long-run relationship between long-term nominal interest rates and expected inflation to the effectiveness of inflation-targeting in the eyes of the public. To a certain extent the Mundell-Tobin effect may well play a role in South Africa; however in an environment where inflation is becoming more securely anchored the

migration of individuals' wealth from real money balances to other hedge assets is less likely to occur.

6.3 LIMITATIONS AND FUTURE RESEARCH

The study suffered from two limitations. Firstly, although the results are generally robust, the Johansen procedure was found to be sensitive to lag length chosen. Various authors including Gonzalo (1994:220), Hawtrey (1997:344) and Yuhn (1996:42) have all also reported similar sensitivity. Secondly, a major challenge in all empirical investigations of the Fisher effect is that inflation expectations are not directly observable. Although there are various approaches available within the South African context, not all are available or have an appropriate length to be used in this study.

Since the adoption of inflation-targeting there has been an increased importance placed on developing accurate expected inflation forecasts. This has spurred an increase in the number of inflation expectations time series available for use in future empirical econometric studies, thereby presenting exciting research opportunities, not only for future Fisherian studies but also for explorative analysis into the relationship between expected inflation and actual inflation. Due to the crucial role played by expectations of future inflation in all policy decisions, further insight into the dynamics of inflationary expectations will provide valuable information for monetary authorities.

APPENDIX A: LITERATURE SUMMARY

Table A: Literature review

Author/country	Date	Econometric technique	Expected inflation proxy	Period	Fisher effect	Short- run Fisher effect
Argentina						
Carneriro, Divino & Rocha*	2002	Johansen	REH, Moving Average	1980-1997	Accepted	
Jorgensen and Terra*	2003	Four variable VAR	CPI	1977-1999	Accepted	
Phylaktis & Blake*	1993	E&G	REH and EMH	1971-1987	Accepted	
Australia						
Hawtrey	1997	Johansen	REH and EMH	1969-1994	Rejected	
Hawtrey	1997	Johansen	REH and EMH	1969-1983	Rejected	
Hawtrey	1997	Johansen	REH and EMH	1984-1994	Accepted	
Inder & Silvapulle	1993	OLS, H&P, ECM estimator	REH and EMH	1965-1990	Rejected	
Mishkin & Simon	1995	E&G	REH and EMH	1962-1993	Accepted	Rejected
Mishkin & Simon	1995	E&G	REH and EMH	1962-1979	Accepted	Rejected
Mishkin & Simon	1995	E&G	REH and EMH	1979-1993	Accepted	Rejected
Olekalns	1996	OLS, ARCH and Maximum likelihood estimation	CPI	1969-1993	Accepted - (weak)	
Olekalns	1996	OLS, ARCH and Maximum likelihood estimation	CPI	1983-1993	Accepted	
Belgium						
Choudhry*	1997	E&G and H&I	CPI	1955-1994	Rejected (Inverted)	
Brazil						
Carneriro, Divino and Rocha*	2002	Johansen	REH, Moving Average	1980-1998	Accepted	
Garcia	1993	Regression(OLS)	CPI	1973-1990	Accepted	
Jorgensen & Terra*	2003	Four variable VAR	CPI	1977-1999	Rejected	
Phylaktis & Blake*	1993	E&G	REH and EMH	1979-1991	Accepted	
Canada						
Atkins & Serletis *	2002	Pesaran <i>et al.</i>	CPI	1880-1983	Rejected	
Atkins & Sun	2003	Discrete wavelet transform	CPI	1959-2002	Accepted	Rejected
Atkins & Coe*	2002	Pesaran <i>et al.</i>	CPI	1953-2000	Accepted	
Crowder	1997	Johansen	ARMA	1960-1991	Accepted	
Dutt & Ghosh	1995	J&J, P&H	CPI	1960-1993	Accepted (weak)	Rejected (strong)
Ghazali & Ramlee*	2003	ARFIMA	CPI	1974-1996	Rejected	
Ghazali & Ramlee*	2003	OLS	CPI	1974-1996	Accepted	
Lardic & Mignon*	2003	F.C. Granger	CPI	1970-2005	Accepted	
Yuhn*	1996	Johansen	REH, Moving Average	1973-1993	Rejected	Rejected
Chile						
Jorgensen & Terra*	2003	Four variable VAR	CPI	1977-1999	Rejected	
Colombia						
Jorgensen & Terra*	2003	Four variable VAR	CPI	1977-1999	Rejected	
Denmark						
Engsted	1996	VAR model	CPI	1948-1989	Rejected(no tax)	Accepted (tax)
Finland						
Junttila	2001	Johansen	ARIMA	1987-1996	Rejected	

France						
Choudhry*	1997	E&G and H&I	CPI	1955-1994	Rejected (Inverted)	
Ghazali & Ramlee*	2003	ARFIMA	CPI	1974-1996	Rejected	
Ghazali & Ramlee *	2003	OLS	CPI	1974-1996	Accepted	
Lardic & Mignon*	2003	F.C. Granger	CPI	1970-2004	Accepted	
Germany						
Choudhry*	1997	E&G and H&I	CPI	1955-1994	Rejected (Inverted)	
Ghazali & Ramlee*	2003	ARFIMA	CPI	1974-1996	Rejected	
Ghazali & Ramlee*	2003	OLS	CPI	1974-1996	Accepted	
Lardic & Mignon*	2003	F.C. Granger	CPI	1970-2006	Rejected	
Yuhn*	1996	Johansen	REH, Moving Average	1973-1993	Accepted	Accepted
Italy						
Atkins & Serletis*	2002	Pesaran <i>et al.</i>	CPI	1880-1985	Rejected	
Ghazali & Ramlee*	2003	ARFIMA	CPI	1974-1996	Rejected	
Ghazali & Ramlee*	2003	OLS	CPI	1974-1996	Accepted	
Lardic & Mignon*	2003	F.C. Granger	CPI	1970-2007	Accepted	
Miyagawa & Morita*	2003	K&W	GDP deflator	1975-1998	Rejected	
Muscatelli & Spinelli	2000	Johansen	CPI	1948-1993	Accepted	
Japan						
Ghazali & Ramlee*	2003	ARFIMA	CPI	1974-1996	Rejected	
Ghazali & Ramlee*	2003	OLS	CPI	1974-1996	Accepted	
Lardic & Mignon*	2003	F.C. Granger	CPI	1970-2003	Accepted	
Miyagawa & Moritai*	2003	K&W	CPI	1976-1989	Rejected	
Yuhn*	1996	Johansen	REH, Moving Average	1973-1993	Accepted	Rejected
Mexico						
Carneriro, Divino & Rocha*	2002	Johansen	REH, Moving Average	1980-1999	Rejected	
Jorgensen & Terra*	2003	Four variable VAR	CPI	1977-1999	Accepted	
Phylaktis & Blake*	1993	E&G	REH and EMH	1972-1984	Accepted	
Thornton	1996	Johansen	CPI	1978-1994	Accepted	
Norway						
Atkins & Serletis*	2002	Pesaran <i>et al.</i>	CPI	1880-1986	Rejected	
Peru						
Jorgensen & Terra*	2003	Four variable VAR	CPI	1977-1999	Rejected	
South Africa						
Wesso	2000	Johansen	CPI	1985-1999	Accepted	
Spain						
Esteve , Bajo-Rubio , Diaz-Roldan	2004	H&S	CPI	1963-2002	Accepted	
Sri Lanka						
Cooray	2002/3	Johansen	Forecasting Model	1952-1998	Rejected	
Sweden						
Atkins & Serletis *	2002	Pesaran <i>et al.</i>	CPI	1880-1986	Rejected	
Miyagawa & Morita *	2003	K&W	GDP deflator	1963-2001	Rejected	
Turkey						
Aksoy & Kutan	2002	GARCH	CPI	1996-2001	Rejected	
UK						
Atkins & Serletis*	2002	Pesaran <i>et al.</i>	CPI	1880-1987	Rejected	
Berument	1999	ARCH	CPI	1958-1994	Accepted	
Esteve, Bajo-Rubio & Diaz-Roldan	2003	S&W	GDP deflator	1961-2001	Accepted	
Ghazali & Ramlee*	2003	ARFIMA	CPI	1974-1996	Rejected	
Ghazali & Ramlee*	2003	OLS	CPI	1974-1996	Accepted	
Koustas & Serletis*	1999	K&W	CPI		Accepted	
Lardic & Mignon*	2003	F.C. Granger	CPI	1970-2002	Accepted	
Yuhn*	1996	Johansen	REH, Moving Average	1973-1993	Rejected	Rejected

USA						
Atkins & Serletis *	2002	Pesaran <i>et al.</i>	CPI	1880-1983	Rejected	
Atkins & Sun	2003	Discrete wavelet transform	CPI	1959-2003	Accepted	Rejected
Atkins & Coe*	2002	Pesaran <i>et al.</i>	CPI	1953-1999	Accepted	
Barsky	1987	Regression(OLS)	CPI	1860-1939	Rejected	
Barsky	1987	Regression(OLS)	CPI	1950-1979	Accepted	
Carlson	1977	Regression+ business cycle variable	Survey Method	1953-1971	Rejected	
Chu, Pittman & Yu	2003	Johansen	(real interest rate) TIIS	1999-2001	Accepted	
Fahmy & Kandil	2003	Johansen	CPI	1980's & 1990's	Accepted	
Fama,	1975	Regression	REH and EMH	1953-1971	Accepted	
Ghazali & Ramlee*	2003	ARFIMA	CPI	1974-1996	Rejected	
Ghazali & Ramlee*	2003	OLS	CPI	1974-1996	Accepted	
Hsing	1997	Regression within a IS-LM Framework	Adaptive	1960-1993	Rejected	
Hsing	1997	Regression within a IS-LM Framework	Livingston Survey	1960-1994	Accepted	
Laatsch & Klien	2002	Regression	Break-Even	1997-2001	Accepted	
Lardic & Mignon*	2003	F.C. Granger	CPI	1970-2001	Accepted	
Lee, Clark & Ahn	1998	Granger causality, R&A and A&R	REH and EMH	1953-1990	Accepted	Rejected
Lee, Clark & Ahn	1998	Granger causality, R&A and A&R	REH and EMH	1953-1979	Accepted	Accepted
Lee, Clark & Ahn	1998	Granger causality, R&A and A&R	REH and EMH	1979-1982	Rejected	Rejected
Lee, Clark & Ahn	1998	Granger causality, R&A and A&R	REH and EMH	1982-1990	Rejected	Rejected
Mishkin	1992	E&G	REH, Moving Average	1953-1990	Accepted	Rejected
Nelson & Schwert	1977	Regression	Extrapolative	1953-1975	Rejected	
Peláez	1995	Engle and Granger	CPI	1959-1993	Rejected	
Peláez	1995	Johansen	CPI	1959-1993	Rejected	
Tanzi	1980	Regression(OLS)	Survey, Adaptive, Distributed, Extrapolative	1952-1975	Rejected	
Wallace & Warner	1993	Johansen	REH and EMH	1948-1990	Accepted	Accepted
Wallace & Warner	1993	Johansen	REH and EMH	1953-1990	Accepted	Accepted
Wallace & Warner	1993	Johansen	REH and EMH	1953-1979	Rejected	Accepted
Wallace & Warner	1993	Johansen	REH and EMH	1953-1971	Accepted	Rejected
Yuhn*	1996	Johansen	REH, Moving Average	1973-1993	Accepted	Rejected
Yuhn*	1996	Johansen	REH, Moving Average	1979-1993	Accepted	
Yuhn*	1996	Johansen	REH, Moving Average	1982-1993	Accepted	

* indicates more than one country included in study.

ARFIMA=Autoregressive fractionally integrated moving average;

A&R= Ahn and Reinse cointegration analysis (1990);

E&G= Engle & Granger (1987);

F.C Granger= Granger fractional cointegration analysis (1986);

H&P=Fully modified OLS estimator of Hansen and Phillips (1990);

H&I=Harris & Inder cointegration analysis (1994);

H&S= Hansen & Seo's threshold cointegration (2002);

Johansen= Johansen cointegration analysis (1988, 1991, 1992, 1995)

J&J= Johansen & Juselius cointegration analysis (1990,1992);

K&W= King and Watson non-structural bivariate autoregressive methodology (1997);

Pesaran *et al.*= Pesaran, M. H., Shin, Y. and Smith, R.J. (2001) ARDL bound;

R&A= Reinsel and Ahn cointegration analysis (1992);

S&W= Stock & Watson (DOLS) dynamic ordinary least squares (1993);

APPENDIX B: JOHANSEN COINTEGRATION ANALYSIS

Table B1: Eviews cointegration results - BA & C5

Date: 03/13/06 Time: 12:37

Sample (adjusted): 2000M07 2005M07

Included observations: 61 after adjustments

Trend assumption: No deterministic trend (restricted constant)

Series: BA C5

Lags interval (in first differences): 1 to 2

Unrestricted cointegration rank test (trace)

Hypothesized no. of CE(s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.**
None	0.174287	15.54823	20.26184	0.1966
At most 1	0.061414	3.866240	9.164546	0.4324

Trace test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted cointegration rank test (maximum eigenvalue)

Hypothesized no. of CE(s)	Eigenvalue	Max-eigen statistic	0.05 critical value	Prob.**
None	0.174287	11.68199	15.89210	0.2052
At most 1	0.061414	3.866240	9.164546	0.4324

Max-eigenvalue test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted cointegrating coefficients (normalized by $b^*S_{11}b=I$):

BA	C5	C
-2.222749	2.313248	6.533416
1.537584	-0.937205	-8.704830

Unrestricted adjustment coefficients (alpha):

D(BA)	0.088853	-0.041823
D(C5)	-0.024939	-0.020384
1 Cointegrating equation(s):	Log likelihood	51.74435
Normalized cointegrating coefficients (standard error in parentheses)		
BA	C5	C
1.000000	-1.040715	-2.939341
	(0.07308)	(0.50877)
Adjustment coefficients (standard error in parentheses)		
D(BA)	-0.197498	
	(0.07624)	
D(C5)	0.055433	
	(0.02927)	

Table B2: Eviews cointegration results - G10 & C5

Date: 02/22/06 Time: 16:25

Sample (adjusted): 2000M07 2005M07

Included observations: 61 after adjustments

Trend assumption: Linear deterministic trend (restricted)

Series: G10 C5

Lags interval (in first differences): 1 to 2

Unrestricted cointegration rank test (trace)

Hypothesized no. of CE(s)	Eigenvalue	Trace statistic	0.05 critical value	Prob.**
None *	0.291029	26.75937	25.87211	0.0387
At most 1	0.090388	5.778993	12.51798	0.4889

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted cointegration rank test (maximum eigenvalue)

Hypothesized no. of CE(s)	Eigenvalue	Max-eigen statistic	0.05 critical value	Prob.**
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None *	0.291029	20.98038	19.38704	0.0291
At most 1	0.090388	5.778993	12.51798	0.4889

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted cointegrating coefficients (normalized by $b'S_{11}b=I$):

G10	C5	@TREND(00M05)
1.598718	0.438921	0.151173
-1.062678	0.548507	-0.040621

Unrestricted adjustment coefficients (alpha):

D(G10)	-0.144198	0.066863
D(C5)	-0.042124	-0.020816

1 Cointegrating equation(s): Log likelihood 40.37350

Normalized cointegrating coefficients (standard error in parentheses)

G10	C5	@TREND(00M05)
1.000000	0.274546	0.094559
	(0.09224)	(0.00989)

Adjustment coefficients (standard error in parentheses)

D(G10)	-0.230531
	(0.06821)
D(C5)	-0.067345
	(0.02058)

APPENDIX C: VECTOR ERROR CORRECTION MODEL

Table C1: Eviews VEC results G10 & C5

Vector error correction estimates

Date: 02/22/06 Time: 16:33

Sample (adjusted): 2000M07 2005M07

Included observations: 61 after adjustments

Standard errors in () & t-statistics in []

Cointegrating Eq:	CointEq1	
G10(-1)	1.000000	
C5(-1)	0.274546 (0.09224) [2.97634]	
@TREND(00M04)	0.094559 (0.00989) [9.56078]	
C	-15.57465	
Error correction:	D(G10)	D(C5)
CointEq1	-0.230531 (0.06821) [-3.37980]	-0.067345 (0.02058) [-3.27186]
D(G10(-1))	0.168401 (0.12296) [1.36960]	0.031790 (0.03710) [0.85678]
D(G10(-2))	0.001090 (0.12110) [0.00900]	0.036383 (0.03654) [0.99564]
D(C5(-1))	-0.147246 (0.43388) [-0.33937]	1.070850 (0.13093) [8.17871]
D(C5(-2))	0.529645 (0.47765) [1.10885]	-0.081922 (0.14414) [-0.56835]
C	-0.059384	0.006537

	(0.04709)	(0.01421)
	[-1.26109]	[0.46001]
R-squared	0.212640	0.907055
Adj. R-squared	0.141062	0.898605
Sum sq. resids	6.106983	0.556124
S.E. equation	0.333221	0.100555
F-statistic	2.970739	107.3491
Log likelihood	-16.36130	56.72272
Akaike AIC	0.733157	-1.663040
Schwarz SC	0.940784	-1.455413
Mean dependent	-0.102295	-0.060984
S.D. dependent	0.359543	0.315788
Determinant resid covariance (dof adj.)		0.001122
Determinant resid covariance		0.000912
Log likelihood		40.37350
Akaike information criterion		-0.831918
Schwarz criterion		-0.312851

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