Essays on the Impact of Inflation Targeting in South Africa

By

Irrshad Kaseeram

Student No. 201001590

Submitted to the Faculty of Commerce, Administration and Law in Fulfilment of the Requirements for the D Com (Economics) Degree

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Supervisor: Professor E Contogiannis

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Declaration

I, the undersigned, hereby acknowledge that the contents of this thesis is my own work, except where otherwise specified, and has not been submitted, in part or full, to any other University for the purpose of obtaining a degree.

Irrshad Kaseeram (March 2012)

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Abstract

Through the literature review this study points out the debate as to whether inflation targeting (IT) has been effective in anchoring expectations, stabilizing output, reducing the inflation rate, and the volatility and persistence of inflation, is still an open question. Further, this study asserts that perhaps the perceived success of IT is nothing more than just 'conservative window dressing' (ie., raising interest rate to maintain low inflation at the expense of output losses).

In the form of three separate essays this study attempts to contribute to the above debate about the effectiveness of IT and the conservative monetary policy assertion. The first essay undertakes a detailed econometric investigation into whether the inflation expectations of the various market players (viz., financial analysts, business executives and trade unionists) are anchored to an inflation target, and if so then it would imply that they find the central bank's IT framework to be credible (termed the credibility proposition). However, if expectations are not anchored to the target then it implies that agents do not find the central bank's IT policy to be credible. When the inflation and expectations data are stationary then the credibility proposition can be tested using the Cruijsen and Demertzis, (2010) vector autoregression framework, but when the mentioned data are nonstationary, as is the case of South Africa, then the Johansen (1991) cointegration and vector error correction modelling techniques must be used. The study found that only financial analysts tend to find the South African Reserve Bank's IT framework to be credible while business executives and trade unionists do not find this policy framework to be credible.

The second essay attempts to investigate whether inflation volatility and inflation persistence have declined since the adoption of IT, since IT purports to anchor expectations around a target or target band, thereby reducing inflation volatility and inflation persistence. This study contributes to the debate by examining South Africa's IT performance in respect of inflation volatility and inflation persistence using the generalized autoregressive conditional heteroscedasticity (GARCH), GARCHM (-in mean) and AR (2) (second order autoregressive model) methodologies. In order to avoid erroneous conclusions the study accommodates for structural breaks in the data using the Bai and Perron, (2003), the Lee and Strazicich (2003), the Andrews and Ploberger (1994) and the Lumsdaine and Papell (1997) unit root tests. The study found no significant changes in inflation volatility and persistence over the pre and post IT periods.

The third essay estimates forward-looking hybrid Taylor-type reaction functions using the general method of moments (GMM) technique. as was estimated by Clarida, Gertler and Gali (1998), Gerdesmeier and Roffia (2003), Hayo and Hofmann (2005). The results showed that over the IT period, South Africa followed a conservative (high weighting on inflation reduction and low weightings on output deviation in setting the repo rate) predictable monetary policy.

The study also presented case studies of the IT experiences of Chile, Brazil, Turkey and compared them to South Africa. The findings suggest that in all the countries, IT is effective in reducing inflation and achieving sustainable economic growth. However, whether IT is effective in reducing inflation expectations, volatility and persistence and stabilizing output close to its normal levels, from a statistical perspective is still an open question.

A synthesis of the three essays suggest that the authorities have not succeeded in convincing price and wage setters that IT can credibily maintain inflation within the target band, hence inflation and inflation volatility persists. Moreover the success of inflation targeting is hinged on raising the repo rate to prevent the second round effects of supply shocks (eg., oil price hikes, exchange depreciations) from manifesting itself, however the effect of this policy stance is at the expense of output stabilization, which poses challenges for the transformation of monetary policy in the future..

Dedication

In memory of my mother and
first teacher
Tara Buddia Vanthee,

Acknowledgements

I am forever grateful to my supervisor Prof Eleftherios Contogiannis, for the time, patience and tremendous effort he put into ensuring that the disertation was completed timeously. Without his dedicated support and interventions at the final stages of completion, it would have not been possible for me to complete timeously. Moreover I truly appreciate the long scintillating converstions we have had over the last three years, where he enthusiastically and generously shared his fourty years of experience in the discipline with me.

My heartfelt gratitude goes to all the guys in the NA fellowship who placed me firmly on the spiritual path and who shared their love strength and hope with me in the darkest of times.

My deepest thanks goes to my family (Victor, Sham, Haalah and Folla) whose constant love, prayer and blessings saw me through this arduous journey. I am much obliged to my adopted families with include that of Deneshan Padayachee, Deelan Naidoo, Tony Swaminathan and Riaz Jogiat, for their dedicated love and support.

My sincere appreciation goes to all the Faculty staff and students that urged me on to the final completion of dissertation, notable amonst them are Augustine Williams, Prof Myrtle Hooper, Prof Kathy Nel, Marlene Muller, Michelle Jugmohan, Carl Mayeza, Prof Adwale Banjo, Prof Bijoy Shrestha (retired), Prof Sathie Moodley (retired), Prof Mark Livingstone, Mr Themba Mngomezulu, Dr Chis Isike, Dr Nicole Dodd, Prof Nan van den Bergh (retired), my current Honours students and many many others.

I am most appreciatve of the love and support I received from my two very special friends, Karen Enslin and Rekha Dunpall. I am grateful to Karen for all the complicated typing and general technical ITC support.

I am also profoundly grateful to the African Finance Journal for publishing two of the papers from this dissertation viz., Kaseeram (2010) and Kaseeram and Contogiannis (2011). Last but not least, I am grateful to the Senate Research Committee for their commitment in developing research capacity among staff and students, without their generous grants, compilation of this study would not have been possible.

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List of Acronyms Used

AR(d) d order Autoregressive Model, eg., AR(2) is a Second Order Autoregressive Model

ADF – Augmented Dickey Fuller Test

ANC – African National Congress

BCB – Central Bank of Brazil

BRSA – Banking Regulation and Supervision Agency of Brazil

DF – Dickey Fuller

DFGLS – DF with Generalized Least Squares Detrending

CBC – Central Bank of Chile

CBT – Central Bank of Turkey

CMN – National Monetary Council of Brazil

COPOM – The BCB Monetary Policy Committee

COSATU – Congress of South African Trade Unions

CPI – Consumer Price Index

CPIX – underlying CPI that excludes mortage payments

ECM – Error Correction Model (or Mechanism)

ERS – Elliot, Rothenberg and Stock Point Optimal Test

EMU – Economic and Monetary Union

GARCH – Generalized Autoregressive Conditional Heteroscedasticity

GARCH-M - Generalized Autoregressive Conditional Heteroscedasticity in Mean

GDP – Gross Domestic Product

GLS – Generalized Least Squares

HPF – Hodrick Prescott Filter

IMF – International Monetary Fund

IT – Inflation Targeting

IPSA – Extensive National Consumer Price Index of Brazil

IS-PC-MR – Investment Savings/Phillips Curve/Monetary Rule

ITMPF – Inflation Targeting Monetary Policy Framework

KPSS – Kwiakowski, Philips, Schmidt and Skin Test

LDC Less Developed Countries

MPC – Monetary Policy Committee

NEDLAC – National Economic Development and Labour Council

NOFP – Net Open Forward Position

OECD – Organisation for Economic Cooperation and Development.

OLS – Ordinary Least Squares

PP – Phillips Perron Test

SACOB – South African Chamber of Business

SARB - South African Reserve Bank

UK – United Kingdom

USA – United States of America

US – United States

VAR – Vector Autoregression (model)

VECM – Vector Error Correction Model

Chapter One – Introduction

In February 2000, South Africa adopted the inflation targeting monetary policy framework (ITMPF) for the purposes of creating an environment conducive to low stable inflation. The primary focus of this study is to undertake rigorous econometric analyses of the impact, this new policy stance has had on three key variables, viz., private agents' expectations, actual inflation and the repo rate. The econometric analyses will be presented in the form of three essays; the first essay will investigate the inflation expectations formation behaviour of private agents and will infer therefrom their perceptions regarding central bank credibility; the second essay will assess the shift in volatility and persistence of monthly inflation rate over the pre-and-post inflation targeting periods; while the third essay will investigate the forward-looking nature of the central bank's policy reaction function that explains the setting of the policy instrument, in response to anticipated inflation. Moreover, by examining the coefficients of the policy reaction function, the third essay will also attempt to characterize central bank behaviour by assessing the relative weights placed on the variability of inflation, output and real exchange rates from their respective targets. The rest of this chapter is structured as follows: first a succinct account of the price stability objective will be presented followed by a definition of inflation targeting as a policy framework and thereafter a rough sketch regarding the industrialized and emerging economies that have adopted inflation targeting is provided. Then brief motivations and insights into the literature, econometric models, data issues and research questions to be investigated in each of the three essays are presented. As a penultimate task, a short account of the value of the research to the different interest groups is given. Finally an outline for each of the remaining chapters of this study is undertaken.

There is a general consensus that low, stable inflation should be the chief objective of monetary policy, especially since price stability is considered by main stream economists as a necessary precondition for faster sustainable growth. Stability is essential for creating an environment that is conducive for the long-term financing of government and private sector debt including labour intensive industries such as construction and small to medium enterprises. However long term planning requires agents to view central bank's forecast of inflation and policy stance in curtailing inflationary pressures as being credible (Bevilaqua, Mesquita & Minella, 2008; Meyer, 2002).

The inflation targeting (IT) monetary policy framework is considered by many mainstream economists as the ideal vehicle for achieving the low, stable inflation objective. Throughout this study the Bernanke, Laubach, Mishkin and Posen (1999) definition of IT will be followed, where IT is described as a framework of monetary policy characterized by the public announcement of official quantitative targets or target ranges for the inflation rate over one or more future periods, and by the explicit acknowledgement that low and stable inflation is the primary long run goal of monetary policy. Moreover IT involves the monetary authority's systematic communication with the public about the plans and objectives of monetary policy and in many instances the mechanisms that strengthen the Central Bank's accountability for attaining those objectives.

In line with the above price stability objective, in 1990, New Zealand was the first country to adopt IT and the overwhelming success it had achieved in regard to inflation and real economy stability, soon led to other countries following suite; Canada in 1991, United Kingdom (UK) in 1992, Sweden, Australia and Finland in 1993. Between 1997 and 2000 the first group of emerging economies, which included in chronological order Israel, Czech Republic, Poland, Brazil, Chile, Colombia, South Africa and Thailand, adopted IT. In 2007 Ghana was the second African country to join the IT club. Presently about 26 countries are explicit inflation targeters, approximately half of them are emerging market or low income economies, while a number of central banks in more advanced economies – including the European Central Bank, the US Federal Reserve, the Bank of Japan and the Swiss National Bank – are widely regarded as implicit inflation targeters since they have adopted many elements of IT and several others are moving towards it (Roger, 2010).

The price stability objective mentioned above became synonymous with anchored expectations. For example Greenspan (1994) asserts that price stability is attained when households and businesses need not factor expectations of changes in the average level of prices into their decisions. An IT policy perceived to be credible by economic agents results in the anchoring of expectations (ie., less-dispersed expectations) to a target that may reduce the variance in relative prices, which in turn can reduce the level of inflation (Ball and Mankiw, 1995). In the same vein, Orphanides and Williams (2005) explain that firms and individuals may rely on expected inflation to set prices and which may result in inflation being less persistent. Additionally the anchoring of expectations to a target enhances the expectations channel of monetary transmission. A number of studies present strong empirical

evidence that an explicit numerical inflation target anchors and stabilizes expectations, see for example, Batini and Laxton (2007), Gurkaynak, Levin, Marder and Swanson (2007), Gurkaynak, Levin, and Swanson (2006), Levin, Natalucci and Piger (2004) and Johnson (2002)

In particular Gurkaynak, Sack, and Swanson (2005) compared the behaviour of daily bond yield data in the UK and Sweden (both inflation targeters) and the United States (US) which is a non-inflation targeter. They use the difference between far-ahead forward rates on nominal and inflation –indexed bonds as a measure of compensation for expected inflation and inflation risk at long horizons (since under IT expectations are believed to co-inside with the target over the long term). For the US, they discovered that the forward inflation compensation exhibits highly significant responses to economic news. They noted that the UK data demonstrated a similar level of sensitivity to that of the US prior to the Bank of England gaining independence in 1997, but noted a striking absence of such sensitivity since the central bank became independent. Sweden also demonstrated a lack of sensitivity to economic news, hence they concluded that a well-communicated and credible inflation target helps to anchor private agents' long run inflation expectations. Reid (2009) replicated the Gurkaynak *et al.* (2005) study for South Africa and found that the data also exhibited a lack of sensitivity to economic news. Another strand of the inflations expectations research which is of relevance to this study is the paper by Cruijsen and Demertzis (2010), who use a bivariate VAR model involving inflation and expected inflation to demonstrate that credible monetary policy has succeeded in breaking the link between actual inflation and long run expectations of inflation for a group of member countries belonging to the European Union (EU). Within the VAR framework they seek to establish causal relationships between actual and expected inflation and they also examine the covariance matrix to see whether shocks from one variable affect the other. They reasoned that under conditions of perfect credibility there is no long run relationship between inflation and expectations (ie., all causality hypotheses are rejected) and that shocks in one variable does not affect the other (ie., covariances are zero). The first essay in this study will replicate the Cruijsen and Demertzis paper in the South African context, but with one significant difference: not just overall expectations (as in the EU case) will be used but also the expectations of the different subsectors of private agents, viz., financial analysts, business executives and trade unionists will also be employed. The results from this approach should provide some insights as to which subsectors of private agents view the South African Reserve Bank's IT policy as being credible. As far as this study is concerned, no studies, as yet, have used the Cruijsen and

Demertzis approach to study disaggregated data. However, the findings of the bivariate VAR approach for the South African data might be spurious since all the mentioned data are non-stationary. The data were found to be I(1) or integrated of order one, upon first differencing they were rendered stationary or I(0). Hence the first essay of this study employs the Johansen (1988, 1991) and Johansen and Juselius (1992) vector error correction methodology to assess the dynamic short and long run relationships between inflation and the various subsectoral measures of expectations. This part of the study makes two original contributions to the field, firstly in section 2.3.3 of chapter two (presentation of theory), the study proposes a mathematical description of how private agents form expectations in an environment where the central bank is unsuccessful in steering inflation towards the target, ie., in the context of nonstationary inflation data. The mathematical proposition asserts that private agents use current inflation to forecast inflation over the central bank's control lag (ie., target horizon when policy instrument is supposed to affect future inflation) . Stemming from this idea, in chapter four (empirical analysis-first essay) the second original contribution of this study, to the literature is made, where a proposition concerning the concept of credibility and the long run cointegrating relationship between inflation and expectations in the context of non-stationary data, is made and tested. In a nutshell the proposition in question asserts that if a long run cointegrating relationship between inflation and expectations exists, then it implies that the expectations-holder does not believe the IT policy as being credible and believes current factors influencing inflation are likely to persist into the future and hence formulates her expectations in this light, thus expectations will not be anchored to the target level (or range) but instead will move in tandem with current changes in the actual inflation. However if IT is perceived to be credible then no statistically significant long run cointegrating relationship will be found, thus implying that current disturbances in inflation do not influence the formation of expectations, ie., a disconnect between inflation and expectations exists. Hence the inflation target is perceived by agents to be credible and thus expectations will be anchored to the target level (or range). Real time quarterly inflation data obtained from the SARB is modelled together with the survey expectations data downloaded from Bureau of Economic Research (BER) . BER is based at the Stellenbosch University and was commissioned by the South African Reserve Bank to conduct quarterly inflations expectations surveys among private agents to ascertain their expectations of current, one and two years ahead expectations of inflation. The mentioned dataset spans the inflation targeting period, viz., 2000Q3-2010Q2.

In regard to the benefits of inflation targeting, the literature remains divided. Studies by Batini, Kuttner and Laxton (2005), Gonclaves and Salles (2008), Mishkin and Schmidt-Hebbel (2007), Vega and Winkelried (2005) , Levin, Natalucci and Piger (2004) and Bernanke *et. al.* (1999) have found that IT successfully reduces inflation and makes it less volatile and persistent for both industrialized and emerging economies. Secondly, Gonclaves and Salles (2008), Mishkin and Schmidt-Hebbel (2007) found that IT reduces the real cost of disinflation. Batini, Kutner and Laxton (2005), Gonclaves and Salles (2008), Mishkin and Schmidt-Hebbel (2007), Gurkaynak, Levin and Swanson (2006), Vega and Winkelried (2005), Levin, Natalucci and Piger (2004), Johnson (2002), Bernanke *et. al.* (1999) have found that IT successfully anchors long run expectations at or very close to the inflation target. However, a study by Ammer and Freeman (1995) contends that the United Kingdom, Canada and New Zealand did not achieve long term credibility for their announced long run inflation intentions nor is there solid evidence that the announcement of these low inflation policies have significantly reduced inflation expectations. These conclusions were based on the observation that after having introduced an IT regime, these countries continued to maintain high interest rates for a lengthy period, which affected output negatively hence they intimated that the cost of reducing inflation may be too high. Ball and Sheridan (2005) studied the macroeconomic performance of 7 inflation targeters and 13 non-targeters, all of whom belong to the Organization for Economic Cooperation and Development (OECD), they found no evidence that IT improves the performance as measured by the behaviour of inflation, output or interest rates. Although they found that in the IT countries inflation fell and became more stable and output growth also stabilized over the targeting period compared to the pre-targeting period, but this was also the case for non-targeters as well, thus suggesting that better performance resulted from factors other than targeting. Average inflation fell for both targeters and non targeters, but the improvements are larger for targeters, the average for targeters went from above that of non-targeters to approximately the same. Neuman and von Hagen (2002) interprets this finding as IT promoting convergence, however Ball and Sheridan (2005) contest this claim

Cecchetti and Ehrmann (2000) considered a sample of both industrialized and emerging economies and their findings and conclusions were similar to that of Ball and Sheridan. They explain that the benign inflation outcome rather than being a product of the IT regime may just reflect the general culture among central bankers in a decade that provided an environment conducive to price stability and therefore an opportunity to move away from the

inflationary processes of the 1970s and 1980s. Siklos (1999) using univariate time series analysis noted that during the 1980s and 1990s there had been a global drop in both IT and non-IT countries, Debelle (1997) considers the IT countries that adopted IT in the early years, he noted that a substantial decline in inflation rates and long term bond rates but noted that unemployment increased significantly during the disinflation period, hence inflation reduction came at a huge cost. He also pointed out that non-targeters also achieved similar reductions in inflation rate during the first half of the 1990s, thus making it difficult to conclude that disinflation is the success of the IT regime alone. The second essay of this study attempts to add to this debate by carefully attempting to assess whether inflation volatility and persistence for South Africa has changed since the adoption of inflation targeting, after first accommodating for structural changes in the inflation series arising from the global fall in inflation rates via the Bai and Perron (2003), Lumsdaine and Papell (1997), Lee and Strazicich (2004) and Andrews and Ploberger (1994) multiple structural breaks test. Similar to the approaches used by Kontonikas (2004) and Miles (2008), generalized autoregressive conditional heteroscedasticity (GARCH) and GARCHM (GARCH-in-mean) models together with dummy variables separating the pre and post IT periods are utilized to examine volatility changes in the monthly inflation rates. The Miles (2008) study investigated inflation volatility and inflation persistence in the Canadian pre and post inflation targeting periods, while Kontonikas (2004) focuses on UK. Thereafter Autoregressive (AR) models together with inflation targeting dummy variables are employed to examine the persistence of inflation in the post targeting period. It is worth noting that the GARCH type models have never been used previously to assess inflation volatility in the South African context. The Gupta, Kabundi, and Modise, (2010) and Gupta and Uwilingiye (2007) are the only other South African studies that investigated the shift in inflation volatility over the pre-and-post inflation targeting period. However, both the studies used different methods to the current study, the former study used the factor VAR approach while the latter used the lesser known Saphe Cracking model which is widely used in the engineering sciences, and interestingly the results of the present study confirm their findings. In regard to inflation persistence, Rangasamy (2009) employs a similar autoregressive model to the one the present study uses. However, he used a data set going as far back as 1980 hence his findings regarding the beneficial influence of IT in reducing inflation persistence in the South African context might be flawed on the grounds of not accommodating for structural breaks in the data.

Meyer (2002) notes that contemporary macroeconomics presumes that economic agents prefer low and stable inflation to high and variable inflation, but, they also prefer high and rising real per capita income and output that is consistently close to the economy's maximum sustainable output level. This presumption is often captured in a quadratic loss function, where loss to society is expressed as a weighted average of inflation deviations from its target and of output from its potential level. The weights which sum to unity, represent the relative intensity of agents' distaste for deviations from their preferred inflation and output rates. Phillips curve analysis has highlighted the trade-off between inflation and output variability. An adverse supply shock (eg., oil price rise) typically raises inflation and reduces output due to purchasing power losses suffered by consumers, thus giving rise to the commonly-known dilemma for monetary policy: should policy be eased to counter output decline or tightened to fight inflation rise? The structure of the economy is such that the faster monetary policy attempts to return inflation to target, the greater is the variability in output. According to Svensson (2010), in practice all IT central banks are flexible inflation targeters who aim at stabilizing inflation around a target, and they also put some weight on stabilizing the real economy. They also explicitly recognize that returning inflation to its target too rapidly may result in substantial output variability hence through setting long policy horizons (1.5-2 years) over which policy makers commit to returning inflation to its target, through small changes in interest, termed interest rate smoothening (or smoothing in US English). The third essay of this study will attempt to assess the relative weights the authorities placed on the trinity objectives of price stability, resource utilization around its normal level and interest rate smoothening, through the use of hybrid Taylor rules (also known as policy reaction functions) which offers a useful characterization of monetary policy especially within an IT setting. According to the original Taylor rule central banks should adjust the target for short term interest rate in response to inflation and output deviations from their respective targets. The Taylor rule is consistent with the mentioned loss function, since the rule prescribes the adjustment of the repo rate in response to inflation and output deviations from target values that are presumed to result in costs to the society. In the original Taylor rule (Taylor (1993)), the federal funds rate is a function of just the variability of inflation and output from their respective targets, later studies included one or more additional variables such as variability of exchange rates, money supply ,stock market indices, yield curve differentials, credit growth and so on, see, for example, Bardsen, Eithreim, Jansen and Nymoen (2005).

Svensson (1997) noted that inflation targeting is difficult to implement because central banks have imperfect control over inflation, since current inflation is predetermined by previous decisions and contracts thus suggesting that they can only affect future inflation. Furthermore monetary policy is difficult to implement because the policy instrument affects future inflation with long and variable lags and shocks tend to complicate matters even further. Hence he stresses that, in effect, inflation targeting implies forecast targeting. Bowen (1995) and King (1994) suggests that to implement monetary policy under inflation targeting, central banks must first use information from a wide variety of sources, to get an accurate forecast of the probability distribution for inflation, over a time horizon defined by how long it will take for a monetary policy response(s) to steer inflation towards the target. The forecasts serve as intermediate targets and monetary policy adjusts in a manner that attempts to ensure that the forecasts over the given target horizon are realized, ie., that monetary policy adjustments direct inflation to within the target band. Clarida, Gali and Gertler (1998) estimated a forward-looking version of the Taylor rule that involved modelling expected inflation deviations from its target together with contemporaneous output deviations and managed to successfully explain the central bank behaviour of a number of EU member countries. The third essay of this study employs the Clarida *et al.* (1998) model, which uses the general method of moments (GMM) technique, to assess the behaviour of SARB using monthly data over the 2000M02-2008M12 period. The Naraidoo and Paya (2011) paper is the only other South African study that applies a similar forecasting model, however, they use a monthly dataset spanning 1986M01-2008M12 and they assume that the IT period began two years before the official announcement. While the Naraidoo and Paya study uses some of the most sophisticated parametric and semi-parametric techniques, their study is exposed to the *Lucas critique*, since their model's estimated coefficients is based on pre-2000 data when different policy regimes were in place, which the present study deliberately avoids. According to Lucas (1976) shifts in economic policy change how policy affects the economy since private agents are forward instead of backward-looking and adapt their expectations and behaviour in accordance with the new policy stance, hence reduced-form econometric models cannot provide useful information on new policies, since the economic structure changes when the policy changes, thereby rendering the reduced form coefficients of the model, inconsistent

This study is considered to be important for three reasons: firstly this study is especially important for emerging economies, since IT is touted as being a panacea for price stability. However a group of studies, mentioned above, have pointed out that disinflation comes at a

tremendous cost to output, thus the findings of this study will help shed further light on the purported benefits of IT; secondly the expectations essay will assist central banks of small open economies, who have adopted the ITMPF, and whose inflation and expectations series are non-stationary, to assess and monitor the degree of credibility that private agents attach to their IT policy stances. Finally the insights gained from the hybrid Taylor rule will assist new entrants like Ghana into the IT club, to set the policy instrument by choosing appropriate weightings for the variability of inflation, output and exchange rates from their respective targets.

The thesis is divided into seven chapters. Chapter two presents the main theoretical interpretations of inflation as well as a theoretical justification of IT including its *modus operandi* and the manner in which private agent's forecast inflation under IT. The chapter is divided into four subsections Thereafter section 2.1 provides a relatively detailed account IS-PC-MR approach to monetary policy. Section 2.2, stemming from the theoretical foundations outlined in the section 2.1, provides snapshot a selection of theoretical papers that led to the development of the ITMPF, Section 2.3 outlines the Svensson (1997) and Capistran and Ramos-Francia (2010) theoretical concept of 'forecast' inflation targeting which is considered to be an insightful account of how IT is conducted. Moreover the section provides a theoretical explanation of how expectations are formed in the context of stationary data. Sections 2.3.3 – 2.3.5 explains the original contribution this study makes to the literature concerning the way expectations are formed when the variable being forecasted is nonstationary.

Chapter three focuses broadly on the experiences of IT economies with specific focus on three emerging market economies similar to that of South Africa. The chapter is divided into four subsections; subsection 3.0 discusses the general aspects of IT, while section 3.1 considers the international debate regarding the impact IT on industrialized and emerging economies. Section 3.2 discusses the case studies of Chile, Brazil and Turkey, the small emerging markets that are similar to South Africa. Lastly Sections 3.3 to 3.4 reviews the inflationary experience in South Africa and examines monetary policy in the context of inflation for the past thirty years.

Chapter four encompasses the first essay which undertakes a detailed VAR and VECM investigation of the relationship between inflation and inflation expectations, where expectations consists of both combined and disaggregated survey data and a linkage to the

theoretical concept of central bank credibility is proposed and estimated. A detailed literature review, data description, modelling technique, proposition presentation, hypothesis testing, discussion of the results and conclusion are presented.

Chapter five, is composed of the second essay which examines the inflation volatility and inflation persistence over the pre-and-post IT periods, with the use of GARCH/GARCHM and AR models together with an IT dummy variable. Additionally the chapter outlines Bai-Perron and Andrews-Ploberger multiple structural breaks tests The chapter provides a detailed literature review, modelling techniques, data description, hypothesis testing, discussion of the results and conclusion are presented.

Chapter six, presents the third essay which estimates a forward-looking hybrid version of the Taylor rule using the GMM technique over the IT period, The chapter provides a detailed literature review, modelling techniques, data description, hypothesis testing, discussion of the results and conclusion are presented.

Chapter seven concludes the study by summarizing the quantitative investigations presented in the three essays and by synthesizing the relevance of the findings to monetary policy in South Africa. Moreover, the results pertaining to the disaggregated expectations models as well as the policy reaction functions will be of particular relevance to the SARB for it will provide insights into the possible interventions that can be implemented to further guide the expectations process and enhance credibility. Finally the weaknesses of this study are highlighted and further research directions are suggested.

Chapter Two – Inflation Targeting: Monetary Theory and Practice

2.0 Introduction

The aim of this chapter is to focus on monetary theory within the context of the IT framework. Inflation distorts investment and saving decisions, raised the risk premium in long term interest rates and undermines the long term efficiency of the price mechanism. Thus by focusing on the single objective of price stability a clear message is sent to savers and investors that they do not need to factor in a large inflation risk in their investment decisions (Casteleijn, 1999). Low inflation is almost universally accepted as the purposes of contributing to solid economic performance (Bernanke *et.al*., 1999; Van Den Heever, 2001).

In the modern era central banks in industrialized and emerging economies irrespective of whether they are implicit or explicit inflation targeters, typically set interest rate to stabilize the economy around an inflation target at which output is at its equilibrium level. According to Mishkin (2007a), Bain and Howells (2009) this practice has emerged from the key principles that were developed over the past fifty years. The principles include: i) "inflation is always and everywhere a monetary phenomenon" (Friedman, 1963); ii) price stability has important economic efficiency benefits; iii) there is no long run trade-off between unemployment (or output) and inflation; iv) expectations play a critical role in the inflation determination and in the transmission of monetary policy in the macroeconomy v) real interest rates must rise with higher inflation, ie., the Taylor Rule principle; vi) monetary policy is subject to the time inconsistency problem where the short-run output/inflation trade-off is exploited ; vii) central bank independence minimises political inflationary biases and improves the efficiency of monetary policy; iix) a successful commitment to a nominal anchor is credibility enhancing leading to favourable outcomes; ix) rendering macro models immune to the Lucas critique[1] by anchoring them in micro-foundations with optimising agents who have rational expectations. These developments eventually led to the derivation of the inflation targeting framework which can be succinctly explained by the IS-PC-MR (Investment-Savings/Phillips Curve/Monetary Rule-also termed the three equation paradigm) theoretical model that is explained in section 2.1. Moreover this section also derives the

[1] It is presumed that rational economic agents take into account the future response of policy makers when choosing their actions. Also see footnote 7, chapter 1 for a definition.

Taylor Rule within the IS-PC-MR paradigm for the purposes of understanding the essay on policy reaction functions presented in chapter six. Section 2.2 discusses the theoretical literature that provides insight into central bank credibility that emerged out of the IS-PC-MR framework and which ushered the way for the development of the ITMPF. Finally, section 2.3 presents the Capistran and Ramos-Francia (2010) conception of inflation forecast targeting, which is based on the ideas of Svensson (1996, 1997). This conception involves explaining the inflation expectation formation process within the IT and non-IT frameworks for stationary inflation time series data. Section 2.3. makes a modest but original contribution to the field by pinning down, in mathematical terms, how agents forecast inflation in the context of non-stationary inflationary data.

2.1 The Monetary Policy Rule within the IS-PC-MR Model

A significant part of this subsection is based on the ideas of Bain and Howells (2009) and on Carlin and Soskice (2006)[2]. The IS-PC-MR model forms the backbone of the theoretical foundations of the ITMPF, which is now explained.

Further the IS/PC/MR does not include the money market (hence the LM curve), since in recent times most central banks chose to use short term interest rate as a preferred instrument, to control inflation. This practice arose especially since the 1980s as central banks lost control over the rate of growth of broad money supply. Hence money supply targeting as an objective of monetary policy fell out of favour[3]. The key assumptions behind the IS-PC-MR models are as follows:

- The ultimate determinant of inflation is monetary policy.
- Short term nominal interest rate is the instrument of monetary policy.
- The mechanism through which the economy adjusts to a new equilibrium with constant inflation following a shock is captured by the interest rate rule.

These assumptions imply that monetary policy within the IS-PC-MR is an 'activist' rules based-approach to monetary policy with frequent adjustments being made by the central bank

[2] Woodford (2003) discusses the same concepts in more technical terms.
[3] However, in the contemporary academic literature the IS/LM-AD/AS framework is still employed, where it is assumed that the ultimate determination of inflation is money supply, and the money supply is the instrument of monetary policy; and the mechanism through which the economy adjusts to the new equilibrium is explained by the IS/LM and expectations augmented Phillips curve.

in order to steer the economy in the desired direction. This viewpoint is consistent with the manner in which IT-oriented central banks conduct monetary policy and where there is a frequent review (every second month in the case of SARB, Bank of England, Norway Central Bank, Central Bank of Chile, Central Bank of Brazil and the Riks (Swedish) Central Bank, for example) of the state of the economy, in particular the nature of the demand shocks and the likely direction of inflation, the impact of the financial crises on inflation and output (Svensson, 2010).

As noted earlier IS-PC-MR model consists of an IS curve, a Phillips Curve and a Monetary Rule function. The IS curve is the standard model that is taught in undergraduate classes and will be outlined briefly. Furthermore monetary rule curve will be derived from the Phillips curve and the central bank's loss function before they are all combined to demonstrate how IT is conducted in the context of a negative shock. This subsection will first outline central bank's loss function and thereafter it will be related to the IS-PC-MR model for the purposes of justifying the relevance of central bank credibility in anchoring expectations (analysed in chapter four) and thus leading to a reduction in inflation uncertainty and persistence (assessed in chapter five). Additionally the linkage of the monetary rule to the central bank's loss function will assist the study to categorise whether SARB is a strict or flexible inflation targeter which will then serve as a basis to better understand the results of the forward-looking Taylor rule that is estimated in chapter six.

2.1.1 The Central Bank's Loss Function

The monetary rule equation is derived from the central bank's loss function, which is a purely theoretical construct that describes the trade-off between price stability and the stability in the real economy. Theoretical literature describes the central bank as minimising a loss function which mainly includes variability in output and inflation (Svensson 2001, 1997).

However, for the purposes of outlining the key features of the theory, this study will follow Svensson (2010, 2001, 1997) and assume that the central bank is concerned with minimising the quadratic loss function of the form:

$$L_t = E_t \sum_{t=1}^{\infty} \delta^{t-1} \left[\beta (\pi_t - \pi^T)^2 + (y - y^e)^2 \right], \quad \beta > 0 \qquad 2.0$$

Equation 2.0 reflects the notion that the deviations of both inflation and output from their respective ideal levels are disliked by the central banks. The $(\pi_t - \pi^T)^2$ term suggests that the central bank is keen on reducing fluctuations on either side of the target (π^*), ie over and undershooting the targeting is considered as been equally bad. Likewise $(y - y^e)^2$ this term also suggests a symmetrical attitude to positive and negative deviations from full capacity output (y^e). The quadratic representations of the deviations suggest that large deviations from the targets are considered to be more costly than small deviations. If inflation deviates substantially from the target or significant imbalances arise in the real economy, a relatively aggressive use of interest rates might be necessary. The loss function implies that the objective of monetary policy is to minimize the expected (E_t) losses, extending into the infinite future weighted by the discount rate (δ). Svensson (1997) explains that under IT the central bank chooses the path of interest rates so as to minimize the loss function subject to the IS (equation 2.7) and PC (equation 2.1) constraints. King (1997) notes that very few, if any, central banks possess a loss function and that realistically most central banks (especially the IT subscribers) conduct monetary policy over a two year horizon. Nonetheless the loss function captures the main rationale behind the practical policy implementation by IT-central Banks.

The β parameter represents the trade-off between inflation stability around the target and stable output growth. If $\beta = 1$ then equal weighting is given to both inflation and output variability and the indifference loss curves for each period is a circle with the optimal point being the centre of the circle (bliss point). The bliss point lies on the vertical long run Phillips curve, eg., consider point A (see Figure 2-Panel A, Appendix A) which is consistent with the objectives of the central bank and it is at this point actual and expected inflation are equal and the economy is at full capacity and hence loss is minimised. However as the loss increases, ie., output and inflation deviate from their respective targets (due to positive or negative shocks) results in the economy being on a point on the circumference of a circle which radiates from the bliss point. In Figure 2, the central bank is indifferent to points B and C. In this case the loss is equally disliked. The central bank is also indifferent to points D and E,

however the loss is disliked more (relative to B and C) since they lie on an indifference curve further away from the bliss point. If $\beta > 1$, the central bank is inflation averse, ie., it is willing to trade-off a given fall in inflation for a large fall in output. The indifference curves are ellipsoidal (flattens out in horizontal plane see Figure 2, Panel B). If $\beta < 1$, the ellipsoidal indifference curves will have a vertical orientation (Figure 2, Panel C) rather than a horizontal one, implying the indifference curves are steep which reflects that the central bank is output averse, ie., for a given fall in inflation it is will to only sacrifice a smaller fall in output. If $\beta = \infty$, the central bank only cares about inflation and the ellipsoidal indifference curve reduces to a horizontal line cutting the y axis at $\pi = \pi^T$.

2.1.2 The Phillips Curve Constraint

The IS-PC-MR model employs the adaptive expectations version of the Friedman-Phelps Phillips curve, (equation 2.1). However, Carlin and Soskice (2006) prefer to refer to it as the *inertia-augmented Phillips curve*, which captures the empirical observations of price stickiness:

$$\pi_t = \pi_{t-1} + \alpha(y - y^e) \qquad \text{(PC-Phillips Curve)} \qquad 2.1$$

As mentioned above it is assumed that the central bank can control the output level through its ability to use monetary policy (by setting interest rate) in order to manage aggregate demand shocks. However, it cannot control inflation directly, but only indirectly through its influence on output (*y*). From observing equation 2.1, it is apparent that output affects inflation via the Phillips curve relationship. The principal of the Phillips curve constraint can best be explained via the use of Figure 3., Appendix A, which shows that the economy is initially in equilibrium at point A, where inflation is at the target level of 5% and output is at full capacity. Now suppose an inflationary shock which causes the SRPC($\pi^e = 5$) to shift and inflation to rise to 9% at point B where the new SRPC ($\pi^e = 9$) cuts the LRPC. If in the next period, the central bank wants to maintain a level of output at $y = y^e$, then it has to accept an inflation rate above its target (ie., 9% inflation at point B). However if it wishes to hit the inflation target then it must accept a very high rate of unemployment at point C. However given its preferences, the central bank can do better and achieve a loss circle closer to point A, than either point B or C, hence it minimises its loss function by choosing point D, where the SRPC($\pi^e = 7$) line is tangential to the indifference curve that's closest to the bliss

point. The study will demonstrate shortly that the movement down the SRPC $(\pi^e = 9)$ from B to D and eventually to A is guided by the monetary rule curve.

2.1.3 Derivation of the Monetary Rule (MR)

The central banks loss function in Equation 2.0 is the discounted sum of each period's loss function extending into an infinite horizon. However, monetary policy is conducted in a per period fashion, hence it is necessary to derive the monetary rule via the use of the a per period loss function (equation 2.2, below). The derivation to follow assumes central banks choose the interest rate in period *t* to affect output and inflation in period *t+1*, and that it is only interested in what happens in period *t+1* and that α and β take on positive values. A central bank chooses *y* to minimise

$$L = (y_{t+1} - y^e)^2 + \beta(\pi_{t+1} - \pi^T)^2 \qquad 2.2$$

subject to

$$\pi_{t+1} = \pi_t + \alpha(y_{t+1} - y^e) \qquad 2.3$$

Equation 2.3 is equation 2.1 that was updated by one period. By substituting equation 2.3 into equation 2.2 and differentiating with respect to y_{t+1}, because this is the variable that the central bank can control via its choice of interest rate, results in:

$$\frac{\partial L}{\partial y_{t+1}} = (y_{t+1} - y^e) + \alpha\beta(\pi_t + \alpha(y_{t+1} - y^e) - \pi^T) = 0 \qquad 2.4$$

By substituting equation 2.3 back into 2.4 gives rise to the monetary rule:

$$(y_{t+1} - y^e) = -\alpha\beta(\pi_{t+1} - \pi^T) \qquad 2.5$$

The larger the α and β (ie both >1) parameters are, implies the flatter the monetary rule curve will be, this can be seen mathematically if one had to make the π_{t+1} variable the subject of the formula, for it is this form that the MR function is plotted in the inflation output space:

$$\pi_{t+1} - \pi^T = -\frac{1}{\alpha\beta}(y_{t+1} - y^e) \qquad 2.6$$

Notice when α and β rise the slope of 2.6 decreases, ie., the MR function becomes flatter, implying a more inflation averse central bank. The degree of flatness can be compared to the benchmark case of a perfectly horizontal MR line which suggests the central bank is completely non-accommodating, ie it will reduce inflation back to target irrespective of the sharp rise in unemployment, and a perpendicular MR line indicates a completely accommodating central bank ie., no loss in employment is tolerated.

The greater the value of β (>1) is, it implies that the more inflation averse the central bank is and the greater the importance attached to the inflation target than to the output target, which results in a flatter monetary rule line. This can be seen clearly in Figure 4, Appendix A, which shows inflation averse central bank loss ellipses; an inflationary shock moves the economy from A to B, the loss ellipses indicate that the central bank must reduce aggregate demand to point C in order to minimise losses, in the next period. In the period thereafter aggregate demand can be increased to point D and then finally another period later the economy will be at the desired level ie., at point A. Joining Points C, D and A produces the monetary rule that guides the central bank's choice of aggregate demand given its loss minimisation preferences.

The slope of the Phillips curve, α, which measures the responsiveness of inflation to output, is the second factor that determines the slope of the MR function. The larger α is (α >1) it implies a steeper Phillips which suggests that any given cut in output has a greater effect in reducing inflation than when $\alpha \leq 1$. This can be seen in Figure 5, Appendix A, where the red SRPC lines have a large α, compared to the green SRPC lines. The steeper red SRPC lines result in flat monetary rule line (MR_0, formed by connecting points C,D and E), while the flatter green SRPC lines result in a steeper monetary rule (MR_1 formed by joining points A,B and E).

Now the study will demonstrate how interest rate is chosen by the central bank in order to affect aggregate demand. First the study has to briefly outline the IS equation, which together with the MR rule outlined above enables the central bank to set interest rate.

2.1.4 The IS Equation

The IS curve is specified in the output gap form, since the central bank is forward looking , ie it must set interest rates in period *t* in order to affect output and hence inflation in period *t+1*, thus:

$$y_{t+1} - y^e = -a(r_t - r_s) \quad \text{(IS-output gap form)} \qquad 2.7$$

This equation suggests that next period's output deviates from equilibrium to the extent that current real interest deviates from stabilizing interest rate. Central banks and economic agents are more interested in the interest rate, r_s, which is defined as the stabilizing rate of interest that equates y_{t+1} to y^e. The study is now in a position to combine the IS curve together with the PC (equation 2.3) and MR (equation 2.6) in order to determine the interest rate rule.

2.1.5 Interest Rate Rule and its link to the Taylor Rule

Once the central bank has calculated the optimal output inflation combination in the Phillips diagram, it then uses the IS curve to find out the appropriate interest rate to set. By combining the IS curve together with the PC (equation 2.3) and MR (equation 2.6) one can determine the interest rate rule which directly expresses the change in interest rate in terms of the current state of the economy. Using The Phillips and MR curves results in:

$$\pi_t - \pi^T = -\left(\alpha + \frac{1}{\alpha\beta}\right)(y_{t+1} - y^e) \qquad 2.8$$

By substituting for $(y_{t+1} - y^e)$ using the IS curve (equation 2.7) results in the interest rate rule:

$$r_t - r_s = \frac{1}{a\left(\alpha + \frac{1}{\alpha\beta}\right)}(\pi_t - \pi^T) \qquad \text{(interest rate rule)} \qquad 2.9$$

Note that the interest rate rule is only expressed in terms of the inflation differential. However all the parameters of the IS-PC-MR model matter for the central bank's response to a rise (or fall in inflation) relative to the target. The following can be gleaned from the interest rate rule equation:

- A more inflation-averse central bank ($\beta > 1$) will raise interest rate by more than a pro-inflation central bank.
- The more interest sensitive is output (a >1) in the IS relation, the central bank will rise the interest rate by less.
- The more responsive is inflation to output changes ($\alpha > 1$) in the Phillips curve relation, ie, steeper Phillips curve, the central bank will raise interest rates by less.

If one assumes that $a = \alpha = \beta = 1$, then the interest rate rule reduces to:

$$r_t - r_s = 0.5(\pi_t - \pi^T) \qquad 2.10$$

Equation 2.10 may be interpreted as stating that if current inflation is above target by 1% then the real interest rate must rise by 0.5%. Since actual inflation is 1% higher, it implies through the Fischer relation (Nominal interest rate = real interest rate + expected inflation) that nominal interest rate must rise by 1.5%. (Fisher, 1930).

2.1.6 Comparison of Interest Rate Rule with the Taylor Rule

This subsection sheds light on the linkages between the interest rule derived above and the famous Taylor (1993) monetary policy rule. While Chapter 6 of this study estimates forward looking Taylor type functions, the succeeding analysis will provide useful insights and theoretical justification for a rule that evolved through empirical data observations. The Taylor Rule may be specified as follows:

$$r_t - r_s = 0.5(\pi_t - \pi^T) + 0.5(y_t - y^e) \qquad 2.11$$

If there is no output gap in the Taylor rule then the Taylor rule reduces to the interest rate rule (equation 2.10). However a zero output gap is counterintuitive, given that Taylor (1993) devised the equation based on observations that was supported by US data that the Federal

Reserve Bank cares about both inflation and output. Moreover other economists made similar observations, which led to the creation of the theoretical loss function incorporating both output and inflation variability.

However, Svennson (1997) and Ball (1999), demonstrated that a slight modification of the assumptions involving the lag structure of the IS-PC-MR results in the derivation of the Taylor rule specification (equation 2.11). They maintain the same assumption that was made that r_t affects y_{t+1} however, the new assumption they make is termed the *double lag assumption* which states that the decision taken today by the central bank to react to a shock will only affect inflation two periods later. Thus the central bank sets r_t to affect y_{t+1} which in turn determines π_{t+2} (inflation two periods ahead). In other words, a central bank in the current period has no effect on current inflation and output or on next year's inflation, but only on next year's output and on in inflation two years' time. The double lag assumption conforms to the observations in the South African setting, where changes in short-term interest rate takes between 18 to 24 months to impact on inflation (Van den Heerver, 2001). Since the central bank can only affect y_{t+1} and π_{t+2} by its interest rate decision, its period loss function can be written as:

$$L = (y_{t+1} - y^e)^2 + \beta(\pi_{t+2} - \pi^T)^2 \qquad 2.12$$

Given the double lag assumption, the 3 equations are modified as follows:

$$\pi_{t+1} = \pi_t + \alpha(y_t - y^e) \qquad \text{PC curve} \qquad 2.13$$

$$y_{t+1} - y^e = -a(r_t - r_s) \qquad \text{IS curve} \qquad 2.14$$

$$\pi_{t+2} - \pi^T = -\left(\frac{1}{\alpha\beta}\right)(y_{t+1} - y^e) \qquad \text{MR curve} \qquad 2.15$$

By following the same steps as was done to derive the MR curve (see equations 2.2 to 2.6 above), one can derive the following interest rate rule which assumes the form of a Taylor rule in a generic form:

$$r_t - r_s = \frac{1}{a\left(\alpha + \frac{1}{\alpha\beta}\right)}\left[(\pi_t - \pi^T) + \alpha(y_t - y^e)\right] \qquad 2.16$$

If $a = \alpha = \beta = 1$, gives rise to the Taylor rule in its original form:

$$r_t - r_s = 0.5(\pi_t - \pi^T) + 0.5(y_t - y^e) \qquad 2.17$$

Under the double lag assumption that output takes a year to affect inflation, then both inflation and output deviations enter the interest rate rule and hence it resembles a Taylor rule. This is because current output deviations serve as the means of forecasting future inflation to which the central bank will want to react to now. The inflation aversion of the central bank affects its response to inflation and to forecast of inflation contained in the output deviation term.

The weights of 0.5 on both inflation and output deviations arise when the IS, Phillips and MR curves all have an absolute slope of one. However if economies differ in the following respects then the weightings will be different:

- Central bank's inflation aversion.
- The supply side structure (factors affecting wage and price setting behaviour) as reflected in the slope of the Phillips curve.
- The interest sensitivity of aggregate demand.

From the above presentation, it is clear that within the IS-PC-MR framework, the central bank is forward looking for it takes all available information into account in order to forecast the position of next period's Phillips and IS curves, respectively and given its preferences embedded in the MR function, it chooses the interest rate to affect next period's output and inflation (inflation two periods later in the Taylor rule framework) . If there is a positive (negative) demand shock it is able to steer the economy, through making a series of one period decisions in forward looking manner, down (up) the MR line back to target inflation level and natural rate of employment (full capacity output).

The useful feature about this paradigm is that it conforms to reality in the sense that when an economy deviates from its steady state it is only with the appropriate policy actions that over time the economy returns to its steady state. As will be discussed in chapter three, it is this feature that has been embedded within the IT framework, where the central bank through a series of interest rate adjustments steers inflation to achieve its prescribed target over a two year horizon. Svensson (1997, 2010) aptly describes this practice as inflation forecast

targeting. SARB's policy reaction function that is estimated in chapter six captures this feature over shorter horizons based on the reported practices of SARB, discussed in chapter three.

2.2 Inflation Bias and Time Inconsistency Problem

Walsh (2003) and Bain and Howells (2009) explain that when monetary policy is under the influence of the governments that are subject to popular elections, it is prone to suffer from an inflation bias. An inflation bias can also arise due to imperfect competition in the product and labour markets where y^e is less that the competitive full equilibrium level that would have arisen in the absence of these imperfections, hence government intervenes and imposes a higher output target.

Inflation bias is defined as the equilibrium interest rate being higher than the optimal rate for an economy. The assumption behind this analysis is that governments can influence central banks to impose an output target (y^T) greater than full capacity (y^e), thus leading to an inflation bias.

The inflation bias can be described mathematically (For a graphical exposition see Appendix A, Figure 6 and the related explanation.) where a bias prone central bank will now want to minimise the following period objective function:

$$L = (y_t - y^T)^2 + \beta(\pi_t - \pi^T)^2 \qquad 2.18$$

where, $y^T > y^e$. This is subject to the Phillips curve (equation 2.1)

$$\pi_t = \pi_{t-1} + \alpha(y_t - y^e) \qquad 2.19$$

Leads to the monetary rule :

$$y_t - y^T + \alpha\beta(\pi_{t-1} + \alpha(y_t - y^e) - \pi^T) = y_t - y^T + \alpha\beta(\pi_t - \pi^T) = 0 \qquad 2.20$$

Note that $\alpha(y - y^e)$ no longer appears on the new MR line since a higher output is now preferred so it is discarded from the equation. Hence the new monetary rule is:

$$y_t - y^T = -\alpha\beta(\pi_t - \pi^T) \qquad 2.21$$

Note that the new rule passes through the point (π^T, y^T). To find the point at which the new MR intersects the LRPC, one uses the equilibrium condition which states that actual and expected inflation are equal (ie., $\pi_{t-1} = \pi_t$) when actual output is at full capacity (ie., $y = y^e$), which we utilize in 2.19 to result in 2.22:

$$y^e = y^T - \alpha\beta(\pi_t - \pi^T) \qquad 2.22$$

$$\Rightarrow \pi_t = \pi^T + \frac{(y^T - y^e)}{\alpha\beta} = \pi_{t-1} \qquad 2.23$$

Equation 2.23 expresses the situation when the economy returns to equilibrium ($y = y^e$) but at a higher inflation rate (ie $\pi_t = \pi_{t-1} > \pi^T$). Inflation is higher by the amount of $\frac{(y^T - y^e)}{\alpha\beta}$ which is termed the inflation bias. The more inflation averse ($\beta > 1$) a central bank is the lower is the inflation bias. The more responsive is inflation to an output change, the lower is the inflation bias. It is out of this kind of analysis that Persson and Tabellini (1990) and Barro and Gordon (1983) have called for an independent central bank free of political interference. These features form the central tenets of an IT regime. IT is a policy option that attempts to eliminate this bias through the features, that include, following a predetermined target, transparency and accountability. Further discussions regarding these issues are tackled further in the subsections to follow.

2.2.1 Time Inconsistency Problem

The time inconsistency problem is rooted in the policy irrelevance proposition that evolved from the rational expectations hypothesis, and is based on the notion that the expectations of private agents regarding the rate of inflation depend on their view of the likely behaviour of the authorities in conducting monetary policy. New classical economists like Barro and Gordon (1983), Kydland and Prescott (1977) asserted that central banks could assist private agents in the formation of expectations by following a clear monetary rule or by making announcements of future policy actions (eg., growth of money supply, setting of interest rate), that is credible, instead of following discretionary policies. To illustrate this argument they consider the dilemma of the central bank that is concerned about both inflation and unemployment in the context of an economy governed by a loss function, a Friedman-Phelps type Phillips curve and a monetary rule. The bank wants economic agents to expect low

inflation so that it faces a favourable trade-off between inflation and unemployment. However, an announcement of a policy of low inflation is not credible because once expectations of low inflation are formed the authority has an incentive to renege on its announcement in order to reduce unemployment. Figure 6, Appendix A, can be used to describe the situation, once private agents have formed the expectation that the target inflation will hold (at point C) with the NAIRU, the bank has an incentive to push the economy to point A, which in the long run leads the economy to point B, ie., back at NAIRU with higher inflation. Private agents understand that the central bank possesses an incentive to renege, because it exercises discretion, hence they do not believe the policy announcement in the first place. Thus Kydland and Prescott (1977) and Barro and Gordon (1983) demonstrate via the use of mathematical models that by removing the authority's discretion and replacing it with a monetary rule, eg., an IT rule of zero inflation, will reduce inflation without causing higher unemployment.

2.2.2 Rational Expectations and the Time Inconsistency Problem

Under the rational expectations hypothesis where it is assumed that inflation inertia is absent, ie., no nominal rigidities in wage and price setting behaviour and institutions operate in a manner that do not produce inflation inertia, then the economy is defined by a forward looking Phillips curve:

$$\pi_t = \pi_t^E + \alpha(y_t - y^e) + \varepsilon_t \qquad 2.24$$

Equation 2.24 states that current inflation is determined by expected inflation (π_t^E), deviation of output for equilibrium and some random shock. Market agents know that when expected inflation is consistent with actual inflation (ie., $\pi_t^E = \pi_t$) then actual output conforms with full capacity output (ie., $y_t = y^e$). Through some manipulation, Equation 2.24 can be transformed into a Lucas (1972, 1975) surprise supply curve as follows:

$$y_t = y^e + \frac{1}{\alpha}(\pi_t - \pi_t^E) \qquad \text{Lucas surprise supply equation} \qquad 2.25$$

In the equation 2.25 the term $\frac{1}{\alpha}(\pi_t - \pi^E) = \xi$ is referred as the inflation surprise, which affects output, where it is argued that output only deviates from equilibrium when there is surprise or unanticipated inflation. Output is pushed away from equilibrium, firms confuse

relative price (price for their own products) changes with change in the general price level (ie., inflation). Generally it is difficult to distinguish a relative from a general price increase, which then results in some output increase following an inflation surprise.

To understand the dynamics of the time inconsistency problem, the study assumes that the bank chooses *y* and hence π after workers have chosen π^E, this defines the central bank acting with discretion. In order for workers to have the correct inflation expectations, they must choose π^E, such that it forces the central bank to chose, $y_t = y^e$. That must be where the bank's MR curve cuts the LRPC, ie., at point B in Figure 6, Appendix A. Note that the SRPC lines are the Lucas supply curves. Inflation must be sufficiently high in order to remove any temptation of the bank to raise output towards its target, ie., point A. The loss to the central bank at point B is higher than its loss at point C, since output is the same but inflation is higher at B. Workers are indifferent between points C and B since employment (output) and real wages are the same in each instance. The problem of time inconsistency prevents the economy from settling down at point C. Although the central bank claims that it has set a target of $\pi^T = 5\%$, once workers form their expectations that is equal to the target, the central bank reneges on the choice of output that is consistent with target, for it has incentive to choose point C. However, at point B there is not incentive for the central bank to cheat.

2.2.3 Solutions: Inflation bias & Time Inconsistency Problems

The above discussions have highlighted the following causes of the inflation bias and time inconsistency problems:

- Governments have strong influence over central banks and central banks (or governments) have over-optimistic output targets (ie $y^T > y^e$).
- Workers and firms form their expectations using rational expectations, they correctly predict the central bank's true losses in regard to inflation.
- Although central banks use monetary rule functions to determine optimal targets, they operate with discretion and choose the output level, after economic agents have formed expectations.

2.2.4 Constitutional Independence

Two strands of motivations have appeared in the literature that have called for central bank independence. The one strand is based on the incentives-preferences arguments of Rogoff (1985) and the other is based on studies by Alesina and Summers (1993), and Pollard (1993) who have recorded empirical evidence of central bank independence being associated with lower inflation rates and low volatility of other real economic variables, observed in a number of industrialized countries[4].

Rogoff (1985) defines central bank independence as being synonymous with a conservative approach to the inflation objective ie., the central banker places a higher weighting on deviations of inflation from target relative to that of output variability.

On the basis of this assumption he argued that monetary policy should be controlled by a conservative central banker, who is more concerned about the losses from inflation than from unemployment compared to society at large. Moreover central banks should enjoy constitutional independence, in order to avoid political interference. But in the same breath he motivated for a clause in the bank's constitution that allows the governments to overrule the central banker in the face of large shocks buffeting the economy.

One implication of the theory discussed above is that should a central bank care more about inflation, irrespective of what happens to output, then one should observe lower inflation accompanied by greater output variability in economies governed by such banks. Alesina and Summers (1993), and Pollard (1993) cite a number of cases of industrialized countries such as Germany, Canada and United Kingdom, where central-bank-independence is associated with low inflation rates, as well as low volatility of other real economic variables.

2.2.5 Contracts Punishment and Incentives

A problem under a discretionary policy arise because central banks respond optimally to the incentive structure they face and which are contrary to societies' objectives, hence if the incentives they face are altered by drawing up contracts that specifically outline the alternative incentives central banks ought to face, then the problem can be eradicated. Rogoff (1985) suggested that policy makers should offer appropriate incentives to the central banks for avoiding time-inconsistency problems for example, a central bank's annual budget

[4] Woodford (2003) discusses a number of other references as well.

should be allocated on the basis of the success that it has been achieved in regard to enforcing a monetary rule, ie., make it costly for central banks to cheat. Garfinkel and Oh (1993) suggest that a targeting rule enforced by legislation sanctioning the central bank for failing to achieve the target. For example the New Zealand Reserve Bank Act authorizes policy makers to dismiss the reserve bank governor for failing to achieve his target. Walsh (1995) demonstrates that despite the fact that central bank board members are largely political appointees, the inclusion of the dismissal rule as in New Zealand's case more or less serves as an optimal contract.

Lohmann (1992) advocates that policy makers should employ a conservative central banker but simultaneously to limit the central bank's independence for example if the bank faces a shock that is too big for it to handle then, clauses in the bank's constitution must give governments overriding power to intervene. Knowledge that the central bank can be overridden alters the way it will deal with shocks. Moreover Lohmann (1992) argues that by directly incorporating the low inflation objective into the central bank's contract alters its preferences towards that of lower inflation provided that sanctions emanating from breach of contract have a high cost attached to it.

2.2.6 Reputation

Barro and Gordon (1983) assess the role of reputation within the context of a repeated game model, where the objective of the central bank is to minimize a loss function over an infinite horizon. If the central bank realized the expected inflation rate in the previous period, then economic agents formulate their expectations for the current period that is lower than the discretionary rate (which is higher than expected rate)[5]. However if in the next period the central bank reneges on is decision and delivers a higher rate then in the succeeding period the public will formulate their expectations that is consistent with the discretionary rate. Hence cheating carries a cost because in the period following the deviation, economic agents will punish the central bank by choosing an inflation rate that is consistent with a maximum loss (ie the discretionary rate on the LRPC). Thus, the central bank will not have an incentive to cheat, as long as the punishment is credible.

[5] The expected rate can be likened to the target inflation rate (point C) while discretionary rate can be likened to point B on LRPC in Figure 6, Appendix A.)

Since the Barro-Gordon paper, many studies[6] emerged that make various assumptions about economic agents (eg., a domineering militant trade union); or about the nature of the successive governments-central banks that might target zero inflation or discretionary rates, and public uncertainty concerning government-central bank type; or lack of knowledge of a central bank's true preferences; or asymmetric knowledge of shocks between central banks and private agents. However, they all correspond to the conception derived within the game theory framework that central bank reputation plays a critical role in sustaining a lower level of inflation. Further, that the quintessential element that shapes a bank's reputation is being consistently tough on inflation over consecutive time periods. Hence private agents perceive a central bank to be credible, based on the reputation they have built over a sustained period of time.

2.2.7 Transparency and Credibility

Central bank independence was strongly influenced by the dynamic time inconsistency theories for the purposes of removing political interference and for committing the central bank to a particular policy path. Chortareas, Stasavage and Sterne (2003) have advocated that central bank transparency, about operating methods and openness about the inflation target, makes it easier for agents to monitor their behaviour, and to also hold them accountable. Additionally they asserted that transparency raises credibility which reduces the sacrifice ratio (output loss to reduce inflation) since agents understand the intentions of central bank's policy actions. King (1997) argued through transparent central bank policy actions, agents make fewer errors in private sector decision making since they understand the macroeconomic environment within which policy makers are operating, which helps anchor expectations about future policy actions. Freeman (2002) argued that anchored expectations implies a full understanding of monetary policy action which reduces the term structure of interest rates since inflation risk premiums are not factored into long bond rates hence effectiveness of stabilization policy is enhanced.

Bean (1998) and King (1997) argue that a transparent central bank has more incentive to deliver and less incentive to engage in unexplained discretionary behaviour. In broad terms, transparency is measured by a fixed schedule of monetary policy committee meetings where decisions are taken; publication of minutes of recording the decisions taken; publication of a

[6] Walsh (2003) conducts a detailed survey of the papers that spun off the seminal Barro and Gordon (1983) paper

voting record where a committee is involved; communicating to public; a quantified target (or target band), issuing inflation forecasts with probability fan charts, access to econometric and forecasting models; and likely domestic and international shocks to impact on inflation.

2.3 Theory behind the Anchoring of Inflation Expectations

This subsection will offer a more sophisticated understanding of how monetary policy is conducted in a forward looking manner and will shed further light on the analysis to be conducted in chapters four, five and six. The ideas of Svensson (1997, 1999) were adapted by Capistran and Ramos-Francia (2010), who use a strict IT (zero output gap tolerance) framework within the context of an IS and Phillips curve macroeconomic model to define what anchoring of expectations mean under IT and to derive the necessary implications that will be tested in chapter four of this study.

Inflation *n* periods ahead may be usefully described as follows:

$$\pi_{t+n} = s_t - i_t + \varepsilon_{t+n} \qquad 2.26$$

Where s_t denotes the underlying inflationary pressures, i_t monetary policy instrument (repo rate, same as above) and ε_{t+n} represents unforecastable shocks with zero mean and constant variance) . Note that s and ε are assumed to be independent of monetary policy actions, and the difference between them is that s is realized prior to choice of monetary policy stance while ε is realized afterwards. Note that *n* represents the control lag, ie., the *nth* period for which inflation is forecasted and policy is required to affect. Equation 2.26 can be derived from a system involving an IS and Phillips curve equation (Bernanke and Woodford, 1997)

This discussion assumes that the central bank is a strict inflation targeter (ie., zero tolerance of output deviations). The central bank's objective in period t is to choose a sequence of current and future repo rates $\{i_\tau\}_{\tau=t}^{\infty}$ so as to minimize:

$$E_t[\sum_{\tau=t}^{\infty} \delta^{\tau-t} \frac{1}{2} (i_\tau - \pi^T) | \Omega_t] \qquad 2.27$$

Where E_t is the expectations operator and denotes that expectations conditional upon the information set $\{\Omega_\tau\}$ available to the central bank in year t. The discount factor δ , fulfils the condition $0 < \delta < 1$. The repo rate is set in period *t* will not affect the inflation rate in period

t, but will affect it in future periods until time $t+n$ is reached. A solution to the optimization problem can be found by assigning the repo rate in period *t* to hit the inflation target, on an expected basis, in period $t+n$ and the repo rate in $t+1$ to hit the target in period $t+n+1$, and so on. Hence the central bank can find the optimal repo rate in period *t* as a solution to the simple period-by-period problem:

$$\min_{i_t} E_t\left[\delta^n \frac{1}{2}(\pi_{t+n} - \pi^T)^2 / \Omega_t\right] \qquad 2.28$$

The first order condition to solve 2.28 is:

$$E_t(\pi_{t+n} / \Omega_t) = \pi^T \qquad 2.29$$

Where, the expectation is evaluated at i_t^* (optimal repo rate). In equation 2.29 the central bank sets the repo rate to make the expected value of inflation conditional upon the information set, equal to the target, ie., the conditional expected value of inflation is the central bank's target. Assuming the central bank knows the parameters

$$E_t(\pi_{t+n} / \Omega_t) = s_t - i_t \qquad 2.30$$

Substituting equation 2.30 into equation 2.29, results in the optimal instrument:

$$i_t^* = s_t - \pi^T \qquad 2.31$$

Equilibrium is obtained by substituting the optimal repo rate (equation 2.31) into the equation for the economy (equation 2.26):

$$\pi_{t+n} = \pi^T + \varepsilon_{t+n} \qquad 2.32$$

Notice that the inflation rate in the *nth* period is not correlated with demand pressures (s_t) and any excess demand pressures will not affect inflation for it is presumed that the central bank has perfect information of sources of demand pressures and it sets the instrument in such a way that neutralizes such pressures in order to achieve the target.

2.3.1 The Representative Agent's Inflation Forecast

The representative agent's forecast of inflation can also be solved by assuming that he/she chooses his/her forecast by minimizing the mean squared error (MSE), and then the period-by-period loss function that he/she solves is:

$$\min_{f_t} E_t \left[(\pi_{t+n} - f_{t+n})^2 / I_t \right] \qquad 2.33$$

Where f_{t+n} is the inflation forecast made at time t for the period $t+n$, conditional upon the information set (I_t). This first order condition is:

$$f^*_{t+n} = E_t \left[\pi_{t+n} / I_t \right] \qquad 2.34$$

If one assumes there is information symmetry between the central bank and the private agent ie., $I_t = \Omega_t$, then the agent is able to calculate the equilibrium condition (equation 2.32) and thus uses it to form the optimal forecast as follows:

$$\begin{aligned} f^*_{t+n} &= E_t \left[\pi_{t+n} / I_t \right] \\ &= E_t \left[\pi^T + \varepsilon_{t+n} / I_t \right] \\ &= \pi^T \end{aligned} \qquad 2.35$$

Result 2.35 suggests that under perfect and symmetric information and full credibility, the optimal forecast for a forecast horizon equal to or greater than the control lag is the inflation target itself. Within the context of this model it is possible that when the agent forms his/her expectations, actual inflation may not be at the target, perhaps it deviates due to some unanticipated disturbance, despite this his/her expectation still conforms to the inflation target. This interpretation of the result assumes that the agent perceives the central bank to be credible and will take the necessary policy actions to return inflation to the target.

2.3.1 Representative Agent's forecast under Flexible IT

The following demonstration of the optimal forecast condition under flexible IT is based on Svennson (1997) and Capistran and Ramos- Francia (2010). Given that the central bank follows flexible IT framework, thus its objective in period *t* is to choose a series of current and future instruments $\{i_r\}_{\tau=t}^{\infty}$ to solve:

$$\min_{\{i_\tau\}_{\tau=t}^{\infty}} E \quad \sum_{\tau=t}^{\infty} \sigma^{\tau-t} \frac{1}{2}[(\pi_\tau - \pi^T)^2 + \lambda y_T^2]\ \Omega_t \ , \qquad 2.36$$

where $\lambda > 0$ is the relative weight on output stabilization, and y_t is the output gap. In the same vein as the strict inflation targeter, the central bank can find the repo rate in period *t* as the solution to the simple period-by-period problem:

$$\min_{i_t} E \ \ \delta^1 \frac{1}{2}[(\pi_{t+2} - \pi^T)^2 + y_{t+1}^2]\ \Omega_t \ , \qquad 2.37$$

Where, Capistran and Ramos-Francia (2010) assumed that the control lag for the output gap is smaller than for inflation (Svensson, 1997).

The first order condition, using the notation $E[\cdot\ \ \Omega_t] = E_t[\cdot]$is:

$$E_t\ \pi_{t+2}\ = \pi^T - \frac{\lambda \frac{\partial y_{t+1}}{\partial i_t}}{\frac{\partial \pi_{t+2}}{\partial i_t}} E_t\ y_{t+1}\ , \qquad 2.38$$

Where the expectations are evaluated at i_t^*, the optimal repo rate, and the study follows Capistran and Ramos-Francia (2010) and assumes that integration and differentiation can be interchanged. In this case the central bank sets the repo rate to make the conditional expected value of inflation equal to the target only if the expected output gap is equal to zero. Otherwise the inflation forecast ought to vary from the inflation target in a proportion of the expected output gap. The proportion increases with the weight attached to output in the central bank's loss function and with the marginal effect of the interest rate on the output gap. Moreover, the proportion decreases with the marginal effect of the interest rate on inflation.

In contrast to the case of the strict inflation targeter (λ=0, zero tolerance for output gaps in the loss function), a flexible targeter accommodates for output and this is reflected in its inflation forecasts. Under these circumstances, the forecast of the central bank is equal to the target only when the expected output gap is zero. Private agents in this economy would need to consider forecasts of the output gap and, typically, estimates of λ in order to calculate their inflation forecasts. This introduces extra sources of uncertainty and will likely generate some dispersion across forecasters. Even under these circumstances the agent's optimal forecast, equal to and beyond the control lag, is the central bank's inflation target. This is so because the agent perceives the central bank to be credible and believes that via the appropriate policy

actions it will succeed in eliminating the output gap (ie., $y_{t+1/t} = 0$) hence the forecasted inflation rate at the control lag is the inflation target $(ie., \pi_{t+2/t} = \pi^T)$.

$$
\begin{aligned}
E[E_t\ \pi_{t+=2}\ ] &= E\ \pi^T - \frac{\succ \frac{\partial_{yt+1}}{\partial i_t}}{\frac{\partial_{\pi\ t}}{\partial i_t^{+2}}} E_t\ y_{t+1} \\
E[\pi_{t+2}] &= \pi^T - \frac{\succ \frac{\partial_{yt+1}}{\partial i_t}}{\frac{\partial_{\pi\ t}}{\partial i_t^{+2}}} 0, \\
E[\pi_{t+2}] &= \pi^T,
\end{aligned}
$$

2.39

where there first step follows from the application of the law of the iterated expectations, and the second from the fact that the unconditional mean of the output gap is zero.

2.3.2 Non-IT and non-credible-IT Central Banks' Expected Inflation Target

This subsection will first present the Capistran and Ramos-Francia (2010) conception of the private agent's inflation expectations formation process under conditions where central banks that do not follow IT, in the context of a stationary inflation data generating process. Thereafter subsection 2.3.3 will expand on this idea by proposing the expectations formation process for IT central banks that have been historically less successful at keeping inflation close to the target level (or range) and which is reflected in the inflation data exhibiting non-stationary properties. Note that this latter conception is an original contribution to the literature on expectations formation.

As a starting point and in the interests of comparing the expectations formation process of private agents under the IT and non-IT policy regimes, the study now presents the Capistran and Ramos-Francia (2010) model under the new assumption that the central bank never reveals its inflation target to the public. Under such circumstances it is assumed that representative agent continues to believe that her best long-run inflation forecast is the target, but the actual numerical value is unknown. Hence, she will have to estimate the inflation target (π^T) using her information set (I_t). The representative agent's optimal forecast may be represented as follows:

$$f^{*}_{t+n} = E_t \left[\pi_{t+n} / I_t \right]$$

$$= \pi^T \qquad 2.40$$

Where π^T is an estimate of the expected mean, assuming the time series inflation data are stationary, then the following simple arithmetic mean will serve as an adequate estimate of the target:

$$\pi^T = T^{-1} \sum_{t=1}^{T} \pi_t \qquad 2.41$$

Equation 2.41, provides a simple average of past inflation, which is an unbiased and consistent estimate of the target, given that the observed inflation is generated by equation 2.3.2, it implies that the precision of the estimate increases with time, as the standard errors of the estimator decreases with a rise in sample size. It must be stressed that this analysis is only valid if the time series are stationary. A stationary time series exhibit the property where its mean, variance, covariance at various lags remain constant no matter at what point in time they are measured, they are said to be time invariant. They are also referred to as mean reverting.

2.3.3 Non-credible IT-Central Banks and Non-stationary Inflation data

As mentioned previously this subsection makes an original contribution to the theoretical literature by using the Svensson (1996, 1997) framework together with the ideas of Capistran and Ramos-Francia (2010) discussed in the previous section to propose that expectations of future inflation will be closely aligned to current inflation when the central bank is perceived not to be credible and that this lack of credibility arises from the central bank's inability to keep inflation at the target level (or within the target band) as demonstrated by the time series which exhibit non-stationary properties. Mishkin and Schmidt-Hebbel (2007) provide evidence of IT emerging economies whose inflation series become stationary are much more successful at controlling inflation expectations formation behaviour of market players. Aron and Muellbauer (2007) provide evidence on the nonstationary characteristics of the South African inflation data and they predict that private agents' expectations will become more anchored should the inflation data achieve stationary traits.

South African inflation data, for the IT period (2000-2011), used in this study is non-stationary (see Appendix B2, Table 2 and Table 7). Non-stationary time series exhibit a time varying mean, or variance or both. The problem with these properties is that it makes inflation unforecastable, in the sense of equations 2,32 and 2.41. Non-stationary data exhibit random walk behaviour ie., the value of inflation at time *t+1* is equal to its value at time *t* plus a random shock (zero mean):

$$E_t(\pi_{t+1}) = \pi_t + \varepsilon_{t+1}$$

$$= \pi_t \qquad 2.42$$

In the same light and through invoking, the Sargent and Ljungqvist (2004) concept of the *Law of iterated expectations* one can write 2.43 below. The law of iterated expectations may be formally expressed as follows: given E_t denotes expectations conditional on only the information observed up to and including time period *t*. In typical models the information set *t* + 1 contains all information available through time *t*, plus additional information revealed at time *t* + 1 (or t+2, t+3…t+n). One can then write: $E_t\ \pi\ = E_t\ E_{t+1}\ \pi\ $. Intuitively the law states that if one expects to see something (say π) at a future date, then one expects to see that something (say π) in the present. Thus, the forecast of inflation over the horizon of the central bank's control lag may be stated as follows:

$$f^*_{t+n} = E_t(\pi_{t+n} / I_t)$$

$$= \pi_t \qquad 2.43$$

Thus, equations 2.42 and 2.43 may be interpreted as saying that since the data is non-stationary, and the information set (I_t) available to the agent include the current inflation as the latest available information, which serves as a best guess of the inflation forecast over the control lag horizon. Alternatively, agents can use a purely adaptive expectations approach, where forecast inflation is a weighted sum of past inflation:

$$E_t(\pi_{t+1}) = (1-\lambda)\sum_{j=0}^{\infty}(\lambda^j \pi_{t-j}) \qquad 2.44$$

where π_{t-j} equals inflation lagged *j* periods in the past. Thus, current expected inflation reflects a weighted average of all past inflation, where the weights get smaller and smaller as one moves further into the past. Hence by invoking the adaptive expectations hypothesis together with the law of iterated expectations, the following forecast of inflation over the horizon of the central bank's control lag may be stated as follows:

$$f^{*}_{t+n} = E_t \left[\pi_{t+n} / I_t \right]$$

$$= \left(1 - \lambda \sum_{j=0}^{\infty} \left(\lambda^{j} \pi_{t-j} \right) \right) \qquad 2.45$$

Note that the implication of both 2.43 and 2.45 is that under circumstances of nonstationary inflation data private agents have no option but to employ the current and past behaviour of inflation to predict its future value, in other words, the nonstationarity nature of the data forces the private agents to view the central bank as being non-credible and hence put more weight on the actual behaviour of current and recent past inflation in determining their expectations about the future inflationary trends.

2.3.4 Implications and Derivation of Testable Propositions

The analysis presented in section 2.3.2 demonstrates that under a successful IT regime, inflation follows a stationary process with the mean equal to the target and the optimal forecast is the inflation target for horizons equal or greater than the control lag. Thus, born out of this theoretical consideration Capistran and Ramos-Francia make the following proposition:

Proposition 1: *Inflation expectations are anchored when private agents' expectations with a forecast horizon equal to or greater than the central bank's control lag are at or very close to the inflation target, even if inflation at the time at which the expectations are formed, deviates significantly from the target.*

2.3.5 Original Contributions of this Study

Proposition two (below) is the first original contribution of this study to the literature, stemming from the Capistran and Ramos-Fancia (2010) theoretical insight that private agents' expectations formation process will be anchored around a target in the context of successful IT regimes whose inflation data generating process is stationary.

Proposition 2: *When a central bank is perceived to be credible, it will be reflected in the stationary properties possessed by the private agents' inflation expectations data generating process*

Proposition three (below) is the second 'original' contribution of this study and it is based on the theoretical analysis presented above (discussed in detail in chapter two, section 2.3.3), which demonstrates that IT in the context of non-stationary inflation, which is probably the case of small open emerging economies like South Africa and other developing economies that are subject to supply side shocks (ie oil price, exchange rates, administrative pricing, wages rates and so on). Private agents form their expectations, over the control lag horizon and beyond, based on the behaviour of current inflation, resulting in strong correlations between the two non-stationary series

Proposition 3: *When central banks are perceived to not to be credible there will be a long run cointegrating relationship between the I(1) current inflation and private agents' expectations measured over the control lag horizon and beyond.*

In chapter four of this study this proposition is rephrased as the **proposition-3-credibility-cointegration conjecture** when it is being tested within a Johansen VAR/VECM context.

2.3.6 Strategy to Test Propositions

Ideally to test the above propositions one should acquire paired expectations and inflation data from economies that comprise both IT central banks and non-IT central banks. The data from economies IT central banks ought to be divided into successful and unsuccessful targeters and then the series should be tested for stationarity. A pattern ought to emerge where successful targeters (credible central banks) will possess stationary data while unsuccessful targeters (non-credible central banks) ought to possess I(1) paired series which ought to be cointegrated. However it was beyond the scope of this study to acquire such a large and varied dataset.

Thus the study decided to test the same propositions by using disaggregated South African expectations data that spans the period 2000Q3-2011Q2, as well as 'breakeven' inflation expectations gained from calculating the yield differentials of index and nominal long dated bonds with similar terms to maturity. The Bureau of Economic Research (BER) conducts quarterly surveys on current, one and two years ahead expectations among three categories of private agents, viz., financial analysts, business executives and trade unionists. Furthermore,

BER combines the expectations of the three categories of private agents' expectations to form a composite series which represents the expectations for the economy as a whole. The study uses two years ahead forecast inflation, for it corresponds with SARB's two year control lag horizon in steering expectations to within the 1-3 percent target range. The breakeven inflation rate will serve as an alternative proxy variable representing financial analysts' long run inflation expectations.

The three expectations series will be tested for stationarity, if found then propositions 1 and 2 will be supported, despite inflation being nonstationary, which would imply that the expectations holder finds the central bank's policy to be credible. If any of the expectations series are found to be I(1) then cointegrating relationships with inflation will be tested for, and if cointegating relationships are found, it will imply that holders of such expectations find the central bank to be non-credible. Chapter four of this study will employ various stationarity tests, and the Johansen (1990) cointegration technique to test the above propositions. Moreover for comparative purposes, the study will employ the VAR methodology proposed by Cruijsen and Demertzis (2010) to acquire further insights regarding the bivariate inflation-expectations relationships and its relationship to the credibility concept.

Conclusion

The introduction to this chapter provided a summary of the theoretical insights that lead to the shaping of the ITMPF in the latter part of the twentieth century. Section 2.1 demonstrated that the ITMF be succinctly explained by the IS-PC-MR three equation paradigm together with a central bank loss function. The section demonstrated that an inflation-averse central bank will raise interest rate by more than the proportionate fall in inflation. However central banks also consider the interest sensitivity of output (IS relationship) and the responsiveness of inflation to output changes (ie., the Phillips curve), in setting the interest rate. Moreover this section also derived the Taylor Rule within the IS-PC-MR paradigm for the purposes of understanding the essay on policy reaction functions to be presented in chapter six.. Section 2.2 discusses the theoretical literature that provides insight into central bank credibility that emerged out of the IS-PC-MR framework and which ushered the way for the development of the core elements of central bank independence, accountability, transparency and an inflation target. Finally section 2.3 presents the Capistran and Ramos-Francia (2010) concept, which is based on the ideas of Svensson (1996, 1997), of inflation expectations formation process

within the IT and non-IT frameworks for stationary inflation time series data. Section 2.3 makes a modest but an original contribution to the field by pinning down, in mathematical terms, of how agents forecast inflation in the context of non-stationary inflationary data.

All the theoretical issues discussed above can be summarised by the overview that central bank credibility is a critical feature that leads to the anchoring of expectations (subject of chapter four) and hence inflation being anchored to a target thus leading to stationary series devoid of volatility and persistence (assessed in chapter five).

Chapter Three – IT Successes, Emerging Economies and the South African Experience

3.0 Introduction

Inflation targeting is a recent monetary policy strategy that was forged out of the theoretical developments and practical experience that suggest that central banks cannot consistently pursue and achieve multiple goals, , such as low inflation, high growth (low unemployment) and a stable exchange rate through just manipulating the policy interest rate. Since 1990 many industrialized countries (New Zealand, Canada, the United Kingdom, Sweden, Israel, Australia and Switzerland), several emerging market countries (Chile, Brazil, Korea, Thailand, South Africa and Ghana the latest entrant), several transition countries (Czech Republic, Poland and Hungary) adopted IT. Japan, USA and the ECB are also widely considered to be implicit inflation targeters. Under inflation targeting price stability is the primary objective and as mentioned in the introduction Greenspan (1994) defined price stability as a rate of inflation that is sufficiently low that households and businesses do not have to take it into account in making everyday decisions. Most industrialized economies define price stability as lying in the range of 1-3% while emerging and developing economies tend to have much higher ranges (roughly between 3-8%) due to their economies being vulnerable to supply side shocks.

One influential interpretation of inflation targeting due to Anna Schwartz, as described in Romer, (2006) is that IT is nothing more than a "conservative window dressing" as its key feature is a commitment by the central bankers to achieve low inflation outcomes. There should be no difference between outcomes for IT and non-IT countries committed to low inflation. The findings of Ball and Sheridan (2005) for industrialized economies and the findings of Brito and Bystedt (2010) tend to support this view. By contrast, some argue that IT's monetary policy framework itself, with the emphasis on credibility and communication matters for inflation expectations, is the key ingredient for its success in maintaining low inflation and output equilibrium levels. Also important, IT is typically accompanied by (somewhat) flexible exchange rates and this feature may make it more resilient to some external shocks than some other monetary framework. However, there is also an outright objection to IT due to its narrow focus on inflation that may blind central bankers from other worthwhile objectives such as reducing unemployment (Stiglitz, 2008). Buiter (2009)

expresses similar sentiments where he argues that IT central banks may also lose sight to important determinants of financial stability as they adopted intellectual frameworks suited to achieving this narrow goal.

The next three subsections dispense with outlining the main elements, strengths and weaknesses of IT. Thereafter empirical studies both supporting and contesting the purported benign influence of IT, are discussed. Then, three case studies of IT in practice regarding the three emerging economies of Chile, Brazil and Turkey will be presented. Along similar lines the IT experiences of South Africa will be explained.

3.1 Key Elements of IT

In practice an ITMPF has the following five distinguishing features compared to other monetary policy strategies (Roger, 2010; Mishkin 2004, Bernake *et al.*, 1999):

Firstly, central bank independence which prevents political interference, together with an institutional commitment to price stability as the primary goal of monetary policy, to which other goals are subordinated when conflicts arise, which builds credibility and anchors expectations rapidly and durably; secondly, the public announcement of medium-term numerical targets for inflation, where the medium term is generally defined as a two-year horizon since IT involves 'forecast' targeting, for inflation is partly predetermined in the short run due to price and wage contracts or indexation to past inflation, so policy can only affect expected future inflation by steering back to target; thirdly, a wide variety of information involving many variables, describing both domestic and global conditions, and not just monetary aggregates or the exchange rate, are used for deciding the setting of policy instruments; fourthly, transparency of the monetary policy strategy through communication with the public and the markets about the plans, objectives, and decisions of the monetary authorities, as well as the publication of forecasts, econometric models used and technical reports on local and global conditions likely to impact on inflation; and fifthly, increased accountability of the central bank for attaining its inflation objectives which includes explanations of likelihood of attaining the target.

3.1.1 Advantages of IT over other Monetary Policy Strategies

The last two decades have seen many countries switch to IT, the question arises what are the advantages of IT over the two main policy alternatives of targeting money supply growth or exchange rate pegs?

A money targeting framework is based on the assumption that the money multiplier (ie., central bank has full control over nominal money stock) is predictable and the velocity of circulation is stable (ie., there is a predictable relationship between long run money growth, income and prices). However in reality this was not the case, for targets were often missed, hence most industrialized and a few emerging economies have abandoned this strategy. Money targeting, involves the resetting of targets every year and are difficult to control due to shifts in money demand or the money multiplier which reduces the authority's capacity to control money supply and alter the long run relationship between money and inflation. IT, however, has the advantage that a stable relationship between money and inflation is not critical to its success, since the strategy does not depend on such a relationship, but instead uses all available information to determine the best settings for the instruments of monetary policy. Under money targeting it is more challenging to anchor inflation expectations since money targets introduce a second layer to the ultimate target of policy, which is the inflation rate. This makes it more difficult for the central bank to attain its objectives and it is harder for the public to monitor its performance. Money targets are unsuitable in economies with high inflation and where central bank credibility is weak. Money targets are based on the assumption that the central bank has full control over nominal money stock (Batini and Nelson, 2005; Goodhart 1989).

IT is considered to be superior to pegging the exchange rate, for the central bank control of exchange rate target is limited because exchange rate level is ultimately determined by international demand and supply of domestic currency relative to that of an 'anchor' currency. Hence shifts in sentiment about the domestic currency can trigger abrupt changes in its relative value that cannot be offset by central bank action. Moreover, the costs to the economy due to the failure of the exchange rate pegging strategy can be very high, usually involving huge reserve losses, high inflation and the banking crises, debt defaults and high unemployment (for example, Argentina in 2001). By contrast the failure to meet the inflation target leads to inflation temporarily overshooting its target and short-term slower growth, as

interest rates are raised to steer inflation back to the target range or level (Batini, Kuttner and Laxton, 2005).

In contrast to money targeting and exchange rate pegging strategies IT enables monetary policy to focus on domestic considerations and to respond to shocks to the domestic economy. Inflation targeting also possesses the critical advantage that it is easily understood by the public due to the central bank transparency. Additionally, an explicit numerical target for inflation increases the accountability of the central bank, and it is very easy for the public to monitor the central bank's performance. The central bank autonomy has the potential to reduce the likelihood that it will fall into the time-inconsistency trap, since it is often overt or covert political pressures for excessive expansionary monetary policy interventions, that is the source of the time-inconsistency problem. Due to central bank independence, transparency and accountability, IT has the advantage of focusing the political debate on what a central bank can do in the long-run (i.e., control inflation), rather than what it cannot do (ie., raise output growth, lower unemployment, increase external competitiveness), through monetary policy. Lastly under conditions of low inflation, central banks have made their inflation targets symmetrical, with undershooting of the targets considered to be as costly as overshooting. It is argued that symmetrical inflation targeting helps central banks to stabilize real output, because in the face of a weak economy, an inflation targeter can ease more aggressively without being worried that the easing will cause inflation expectations to rise Mishkin, 1997; Bernanke *et al*., 1999).

3.1.2 Success Formula: IT Institutional Practices

As mentioned above, for IT to deliver on the benign outcomes just mentioned, a strong institutional commitment must exist in its day-to-day procedures, practices and conventions, to make price stability the primary goal of the central bank. According to Mishkin and Posen (1997), and in Bernanke, *et al.* (1999), a critical practice that led to the success of IT in industrialized economies, is to make monetary policy transparent and to maintain regular channels of communication with the public. These central banks have regular communications with the government (including addressing parliament), and their officials, and they take every opportunity to make public speeches on their monetary policy strategy. IT central banks have taken public outreach a step further: they publish periodic *Inflation Report*-type documents (initiated by the Bank of England in February 1993) to clearly present

their views about the past and *future* performance of inflation and monetary policy. These reports include a detailed analysis of local and global economic and financial pressures that could adversely impact on inflation; the domestic components of CPI that are the cause of inflationary pressures; they publish and forecast of inflation together with fan charts, and based on their analysis to spell out the possible future path of interest rate. In recent times many central banks publish the debates and voting outcomes concerning policy stance, at monetary policy committee (MPC) meetings. All these aspects constitute policy transparency associated with IT regimes that has tended to make the central bank highly accountable to the public. Sustained success in the conduct of monetary policy as measured against a pre-announced and well-defined inflation target can be instrumental in building public support for an independent central bank, even in the absence of a rigidly defined and legalistic standard of performance evaluation and punishment as in the case of New Zealand (see, Meyer, 2002), where the constitution guarantees central bank independence. This guarantee is accompanied by a contractual agreement between government and the central banker which stipulates that the banker can be dismissed for missing a pre-defined target.

3.1.3 The Disadvantages of IT

Rivlin (2002) and Blanchard (2003) argue that IT is too rigid, for it offers too little discretion thus restraining growth unnecessarily. They assert that IT success hinges on the establishment of a reputational equilibrium between the central bank and domestic private agents, and that IT can only work effectively if the central bank builds credibility by consistently attaining the target., ie., for IT to be effective, central bank must demonstrate its commitment to low inflation, which may require aggressive and sustained interest rate rises which could temporarily reduce output. Thus, IT is too restrictive for it constrains discretion inappropriately in the interest of hitting a numerical target over a particular horizon, that could unnecessarily inhibit growth. However, Mishkin (1999) and in Bernanke, *et al.* (1999), output losses caused by restrictive IT policy actions are only a temporary setback for once the central bank is perceived to be credible and agents' expectations become anchored, then policy responses result in inflation stabilized at the target and resource utilization at its normal level in the long term. They further assert that under the optimal functioning of the IT strategy it is best characterized as affording the central bank constrained discretion.

Kumhof (2002) argue that IT cannot anchor expectations because it offers too much discretion. The anchoring of expectations can only succeed if agents perceive the central bank's policy action to be credible. However the authors argue that credibility cannot be built in countries where it is lacking for the mechanisms available to build it allows for excessive discretion over when and how to bring inflation back to target. Moreover targets can be changed. At best IT can only produce weak central bank accountability (and hence fails to build credibility) because inflation is hard to control and because there are long lags from the monetary policy instruments to the inflation outcome. This is an especially serious one for emerging market countries whose economies are typically vulnerable to shocks, have thin financial markets and the authorities lack the requisite technical capacity and institutional setup to effectively implement a sophisticated policy like 'forecast' inflation targeting in which the central bank seeks to make its inflation forecast equal to the inflation target over the relevant policy horizon.

Most emerging and developing economies are prone to high inflationary pressures, hence the inflation rate cannot be easily controlled by the central bank due to technical and institutional capacity constraints. Moreover, interest rate as a policy instrument affects inflation after long and variable lags hence it is difficult to implement inflation 'forecast' targeting. This problem is exacerbated even further when inflation is being brought down from relatively high levels. Under these circumstances, inflation forecast errors are likely to be large, inflation targets will tend to be missed, and it will be difficult for the central bank to gain credibility from an inflation targeting strategy, and for the public to ascertain the reasons for the deviations. According to, Mishkin and Savastano (2001), Bernanke, *et al.*, (1999) and Masson, Savastano and Sharma, (1997), under the aforementioned circumstances, IT is likely to be a more effective strategy if it is phased in only after there has been some successful disinflation.

Mishkin and Savastano, (2001) and Masson *et al.*, (1997) noted that a successful IT policy goes hand in hand with strict fiscal discipline, and that IT by itself is incapable of preventing fiscal dominance. This is of particular relevance to emerging market economies where the risk of fiscal dominance arises hence it is possible to have situations where governments can still pursue irresponsible fiscal policy with an inflation targeting regime in place. Over the long term, large fiscal deficits will cause an inflation targeting regime to break down: the fiscal deficits will eventually have to be monetized or the public debt eroded by a large

depreciation, and high inflation will follow. Fiscal discipline is therefore a quintessential prerequisite for inflation targeting, and the setting up of institutions that help keep fiscal policy in check are crucial to the success of the strategy.

Batini *et al.,* (2005) raised the point that IT might imply high exchange rate volatility. They argued that since price stability is elevated to the status of primary goal it requires the exchange rate to find its own equilibrium level (ie., floating exchange rate regime), thus resulting in exchange rate volatility which could affect economic growth. In a similar vein, Calvo, (1999) noted that since IT necessarily requires nominal exchange rate flexibility, exchange rate fluctuations are unavoidable. However, large and abrupt depreciations may increase the burden of dollar-denominated debt (many Latin American households and firms' assets and debt are denominated in dollars), produce a massive deterioration of balance sheets, and increase the risks of a financial crisis (see, Mishkin, (1996) for further details). This suggests that emerging market economies cannot afford to ignore the exchange rate when conducting monetary policy under IT, but the role they ascribe to it ought to be subordinate to the inflation objective.

Finally, most of the disadvantages of inflation targeting, especially in the context of emerging economies, have been presented above in the form of preconditions that economies must possess for IT to be successful. These included technical capacity, institutional setup, absence of fiscal dominance and flexible exchange rates. However two remaining preconditions that may pose a challenge to emerging economies include a liberal economic structure and financial market soundness. In order for IT to work optimally prices in an economy must be fully deregulated, the economy should not be overly sensitive to commodity prices and the exchange rates and dollarization should be at a minimum. It has been argued that to minimize potential conflicts with financial stabilization objectives and guarantee effective monetary policy transmission, the banking system should be sound and capital markets well developed. Typically in emerging market economies when financial systems are under stress, there is a surge in inflation.

3.2 Impact of IT on Emerging Markets: Literature Review

Once ITMPF came into vogue, the key questions researchers attempted to answer, over the last decade or more are: *does inflation targeting make a difference?* or *does inflation*

targeting matter, especially for emerging economies? From a policy evaluation perspective it is critical to find answers to these questions in the interest of promoting an economy that achieves sustainable growth along a steady path over the business cycles without serious disruptions. The key issues that the IT literature has covered include the reduction in average inflation and its volatility, the stability of output, the anchoring of inflation expectations among private agents and the predictability of policy stance. The literature review that follows is divided into pre-and-post-2005 studies, since most of the post-2005 studies often responded to the controversial findings of Ball and Sheridan (2005).

3.2.1 Pre-2005 Literature Evaluating IT

Some of the earliest literature, that provided empirical assessment of IT, that have provided insights into the aforementioned questions, include Ammer and Freeman (1995), who found that IT, in the UK, Canada and New Zealand, failed to anchor expectations or build central bank credibility. The authors observed that after having introduced an IT regime, these countries continued to maintain high interest rates for a lengthy period, which affected output negatively hence they intimated that the cost of reducing inflation may be too high. This latter point was corroborated by Debelle (1997) who considered the IT countries that adopted IT in the early years, noted that a substantial decline in inflation rates and long term bond rates occurred but also noted that unemployment increased significantly during the disinflation period, hence inflation reduction came at a huge cost. He also pointed out that non-targeters also achieved similar reductions in inflation rate during the first half of the 1990s, thus making it difficult to conclude that disinflation is the success of the IT regime alone. Similar conclusions were recorded by Cecchetti and Ehrmann (2000) who considered a sample of both industrialized and emerging economies. They maintain that the benign inflation outcome rather than being a product of the IT regime may just reflect the general culture among central bankers in a decade that provided an environment conducive to price stability and therefore an opportunity to move away from the inflationary processes of the 1970s and 1980s, in other words, the 'conservative window dressing' concept.

Corbo, Landarretche, and Schmidt-Hebbel (2002), for instance, compared policies and outcomes in fully fledged IT countries for two groups, namely, potential inflation targeters and non-IT targeters. They found that sacrifice ratios were lower in IT compared to non- IT

countries. Moreover they noted that inflation forecast errors reduced drastically, and that inflation persistence has declined strongly among IT relative to non-IT economies.

Johnson (2002), focused on industrialized economies alone, he compared five IT to six non-IT economies, found that the period after the announcement of IT was associated with a statistically significant reduction in the level of expected inflation. Furthermore, he found that IT has not reduced absolute average forecast errors in IT relative to those in non-IT countries. However, his study found that inflation targeters did avoid, even larger forecast errors than those that would have occurred in the absence of IT. In contrast, Neumann and von Hagen (2002) consider a group of six industrial IT countries and three non-IT countries and perform an event study to quantify the response of inflation to long-run as well as short-run interest rates to supply shocks (increases in the world oil price in 1978–79 and in 1996–1998). They find that the effect of IT in the reduction of average inflation is statistically insignificant, but found statistically significant downward responses for interest rates, thus implying a gain in credibility among inflation targeters.

Petursson (2004) analysed a dataset involving twenty one IT countries which included emerging market economies. A dummy variable was employed to separate out the pre-and-post-IT periods on a country basis. He found that IT caused a significant reduction in the level, persistence, and variability of inflation. However, the drawback of the technique used in this study is that it does not address the fundamental issue of relative performance between an IT country and its counter-factual. Nonetheless, it provides a clear and robust account for the evidence of the absolute benefits of IT and corroborates previous findings of other studies that investigated similar issues using alternative techniques.

Levin, Natalucci, and Piger (2004) studied inflation persistence using five industrial IT economies that are compared to seven industrial non-IT economies. The study performed univariate regressions on inflation for each country and found that inflation persistence is estimated to be quite low among the inflation targeters, whereas the unit root hypothesis cannot be rejected for non-targeters, implying that their inflation was unstable and not mean reverting. Benati (2004) using a similar method and a larger sample of twenty OECD countries confirmed these findings. Levin and Piger (2004), on the other hand, in a similar empirical framework with twelve industrial countries, allowed for structural breaks and found that inflation, in general, exhibits low persistence for both IT and non-IT countries. They also

suggest that IT does not seem to have had a large impact on long-term expected inflation for a group of eleven emerging market economies.

Ball and Sheridan (2005) studied the macroeconomic performance of 7 inflation targeters and 13 non-targeters, all of whom belong to the Organization for Economic Cooperation and Development (OECD). They found no evidence that IT improves the performance as measured by the behaviour of inflation, output or interest rates. Although they found that in the IT countries inflation fell and became more stable and output growth also stabilized over the targeting period compared to the pre-targeting period, but this was also the case for non-targeters as well, thus suggesting that better performance resulted from factors other than targeting. Average inflation fell for both targeters and non targeters, but the improvements are larger for targeters, for the average for targeters went from above that of non-targeters to approximately the same.Neuman and von Hagen (2002) interpret this finding as IT promoting convergence, however Ball and Sheridan (2005) contest this claim.

3.2.2 Post-2005 Literature evaluating IT

The seminal Ball and Sheridan (2005) study, mentioned above, spawned a plethora of papers, that attempted to either confirm or reject their results through the use of a wide range of econometric techniques. Thus it is fitting for this study to briefly outline the econometric technique they employed. The following was the initial flawed 'difference- in-difference' regression they had run:

$$X_{post} - X_{pre} = a_o + a_1 D + \varepsilon \qquad 3.0$$

Where, X_{post} is a country's value of X (inflation, output or any other macroeconomic variable. However for this outline the study will assume that it refers to inflation) in the post-targeting period, X_{pre} is the pre-targeting value and D is a dummy and represents 1 is if the country is a targeter, otherwise 0. However, a regression involving equation 3.0 is misleading, since X_{pre} is substantially different on average for IT and non-IT economies, ie., average inflation was much higher in the pre-targeting period for IT economies, hence the switch to IT due to poor experiences with previous policies. They found that targeters reduced higher-than-average inflation rates toward equilibrium which was reflected in $a_1 > 0$

being statistically significant but was really spurious since X_{pre} is correlated with the targeting dummy. In other words, past poor performers made bigger improvements compared to past good performers in reducing inflation which could be due to transitory effects and not IT, they termed this phenomena *regression to the mean* and they explained it as:

> *" Just as short people on average have children who are taller than they are, countries with unusually high and unstable inflation tend to see these problems diminish, regardless of whether they adopt inflation targeting."* Ball and Sheridan (2005: 250)

Essentially they raised a methodological point which Vega and Winkelried (2005) interpreted as implying that if there is a targeter with poor performance before IT, then it should be compared with a non-targeter with equally poor initial performance. Otherwise, the targeting effect would be overstated. Ball and Sheridan (2005) controlled for the regression to the mean problem by adding X_{pre} as a regressor in equation 3.0, which gave rise to:

$$X_{post} - X_{pre} = a_o + a_1 D + a_2 X_{pre} + \varepsilon \qquad 3.1$$

Now a_1 reflects whether targeting affects a country's change in performance for a given initial performance. If a_1 is significant then a targeter with poor initial performance improves more than a non-targeter with equally poor initial performance.

Batini, Kuttner and Laxton (2005), Batini and Laxton (2007) and Gonclaves and Salles (2008) were the recent attempts to apply the Ball and Sheridan (2005) cross-section difference-in-difference ordinary least squares (OLS) method to test whether IT adoption impacted on inflation and output growth. The later studies progressively included both, a larger number of economies and longer time series in their dataset. Their findings reveal that IT economies lowered their inflation and output growth volatilities, relatively more than non-IT economies. Moreover, they also lowered their inflation rates relative to their non-IT counterparts. Based on this evidence these studies concluded that there is no evidence that IT hinders output growth.

Vega and Winkelried (2005) criticised the Ball and Sheridan study for not matching IT economies with suitable counterfactuals (ie non-IT economies that share similar characteristics), hence they harness the propensity score matching procedure borrowed from

the policy evaluation literature to find suitable counterfactuals to the actual inflation targeters. They found that IT has helped in reducing the mean inflation around a target and volatility of the targeters relative to non-targeters. Furthermore, they noted that IT has reduced the persistence of inflation in emerging economies. Nevertheless, the small magnitude of the reduction is such that it prevented from categorically concluding in favour of IT, in this particular dimension of the inflation dynamics. Lin and Ye (2009) employed a similar econometric method to that of Vega and Winkelreid (2005), to carefully match emerging market IT economies with other such non-IT economies, and found that on average IT has large and significant effects on lowering both inflation and inflation volatility.

Mishkin and Schmidt-Hebbel (2007) employ a dataset comprising of both industrial and emerging market targeters and compare them against a control group of high achieving non-IT industrailized economies. Then, they use panel data analysis to estimate the inflation and output variability trade-off faced by these countries. Their results suggest that inflation targeting helps countries achieve lower inflation in the long run, have smaller inflation response to oil-price and exchange-rate shocks, strengthen monetary policy independence, improve monetary policy efficiency, and obtain inflation outcomes closer to target levels. Some benefits of inflation targeting are larger when inflation targeters have achieved disinflation and are able to make their inflation targets stationary. Despite these favourable results for IT, it generally does not suggest that countries that adopt inflation targeting have attained better monetary policy performance relative to the control group. However, inflation targeting does seem to help all country groups to move toward performance of the control group. The performance attained by industrial-country inflation targeters generally dominates performance of emerging-economy inflation targeters and is similar to that of industrial non-inflation targeting countries.

Brito and Bystedt (2010), contended that the studies by Batini, Kuttner and Laxton (2005), Batini and Laxton (2007) and Gonclaves and Salles (2008), who used Ball and Sheridan's (2005) cross-section difference-in-difference approach is inefficient because it does not accommodate for endogeneity or control for time or country fixed effects. These factors must be taken into account because the adoption of IT is an endogenous choice taken at different times by countries with different unobservable characteristics. Brito and Bystedt argue that the Lin and Ye (2009) and the Mishkin and Schmidt-Hebbel (2007) papers, because of their cross- sectional nature involving static panel data analysis, do not accommodate for time

trends and the countries' unobservable characteristics or persistence. Hence they utilize dynamic panel estimator which controls for endogeneity and omitted variable biases. Moreover their method also controlled for the worldwide downward trends in inflation which resulted in a weaker impact of IT on inflation reduction and inflation variability, and it also revealed a high output loss due to IT disinflation. Thus they conclude that the 'conservative window dressing' view of IT was reiterated by the findings.

Mollick, Cabral and Carneiro (2011), also applied dynamic panel data analysis to thirty four emerging market economies and twenty two industrialized economies for the purposes of examining output growth. They found that that IT regimes generate higher output growth for both industrialized and emerging economies, but it is lower for emerging markets probably due to their having adopted IT much later than industrialized economies.

Angeriz and Arestis (2008) did not follow or respond to the Ball and Sheridan (2005) paper. Instead they applied an Intervention Analysis to Multivariate Structural Time Series Models to a number of OECD countries. Their results demonstrate that both the IT and the non-IT central banks have been successful in achieving low inflation rates. Angeriz and Arestis have included only nine OECD countries in their sample: Australia, Canada, Finland, South Korea, New Zealand, Norway, Spain, Sweden, and the United Kingdom. The United States (US) and the Economic and Monetary Union (EMU), have been included as the control group as they are non-targeters.

Lastly there is a growing body of literature that demonstrates that IT promotes the anchoring of long run expectations, for example studies by Gurkaynak *et al*., (2006) study UK a targeter and USA a non-targeter data, respectively, on the difference between far-ahead forward rates on nominal and inflation-indexed bonds as a measure of compensation for expected inflation and inflation risk at long horizons. They examined how much, if at all, far-ahead forward inflation compensation moves in response to macroeconomic data releases and monetary policy announcements. They found that forward inflation compensation exhibits highly significant responses to economic news for USA but not so for UK. Reid (2009) found that South African expectations data behaved in a similar fashion as that of a targeter. Cruijsen and Demertzis (2010) using a bivariate VAR approach found that in an IT context when survey expectations are anchored to a target then there is no relation between movements in

current inflation and survey expectations. Chapter four examines this latter relationship in greater detail.

In conclusion to this subsection, the afore-presented literature review reported conflicting findings regarding the impact of IT on economic performance in both industrialized and emerging market economies. Moreover, in both in the pre-and-post studies the results remain mixed; some papers attest to the positive effects of IT while others to no significant changes in the performance of the economies in the dataset. The only difference is that the datasets become larger since both the time series became longer and more countries joined the IT club. Additionally more sophisticated panel data analyses were undertaken in the post sample as the technique became more assessable. Hence, there is no final word on any noteworthy advantage of inflation targeting. In this context, part of the difficulty is the short time series data that researchers are forced to work with. Similar findings emerge in empirical studies involving South Africa (see chapters four and five). It must be stressed that precisely because of the continued mixed findings in the post-2005 period, this study involving IT in South Africa became all the more important to shedding light on the IT debate.

3.3 Case Studies of four Small Open Economies

This section illustrates the IT experiences of Chile, Brazil and Turkey which are three small open emerging market economies that officially embraced IT around the same time as South Africa. Additionally South African enjoys a GDP per capita adjusted for purchasing power parity similar to that of the mentioned countries. According to IMF in 2010 South Africa's GDP per capita was $10,518, while that of Chile, Brazil and Turkey was $15,040, $11,273 and $13,577, respectively.

3.3.1 Experiences of Chile

Chile informally adopted IT in September 1990, and gradually moved towards fully-fledged IT over a decade. At the time of IT-adoption the Central Bank of Chile (CBC) enjoyed a large degree of constitutional independence in terms of both objectives and instruments. The Constitution defined the sole objective being one of price stability and the normal functioning of the internal and external payments system; conditions under which board members can be dismissed; and explicitly freed the CBC from any form of fiscal dominance (ie., any form of

central bank financing of government debt) Over the period 1984-1999, the CBC pursued an exchange rate target and simultaneously it attempted to steer inflation within a range of 8-10 %, with their ultimate goal being single digit inflation identical to that of their major trading partners. Over the 1990-1999 convergence period, the CBC succeeded in reducing inflation from 30% in 1990 to 3% in 1999, albeit with significant fluctuations in the intervening years (Cespedes and Valdes, 2006; Schmidt-Hebbel, Werner, Hausmann and Chang, 2002).

Over the convergence period monetary policy exhibited a few IT characteristics, which included periodic reports to government, the announcement of an annual quantitative inflation target and a predominance of these targets as the nominal anchor when conflicts arise. However, these targets at times conflicted with the exchange rate target which was the main nominal anchor. The announcement always specified a target for each year; however, it was generally kept fixed; only once in 1995 it was lowered from 9 to 8%. The announcements were accompanied by explicit statements that the notion of slow convergence to lower inflation was desirable because of inflation inertia (backward-looking indexation, see chapter two) and that rapid convergence is risky and is likely to be disruptive to the real economy and derail the disinflation programme. Other typical features of an IT system were absent, which included transparency and the communication devices with the public (Cespedes and Valdes, 2006; Valdes, 2007b).

Over the convergence period the CBC also managed an exchange rate target band together with capital controls to manage disruptive short-term capital inflows. The band was perceived to be the key instrument for the normal functioning of the balance of payments system, which became the effective target for the current account deficit. The band underwent a number of modifications, and they intervened in the foreign exchange market directly through state owned companies or indirectly through open market operations, all in the interest preventing real appreciations. Over the 1990-1997 period, the CBC intervened aggressively in the foreign exchange market to sterilize inflows, its position changed from a 5.1% deficit to a 25% surplus of GDP. The implementation of monetary policy improved progressively over the 1990s, from having a weak control over interest rates on a variety of instruments in 1990, to managing liquidity through explicitly targeting the overnight interest rate in the interbank market (Cespedes and Valdes, 2006; Schmidt-Hebbel *et al.*, 2002).

Valdes (2007b) considers the period since September 1999 (formal adoption of IT), the *steady state* period. Over the 1997-1999 the economy moved from being overheated to that of a recession by 1999, caused by the Asian and Russian Crises of 1997-1998 which affected the economy through real and financial transmission mechanisms. In the second half of 1999 the authorities introduced major reforms that led to the official adoption of fully-fledged IT, which included a free floating exchange rate regime; the deepening of the foreign-exchange-derivatives forward markets; the total opening of the capital account; and the normalization of monetary policy in the sense of switching from a CPI-indexed real interest rate to that of a nominal interest rate instrument. The CBC justified these changes on the grounds that inflation had already converged to low levels and that greater exchange rate flexibility was possible due to the development of hedging mechanisms and lower exchange rate volatilities and the need to accommodate transitory inflationary shocks and the need for a longer time span for monetary policy to affect inflation in order to prevent unnecessary output volatility.

In September 1999 a new 2-4% target band was announced which was maintained until 2007, when it was changed to 3% with a tolerance band of $\pm 1\%$, which remains the same up to the present (Roger, 2010). The CBC also stipulated that the target horizon of 12-24 months will be the period within which inflation will be steered back to its target. In 2007 this target horizon was simplified to that of two years. Between 2001 and 2007 inflation averaged 2.8%. Furthermore, 73% of the time it was within the band, and 17% of the time below 2% and only 10% of the time above 4% (Valdes, 2007a, 2007b).

Since September 1999, the IT has evolved into a sophisticated practice, on par with that of industrialized economies, for example the Norges Bank or the Riksbank (see Svensson, 2010). The new practices included the publishing of an inflation report thrice yearly; the announcement of the dates of monthly monetary policy meetings six months in advance; full disclosure of monetary policy meeting minutes with a three-month lag which was subsequently shortened to three weeks; publishing of forecasts, together with views concerning transmission mechanisms; and the National Treasury's clarification of a rules based fiscal policy, where a surplus target of 1% of GDP was to be achieved through the cyclical tax and copper revenues adjustments and the commitment to prevent sudden expenditure changes (Valdes, 2000b).

According to Garcia and Valdes (2005), the conservative monetary policy practiced in 1998, strengthened the CBC's anti-inflationary reputation and which paved the way for fully fledged IT as well as for the authorities to introduce fiscal targeting rules. Additionally, the CBC monitors the formation of inflationary expectations through various sources which include breakeven inflation (recall it is the difference between indexed bonds and nominal bonds of similar terms to maturities); the interviewing of 35-40 economists; the conducting of monthly expectations surveys, where financial analysts, households and firms are interviewed and weekly CBC's surveys of banks and institutional investors. These expectations indicators serve four key functions, which include a benchmark to the CBC's inflation forecasts; an early warning indicator of second-round-effects of shocks; assists in evaluating the real effect of monetary policy; and help the central bank to evaluate their credibility at any point in time. This latter point is especially significant since the acceptance nominal anchor (ie., inflation target) reflects the private agents' confidence that the central bank will take action to ensure inflation reverts back to target. Hence, medium and long-term expectations precisely measure this confidence. Although it is not at all clear how these expectations are formed they do affect the inflationary dynamics and influence the price setting behaviour.

The statistics show that inflation had been anchored to the target level, there has been a reduction in inflation and output volatility in line with what has been observed in industrialized economies (Valdes, 2007b). Over the 2007-2009 credit crunch period the inflation rate remained within the target band except for 2008 where it surged to 8.7% but by 2009 it fell below 2%. Real GDP over the 2007-2010 period ranged between 3.7and 5.35%, however in 2009 it shrunk by 1.7%. Over the near future the growth is expected to surge with inflation being contained within the target band (IMF, 2010).

South Africa can learn much from the Chilean experiences, which may include that IT is well supported by fiscal surpluses; concerted efforts to acquire inflation expectations data from a wide variety of survey based sources and the full disclosure of the monetary policy committee minutes.

3.3.2 Experiences of Brazil

In the 1994 Brazil introduced the '*Real* Plan' stabilization policy that involved, using the exchange rate as a nominal anchor, introducing trade and financial liberalization and freeing

the capital accounts. The Real Plan was characterized by a fixed or crawling-peg exchange rate, in combination with a more open trade policy. The exchange rate was the price anchor utilized throughout the 1990s, which was combined with very high interest rates for the purpose of attracting short-term foreign capital for the purposes of maintaining small balance-of-payments surpluses. However, the volume of those capital flows tended to be larger than anticipated, resulting in huge surpluses that led currency appreciations, which in turn caused significant trade deficits. The effect of that liberal economic policy stance aggravated Brazil's external fragility and, consequently, the country had three speculative attacks on its currency over the three year period from 1995 to 1998. Furthermore, from the third quarter of 1998 to the first quarter of 1999, the Brazilian economy was characterized by macroeconomic instability, resulting in a sharp outflow of short-term capital. This situation was exacerbated by the South East Asian and the Russian crises, along with the 1997-1998 global recession, thus contributing further to the deterioration of the Brazilian economy. Hence Brazil was forced to abandon its crawling-peg exchange rate and adopt a floating exchange rate regime.

The exchange rate depreciated resulting in significant inflationary pressures. Following the transition to a floating exchange rate in January 1999, Brazil adopted an IT regime in June 1999 to keep inflation under control. At the same time, the Central Bank of Brazil (BCB) raised the basic short-term interest rate to accommodate the currency-depreciation shock. As a result, an appreciation to the exchange rate occurred very fast, and inflation, despite the huge devaluation in the beginning of 1999, ended the year in single figures. (Ferrari-Filho and Paula, 2003) Serrano and Summa (2011) summarise the overall policy framework since 1999 has been made up of a "tripod" of explicit inflation targets, a (very "dirty") floating exchange rate regime, and specific (and quite large) targets for the primary budget surplus. The Brazilian inflation-targeting system requires that the monetary authority pursues a single objective, the control of inflation, which must remain inside a pre-defined range within a calendar year.

According to Schmidt-Hebbel *et al*., (2002) the Brazilian IT monetary policy regime is modeled on the basis of the British and Swedish IT model. The National Monetary Council (CMN) sets the inflation target, which is proposed by the finance minister. CMN comprises of three directors, viz., the ministers of finance and planning, and the BCB governor, all of whom are appointed by the president of Brazil and do not have fixed mandates (unlike Chile and New Zealand for example). The CMN establishes the inflation targets on a yearly basis

and their corresponding intervals of tolerance for the next two years. The CMN is responsible for the setting and achieving the inflation target, conducting monetary and exchange rate policies, and regulating the financial system. The BCB Monetary Policy Committee (COPOM)[7] steers inflation toward the target through the use of the short-term interest rate (Selic)[8]. Inflation targets are based on the headline inflation index, i.e., extensive national consumer price index (IPCA). The inflation target is defined as being 2 or 2.5 percentage points above and below the central point target of 4.5%[9] The BCB prefers this flexible targeting arrangement since it enables them to achieve the inflation target in an economy that is extremely vulnerable to supply shocks. The inflation target is fulfilled when the yearly variation of the inflation index is inside the set range. If inflation breaches the target, the BCB governor is required to write an open letter to the finance minister explaining the reasons for the breach, and the proposed measures, to bring it back to target and the time horizon over which these measures are expected to take effect. The policy instrument (Selic) is set by COPOM, for a fixed period between its regular meetings. The BCB governor, however, has the right to alter the Selic interest rate target anytime between monthly COPOM meetings depending on the nature of the inflationary pressures in the economy. Eight days after each meeting, the committee releases the minutes on the BCB website and to the press through the BCB press officer. The minutes provide a summary of the COPOM's discussion and decisions. The COPOM publishes a quarterly BCB inflation report; which provides detailed information on the local and global economic conditions, as well as the COPOM's inflation forecasts upon which changes in the Selic interest rate are determined. The objective of this report is to inform the public and the market about the goals, design, and implementation of monetary policy (Arestis, Paula and Ferrari-Filho, 2008).

COPOM mainly relies on survey based expectations, whose medians often are fed into formal models and are closely monitored and analysed. Moreover they receive much attention from the media and market participants. The BCB implemented in 1999 a survey as part of the transition to the inflation targeting system. Moreover, it was developed in order to monitor market expectations and improve the inputs for the monetary policy

[7] COPOM was established in June 1996, its purpose is to determine the monetary policy stance through setting interest Rates. Its membership comprises the board of directors of the BCB.

[8] Selic interest rate—the interest rate for overnight interbank loans, collateralized by those government bonds that are registered with and traded on the "Sistema Especial de Liquidação e Custodia" (Selic)

[9] Note that the target itself varies for it is set on a yearly basis by the CMN, however 4.5% reflects a reasonable average value based on the actual experiences of Brazil.

decision-making process. The BCB conducts a daily survey of roughly 100 financial and non-financial institutions' forecasts for the Brazilian economy. These surveys are summarized into weekly press releases and are closely analysed and discussed in the BCB's quarterly reports. These surveys monitor market expectations for inflation rates, GDP growth, industrial production growth, the exchange rate, the Selic interest rate, fiscal variables, and external sector variables. Furthermore, in order to foster private sector forecasting expertise, a top 5 ranking of forecasters, in terms of forecasting accuracy, is published on a monthly basis (Henzel, 2008).

In 1999 and 2000 inflation stayed within the target range. However inflation overstepped the target band from 2001 to 2003, but, since 2004 the government was successful in keeping inflation within the range every single year, even over the 2007-2009 global credit crunch period. Arestis *et al*., (2008) explain the 2001-2003 target breach by reasoning that, in 2001 and 2002, due to external and domestic shocks, which included the domestic energy crisis in Brazil, effects of September 11, 2001, the Argentine crisis, and the confidence crisis related to the 2002 presidential election led to currency depreciations that fed into inflationary pressures, where inflation rate reached 7.7% in 2001, 1.7% above the target's upper range, and 12.5% in 2002, more than 5 percentage points above the upper range. According to Minella, Freitas, Goldfajn, and Muinhos (2003), the exchange depreciated by 20.3% and 53.5% in 2001 and 2002, respectively. As a result, in 2001, 38% of the inflation rate could be explained by the exchange rate depreciation, whereas for 2002 the contribution of the exchange rate stood at 46%. In 2003, the inflation rate was 9.3% above the adjusted target of 4.0% and outside the range of 2.5% tolerance interval. The high inflation in 2003 was due mainly to the initial effect of the 2002 high inflation, in spite of the maintenance of the conservative economic policy with very high interest rates by the new president, Lula da Silva. In 2004, the IPCA was 7.6%, well above the target of 5.5%. Growth of administered prices (mainly gasoline, health plans, fixed telephone, and electricity rates) in the same year reached 10.2%, accounting for 29.0% of the change in the IPCA or, equivalently, 2.94% out of 10.2%. In 2005, the inflation rate was 5.7%, which was within the upper and lower tolerance levels for inflation set by the CMN for that year. The factors that influenced the lower growth rate in prices (mainly in market prices) in 2005 were, among others, an abundant supply of farm products (rice, perishable foodstuffs, and soybean) and, especially, exchange rate appreciation. In 2006, the inflation rate was 3.14%—it was the lowest inflation rate in the period 1999–2007. Once again, the exchange rate appreciation explains the low

inflation rate for 2006. In 2007, the inflation rate was 4.46% (0.04% below the inflation target).

Serrano and Summa (2011) assert that the BCB was able to meet its inflation target after 2004 through a continual appreciation of the exchange rate. They contest the widely held view that is endorsed by the BCB and others, that inflation is driven by changes in aggregate demand. The commonly accepted view is that when the BCB raises interest rates, it causes a reduction in aggregate demand and therefore lowers inflation. However, the authors demonstrate by showing a close correlation between currency appreciation, accompanied by lower inflation and sustained economic growth since 2004. They conclude that, inflation in Brazil is driven by cost-push pressures which is supported by the data that shows that there was a reduction in import and export prices, due to appreciation of the Brazilian Real, that has allowed Brazil to maintain its inflation target during these years. When the Central Bank raises policy rates, this attracts capital inflows, thus appreciating the currency and reducing inflation by reducing import and export prices. Therefore, the Brazilian inflation-targeting system, in which the interest rate is used to control inflation, actually works directly through the exchange-rate cost channel.

Arestis *et al*., (2008) made similar observations to that of Serrano and Summa (2011) where they noted that high real interest rates, combined with the current account surplus from 2005 to 2007, resulted in a gradual appreciation of the Brazilian exchange rate that contributed to the reduction of the inflation rate. They reasoned that exchange rates can influence inflation rate ("exchange rate pass-through") through the prices of traded final goods and imported intermediate goods, and their impact on agents' inflation expectations.

The link between exchange rate appreciation and inflation reduction is especially relevant to the South African situation, for example, from 2004 to July 2007 South Africa's exchange rates appreciated steadily and stabilised in a narrow band of between R6-R7 per dollar at the same time the economy experienced very low inflation rates of within the target band. Similar observations can be found in the data in the data in the aftermath of the global financial crisis. Maintenance of a primary fiscal surplus, building of foreign exchange surpluses, flexible wage policies, the high frequency monitoring of expectations, the release of monetary policy committee minutes to the public, and the policy mix that resulted is an

unprecedented reduction in poverty are other lessons South Africa can take from the Brazilian experience.

3.3.3 The Experiences of Turkey

Kara (2006) noted that in the two decades before the February 2001 economic crises which led to the adoption of implicit IT, Turkey's economy was characterised by chronically high inflation, persistent fiscal imbalances, financial volatility and wide fluctuations in economic activity. According to Sahinbeyoglu (2008), the large budget deficits during the 1990s culminated in a rapid increase in the government indebtedness, a sharp rise in interest rates which harmed private investment and entrenched unsustainable debt dynamics. These factors catapulted the economy into an inflationary trap with persistently high inflation, high and rising nominal interest rates. Ersel and Ozatay (2008) recorded that the public sector borrowing requirement was mainly met by issuing domestic debt rather than by inflation tax, which caused a continuous rise in the public debt stock, and also the real interest rate remained at high levels which in turn spurred the inflation rate to persist at high double digit levels. Given the absence of a stabilization program that aims to give an end to this fiscal laxity, it was impossible for the monetary authorities to implement a tight monetary policy. At that time, the main concern of the authorities was not to dry up liquidity in the domestic debt market. Given the high and increasing financing requirements, a sharp decline for government securities would be a call for debt monetization. Hence, the Central Bank of Turkey (CBT) tried to leave enough liquidity in the market to minimize this risk. At the end of 1999, Turkey attempted to reduce inflation and enhance the economic growth by signing a standby agreement with the International Monetary Fund (IMF). The policymakers put the pre-announced crawling peg system at the core of the program together a tight fiscal policy and structural reforms. Sahinbeyoglu (2008) argued that this programme was a precursor to adopting fully-fledged IT, for it placed limits on the CBT's creation of domestic assets, as well as an exit strategy from the peg, where the exchange rate band was to widen by 15% per year until its freely floating. However, during 2000, the programme appeared to be working, for the primary budget surplus increased to 3% of GDP. Furthermore, both inflation and interest rates fell which helped debt sustainability and the crawling peg gained initial credibility. However the programme was abandoned in February 2001 thus precipitating a serious economic crisis. The failure of the programme can be attributed to the inflation rate having fallen by less than the depreciation of the lira which was governed by the crawling

peg resulting in a real appreciation of the lira. Together with a boost in domestic demand caused by a fall in the real interest rate, the real appreciation led to the widening of the current account deficit and hence raising doubts about the sustainability of the crawling peg. The banking system also contributed to the failure of the programme, since a number of banks speculated on the success of the programme by borrowing short or in a foreign currency and investing the proceeds in higher-yield longer term lira-denominated government bonds, taking large open positions. When short term interest rates had to be raised to defend the peg, it raised issues about the liquidity and solvency of the banks which eventually forced the abandonment of the peg. The ensuing crisis forced the authorities to develop an alternative programme, however it possessed similar features to the previous one: tight fiscal policy, pursuing disinflation and implementing structural reforms to achieve rapid economic growth. The depreciating exchange rate and ensuing inflation, the financial system weakness and the raising government (foreign denominated) debt caused by currency depreciation, and sustained rises in interest rates caused by defending the peg, decreased the probability of success of the alternative programme, hence it had to be buttressed by IT, since exchange rate anchoring was not viable (for reasons discussed above) nor was money targeting due to the instability of the money demand relationship.

However, despite IT being the only remaining option Turkey did not possess the requisite preconditions for IT to take root: firstly, in May 2001 inflation was at 52% and was approaching 70% by year end, hence the announced target would not be credible and no other country introduced IT under such circumstances; secondly, backward wage and price indexation was rife , as well as the pass-through from exchange rates to prices and to worsen matters, higher inflation due to currency depreciation was in the pipelines, hence it was hardly the conditions to introduce IT; thirdly, the fiscal dominance dynamics both in terms of size of government debt and the rollover problems due to maturity of short-dated debt, made the feasibility of using short-term rates to control inflation doubtful, for the raising of short term rates by the CBT in July 2001 led to unfavourable market reaction in the form yields across all maturities rising and rates and the lira depreciated; fourthly, financial dominance and a weak banking system raised concerns that short-term rates will serve as a weak instrument to inflation the direction of interest rates (Kara, 2006; Ersel and Ozatay, 2008).

Against this backdrop the CBT adopted ‘implicit IT’ which assumed the form of a hybrid regime involving two aspects. The first aspect, involved targeting base money supply. They

asserted that money demand instability is only a problem at low inflation levels compared to the high actual levels being targeted, forecast errors were expected to be small, and they set a money target of 40% roughly in line with nominal GDP (35% inflation plus 5% real GDP).
The second aspect involved the CBT, in consultation with government, set an implicit inflation target of 35% to be reached by the end of 2002. This target was meant to complement the target involving base money in the event of difficulties arising in forecasting money demand. This dual strategy was adopted with the intention of eventually adopting formal IT, thus the CBT committed itself to improving transparency of monetary policy by communicating its inflation forecast and evaluation of the economy to the public. Moreover it began releasing the results if its new survey of inflation expectations, both as a valuable source of information and as a check on its own forecasts. By the end of 2002 inflation fell to 30% well below the target level (Sahinbeyoglu, 2008, Ersel and Ozatay, 2008).

In its drive to formally adopt IT, the authorities set about creating the appropriate institutional arrangements and practices necessary for conducting IT optimally. These features included the operational independence of the central bank together with increased transparency concerning its policies and accountability for failure to achieve its goals. Specifically, the Central Bank Law was amended to grant CBT operational independence to pursue its primary mandate of maintaining price stability. In terms of the provisions, the CBT is required to submit formal and regular (twice yearly) reports, to the necessary government departments, in regard to the pursuit of price stability. The CBT is also compelled to compile detailed reports on the forecasting, technical analyses, implementation and other related issues to the public on a periodic basis. Moreover, should the CBT, for whatever reasons miss the target, it must write a letter to government and explain to the public the reasons for the target breach and measures to be taken to remedy the situation. The law also stipulated the fixed terms for the CBT governor, deputy governors and board members as well as provisions for the establishment of a monetary policy committee whose function is to design and implement monetary policy. The law also prohibited the CBT from lending directly to the treasury (Banking Regulation and Supervision Agency (BRSA), 2001a and 2001b).

In an attempt to rid the economy off fiscal dominance, the adjustment programme adopted a two-pronged strategy: firstly, to address short-term liquidity needs, the government relied heavily on external funding from international institutions. Secondly to achieve medium-term debt sustainability the government increased its primary surplus target, first to 5.5% of GDP

in 2001 and then to 6.5% of GDP in 2002. These ambitions targets were meant to build credibility sending a decisive signal that it is breaking with the past.

The CBT used the transitional period to formal IT, to create the necessary IT infrastructure which included the development of core econometric models for analysis and forecasting; setting up of a broad economic database; making regular briefings to decision makers on conjectural issues; publishing regular technical reports on monetary policy and inflation; providing regular inflation forecasts using the CBT's core econometric models available to all staff and other decision makers; and lastly the CBT established its own inflation expectations survey and published new leading indicators pertaining to the inflationary trends and the state of the economy.

All the aforementioned measures strengthened the CBT's capacity to conduct IT optimally. Between 2002 and 2006 inflation fell for the first time in three decades to single digit levels, real and nominal interest rates declined sharply and so did the public debt ratio, which eased concerns about debt sustainability. This transformation has led to the gradual adoption of fully-fledged IT. By the end of 2005, concerns over fiscal and financial dominance had largely eased and exchange rate considerations had lessened. The shift to a floating exchange rate reduced the exchange rate pass through to wages and prices in terms of both speed and magnitude. Additionally there was a drastic reduction in dollarization compared to the pre-2002 period. Moreover the CBT was institutionally well prepared and technically proficient to adopt formal IT, which they did in January 2006. Over the 2005-2010 period the average government budget deficit was 2.15% below the Maastricht criteria of 3%. Moreover the European-Union-defined-public debt for Turkey, over the 2005-2010 period, averaged 40% of GDP, well below that of the Maastricht criteria of 60%. (Yilmaz, 2011). However the IMF World Economic Outlook (2010) views the Turkish government budget deficits as being problematic for apart from reflecting poor management of the economy, it could reverse all credibility gains thus derail the disinflationary endeavours.

As a direct result of the strong macroeconomic policy framework, Turkey emerged relatively unscathed from the global financial crises. Despite the fiscal stimulus to stabilize the economy due to the financial crises that resulted in a budget deficit of 6.6% in 2009 and 3.7% in 2010, the private agents interpreted it as a temporary phenomenon and inflation temporarily spiked above the target of 4% in 2008 and 2009, but tracked downwards towards

the target thereafter, and is converging towards the average level of other IT countries. Presently Turkey's exchange rate volatility is lower than that of its European neighbours, and the risk premium (as measured by the 5 year credit default swap premium) is much lower than of Portugal, Spain and Italy (Yilmaz, 2011; OECD, 2010).

The important lesson that emerges from the Turkish experience is that IT can be phased in, in a very short time, even in the absence of the necessary preconditions that many emerging economies lack, which include, a technically proficient and independent central bank, single digit inflation, a well-functioning banking and financial system, budget surpluses and a freely floating exchange rate for a fully-fledged IT system to take root.

3.3.4 The Experiences of South Africa.

This subsection discusses the policy reforms since the 1980s, that South Africa had undertaken to pave the way for ITMPF to be adopted in 2000. Moreover South Africa's economic performance and potential problems with IT as a policy framework are discussed.

According to Nattrass (2000); Aron and Muelbauer (2007), between 1976-1989 the authorities were concerned with stabilizing output fluctuations in order to stimulate the economy, negative real interest rates reigned supreme, hence double digit inflation resulted. A tight monetary policy orientation, since 1989, with Chris Stalls becoming governor of the SARB, ushered in a period of relatively stable real interest rates and declining inflation that has become the norm which extended into recent times. One interpretation (and a central theme of this study) of the low inflation rates experienced since the 1990s could be traced to the policy stance of a tight (conservative) monetary policy stance that was initiated in 1989, and together with the global trends of the 1990s (discussed further in chapter five) are the true causes of reduction in inflation in South Africa, and that IT is nothing more than a "conservative window dressing" version (see, Romer, 2006) of the 1989 policy that was initiated by Stals.

In the mid-1980s, the De Kock Commission Report (1985) ushered in a new era involving market related forms of monetary control termed the classical cash reserve system. The system in the main involved targeting money supply influencing market interest rates through overnight lending rates via the discount window and open market operations. The SARB still

applies this system where they actively seek to create liquidity shortages by levying a cash reserve requirement on banks as well as through engaging in open market operations. However the problem with this system was that interest rates were insensitive to fluctuations in liquidity in the economy because accommodation was freely available thus short term interest rates were rarely affected by money market shortages, hence the SARB's ability to send clear signals about its monetary policy stance was severely affected leading to agents finding them to be non-credible. Furthermore SARB was unable to receive clear signals from the market about underlying liquidity conditions or the commercial banks' perception of the SARB's monetary stance thus hampering its ability to regulate domestic money supply. Lastly, automatic provision of accommodation discouraged the development of inter-bank trading in surplus funds and treasury bills (Nattrass, 2000). In an attempt to address the deficiencies of accommodation and the Bank rate control, in 1998 the 'repurchase system' of liquidity control was introduced, where the Repo rate replaced the Bank rate and is influenced by the SARB according to the liquidity it makes available. Since its inception the system underwent many changes. However, post-2001 the system has been streamlined where, the main refinancing operation is the weekly seven day repurchase auction, which is conducted with the commercial banks, at the repo (policy) rate as determined by the MPC. SARB lends funds to the banks against eligible collateral, which comprises assets that also qualify as liquid assets in terms of the prudential liquid asset requirement (Aron and Muellbauer, 2005). Moreover this system is augmented by a marginal lending facility where in circumstances of unforeseen liquidity shortages, banks borrow overnight funds or loan for a few days at punitive rates compared to the repo rate. This system is designed to allow underlying liquidity conditions in the market to reflect the short term market interest rates. It also gives the SARB greater discretion concerning liquidity provision instead of automatically providing it, therefore its interest rate stance are made more transparent (SARB Website: Conduct of Monetary Policy, 2005)

In the early 1990s, the authorities liberalised the financial markets, the integration of our economy into the global financial markets and the increasing importance of large and volatile capital flows, and the extension of banking services to previously unbanked, diluted the usefulness of the M3 money supply as a target for monetary policy. Hence these structural changes altered the relationship between money supply, output and prices that resulted in the SARB employing other indicators (the eclectic approach) that include domestic credit, the yield curve, output gap, exchange rates, balance of payments, foreign reserves and expected

inflation, to guide monetary policy decisions, Stals (1997b); Casteleijn (1999). However Stals (1997a) noted that although the above eclectic approach to monetary policy was pragmatic, particularly in an environment of significant structural changes and volatile global capital shocks, but its major disadvantage is that it lacks transparency in the sense that the authorities may revert to muddled discretionary behavior that is not apparent to economic agents. Moreover recall that discretionary approaches to monetary policy result in credibility problems concerning the authorities' policy stance, which is one of the key reasons for the authorities adopting an ITMPF as discussed in chapter 2 of this study.

Under IT, the MPC still follows movements in money supply as one of the indicators (from its smorgasbord of indicators) that reflects demand pressures, but it no longer holds centre stage as it once did in the 1980s and 1990s. Kantor (2011) found the M3 and bank credit growth rates are highly correlated with pro-cyclical movements in nominal GDP and are very similar before and after 2000, however, the striking difference is that now the inflation is much lower and no longer strongly correlated with M3.

In the 1990s SARB shifted its policy stance in regard to exchange rates and inflation, the SARB's mission was to protect the internal and external value of the rand. This implied a tight monetary policy that resulted in reduced inflation and smoother but consistent depreciation until 2004 (where the rand began to appreciate steady until mid-2006) of the rand due to the sizeable inflation rate differential with that of our major trading partners. In an attempt to integrate into the world economy, since 1995 with the abolition of the financial rand the authorities decided to opt for a gradual relaxation rather than to adopt a "big-bang" approach (ie., the complete and immediate scrapping of all capital controls). This strategy arose from the attempt to create minimal disruption to the domestic financial markets and hence the currency. Much of the progress made in relaxing exchange controls has come from the realisation that these are difficult to enforce. Moreover, partial controls appear more difficult to administer than total controls, since they are subject to legislative loopholes and misinterpretation. Ultimately, foreign exchange controls deter fixed direct investment and may raise the cost of capital. Thus, in deciding to gradually relax foreign exchange controls, South Africa has aligned itself with global best-practice and it paved the way for ITMPF to be introduced and take root.

South Africa pursues exchange controls (albeit gradually diminishing), freely floating exchange rate, while concurrently retaining autonomy in the conduct of the monetary policy.

Although, the SARB is committed to let the rand find its own value, determined by market forces; as explained above when the rand appreciates significantly they do intervene to shore up their foreign currency reserves. Moreover SARB closely observes exchange rate movements in order to gain insights into its impact on inflation so that an appropriate monetary policy stance can be assumed. However exchange rate volatility, remains a major problem in many emerging market countries including South Africa. The volatility in the rand in fact has increased in recent times; instances of the rand's volatility since the introduction of IT include the 2000-2003 and 2007-2009 periods (see, SARB Bulletin, March 2003, 2008, 2009). The hope is that, as the economy and financial regime normalise is a manner that is perceived to be credible by market players, then only will the volatility of the rand be contained (Aron and Muellbauer, 2007).

In the Apartheid era domestic residents faced severe exchange controls where the outward capital movements were tightly controlled (e.g. extreme limits on foreign exchange for tourism, portfolio capital outflows virtually prohibited). In 1994 the post-Apartheid government inherited the dual exchange rate system[10], where the alternative market determined exchange rate applied to foreigners, who were free to move their capital. The financial rand was eventually abolished in 1995 and exchange controls on residents gradually eased. The net open forward position (NOFP) which involved exchange controls and interventions in the form of long-term forward currency transactions were used by the old regime to deal with exchange rate crises in the Apartheid era. These transactions had to be introduced because the introduction of exchange controls or restrictions on capital movements prevented the private sector from insuring against exchange rate changes through the market mechanism. Thus, in the absence of a fully functional forward cover market, the SARB was forced to provide a hedging mechanism against foreign exchange risk. The SARB operated in the forward foreign exchange market, swapping rands for US dollars with a commitment to repay the dollar liability at the forward rate once the contract matured. This enabled SARB to operate in the foreign exchange markets in excess of its reserves and unutilized foreign credit facilities. This resulted in the NOFP mechanism being created, which represented the central bank's forward US dollar liabilities less its forward US dollar assets (the "open" position), less the central bank's holdings of international reserves. Large

[10] The securities rand and the commercial rand were introduced. The securities rand involved a market in blocked balances directly transferable between non-residents that could be used by selected shares government securities and semi-gilts, often at a significant discount relative to the commercial rand. Non-residents were prohibited from repatriating funds, but they could sell financial assets to other non-residents (Mohr and Rogers, 1998).

currency depreciations cause these contracts to incur substantial losses, which lead to higher risks of the central bank defaulting on its forward commitments, and thus reducing foreign investor confidence (Rustomjee, 2006). In February 2004 the forward book was closed and SARB shifted its attention to gradually strengthening its foreign reserve holdings. The current-account deficit continued to be easily financed through a combination of foreign direct investment, portfolio and other types of foreign capital inflows. The improvement in the overall balance of payments was reflected in the exchange value of the rand, which over the year to the end of December 2003 appreciated by 16 per cent against a basket of currencies, followed by a further 9 per cent over the seven months to the end of July 2004. This appreciation helped to moderate inflationary forces. Similar patterns regarding currency appreciations and inflation reduction were observed in the 2005-2006 period and again 2009-2010 periods, where the authorities continued with the accumulation of foreign currency reserves, raising the level of gross gold and foreign-exchange reserves from $40 billion at the end of 2009 to $50 billion most recently and thereby reducing South Africa's vulnerability, should the international headwinds change direction. (SARB Quarterly Bulletin, March 2005; March 2007; September 2011).

Intervention in the foreign exchange market is precisely the policy prescription Frankel, Smit and Sturzenegger (Harvard-CID Report, 2006) advocated for South Africa which is a commodity based economy where the impressive growth in the post 2000 era has resulted concomitantly with a current account deficit which makes South Africa vulnerable to sudden reversal in inflows, hence the need for interventions in the foreign exchange market to manage inflows and prevent currency overvaluation. Also along similar lines, they assert that high reserve ratios to short term liabilities serve as the most reliable protection against currency crises. Additionally, they argued that currency appreciation weakens the manufacturing sector for scarce resources are shifted to the booming commodities sector, a type of 'Dutch disease' effect especially when the commodity boom subsides. However, some authors believe that it is better for emerging economies like South Africa to maintain fully flexible exchange rates in order to minimise the risk of speculative attacks on the currency.

IMF (2008) noted that the MPC does not indiscriminately raise repo in response to supply shocks (eg oil price hikes) or in relative price rises (eg., food prices) but respond to them only when there is a general deterioration in the inflation outlook and the shock is likely to exacerbate this negative outlook, for example oil price rose drastically in April 2006 but it

was only when the general outlook for inflation became bleak by June 2006 that the repo rate was raised. Moreover the MPC is sensitive to the impact a tight monetary policy will have on the economy and thus pursues a policy of interest smoothening, for example in 2008, despite all indicators suggesting that inflation will remain above the upper bound of the target range for longer than the control lag of two years, they increased the repo rate by only 0.5%, however they continued to raise the repo at subsequent MPC meetings by the same magnitude, until the inflationary threat subsided.

Stals (1997a) noted that inflation is a symptom of malfunctioning markets and the cure lies not with monetary policy, but with a restructuring of markets. Hence the South African authorities' restructuring efforts through trade and industrial policy reforms, privatization and fiscal restraint, organizational and regulatory transformation of the financial markets and gradual relaxation of exchange controls is a step towards enhancing the functioning of the various markets. The SARB's monetary policy is aimed at creating an environment of financial stability that is conducive to economic growth in the medium to long term. In achieving the objective of financial stability the focus of monetary policy since 1989 has been on the single objective of price stability.

Stals (1997a) noted that the "prevailing inflation psychosis" which has settled at around 8 % per year in the late 1990s, has not yet been suppressed in South Africa. Moreover Stals (1997b) asserted that as long as the inflation rate differential with that of our major trading partners remains significantly high, and due to the complex interaction between interest rates, inflation rates and exchange rates, disruptive adjustments are necessary. This partly explains the successive exchange rate devaluation and high interest rates we have experienced from mid-1996 to 1998. Similar experiences were noticed in the 2000-2003 and again from mid-2006-2009. Further Casteleijn (1999) believes that in many emerging market economies the currency was attacked, because the authorities had an exchange rate objective that was not perceived to be credible.

Over the 2000-2008 period, the SARB had chosen the CPIX[11] as the target inflation variable, for it included a wide range of consumer items and enjoys wide geographical coverage (14 metropolitan and 39 other urban areas). However, since January 2009, SARB adopted the headline CPI inflation covering all urban areas, as the target variable since this new estimate

[11] CPIX is headline CPI excluding mortgage payments. Headline CPI is the official measurement of consumer inflation in South Africa's urban areas. The weighting for the different categories of goods are determined from household surveys conducted every five years.

of inflation uses the more efficient rental equivalence estimate as a proxy for mortgage costs and most of the other items in the consumer basket are rebased to reflect current trends in consumer consumption patterns (see, SARB, Monetary Policy Review, November 2008)

A two year time horizon was chosen since a typical lag of 1,5 to 2 years (for the South African conditions) arises between a change in the short term interest rates and its impact on inflation. Hence the chosen time length is a realistic period in which the authorities can be expected to achieve the target (Van Den Heever, 2001).

The 3 % width allows the limited variability in the inflation rate and at the same time it is not too wide to reinforce divergent inflationary expectations. Some of the inflation targeting countries (eg., New Zealand, United Kingdom and Sweden) use a similar approach (Debelle, 1997).

Mayes and Chapple (1995) note that many inflation targeting countries (eg. Australia and New Zealand) formally include 'escape clauses' in their policy directives for the purposes of making provisions for conditions under which temporary deviations from the inflation target are allowable (eg., sudden shocks due to oil price rises). Neutralizing the first round effects on inflation as a result of such shocks may require huge counterproductive interest rate hikes. The South African IT framework possesses a similar feature in the form of a letter issued by the Minister of Finance, addressed to the Governor of the SARB, stating that should the target be missed, it will not be considered as a breach of SARB's commitment to contain inflation within the target range, if it were due to an uncontrollable exogenous shock that is of a temporary nature, and that the Governor must explain to the public the reasons for the breach and the actions taken to ensure that inflation will hit the target over a specific time horizon. (Mnyande, 2008).

Apart from sophisticated financial markets, the government's commitment to prudent fiscal and monetary policies, a flexible exchange rates regime, another key feature of all inflation targeting economies is that of central bank independence especially concerning the freedom to set policy instruments (mainly short term interest rates) and freedom from budgetary demands (Masson *et. al.*, 1997). The South African Constitution and the South African Reserve Bank Act guarantees the SARB the necessary degree of independence in conducting its activities. However despite these freedoms regular consultation with the Minister of Finance continues in the interest of policy coordination, which has an added advantage of preventing government from allowing fiscal policy to impact negatively on the inflation rate.

The inflation targeting policy framework demands that progress towards the target and policy steps must be communicated to all relevant parties regularly. The SARB has developed a rich tradition of communicating its policy stance to the public and other relevant parties via regular formal publications, the national press and through monetary policy forum meetings. These meetings, which co-inside with the biannual publication of the *Monetary Policy Review,* are held twice a year in ten centres covering all provinces, where the SARB's MPC members address organized business and labour as well as politicians and academics on monetary policy developments. Moreover the Governor regularly appears before the portfolio committee on finance, delivers speeches in parliament and also participates together with senior Bank staff in panel discussions and other public events.

One of the key aspects of an inflation targeting framework is that suitable econometric models involving relevant variables aimed at understanding the inflationary dynamics and forecasting inflation are indispensable in the context of an IT regime. Econometric modeling is important, especially since an IT regime involves a forward –looking operating procedure, where the setting of policy instruments depends on the assessment of inflationary pressures and where the inflation forecasts are used as the main intermediate target (Svensson, 1997; Haldane, 1995; Masson, Savastano and Sharma, 1997). The econometric models used by SARB to generate its forecasts are available to the public. Moreover SARB's forecasts together with the fan charts are published in the biannual *Monetary Policy Review*. The Monetary Policy Review as well as the *SARB Quarterly Bulletins* provide detailed accounts in the form of technical analyses of the various domestic and global factors impacting on the economy in general and on inflation specifically. Moreover detailed analyses of the various measures of inflation expectations over future horizons are published in the aforementioned publications. Inflation expectations are routinely considered by the MPC together with other variables in choosing their policy stance. Since the adoption of IT, inflation expectations became anchored in a sustained manner over the 2004-2008 period, however there is significant divergence regarding the level of inflation expectations by the different stakeholders (analysed in detail in the next chapter)

The MPC comprises eight members: the Governor, three Deputy Governors and four senior officials. MPC meetings are held six times (two months apart) a year except in turbulent times (eg., height of global financial crises) where more frequent meetings are held. Typically

the MPC convenes two to three weeks before the scheduled[12] meetings, where they are briefed about the global and domestic financial and real factors, affecting the economy. The scheduled meetings are held over two days, on the first day summarized reports and specific inputs requested by the MPC are presented by the heads of the various technical departments and discussions are entertained. On the second day, a summary of the previous day's discussions are presented, followed by the MPC members having a closed discussion of the monetary policy stance that ought to be taken. Generally final decisions are taken by consensus or majority view, no formal voting occurs. Thereafter a press release is issued and the Governor presents the statement, live on national television (Mnyande, 2008).

IMF Country Report for South Africa (2007), notes that IT has led to lower inflation and real interest rates in South Africa. South Africa recorded impressive real growth rates from 2003 until the global economic crisis hit South Africa in late 2008, economic growth had been steady and unprecedented in an environment of rapid credit expansion, booming asset prices, strengthening public finances, and rising international reserves financed by large capital inflows. GDP rose by 2.7% in 2001, 3.7% in 2002, 3.1% in 2003, 4.9% in 2004, 5% in 2005, 5.4% in 2006, 5.1% in 2007 and 3.7% in 2008. Consumer inflation came in at under 5% from 2004 through 2006 before global prices pushed it up to 6.5% in 2007 but has returned to below 6% in 2011. In 1994 it stood at 9.8%. Economic growth and prudent fiscal management have seen South Africa's budget deficit dropped dramatically, from 5.1% of GDP in 1993/94 to 0.5% in 2005/06 but rose during the economic financial crises to manageable levels of just over 5%. However unemployment and poverty levels remain high relative to Brazil. Nevertheless, with a continuance of IT, prudent fiscal policies, further trade and financial liberalization, enhanced competition policies together with much needed labour market reforms, there is still great scope for improvement.

A Harvard Center for International Development Report compiled by Frankel, Smit and Sturzenegger (2006) predicted that South Africa will weather the storm of a global financial crisis since much of South Africa's debt is rand denominated due to its sophisticated financial markets, almost freely floating exchange rate with minimal intervention, much of the inflows are foreign direct investment or for equity purchases. Hence an asset bubble type of market correction with not result in a painful currency crash and a resulting balance sheet correction. However their simulations further correctly predicted that significant capital reversals will

[12] Scheduled meeting are published at the beginning of the year in the interest of transparency.

slow growth, harm investment and worsen the fiscal accounts. This is precisely what occurred between 2009 and 2011 where the repo rate had to be reduced in 0.5% decrements from a high of 12,5% to a low of 5.5%.

As noted earlier, Ammer and Freeman (1995)) contend that the New Zealand, Canada and the United Kingdom did not achieve long term credibility for their announced long run inflation nor is there solid evidence that the announcement of inflation targets lead to low inflation expectations. These conclusions were based on the observation that after having introduced an IT regime, these countries continued to maintained high interest rates for a lengthy period, which affected output negatively, thus, they assert that the cost of reducing inflation may be too high. In some senses the Ammer and Freeman paper supports the argument of Stiglitz (2008) and Van Den Heever (2001) who assert that IT is unsuitable for emerging economies since a single minded endeavor to neutralize inflationary effects of supply shocks will lead to huge output losses, it may require steep interest rate adjustments in order to achieve target goals timeously. Along similar lines, the Harvard Report by Frankel, Smit and Sturzenegger (2006) note that capital outflows lead to the depreciation of the rand which in turn raises the inflation rate that results in the MPC raising the repo rate. They summarise the problem by assessing that demand shocks move both inflation and output in the same direction, hence stabilizing one (via the repo rate) stabilises the other. However, supply shocks move output and inflation in different directions, hence stabilizing inflation worsens output, hence forcing the state to employ fiscal policy to stabilize output.

Van Den Heever (2001) iterates that inflation targeting is a complicated approach relying heavily on econometric forecasts in an uncertain economic environment. If forecasts turn out to be wrong, even if for completely unforeseeable circumstances, SARB's credibility could be impaired.

Schaling and Schussler (2001) noted that inflation in South Africa has a significant cost push component, ie., inflation is an outcome of wage rises and profits. Firms tend to increase prices by more than the wage cost increase due to insufficient local competition (de facto cartels and monopolies including state monopolies) and a virtual absence of international competition. Thus if an inflation targeting regime is to succeed, radical supply side measures must be implemented to eliminate the sources of insufficient local competition.

Administrative pricing which the government regulates in a monopolistic manner is another factor that significantly affects the South African inflation rate. Schaling and Schussler

(2001) recorded that of the monthly increase of 0.9 % in the CPIX in mid-2000, about 0.8 % was accounted for by administrative price increases, mainly in the form of petrol, electricity and water rates. Inefficiencies at the local government, the recent blackouts and successive electricity price hikes all bear upward pressure on administrative prices. Administrative prices are difficult to bring down using interest rates, however if government hastens the pace of privatization reforms, develops efficient delivery and infrastructural maintenance systems and contains monopolistic pricing, then it should be able to meet the target.

Kaseeram, Nichola and Mainardi (2004) noted that due to trade union militancy, nominal wage settlements in South Africa have the potential to add to inflationary pressures which frustrate attempts of IT achieving its objectives. Aron and Muellbauer (2007) in their study of the expectations formation process in South Africa, found that while the expectations of financial analysts have stabilized soon after IT was adopted but businesses and trade unionists have remained backward looking in forming their expectations of inflation and thus have been slower to conform to the target

3.4 Conclusion

This chapter undertook a detailed discussion of the key features of IT in terms of a definition, institutional arrangements and practices, strengths, weaknesses and its performance in achieving low stable inflation with low volatility and persistence, as well as the anchoring of expectations to a target point (or range), in emerging and industrialized economies. It highlighted that the debate concerning the success of IT for both industrialized and emerging markets is not yet resolved and that some economists claim that IT is nothing more than 'conservative window dressing' in a new guise. The IT practices and experiences of three small open emerging economies of Chile, Brazil and Turkey that are similar to South Africa were presented, and juxtaposed against South Africa's experiences of just over a decade long. The experiences stressed the essential preconditions needed for the successful implementation of IT and include, central bank independence, absence of fiscal dominance, floating exchange rate, sound financial markets for the interest rate policy instrument to have the desired effect, and the appropriate technical and institutional central bank framework. However the experiences of Chile and Turkey showed that IT can be introduced gradually through first undertaking various structural reforms, while the experiences of South Africa and Brazil show that IT can be implemented relatively quickly. In regard to South Arica and Brazil the appreciated exchange rates appear to play a benign role in reducing inflation, but,

future studies need to examine this dynamic more closely. The chapter provided insights into the factors, which included global and local conditions, various sources of demand pressures exchange rates movement, inflation forecasts and expectations that the MPCs of these economies consider when deciding on the monetary policy stance to be taken. The IT experiences of all four economies seem to suggest that the ITMPF is effective in reducing inflation volatility and stabilizing output close to its normal levels, however from a statistical perspective the literature review of section 3.2 pointed out that the debate is still open regarding the benefits of IT.

Chapter Four – The Anchoring of Inflation Expectations in South Africa

4.0 Introduction

Based on the consensus in the literature (see, chapter three, section 3.0) that inflation expectations anchored to (or stabilized around) a target, this is a critical factor that assists in stabilizing inflation. The case studies of the IT experiences of Chile, Brazil, Turkey and South Africa have outlined the critical role that inflation expectations indicators play in the policy decision making process of the respective central banks. It is widely argued that if expectations are anchored then the second round effects of supply shocks are diminished and thus, the central bank can pursue a policy of low interest rates thus reducing the cost of capital which is so crucial for economic growth.

This part of the study examines whether the inflation targeting monetary policy framework introduced since February 2000 has been effective in dislodging the link between actual and expected inflation and hence resulting in expectations being anchored to a target. Guided by the expositions (in chapter two) of Svensson's (1997, 2010) theoretical concept of inflation forecast targeting and Capistran and Ramos-Francia's (2010) conjectures of how expectations are formed under IT as well as this study's original contribution in regard to the manner in which expectations are formed in the presence of nonstationary inflation data, the study will formally assess the extent to which the different South African market players consider the central bank to be credible.

This study uses the methodology of Cruijsen and Demertzis (2010) to define this 'disconnect' between inflation and inflation expectations and then employs the VAR approach to examine the extent to which this disconnect exists. Since the South African data on inflation and expectations are nonstationary, the Cruijsen and Demertzis (2010) VAR approach might be spurious, hence this study goes further and uses the more appropriate Johansen (1991) and Johansen and Juselius (1992) cointegration and error correction methodology to both verify the Cruijen and Demertzis approach as well as to give new insights into the direction of causality and long run adjustments between actual and expected inflation for nonstationary data. Moreover, the study investigates whether inflation expectations formation processes and the 'disconnect' are different for the financial sector compared to that of business executives

and organized labour. Both quarterly survey data and breakeven expectations (ie., the differential between nominal and inflation linked bonds of similar maturity) data are used as proxies for inflation expectations.

4.1 Background

As discussed fully in chapter three, the ITMPF has gained world-wide ascendancy, in both emerging and industrialized countries, since three main benefits have been observed which include lower and less volatile inflation rates, the reduction in the real cost of disinflation and the anchoring of long term inflation expectations at or very close to the target (Mishkin, 2007; Roger, 2010; Levin, Natalucci and Piger, 2004).

Recall IT may be described as a framework of monetary policy characterized by the explicit acknowledgement that low and stable inflation is the primary long run goal of monetary policy and by the public announcement of official quantitative targets or target ranges for the inflation rate over one or more future periods. Moreover, IT involves the monetary authority's systematic communication with the public about the plans and objectives of monetary policy and in many instances the mechanisms that strengthen the Central Bank's accountability for attaining those objectives (Bernanke, *et. al*., 1999). King (1997) described IT as a simple "constrained discretionary" rule-like (heuristic) framework involving a precise numerical target in the medium term and a transparent response to economic shocks in the short term thus enabling economic agents to anchor expectations about future inflation.

IT is regarded as the latest of formal goals for monetary policy (the others being money supply, output, interest rate and exchange rate targeting). IT supporters claim that central banks gain credibility since they are better able to anchor expectations on the future movement of prices and thus reduce inflation persistence even in the face of inflationary shocks. Moreover, since IT involves observing a target or target range, it is easily understood by the public, thus leading to low inflation expectations and low nominal interest rates. Furthermore, by anchoring expectations, inflation targeting should decrease inflation uncertainty. Finally it alleviates the time inconsistency problem by reducing the government and private sector pressure on the monetary authorities to trade off inflation for short term output gains, (Mishkin and Posen, 1997; Bernanke, *et. al*., 1999; Van der Merwe, 2004).

The rest of this chapter is divided as follows: first a literature review that will help place this study in perspective will be presented. Thereafter the Cruijsen and Demertzis (2010) VAR approach for stationary data and the Johansen (1991) and Johansen and Juselius (1992) cointegration and error correction methodology for nonstationary data and a motivation linking these methodologies to the testable propositions will be offered. Then the results will be presented and discussed. Finally the results will be discussed in relation to the Reid (2009) and Rigobon (2007) studies on central bank credibility.

4.2 Literature Review

The extensive literature on expectations can be broadly divided into univariate and multivariate approaches to analysing the behaviour of inflation expectations data. This subsection will first discuss a few univariate studies followed by the single equation model and finally the VAR models, the last of which this study uses to assess the anchoring of expectations.

In a South African study, Ehlers and Steinbach (2007) conduct univariate type analyses on inflation expectations survey data of the quarterly variety obtained from the Stellenbosch University's Bureau of Economic Research (BER) and monthly survey data gathered by the Reuters News Agency. This study uses the BER quarterly survey quarterly data as well (see the data section of this paper for a detailed description). The currently available Reuters survey data comprises six months and one year ahead expectations gathered from monthly surveys administered to financial analysts from 14 companies that regularly generate forecasts of inflation. However, between 2000 and 2007 they used to generate 6 quarters ahead data as well. The BER data includes expectations of householders, financial analysts, business executives and trade unionists while the Reuters data consists of mainly financial analysts. The Ehlers and Steinbach study follows earlier studies by Razzak (1997), Pearce (1979, 1987), Holden and Peel (1990), Mills and Pepper (1999) and Forsells and Kenny (2002), where they test for the data exhibiting rational expectations. If the data passes tests for unbiasedness in predicting future inflation, efficiency in use of past information to predict future inflation and orthogonality of innovations, then the data is considered to be *weakly rational*. On the whole the South African data failed the test of weak rationality, however, despite this weakness, the Ehlers and Steinbach study went on to test for *sufficient rationality* and *strict rationality* in the same vein as the studies by Granger and Newbold (1973), Pearce (1979, 1987) and Koutsogeogopoulou (2000). If survey data outperforms an ARMA

(autoregressive moving average) or random walk model then it is classified as sufficiently rational, however if it outperforms a combination of models (eg., both the ARMA and random walk models) then it is classified as strictly rational. The Reuters survey was found to outperform both the ARMA and random walk models at all horizons except for the current-quarter inflation. Financial analysts from the BER survey outperformed both the ARMA and the random walk models. While the business executives and trade unionists' expectations at the one and two year horizons outperformed the random walk model only. Additionally Ehlers and Steinbach, similar to the Figlewski and Wachtel (1981) study, assessed the extent to which expectations are determined according to the adaptive expectations process, ie., where agents adjust their expectations about future inflation by some proportion of the percentage forecast error they made in estimating current inflation. The financial analysts appear to form long term expectations in a more rational fashion since they are not influenced significantly by past information compared to the business executives and trade unionists. The trade unionists appear to be most adaptive in forming expectations compared to the other two groups.

Aron and Muellbauer (2008) conducted univariate studies by providing graphical evidence based on the BER data to demonstrate that expectations have become anchored over time and thus conclude that SARB has successfully achieved credibility. Aron and Muellbauer (2007) made use of simple observations of the expectations data of financial analysts, business executives and trade unionists and noticed that the financial analysts' expectations conformed much faster to the upper end of the 3-6 per cent target band relative to business executives and trade unionists and predicted that once actual inflation is stabilised, expectations will conform to the target band.

Rossouw and Padayachee (2009) utilized data retrieved from Markinor which is a private company that conducts opinion surveys on socio-political and economic issues. Surveys conducted from 1995 to 2008, to investigate perceptions of some 3500 respondents, across various race, class and age (16 years and older) groups, in regard to how well government is controlling inflation. They noted that perceptions of inflation being contained improved during periods of disinflation and deteriorated during periods of accelerating inflation. They further noticed that changes in perceptions occurred once inflation breached (either upwards or downwards) certain critical inflation levels and that further research is required to identify these levels. However only about a 47% of the respondents tend to have an opinion about inflation, and highest education levels that majority of these opinion holders possess are

matric or above. The said researchers also used cross-section data from a commissioned Mariknor survey, to construct an inflation credibility barometer, which measures the degree of acceptance of inflation credibility out of 100. Only 18% of respondents answered the relevant question and they derived a barometer reading of 39.2, ie., only about 39% of those who answered the question believed that the inflation figures released by the South African authorities are accurate. The finding relating to educated respondents being highly opinionated in matters regarding inflation is consistent with international studies conducted by Pasaogullari (2011) and Trehan and Huang (2008).

Reid (2009), based on studies by Gurkaynak, Sack and Swanson (2006), she uses real and nominal forward rates to investigate the extent to which long term inflation expectations have become anchored in South Africa. Specifically she considered how surprises in macroeconomic variables (eg., CPIX, PPI, GDP, current account and repo rates,) at the time of data release, affects long term inflation expectations - proxied by the difference between ten year indexed & nominal bond yields (far-ahead forward inflation compensation). The Reid study found that long run financial analysts' expectations are insensitive to macroeconomic surprises thus suggesting that inflation targeting in South Africa has succeeded in anchoring long run expectations. This finding is consistent with the findings of Gurkaynak *et al.* (2006) and Gurkaynak, Levin, Marder and Swanson (2007) papers, where it was established that long run expectations are significantly weakly sensitive to macroeconomic news in inflation targeting countries like United Kingdom, Sweden, Canada and Chile whereas it is still highly sensitive to an non inflation targeter like the United States.

Rigobon (2007) uses a novel approach to test for the anchoring of expectations since the adoption of IT in South Africa. More specifically he tests the proposition that under conditions of central bank credibility the pass-through of exchange rate depreciation to prices will be diminished. He recorded that the pass- through of exchange rate depreciations to inflation dropped markedly from 2003-2006 period compared to the early days of IT viz., the 2000-2002 period. Thus he interpreted these findings as implying that after three years of ITMPF, central bank's credibility has progressively improved.

Structural VAR studies by Mehra and Herrington (2008) and Holub and Hurnik (2008) consider the determinants of inflation and their impact on the private sector's expectations of inflation. The Mehra and Herrington study uses the Livingston survey measure of inflation expectations which is conducted biannually by the Federal Reserve Bank of Philadelphia and

targets financial analysts alone, while the Holub and Hurnik study is conducted by the Czech National Bank on a monthly basis and is administered to financial analysts, firms and households. They consider how these macroeconomic variables influence the movement in inflation expectations through the use of impulse response functions (IRF), which captures the responses of expectations to temporary surprise movements in these macro variables. Moreover they use the forecast error variance decomposition of inflation expectations to assess the importance of the various macro variables in explaining the variability of expected inflation. The Mehra and Herrington VAR model include CPI inflation, commodity price index, the unemployment rate, nominal short term interest rates, expected inflation and an oil shock variable. While the Holub and Hurnik VAR model include commodity price inflation, food price inflation, administrative pricing inflation, monthly nominal exchange rate changes, inflation and inflation expectations. These types of published studies have not been conducted for South Africa as yet.

Cruijsen and Demertzis (2010) use a bivariate VAR model involving inflation and expected inflation to demonstrate that credible monetary policy has succeeded in breaking the link between actual inflation and long run expectations of inflation. They define long run as 5-6 years and longer, but suggest that 2 years might also qualify as the long run. Essentially, their study may be viewed as a Granger causality type study where they use Wald tests to ascertain whether the direction of causality runs from actual inflation to expected inflation or vice versa or both. They also examine the covariance matrix to see whether shocks from one variable affect the other. They reason that under conditions of perfect credibility there is no long run relationship between inflation and expectations (ie., all causality hypotheses are rejected) and that shocks in one variable does not affect the other (ie., covariances are zero). Lastly, they suggest that the most perfect sign of central bank credibility in the data is when inflation is perfectly anchored to a constant which turns out to be the inflation target itself.

4.3 Testing the Propositions

The propositions outlined in chapter two, section 2.3.3, are tested by using the Bureau of Economics Research (BER) survey based on disaggregated South African expectations data that spans the period 2000Q3-2011Q2, as well as monthly ‘breakeven’ inflation expectations estimated from the yield differentials of nominal long dated and indexed linked bonds with similar terms to maturity that covers the 2002M4-2010M9 time period. BER conducts quarterly surveys on current, one and two years ahead expectations among three categories of

private agents, viz., financial analysts, business executives and trade unionists. Furthermore BER combines the expectations of the three categories of private agents' expectations to form a composite series which represents the expectations for the economy as a whole. The study uses the two years-ahead forecast of inflation, for it corresponds with SARB's two year control lag horizon in steering expectations to within the 3-6 per cent target range. The breakeven inflation rate will serve as an alternative proxy variable representing financial analysts' long run (12-19 years) inflation expectations. Section 4.4, below, provides a fuller account of the data to be used, while section 4.6.1 discusses the unit root properties of the data.

The aforementioned expectations series will be tested for stationarity by using a battery of tests available in *Eviews version 6* (2007) and fully outlined in Maddala and Kim (1998), appendix B2 provides detailed references to these tests.. If a unit root is found, then propositions 1 and 2 will be supported, despite inflation being nonstationary. This would imply that the expectations holder finds the central bank's policy to be credible irrespective of the behaviour of the inflation series. If any of the expectations series are found to be I(1) then cointegrating relationships with inflation will be tested for, and if cointegating relationships are found it will imply that the holders of such expectations find the central bank to be non-credible. This study will employ various stationarity tests, and the Johansen (1990) cointegration technique to test the above propositions. Moreover, for comparative purposes the study will employ the VAR methodology proposed by Cruijsen and Demertzis (2010) to acquire further insights regarding the bivariate inflation-expectations relationships and its relationship to the credibility concept. Specifically, the Cruijsen and Demertzis (2010) VAR methodology will be used to test whether long run inflation expectations are anchored within the South African setting. Furthermore the study extends this analysis to test whether there is homogeneity in regard to the formation of expectations across the three types of economic agents, viz., the financial analysts, the business executives and the trade unionists. Moreover since the Cruijsen-Demertzis methodology may not be robust to nonstationary data this study will employ the Johansen (1991) and the Johansen and Juselius (1992) cointegration and error correction methodology as an alternative approach and will propose that non-cointegration between actual and expected inflation might be interpreted as long run expectations being anchored, thus implying central bank credibility. This approach will serve as an alternative method to both the Reid (2009) and Rigobon (2007) studies. Additionally the use of the Cruijsen-Dmertzis (and Johansen and Johansen and Juselius) method(s) to test

homogeneity might give us further insights into whether expectations are formed rationally or adaptively across the mentioned groupings and hence could be usefully compared to the findings of the Ehlers-Steinbach (2007) paper.

4.4 Data Issues

This study uses just two variables in its analysis, viz., inflation and inflation expectations, both of which are measured in percentages. Real-time or vintage inflation data, (see, Orphanides (2001) and Croushore and Stark (2003) for further insights into real-time or vintage data) was employed in this study, which refers to data that appeared in the public domain, at the time of release before it was subsequently changed due to data revision in the form of component reweighting or rebasing of the series at much later dates. Component reweighting and series rebasing have the effect of changing the indices and hence changing the inflation rate. Since the focus of the study is to scrutinize the relationship between expectations and actual inflation it is critical that the inflation data employed was the rate that agents observed when formulating their perceptions of future inflation. The real-time inflation variable that was estimated using the old CPI indices was obtained upon request from the SARB[13], since it is no longer available for downloading directly from the website. Since January 2009 Stats SA introduced a new CPI measure in which imputed rent is adopted as the measure of homeowner's housing cost instead of interest mortgage cost for metropolitan and other urban areas as was used in the old estimation of CPI. The imputed cost method uses to estimate what would the rental costs be, should owner-occupied houses of various kinds, be let on the rental market (Aron and Muellbauer, 2008).

The study opted to use the old estimate of CPI inflation because it is these values of CPI inflation reported in the media, which had influenced economic agents in formulating their expectations of inflation over the 2000Q3-2008Q4 period. The post-2008 inflation rates based on the new CPI indices were simply attached from where the old series ended. The inflation expectations data was downloaded from the BER website. In 1999 the SARB commissioned the BER to conduct inflation expectation surveys on its behalf (Kershoff, 2000). The BER samples inflation expectations of financial analysts, business executives, trade unionists and households on a quarterly basis. The first three groups form a panel of participants to whom questionnaires are emailed quarterly. In 2000 the panel of participants

[13] This study is grateful to Mr Ossie Van de Walt from SARB for providing the data.

were 1126. At that time a minimum sample of 1000 participants was considered to be a representative sample. The sampling of households is outsourced to AC Nielsen as it involves personal interviews with 2500 households across the race, class, rural-urban and gender divide. The overall expectations are calculated as an unweighted average expectations of the averages of the four groups (Kershoff and Smit, 2002). Unfortunately the AC Nielsen time series data on households' inflation expectations is not available on the BER website. This study employs the overall unweighted, the financial analysts, the business executives' and the trade unionists' expectations of inflation two years ahead, which extends from 2000Q3 to 2011Q2. BER also estimates a composite expectations series that comprises the averages of financial analysts', business executives' and trade unionists' expectations of inflation. Here again, this study will employ the two years ahead series of this composite series and it will be termed the 'combined' expectations. The main reason two years ahead expectations data is preferred by this study is that monetary theory suggests that credible IT policies anchor long run inflation expectations. Two years ahead expectations of inflation might not be long enough for it to be classed as long term. However, the Cruijsen and Demertzis study on which this chapter is partly based uses the 2 year horizon for inflation expectations as a long run estimate since there were no data available for some countries at their preferred long run horizon of 5-6 years. Hence in an attempt to find a longer horizon indicator, the study follows the approaches of Scholtes (2002), Kwan (2005), Hordahl (2009) and Reid (2009) by considering the spread between inflation index-linked bonds and other nominal domestic bonds of a similar maturity. This approach posed a bit of a challenge since index-linked bonds were introduced only since 2000 and there are just few of them at long time horizons with precise maturity matches being impossible. In this context the best the study could do was to match the R186 (nominal bond) which matures in 2023 to the R197 inflation index-linked bond which matures in 2030. The long horizon (12-19 years) inflation expectations proxy was estimated as follows:

Nominal (R186) Yield – Inflation-indexed (R197) Yield = Break Even Inflation Expectations

4.0

The above yield differential (equation 4) is widely used in the Finance industry as a proxy for long run inflation expectations (see, Kwan, 2005; Hordahl, 2009). Although the above yield differential is largely a function of expected inflation rate over the horizon, but also reflects risk and liquidity premia as well as market supply constraints, in other words, high demand

for small bond issues which affect the perceived liquidity that drives down yield (Kwan, 2005; Hordahl, 2009; Reid, 2009). Notwithstanding these weaknesses this study assumes that inflation risk is the dominant factor driving yield differential and the other factors are not high enough to seriously distort the expectations proxy. The break-even expectations data is at a monthly frequency and extends from 2002M4 to 2010M9.

4.5 Graphical and Descriptive Statistical Evidence

This section considers basic descriptive statistical and graphical evidence of long run expected inflation of the financial analysts, business executives, trade unionists and the break-even proxy.

In the light of the theoretical framework and the ensuing discussions above, one can assess the performance of ITMF and hence SARB's credibility through analysing the stabilization of stakeholders' expectations. As noted above, anchored expectations are a signal that the central bank has committed itself successfully to low inflation. To assess the performance of SARB in anchoring expectations, as mentioned before, the study examines both inflation expectations survey data as well estimated long term expectations inferred from the yield differentials between nominal and inflation indexed bonds of similar terms to maturity (12-19 years). With reference to Table 1 of Appendix B1, one notices the expectations – both the one and two year series - of financial market analysts have largely been within the 3-6% target band. Moreover Appendix B1, Figure 9, which depicts the two-years-ahead financial analysts' expectations series as well as the long term break-even estimates of expectations (over the 12 to 19 year horizon) may also be categorized as financial analysts' long term expectations of inflation, also show relative stability about the target band. Strictly speaking the long term break-even estimate of expected inflation does not belong in Figure 9, since it represents inflation expectations over a very long term horizon of 12 to 19 years, however it was included for the purposes of benchmarking analysts' shorter terms expectations to that of the long horizon. Note that the monthly data was averaged out to obtain the quarterly data so that it is comparable to the financial analysts' BER survey data.

The two-years-ahead survey of analysts' expectations as well as the break-even-estimates, possess the smallest variance and the lowest RMSE, respectively. As expected the one-year-ahead analysts' expectation of inflation ought to be more volatile compared to the two-years-ahead, since in terms of the policy framework inflation is only expected to hit the target over

a two year horizon. Due to short term deviations from the target caused by supply shocks but in the longer run inflation is expected to return to its target especially since monetary policy will be invoked to curtail second round effects of such disturbances. Nevertheless the analysts' one-year-ahead inflation still has a reasonably small variance and RMSE, especially when compared to the expectations of the business and trade union sectors. This implies that the financial analysts find the ITMF to be credible and have accordingly anchored their expectations over the last decade.

However, by contrast, the inflation expectations of both the business and trade union sectors appear to be quite volatile compared to that of the analysts. Appendix B1, Tables 1 and Figure 8, show that for most of the decade their expectations of inflation lay above the 6% level of the 3-6% target band. It is interesting that the expectations of the business and trade union sectors appear to be highly correlated and their respective expectations of 27 and 24 quarters lie above the 6% inflation target band for a significantly longer duration over the last decade compared to that of the analysts. One would expect business executives to invest similar amounts of resources as analysts in ascertaining the future course of inflation, yet this is clearly not the case. In order to make economic sense of this phenomenon this study postulates either one of two plausible explanations. The first is that trade unions and business executives do not view the authorities as being credible in the conducting of monetary policy and are more adaptive (backward looking as explained by Ehlers and Steinbach (2007) discussed above) in formulating their respective perspectives on inflation. Moreover these observations also support the Rossouw and Padayachee (2009) finding. Under this scenario the economic agents observe the past dismal record of SARB's limited success at containing inflation within the target band, and hence formulate their expectations in this light. The alternative view is that trade unions and business executives do not view the authorities' claim to contain inflation within the target band as credible and expect them to renege on their claim and target some preference based optimal level above the pre-announced-target-band and hence the agents engage in strategic or optimizing behaviour themselves[14].

[14] The inflation bias was discussed in chapter two, section 2.2.

4.6 Methodology and Results

The study will replicate the Cruijsen and Demertzis (2010) VAR models in the South African context. This model will serve as a benchmark against which the Johansen (1988, 1991) VECM will be compared since richer insights can be obtained from the VECM approach in regard to the short and long run dynamics between actual inflation and inflation expectations. This methodology is only viable because the data exhibits nonstationary properties (ie., they were shown to be I(1)) as will be demonstrated below.

4.6.1 Unit Root Tests

The inflation series and the various measures of inflation expectations were found to be non-stationary. A battery of unit root tests, that included the Augmented Dickey-Fuller (1979); Dickey Fuller with general least squares detrending (DF-GLS), by Elliot, Rothenberg and Stock (1996) ; Phillips and Perron (1988); Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992); Elliot, Rothenberg and Stock (1996) and the Ng and Perron (2001) tests, the results of which are reported in Appendix B2, Tables 2 to 9, were used in the study. All tests, except for the KPSS test, were unanimous in their conclusion that the data is integrated of the order one. This implies that proposition 2 is not supported by the South African data, neither the two measurements of the financial analysts' expectations nor the trade unionists' and business executives' expectations were found to be stationary. Hence by proposition two alone it implies that mentioned economic agents do not find the central bank to be *entirely (or strictly)* credible. However, the study acknowledges that this is a strong requirement and might only be observable in industrialized economies that are not as sensitive to adverse supply shocks as are the emerging economies.

However, the unit root tests were also useful in regard to establishing that all the mentioned series were integrated of the order one (ie., I(1)). Generally VAR models require the data to be stationary otherwise the results might reflect spurious relationships, thus leading to erroneous conclusions concerning the credibility conjecture. Therefore, it becomes important to verify the above findings through the use of the Johansen (1988, 1991) cointegration and vector error correction model (VECM) approach, which is a popular method of quantifying long run relationships between I(1) variables as well as their short run adjustments to such long run relationships. However, if the I(1) variables are cointegrated then the resulting VAR models might be stable; root tests as well the diagnostic tests for the two equations within the

bi-variate model are reported in Appendix B3, Tables 9 to 13 and the roots stability tests are reported in Figures 10 to 14. These tests confirm that the VAR models are stable, for all the roots lie within the unit circle, moreover the diagnostic tests confirm that the individual equations within the VAR system are valid.

Section 4.6.2 explains the Cruijsen and Demertzis (2010) VAR methodology, which this study adopts in order to investigate central bank credibility and the *'disconnect'* between inflation and the various inflation expectation variables (viz., the combined, financial analysts, business executives, trade unionists and breakeven inflation expectation) exhibit. This will then be followed by the presentation and discussion of the VAR results. A weakness of this methodology for the non-stationary South African data will also be highlighted and its implication for the concept of the *'disconnect'* will be discussed. Thereafter Section 4.8 will propose and explain how the Johansen (1991) and Johansen and Juselius (1992) cointergration VECM (vector error correction mechanism) approach might be more appropriate to testing proposition 3. Additionally this section will show how proposition 3 can be associated with the central bank credibility concept from a time series econometrics perspective.

4.6.2 The Cruijsen and Demertzis Conjecture

Cruijsen and Demertzis (2010) and Demertzis, Marcellino and Viegi (2008, 2010) assert that a credible central bank will be associated with a '*disconnect*' between inflation and inflation expectations dynamics. This conjecture is identical to proposition 1, made by Capistran and Ramos-Francia (2010), and is implied by proposition 2, since inflation will remain stationary around the target point or band.. They model inflation (π_t) and inflation expectation (π_t^e) dynamics using following VAR model and use it to frame the '*disconnec*t' in the form of five hypotheses:

$$\begin{pmatrix} \pi_t \\ \pi_t^e \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} \pi_{t-1} \\ \pi_{t-1}^e \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix}, \qquad 4.1$$
$$\begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix} \sim iid\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{pmatrix} \right).$$

The intuition behind this conjecture is that two variables are intrinsically related when credibility is low, inflation will not reach its target because expectations will drive it away, (ie., expectations feed into inflation). By the same token, when credibility is high, the target is reached due to the *'disconnect'*, ie., there is no causality from expectations to inflation.

However a disconnect also implies that no causality runs in the opposite direction as well, eg., supply shocks causing first round price rises which then cause inflation expectations to take root thus resulting in further rounds of price rises to become entrenched. Thus credible expectations 'disconnect' implies that the following hypotheses are met:

H1: Inflation expectations are not affected by actual lagged inflation, ie., c(L)=0

H2: Inflation expectations are anchored to a constant on average, ie., c(L)=0 & d(L)=0

H3: Actual inflation is not affected by inflation expectations, ie., b(L)=0

H4: The persistence of actual inflation decreases with credibility, ie., sum of a(L) coefficients deceases with credibility.

H5: There is no contemporaneous transmission of shocks from actual to expected inflation and vice versa, ie., covariances are zero.

Following Cruijsen and Demertzis (2010), hypotheses H1 to H3 will be tested using Wald restriction tests on the relevant coefficients. Note that the tests for H1 and H3, boils down to Granger causality tests. Since the data set spans a mere 10 years it is impossible to test the fourth hypothesis which requires one to test and compare the changes in coefficients over at least two sub-periods. The fifth hypothesis is satisfied when the VAR residuals (e_{1t} and e_{2t}) are uncorrelated,(ie.,$cor_{e_{1t}e_{2t}} = 0$). Additionally, the study considers impulse response functions (IRFs) of actual inflation to shocks in inflation expectations and vice versa. If the null hypotheses of H1, H3 and H5 are not rejected, it implies that the all elements of the mentioned IRFs to be zero.

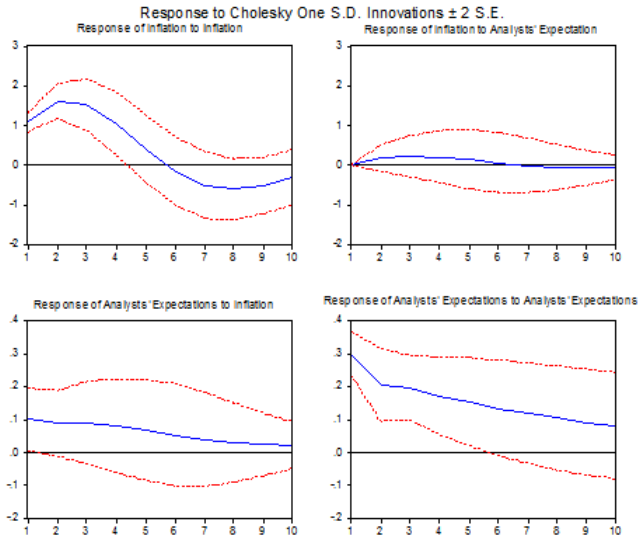
4.7 VAR Results

The graphical and descriptive evidence presented in section 4.5, above show that business executives and trade unionists do not believe in the credibility of the central bank, moreover both their expectations series (see, Appendix B, Figure 8 and Table 1) in most part tend to move together. In contrast the evidence, suggests that the financial analysts' expectations both of the survey data and the breakeven proxy variety (see, Appendix B, Figure 9 and Table 1) believe the SARB to be credible in its policy stance. These insights were subjected to more rigorous econometric scrutiny through applying the VAR methodology outlined above.

4.7.1 Financial Analysts' BER Survey VAR Results

As noted above, the unit circle stability test of Figure 11 and Table 10 (see Appendix B3) which records the diagnostic tests for the individual equations within the VAR system confirm that the bi-variate inflation-financial analysts' expectations, second order VAR model is stable. The hypotheses (1,2,3 and 5)test results of the VAR models are presented in Appendix B3, Table 14, of the five estimated VAR models, only the bivariate model involving inflation and the financial analysts' expectation of inflation comes closest to exhibiting a partial disconnect between inflation and expectations. The results demonstrate that there is no causality in either direction, thus supporting hypotheses, H1 and H3. However, there is significant contemporaneous transfer of shocks in both directions since $cor_{e1t\ e2t} = 0.32$, thus rejecting H5. This bidirectional contemporaneous transfer of shocks implies that inflation and expectations affect each other contemporaneously, perhaps through the mechanism of supply shocks and other vulnerabilities (discussed in chapter three). An examination of the Impulse Response Functions (IRF) reveals further insights into the impact of unanticipated shocks on the variables in question.

Figure 15: Inflation – Financial Analysts' Expectations



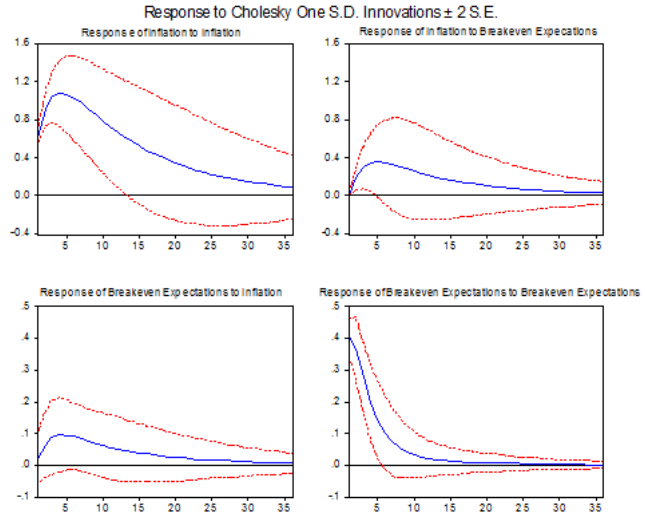
The off-diagonal of Figure 15, shows that inflation is unresponsive to shocks to the analysts' expectations, while analysts' expectations respond significantly to inflation shocks – about 10% response to a 100% shock in inflation, but it is the lower than similar responses from business and trade unionists' expectations. However, this effect diminishes steadily and in about 6 quarters it is at economically insignificant levels. However, since there is some

persistence one concludes that $c(L) \neq 0$ but are small in magnitude. By contrast the main diagonal of Figure 16 shows that there is significant persistence in both the variables, arising from own shocks. A shock to inflation causes a rise in inflation over the first two quarters – a 100% inflation shock leads to inflation rising by up to 150% – before it starts to diminish and is eliminated after 6 quarters. In regard to a response of inflation to its own shock, similar patterns are observed in all the bivariate models (see, Figures 16 to 18, below) thus suggesting that that despite a decade of IT inflation persistence still predominates in the South African Economy. However, returning to the issue of expectations, one notices that there is substantial persistence in analysts' expectations - a 100% shock results in expectations rising by 30%, which gradually declines for more than 10 quarters before it diminishes to insignificant levels, hence $d(L) \neq 0$. To establish whether H2 is supported one considers the bottom two panels of the IRFs that involves the expected inflation variable, and which were discussed above, where it was established that $d(L) \neq 0$ and $c(L) \neq 0$, hence H2 is not supported. Since H1 and H3 are not rejected and that although H2 is rejected, the $c(L)$ coefficients are considered to be small, one concludes that there is a partial disconnect between inflation and the analysts' expectations. **Thus, suggesting that the financial analysts consider the inflation targeting monetary policy to be partially credible.**

4.7.2 Breakeven Expectations VAR Results

As noted above unit circle stability test of Figure 12 and Table 11 (see Appendix B3) which reports the diagnostic tests for the individual equations within the VAR system confirm that the bi-variate inflation-financial analysts' expectations, second order VAR model is stable. With reference to Table 14, Appendix B3, the Inflation – breakeven VAR model which was meant to serve as an alternative proxy to the financial analysts' VAR model demonstrates very weak partial disconnection between inflation and expectations, if one interprets the results liberally. The model resulted in $cor_{e1t\ e2t} = 0.051$, which is quite small relative to the other four estimated models hence this study will assume that H5 is not rejected. However the Cruijsen and Demertzis paper, asserts that a correlation of 5% is still quite significant and hence H5 should be rejected, however they were focusing on industrialized EU member states, emerging economies on the other hand due to various structural constraints are vulnerable to supply side shocks (as discussed in chapter three) thus a 5% cross correlation is considered too small under used circumstances. Moreover the results in Table 14 show that there is a unidirectional causality from breakeven expectations to inflation (H3 is rejected) but there is no causality in the other direction (H1 is not rejected).

Figure 16: Inflation – Breakeven Expectations

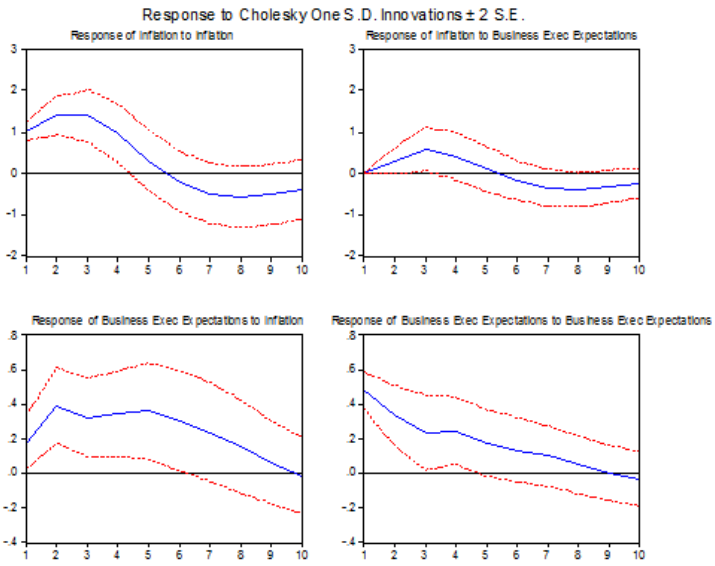


The main diagonal of Figure 16, shows that the inflation response is strong and quite persistent to its own shock and only reaches insignificant levels after 30 months. Furthermore inflation is quite responsive to breakeven expectations shocks; a 100% shock leads to inflation rising by almost 40% after 5 months and persists for more than 15 months before it reaches insignificant levels. By contrast, the response of breakeven expectations to an inflation shock is relatively small; it rises to a maximum of under 10% after about three months and diminishes rapidly to insignificant levels after about 12 months. Thus, although one notices that the degree of persistence of breakeven expectations' response to its own shock, declines rapidly and within a year its reduces to insignificant levels, thus although *c(L)* $\neq$ 0 their magnitudes are small. Breakeven expectations is also sensitive to its own shocks, with an immediate impact of 40% which then declines rapidly and is rendered insignificant within a year. Since H1 and H5 are not rejected and although H2 is rejected, the magnitudes of the *c(L)* coefficients in question are small, the study concludes that there is a weak partial disconnection between inflation and breakeven expectations. **Hence, in view of both the visual and VAR evidence propositions 1 and 2 are partially supported in that the financial markets believe that the SARB has a limited capacity to maintain inflation within the target band.**

4.7.3 Business Executives' Expectations VAR Results

The unit circle stability test of Figure 13 and Table 12 (see Appendix B3) which reports the diagnostic tests for the individual equations within the VAR system confirm that the bi-variate inflation-financial analysts' expectations, third order VAR model is stable. In regard to the remaining bivariate VAR models, at the opposite extreme to the analysts' VAR model is the inflation-business executives expectations' model, where all hypotheses (H1, H2, H3 and H5, see Table 14, Appendix B3) are rejected, thus suggesting that there is a bidirectional causality between inflation and business executives expectation of inflation (ie., H1 and H3 are rejected).

Figure 17: Inflation – Business Executives' Expectations



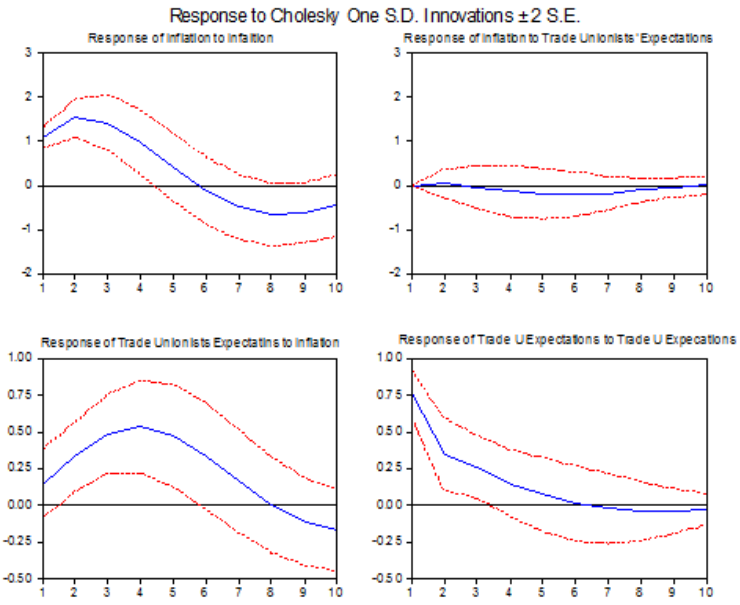
The inspection of the off-diagonal of Figure 17, reveals that inflation is quite responsive to shocks to business executives' expectations – inflation response is gradual and reaches a maximum of 50% after 3 quarters to a 100% shock in expectations. While a 100% shock to inflation causes business executives' expectations to strongly rise to 40% in the second quarter and to hover above 30% until the fifth quarter before it gradually diminishes to zero by the tenth quarter. The main diagonal shows that the response of inflation to its own shock is identical to the financial analysts' VAR model discussed above, hence $c(L) \neq 0$. Further the degree of persistence of business executives' expectations immediate response is a 50% rise relative to a 100% own shock and takes about nine quarters to diminish, thus $d(L) \neq 0$. Hypothesis H5 is also rejected since $cor_{e1t\ e2t} = 0.35$. **Thus there is a clear connection**

between inflation and business executives' expectations, thus implying that business executives do not find SARB's ITMF credible.

4.7.4 Trade Unionists' Expectations VAR Results

The unit circle stability test of Figure 14 and Table 13 (see Appendix B3) which reports the diagnostic tests for the individual equations within the VAR system confirm that the bi-variate inflation-financial analysts' expectations, second order VAR model is stable. In the case of the inflation-trade unionists' and the inflation-combined expectations VAR models all the hypotheses (see Table 14 Appendix, B3), except H3, are rejected. The non-rejection of H3 implies that inflation is not affected by unionists' and combined inflation expectations. However, causality runs in the opposite direction from inflation to expectations (ie., H1 rejected). Further, there are significant contemporaneous correlations of shocks in both the models (H5 rejected). But it is more pronounced for combined expectations model.

Figure 18: Inflation – Trade Unionists' Expectations



The IRFs for the inflation – trade unionists' expectation are very similar to that of the inflation – business executives' expectations model, thus indicating that H2 is also rejected. **Hence the study concludes that there is a strong connection between inflation and the mentioned measures of expectations. It is worth noting that the combined expectations, as mentioned before is a composite series that is dominated by trade unionists' and business executives' expectations and hence will necessarily reflect similar trends.**

4.8 Johansen VECM Cointegration Methodology and Results

This section proposes and explains the use of the more appropriate Johansen (1988, 1991) cointegration and error correction methodology to investigate whether proposition 3, which is a version of the 'credibility-disconnect' hypothesis that is exclusively framed for nonstationary inflation and expectations bivariate relationships, prevalent in the South African situation and might also be the case for supply shock sensitive economies like Brazil, Turkey and others. Thereafter the results and its implications for 'proposition-3-credibility-disconnect' will be discussed.

4.8.1 Proposition-3-Credibility-Cointegration Conjecture

The intuition behind a credibility disconnect when both actual inflation and expected inflation are nonstationary, is that when credibility is low, far ahead inflation expectations formed in the current period will be highly sensitive to movements in the current and recent past inflation rates as explained by equations 2.43 and 2.44 of section 2.3.3 of chapter two. Moreover inflation expectations will feed back into movements in inflation resulting in inflation being driven away from its target and expectations themselves will not be anchored to the central bank's target. Hence this dynamic relationship should show up in a long run cointegrated relationship between actual and expected inflation, with both the long (β) the short (α) run adjustment coefficients should be statistically significant – the α and β coefficients are explained in greater detail below**,** see equations 4.2 and 4.3 , as well as the related explanations. The short run adjustment coefficients are part of the error correction term, which captures the rate of adjustment of a variable (say expectations) to its long run equilibrium relationship with (inflation), after it has temporarily deviated away from its long run association. Some researchers (see, for example, Gurgul and Lach (2011) and Gosh (2009)) term such relationships as long run causality relationships which could either be unidirectional or bidirectional.

Alternatively, if there is a high degree of credibility that the central bank will maintain inflation at a target point or within a target range, over a sustained time period, then one would not expect far ahead inflation expectations to be affected by movements in inflation. Moreover inflation in turn is not affected by movements in expectations, hence one would not expect a long run cointegrating relationship between the two variables. However there might be short run relationships between the two variables since shocks affecting one variable could lead to contemporaneous effects on the other variable and *vice versa*, due to various wage-

price, wage-wage, price-price interrelationships in the economy, as well as the interaction between domestic prices, the balance of payments and exchange rates; and inflationary expectations (see the Structuralists' viewpoint (Lioi (1974), in particular see Mohr (2008) for the South African version of this argument)

4.8.2 The Johansen Vector Error Correction Model (VECM)

Equation 4.1, above represents a reduced form VAR model which treats inflation and expected inflation as endogenous variables and assesses them jointly in the system. A pth order reduced form VAR system as represented by equation 4.1 can be represented by the following Johansen (1991) and Johansen and Juselius (1992) augmented VECM that is used by this study:

$$\Delta y_t = \mu_0 + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_{iy} \Delta y_{t-i} + \Psi D_t + \varepsilon_t \qquad 4.2$$

y_t is a k x 1 vector of endogenous I(1) variables, μ_0 represents the intercept coefficients, Π is a k x k long run multiplier matrix and Γ_{iy} are k x k coefficient matrices describing the short run dynamic effects. p is the VAR order (or lag length), since the VECM representation is in differenced form the lag order reduces to p-1. ε_t is a vector of independently and identically distributed innovations with zero mean. D_t denotes a vector of I(0) exogenous variables and or dummies to accommodate for short run shocks; these variables play no role in determining in determining the long run cointegrating relationships, they merely have short run contemporaneous feedback(s) on the cointegrating variables and hence are included in the short run VECM.

In this study $y_t' = [\pi_t \quad \pi_t^e]$ ie., the y_t vector consists of actual inflation and expected inflation, respectively, measured in percentages. While the D_t contains a dummy variable as representing the credit crunch episode, for monthly data it takes on a value of 1 from 2007M8 to 2009M3 otherwise zero, while for quarterly data it takes on the value 1 from 2007Q3 to 2009Q1.

Within the context of equation 4.13 above, the presence of cointegration is tested for by examining the rank of Π. The presence of a reduced rank of Π (ie., where the rank(Π)= r<n, where n is the number of endogenous variables), implies that there exists r cointegrating

vectors and the matrix can be written as $\Pi = \alpha\beta'$, with β containing the r cointegrating vectors and α describing the speed of adjustment to the long run equilibrium. If r>1, then the issue of identification arises, however, within this study, r cannot be greater than one because there are only two endogenous variables (n=2) and hence the study expects r to be either one (signifying a long run cointegrating relationship between π and π^e) or zero (implying no long run relationship between the two endogenous variables). The latter case would imply that agents find the the IT regime to be credible since agents are not basing their expectations on the current movements in actual inflation but instead on an announced target. While the former case implies that the IT regime is not considered to be credible because agents are relying on the current movements in actual inflation to form their expectations of inflation two years ahead.

In the light of the preceding discussions, the Πy_{t-1} term, which is also known as the vector error correction mechanism (VECM)[15], captures the long relationship between π and π^e, and the short run adjustments consistent with the long run relationship, hence this study will now exploit this feature in order to derive the *credibility cointegration conjecture,* since it is argued that the inflation targeting monetary policy framework is supposed to anchor the long run expectations of private agents (see Gurkaynak, 2006, for example). The Πy_{t-1} term of equation 3 can be expanded as follows, in order to frame the *credibility cointegration conjecture* into testable hypotheses:

$$\Pi y_{t-1} = \begin{bmatrix} \alpha_{11} \\ \alpha_{21} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} \end{bmatrix} \begin{bmatrix} \pi \\ \pi^e \end{bmatrix}_{t-1} \qquad 4.3$$

A **proposition-3-credibility-cointegration** conjecture would imply the following null hypothesis:

*H_0: Inflation expectations and actual inflation do not share a long run cointegrating relationship which will show up in the trace and maximum eigenvalue statistics indicating that no cointegrating relationship exists. Hence the **proposition-3-credibility-cointegration** conjecture will be confirmed.*

[15] If one is considering just one equation from the matrix then the term is known as the error correction mechanism (ECM).

Moreover there is no need to proceed further to estimate the equation 4.2/4.3 (Note equation 4.2 ($ie., \pi\, matrix$) is a subcomponent of equation 4.3.) for either insignificant or spurious results will be obtained, for example, if one persisted in estimating equation 4.2/4.3 then the results will show:

β_{11} is normalized to equal 1, which is the standard practice in estimating cointegrating relationships. $\beta_{21} = 0$, or if non-zero it will be statistically insignificant, alternatively a bogus result will appear, ie., if $\beta_{21} < 0$ do appear to be statistically significant it will be spurious, for example it will have implausibly large magnitude (in absolute value) that are contrary to economic common sense. Note that $\beta_{21} > 0$, but it is $\beta_{21} < 0$ when it appears in equations 4.2 or 4.3 since it is in an Error Correction Mechanism format, ie., $\varepsilon = \pi - \beta_{21}\pi^{e}$. Additionally it is hypothesised that $\alpha_{11} < 0$ or $\alpha_{21} > 0$ could be significant with plausible magnitudes due to it capturing adjustment to supply shocks but the definitive result will be $\beta_{21} = 0$ or an implausibly high absolute value of the coefficient.

A rejection of the **proposition-3-credibility-cointegration** conjecture would imply the following alternative hypotheses:

H_a: Inflation expectations and actual inflation share a long run cointegrating relationship which will show up in the trace and maximum eigenvalue statistics indicating that a cointegrating relationship exists. Moreover an estimation of 4.2/4.3 will yield plausible results: $\alpha_{11} < 0$ *or* $\alpha_{21} > 0$ *and* $\beta_{21} > 0$.

The alternative hypothesis (H_a) suggests that the central bank is not considered to be credible and hence there is a long run cointegrating relationship between inflation and expectations, β_{21} will register as being significant by a t-statistic with plausible magnitude. Moreover the significant α_{11} and α_{21} will be negative and positive, respectively. If actual inflation overshoots its long run equilibrium relationship with expected inflation then there will be a quarterly adjustment in the opposite direction, while expectations will have to rise in order to catch up with the higher inflation level in an attempt to remove the disequilibrium. Since both α_{11} and α_{21} are significant, this suggests there is a bi-directional Granger causality between inflation and expected inflation, hence both variables adjust to its longer run relationship with the other (Ghosh, 2009; Gurgul and Lach, 2009). This type of lack of credibility will occur in a highly prone inflationary environment. Furthermore, it is possible

to also have unidirectional causality, where, although both will have the correct sign but either α_{11} or α_{21} will be significant. If only α_{11} (α_{21}) is significant then inflation (expectations) adjusts to its long run relationship with expectations (inflation).

In order to demonstrate the Johansen (1988, 1991) maximum eigenvalue and trace statistics for testing the study uses the vector autoregressive (VAR) system depicted in equation 4.2. The relevant hypotheses have to do with Π; if the rank of Π is *r*, where $r \leq n-1$, then *r* is called the cointegration rank. By including μ_0 in the model of Δy_t, allows a linear time trend to be present in the data generating process of y_t.

Regressing Δy_t ΔX_t, and y_{t-1} on Δy_{t-1} …, Δy_{t-k+1} , and one generates residuals R_{0t} nd R_{1t} , which are used to create the residual product matrices:

$$s_{ij} = T^{-1}\sum_{t=1}^{T} R_{it} R_{jt}^{'} \quad ,i, j = 0,1 \qquad 4.4$$

Thereafter one solves the eigen-value system

$$\lambda S_{11} - S_{10} S_{00}^{-1} S_{01} = 0 \qquad 4.5$$

for eigenvalues $\lambda_1 > \ldots > \lambda_n$ and eigenvectors $V=(v \ldots, v_n)$. To determine the number of cointegrating relationships - with r being conditional on the assumptions made about the trends – one proceeds sequentially from r=0 to r = k-1 until one fails to reject Ho. Then, one compares the maximum eigenvalue statistic, for the null hypothesis of *r* cointegrating vectors against the alternative of *r* + 1 cointegrating vector, which is:

$$\lambda_{max}\ r\ r+1) = -T1n(1-\lambda_{r+1}) \qquad 4.6$$

and the trace statistic for the null hypothesis of the most *r* cointegration vectors is :

$$Trace(r) = -T\sum_{j=r+1}^{n} \ln\left(-\hat{\lambda}_j\right) \qquad 4.7$$

Eviews 6 Users Guide II (2007), estimates the above maxim eigenvalues and trace statistics, however, one is first required to make assumptions about the deterministic trends in the cointegrating relationships, these include that the level data: (i) have no deterministic trends and the cointegrating equations do not have intercepts; (ii) have no deterministic trends but the cointegrating equations have intercepts; (iii) have linear trends but the cointegrating equations only have intercepts; (iv) and the cointegrating equations have linear trends and; (v) have quadratic trends and the cointegrating relationships have linear trends.

Most macroeconomic relationships tend to follow (ii) and (iii). Assumption (i) is too trivial and is unsuitable for most econometric investigations, while the use of assumptions (iv) and (v) is usually based on having a priori knowledge of the nature of the relationships between the variables. Since this study is estimating a simple bivariate model it confined its analysis to just estimating models based on assumptions (ii) and (iii) and chose the most plausible model in terms of the cointegration results and the generation of the resulting VECM (Enders 2004).

Finally the reported critical values derived for the maxim eigenvalues and trace statistics are based on that of Mackinnon, Haug and Michelis (1999) p-values, however, their results generated the same outcomes as that of Osterwald-Lenum (1992).

4.9 Cointegration and VECM Results

The cointegration and VAR-VECM results are presented in Appendix B4, Tables 15.0 to 20.1. Broadly the Financial Analysts' and Breakeven Expectations (also a proxy for Financial Analysts) models tend to support the notion of no long run cointegration with inflation thus implying that financial analysts perceive the central bank to be credible. Business executives' expectations, trade unionists' expectations and combined expectations share cointegrating relationships with inflation thus suggesting that they perceive the central bank to be non-credible. The succeeding subsections elaborate on these findings.

4.9.1 Financial Analysts' Expectations VECM Results

The statistics generated from the Inflation – Financial Analysts' VAR model is presented in Table 15, show that there is no cointegration, because according to the hypothesis testing explained above, both the trace and maximum eigenvalue statistics cannot reject the Ho: r = 0, because these statistics are less than the corresponding critical values at the 5% level of

significance. This result gives validity to the conjecture that there is a 'disconnect' between inflation and the analysts' expectations of inflation. Nonetheless, the study persisted in estimating a long run and short run relationships reported in Table 15.1, in order to establish the nature and significance of the α and β coefficients. The long run relationship is presented in its ECM form with normalization on inflation, this relationship can be restated as: $\boldsymbol{\pi_{t-1} = 1.37 + 0.74\pi^{e}_{FA\,t-1}}$. The results show that $\boldsymbol{\beta_{21} = 0.74}$ is statistically insignificant at the conventional significance levels with 42 degrees of freedom, thus confirming the inflation-expectations disconnect. Hence the sufficient condition for the 'disconnect' is met. However the VECM results show that, $\boldsymbol{\alpha_{11=} - 0.29}$, which may be interpreted as a 30% adjustment of inflation this quarter, as a result of a disequilibrium last period, to its long run equilibrium relationship with expectations. The coefficient has the expected sign and is highly significant at convention significance levels, but the adjustment is to a statistically non-existent equilibrium relationship. Moreover $\boldsymbol{\alpha_{21} = -0.008}$ implies a 0.8% adjustment of expectations to its equilibrium relationship with inflation, however, it is small and has an incorrect sign. Although both the coefficients are statistically significant their adjustment is to a statistically insignificant long run relationship. *Thus the overall results support the notion of a 'disconnect' between inflation and the analysts' expectations, thus suggesting that financial analysts find the ITMF to be credible. Hence, these results support the Ho hypothesis of* ***proposition-3-credibility-cointegration*** *conjecture.*

4.9.2 Breakeven Expectations VECM Results

The results on Inflation – breakeven inflation expectations VAR-VECM model, in Table 16, were generated on the assumption that trends exist in the levels data and the cointegrating vector contains an intercept. The trace and maximum eigenvalue statistics cannot reject the Ho: r = 0, because these statistics are less than the corresponding critical values at the 5% significance level. This result supports the proposition that there is a 'disconnect' between inflation and breakeven-analysts' expectations of inflation. Furthermore notice that the long and short run adjustment relationships reported in the Table 16.1 generate spurious results, although their $\boldsymbol{\alpha\ and\ \beta}$ coefficients which have the correct signs with significant t statistics. However, $\boldsymbol{\beta_{21} = 10.2}$ is implausibly high, suggesting that a 1% increase in monthly expectations lead to a 10,2% rise in inflation. This is implausible for it suggests a 10 fold response of inflation to expectations changes. Another problem is that the breakeven expectations data set spans only seven years which is too short a time to establish long run relationships despite the data being of a higher frequency. This weakness also applies to the

all the other data sets used in this study which spans a mere ten years, Aron and Meullbauer (2008) for example suggest a data set of at least 20 years ought to be used for long run time series studies, however this and the study by Cruijsen and Demertzis (2010) use shorter data sets and estimated plausible models. *Considering the overall results at best it offers weak evidence of a credibility disconnect at worse it is inconclusive. Thus, these results support the Ho hypothesis of* ***proposition-3-credibility-cointegration*** *conjecture*.

4.9.3 Business Executives' Expectations VECM Results

In regard to inflation – business executives' expectations VAR-VECM model, the statistics presented in Table 17, show that there is a long run cointegrating relationship, because according to the hypothesis testing explained above, both the trace and maximum eigenvalue statistics cannot reject the Ho: $r \leq 1$, as opposed to Ha: $r > 1$, because these statistics are less than the corresponding critical values at the 5% level of significance. This result implies that there is a connection between inflation and business executives' inflation expectations. Table 17.1, presents the long and short run relationships together with all the relevant statistics. The long run relationship is presented in its ECM form with normalization on inflation, this relationship can be restated as:

$$\boldsymbol{\pi_{t-1} = 0.18 + 0.86\pi^{e}_{BE\ t-1} + 0.005trend}$$

Note that the long run relationship can also be stated without lags as follows, for both forms are equivalent: $\boldsymbol{\pi_t = 0.18 + 0.86\pi^{e}_{BE\,t} + 0.005trend}$

The results show that $\boldsymbol{\beta_{21} = 0.86}$ is statistically significant at the conventional significance levels with 42 degrees of freedom, thus confirming a plausible long run relationship between the inflation and business executives expectations of inflation. The results imply that business executives do not find SARB's disinflation pronouncements to be credible. This statistical result supports both the results from the visual evidence (Figure 8 and Table 1 of Appendix B) and then the VAR results. Moreover the VECM results show that, $\boldsymbol{\alpha_{11} = -0.41,}$ and $\boldsymbol{\alpha_{21} = 0.14,}$ have plausible magnitudes with the correct signs, additionally their corresponding t statistics show that both coefficients are highly significant. Coefficient $\boldsymbol{\alpha_{11},}$ which may be interpreted as a 41% downward adjustment of inflation this quarter, as a result of an overshooting of its long run equilibrium relationship with expectations last period. Further, $\boldsymbol{\alpha_{21}}$ suggests that as a result of the inflation overshooting its long run relationship with expectations last period causes expectations this period to rise by 14% in order to restore

equilibrium. *These results support the alternative hypothesis of* ***proposition-3-credibility-cointegration*** *conjecture.*

4.9.4 Trade Unionists' Expectations VECM Results

In regard to inflation-trade unionists' expectations VAR-VECM model, the statistics presented in Table 18, show that there is a long run cointegrating relationship, since both the trace and maximum eigenvalue statistics cannot reject the Ho: $r \leq 1$, as opposed to Ha: $r > 1$, because these statistics are less than the corresponding critical values at the 5% level of significance. This result implies that there is a connection between inflation and trade unionists' inflation expectations, which suggests that trade unionists' do not find the SARB's IT policy frameworks as being credible. Table 18.1, presents the long and short run relationships together with all the relevant statistics in the ECM format with the normalization on inflation, it can be rewritten as: $\boldsymbol{\pi_{t-1} = 1.92 + 0.70\pi^{e}_{TU\ t-1} + 0.02trend}$. The results show that $\boldsymbol{\beta_{21} = 0.70}$ is statistically significant at the conventional significance levels with 42 degrees of freedom, thus confirming a plausible long run relationship between the inflation and trade unionists expectations of inflation. The results imply that trade unionists find SARB's disinflation pronouncements to be non-credible. This statistical result supports both the results from the visual evidence (Figure 8 and Table 1 of Appendix B) and the Cruijsen and Demertzis VAR hypotheses testing results (Table 14 Appendix B3). Moreover the VECM results show that, $\boldsymbol{\alpha_{11} = -0.33,}$ and $\boldsymbol{\alpha_{21} = 0.13,}$ have plausible magnitudes with the correct signs; additionally their corresponding t statistics show that both coefficients are highly significant. Coefficient α_{11}, which may be interpreted as a 33% downward adjustment of inflation this quarter, as a result of an overstepping of its long run equilibrium relationship with trade unionists' expectations last period. Further, $\boldsymbol{\alpha_{21}}$ **s**uggests that as a result of the inflation overshooting its long run relationship with trade unionists' expectations last period causes expectations this period to rise by 13% in order to restore equilibrium. *These results confirm the alternative hypothesis of the* ***proposition-3-credibility-cointegration*** *conjecture.*

4.9.5 Combined Expectations VECM Results

Recall, the combined inflation expectations indicator represents the overall expectations of inflation for the economy; it combines all three market players mentioned above. In regard to inflation-combined expectations VAR-VECM model, the statistics presented in Table 19, show that there is a long run cointegrating relationship, since both the trace and maximum

eigenvalue statistics cannot reject the Ho: r ≤ 1, as opposed to Ha: r > 1, because these statistics are less than the corresponding critical values at the 5% level of significance. This result implies that there is a connection between inflation and combined expectations, which suggests that the average market player (which is dominated by business and labour) do not find the SARB's IT policy framework as being credible. . Table 19.1, presents the long and short run relationships together with all the relevant statistics in the ECM format with the normalization on inflation, it can be rewritten as: $\boldsymbol{\pi_t = 0.28 + 0.99\pi^e_{com\ t}}$. The results show that $\boldsymbol{\beta_{21} = 0.70}$ is statistically significant at the conventional significance levels with 42 degrees of freedom, thus confirming a plausible long run relationship between the inflation and combined inflation expectations. The results imply that private agents in general find SARB's disinflation pronouncements to be non-credible. This statistical result supports both the results from the visual evidence (Figure 8 and Table 1, of Appendix B) and the Cruijsen and Demertzis VAR results discussed in sections 4.7 and 4.8.2 respectively. Moreover the VECM results show that, $\boldsymbol{\alpha_{11} = -0.40}$, and $\boldsymbol{\alpha_{21} = 0.12,}$ have plausible magnitudes with the correct signs, additionally their corresponding t statistics show that both coefficients are highly significant. Coefficient $\boldsymbol{\alpha_{11}}$, which may be interpreted as a 40% downward adjustment of inflation this quarter, as a result of an overstepping of its long run equilibrium relationship with combined expectations last period. Further, $\boldsymbol{\alpha_{21}}$ suggests that as a result of the inflation overshooting its long run relationship with combined expectations last period causes expectations this period to rise by 12% in order to restore equilibrium. **These results confirm the alternative hypothesis of the proposition-3-credibility-cointegration conjecture.**

4.9.6 Trade Unionists' – Business Executive Bivariate VECM Results

Lastly, purely out of curiosity the study decided to investigate the cointegration relationship between business executives expectations and that of the trade unionists', the results are reported in Table 20, which indicates that both the trace and maximum eigenvalue statistics confirms that a long run cointegrating relationship exists between the two variables. This long run relationship may be stated as follows: $\boldsymbol{\pi^e_{BE\,t} = 0.72 + 0.90\pi^e_{TU\,t}}$, where $\boldsymbol{\beta_{21}}$ **=0.90** with a highly significant t statistic, implying that a plausible long run relationship between the two variables exist (see, Table 20.1). Although $\boldsymbol{\alpha_{11}}$ and $\boldsymbol{\alpha_{21}}$ have the correct signs only $\boldsymbol{\alpha_{21}}$ is statistically significant, which implies that in the short run only trade unionists expectations adjusts to restore equilibrium when business executives overshoot their expectations relative to this long run relationship, hence business executives expectations is a dominant factor in

this relationship for the trade unionists expectations merely adjust towards it in order to restore equilibrium, this is consistent with macroeconomic theory which suggests that firms have an information advantage over labour and that labour revise their expectations a while after firms have set prices.

4.10 Overall Discussion of Results in the Light of other Studies

The cointegration results of both the BER survey data and the breakeven expectations proxy show that financial analysts find the central bank to be credible, The VAR results show the financial analysts to find the central bank to be partially credible. However more weighting is attached to the cointegration results for it enables the study to definitively conclude that there is a disconnection between the expectations formation behaviour of financial analysts and actual inflation. These results are strongly supported by the Reid (2009) study for she concludes that surprises in macroeconomic and financial news releases are not factored into long run bond yields. Since the Reid (2009) study focuses exclusively on bond yields which are determined in financial markets, her study is silent about the expectations of business executives and trade unionists. Hence this study is an advancement over hers with regard to these aspects.

The results of the Rigobon (2007) study can be assessed from the price setters' perspective, since standard macroeconomic theory suggests that firms (business executives) set prices in the economy. As explained above Rigobon (2007) proposed that the degree of pass-through from exchange rate depreciation to inflation might serve as a suitable indicator of central bank credibility. He found that there was a striking difference in the pass-through rate over the 2000-2002 period where it was much higher compared to the 2003-2006 period. Hence he concluded that since the South Africa's adoption of IT the SARB has gained credibility. However he does caution that more investigation is needed to ratify his proposition. In regard to the visual inspection of figure 8, Appendix B1, parallels Rigobon's study (albeit entirely different variables are being compared), however notice that post 2007, business executives expectations moved out of the targeting range, hand-in-hand with inflation (the cointegration and VECM results supports the visual evidence). It will be interesting to estimate the pass-through rates of depreciation over this (2007-2010) period. This study hypothesises that the pass-through rate of 2000-2002 and 2007-2010 periods would be similar. If this proves to be the case then the finding of the present study that business executives do not find the central bank to be credible would be confirmed. It is the opinion of this study that the reason

Rigobon found the striking differences is that benign conditions predominated over the 2003-2006 period. These benign conditions included low inflation, low interest rates and appreciated exchange rates (due to capital inflows caused by 'easy' global monetary conditions with foreign investors taking advantage of the interest rate differential between us and the developed world and our appreciating commodity stocks due to the commodity boom). Since our production processes are highly dependent on imported intermediate and capital inputs, the appreciated exchange rates over the period in question resulted in a low pass-through to inflation.

4.10 Conclusion

Chapters two and three argued that central bank credibility is critical is anchoring inflation to a target. If the central bank succeeds in anchoring private agents' expectations to a low level then it affords the central bank the opportunity to maintain low real interest rates which is critical for economic growth and employment. In the South African setting only the Reid (2009) and Rigobond (2007) studies attempted to explore the link between central bank credibility and stabilization of expectations. The Reid study in effect only focused on the financial analysts' expectation of inflation and found it to be well anchored since macroeconomic and financial surprises do not elicit an adjustment to the long bond yields. This finding is supported by the results of the present study where financial analysts' expectations were found to share no long-run cointegrating relationship with actual inflation thus implying that there is a disconnect. However the present study went further and found that different categories of private agents have different perceptions of central bank credibility. In particular it was found that the two years ahead inflation expectations of business executives and trade unionists are cointegrated with actual inflation, thus implying they do not believe that SARB will succeed in steering inflation back to target over the two year horizon. This is an important finding from a perspective of macroeconomic theory since business executives and trade unionists are price and wage setters respectively, and should the central bank succeed in anchoring the expectations of these agents, it will lead to lower wage and price determination in the economy thus resulting in lower stable inflation and in turn lower real interest rates, thereby, resulting in greater economic wellbeing. The findings of Rigobon (2007) tend to suggest that the central bank had gained credibility after three years into the IT regime since the pass-through from depreciations to inflation dropped drastically over the 2003-2006 period. However this study contests that view especially since

the period in question saw benign conditions of appreciated exchange rates, low inflation and interest rates. The study showed that the 2000-2002 and 2007-2010 saw high inflation rates as well as high expectations of inflation among business executives (price setters), and hence hypothesises that should one test for the pass-through from depreciations to inflation it would most likely be similar to the 2000-2003 period.

Chapter Five – The Impact of IT on the Volatility and Persistence of Inflation in South Africa

5.0 Introduction

This chapter makes a small but significant contribution to the raging debate regarding the benefits of IT, which has been extensively covered in chapters one and three. The main contribution of this chapter is to highlight the need to accommodate for structural breaks in the data before any conclusions can be drawn regarding the volatility and persistence of inflation under the IT regime. Using monthly data from 1985 through to January 2010, this chapter employs the generalized autoregressive conditional heteroskedastic (GARCH) and GARCH-M (mean) methodologies to estimate the impact of Inflation Targeting (IT) on inflation uncertainty as well as to study whether an increase in inflation causes increased uncertainty and whether a rise in uncertainty causes higher inflation. Moreover the study assesses whether Inflation Targeting has influenced a decline in inflation persistence since its adoption. Due to structural breaks the study uses a shorter series and has found that Inflation Targeting has not been successful in reducing monthly inflation uncertainty. Given that uncertainty has been shown to impose real economic costs, the failure of IT to lower uncertainty as well as inflation persistence in South Africa gives a cautionary lesson for other emerging economies contemplating the adoption of an inflation targeting monetary policy framework.

This paper proceeds as follows: the next section undertakes a brief survey of the main theoretical literature that attempts to draw a link between IT adoption and the reduction in the volatility of inflation; in particular the Friedman–Ball and the Cukierman–Meltzer hypotheses will be discussed. Thereafter of the pertinent findings of IT studies and potential challenges IT may face in the context of the South African inflationary scenario is discussed. This is followed by a brief literature review of a selection of papers that investigate the Friedman–Ball and the Cukierman–Meltzer hypotheses. Then a case will be made for paying special attention to structural breaks in the South African data in order to avoid erroneous conclusions involving the effectiveness of IT. The penultimate task is covered in section 5.3, which explains the GARCH methodology, the study will utilize to investigate the impact of IT within the South African context and then followed by the presentation and discussion of

the results. Finally the inflation persistence model will be explained and estimated in section 5.6.3. Thereafter the conclusion to this chapter will be made.

5.1 Background

IT is regarded as the latest of formal goals for monetary policy (the others being money supply, output, interest rate and exchange rate targeting). IT supporters claim that a formal inflation target increases credibility, and thus decreases inflation persistence by anchoring expectations in the face of inflation shocks (Van der Merwe, 2004). Moreover, by anchoring expectations, inflation targeting should decrease inflation uncertainty (Bernanke, *et. al*., 1999). If valid, then this is a significant feature of IT, since a low to moderate level of inflation may be neutral for output in the long run, inflation uncertainty implies future price uncertainty which adversely affects the decision making process of both firms and consumers since they tend to develop an inflationary bias. This, in turn, via the interest rate channel causes higher long term interest rates thus adversely affecting the economy. Moreover increases in inflationary uncertainty is reflected in a stronger risk component of long term interest rate instruments, which arises due to increasing uncertainty about real profits thus explaining why investors impose higher long term interest rates. Inflation variability creates uncertainty about the real future value of wages among both employees and employers. Additionally, inflation variability impacts on the uncertainty regarding future value of rents. The effect of inflation uncertainty on interest rates and other economic variables can potentially lower investment and hence output growth (Friedman, 1977; Grier and Grier, 2006; Ajevkis, 2007).

Furthermore Friedman (1977) asserted that a rise in inflation causes inflation uncertainty. This may occur because an inflation increase may induce an erratic policy response by the central bank that may thereby lead to more uncertainty about the future inflation rate. Ball (1992) formalized the mentioned arguments about the economic and inflation's impact on uncertainty in a model of asymmetric information between policy makers and economic agents. Cukierman and Meltzer (1986) suggested the possibility of the converse relationship of inflation uncertainty causing higher inflation as the central bank takes advantage of the uncertain environment to induce inflation surprises for the purposes of stimulating the economy. Such behaviour might further encourage the central bank's inflationary bias and thus resulting in lower long term economic growth.

Many empirical studies which are discussed in Section 5.2 below, have been conducted to test the Friedman – Ball and the Cukierman –Meltzer hypotheses. The findings appear to largely support the Friedman – Ball prediction, thus implying that policies that reduce average inflation will lower inflation uncertainty with likely long term economic benefits. However just two GARCH type studies by Kontonikas (2004) and Miles (2008) which focus on the developed economies of the United Kingdom and Canada respectively have attempted to answer the question whether explicit IT leads to a greater decrease in inflation uncertainty. Presently no GARCH type studies exist that focus on the impact of IT on inflation uncertainty in inflation targeting emerging economies[16]. However in the case of South Africa, Gupta and Uwilingiye (2007) using a non-GARCH approach have investigated the effect of IT on inflation uncertainty in South Africa. They divide the quarterly CPI inflation rate series into the pre-2000 and post-2000 (secondary) series. They then argue that if the secondary series blends in at the point of the implementation of the IT regime and is thereafter perfectly in-phase with the pre-2000 series then the volatility is similar to that of eclectic regime[17]; however if it is perfectly out-of-phase, then volatility has decreased. They apply the relatively unknown *cosine – squared cepstrum* technique to determine whether or not the secondary series was in or out of phase with the pre-2000 series. They found that the IT regime has increased the volatility (variance, a commonly used indicator of uncertainty) of inflation relative to the case of the eclectic monetary approach, thus they conclude that the IT regime has failed to attain its primary objective of price stability in terms of both the mean and variance of inflation. In another non-GARCH study by Gupta, Kabundi and Modise (2010) involving a factor-augmented vector autoregressive model comprising 107 equal-length (1989M1-1997M12 and 2000M1-2008M12) monthly time series which included the inflation rate series over pre- and post-IT periods for South Africa, they found that IT succeeded in influencing most of the variables including the reduction in the inflation rate but the effects were insignificant. They proposed that these results are perhaps due to the shorter length of the sub-samples relative to the number of variables used in their study.

[16] However Thornton (2007) considers the relationship between inflation and inflation uncertainty in twelve emerging market economies of which five are inflation targeters, using a GARCH (q,p) model. But, he did not explicitly test for the IT effects on inflation uncertainty in most cases the data set ended before the IT regime was introduced.

[17] Monetary policy during the Stals era (1989-1998) is generally described as the eclectic approach because the bank rate (later the Repo rate) was determined by using a wide range of indicators, including exchange rate, yield curve, asset prices, output gap, balance of payments, wage rates, credit extensions, fiscal stance and trade union and private sector expectations (Stals, 1997a).

Surprisingly no South African studies thus far have used the commonly employed Generalized Autoregressive Conditional Heteroscedasticity (GARCH) methodology to investigate the relationship between IT and inflation uncertainty. This study endeavours to remedy that gap by employing the GARCH methodology to estimate the impact of IT on inflation persistence and uncertainty. Studying the effects of IT on the relationship between inflation and inflation uncertainty is vital for policy purposes given the real costs of inflationary persistence and uncertainty to the economy. Moreover the results of this study will make a contribution to the debate involving the mainstream-economists who advocate the retention of IT and the influential leftists who are vociferous in their criticisms of the IT Monetary Policy Framework (ITMPF).

5.2 Literature on the IT and Inflation Concerns Relevant to South Africa

This subsection reviews literature that addresses the concerns of IT and the inflation challenges facing the South African economy. As mentioned above IT has been promoted as a means to lower the level, expectations of, and uncertainty surrounding inflation. IT came into vogue since the early 1990s, as a result of the perceived failure of previous policies, namely monetary and exchange rate targets.

Mishkin (2000) argues that IT should increase transparency of the monetary regime, since it is easier for the public to comprehend the notion of the inflation rate rather than other potential formal goals such as the money supply or exchange rates. Moreover he asserts that IT will increase monetary discipline and decrease harmful inflation uncertainty and hence increase the credibility of the monetary authority. Svensson (1997) offers a theoretical justification that IT will lead to lower inflation variability than monetary or exchange rate goals, if the central bank chooses its own forecast of inflation as the target.

As mentioned before Ammer and Freeman (1995) contend that the United Kingdom, Canada and New Zealand did not achieve long term credibility for their announced long run inflation intentions nor is there solid evidence that the announcement of these low inflation policies have significantly reduced inflation expectations. These conclusions were based on the observation that after having introduced an IT regime, these countries continued to maintain high interest rates for a lengthy period, which affected output negatively hence they intimated that the cost of reducing inflation may be too high. Van Den Heever (2001) echoed similar

views by suggesting that if IT is pursued at any cost, it runs the risk of inefficient output stabilization. Significant supply shocks (eg. huge oil price rises to which South Africa is particularly vulnerable) may require steep interest rate adjustments in order to achieve target goals timeously. The Saville (2004) study using the Taylor Rule (1993) framework showed that SARB has followed an excessively restrictive monetary policy which has hindered economic growth, since the adoption of ITMPF. Lastly Van Den Heever (2001) further noted that IT is a complicated approach relying heavily on econometric forecasts in an uncertain economic environment and if forecasts turn out to be wrong, even for unforeseeable circumstances, SARB's credibility could be impaired. Impaired credibility exacerbates both inflation uncertainty and inflation variability.

Schaling and Schussler (2001) explained that inflation in South Africa has a significant cost push component, that is, inflation is an outcome of wage rises and profits. Firms tend to increase prices by more than wage cost increases due to insufficient local competition (*de facto* cartels and monopolies including state monopolies) and insignificant international competition. Hence ITMPF must be complemented by radical supply side measures to eliminate sources of insufficient local competition.

Kaseeram, Nichola and Mainardi (2004) used the Johansen vector error correction modelling technique to demonstrate the significant pass-through effects from unit labour costs to inflation and noted that the trade union militancy phenomenon is another causal factor of inflationary pressures in the South African economy. The SARB Quarterly Bulletin (March, 2008, 2009) noted the inflation bias inherent in wage settlements with grave concern, for example they noted that wage demands for 2007 and 2008, respectively were well above the inflation rate and intimated that it is impossible for productivity gains to offset such exorbitant real wage increases especially in the light of falling global real wages due to downward pressures emanating from South East Asia, China, Brazil and other emerging economies.

Administrative pricing such as electricity and water costs, which the government and parastatals regulate in a monopolistic manner is another factor that significantly affects the South African inflation rate. Administrative prices are difficult to bring down using interest rates, hence it is doubtful the extent to which inflation targeting can succeed within the South African setting (Schaling and Schussler (2001)). Moreover, Lodge (1998) contends that bloated state departments, corruption and the populist tendencies of some factions of

government might create perceptions of the preponderance of fiscal dominance in the near future hence creating an inflation bias in the economy.

Recent empirical evidence tends to be mixed in regard to the performance of IT-adopting countries compared to non-IT countries. For example, a study by Fatas, Mihov and Rose (2006) indicates that inflation targeting countries have had lower inflation than non-targeting countries and lower inflation than those countries targeting money or exchange rates. However, in contrast Ball and Sheridan (2005) using difference-in-differences analysis demonstrate that there is no statistically better performance by IT countries compared to non-IT countries regarding the level of inflation.

In regard to whether IT successfully reduces inflation expectations, some evidence does exist, for example, Johnson (2002) utilized an eleven-country panel data analysis to estimate the impact of IT on the consensus of professional inflation forecasts and found that in all of the IT-adopting countries, inflation forecasts fell significantly. However the study in question finds that while IT lowers the average forecast of inflation, it has no effect on the variance of forecasts in any inflation targeting country under study. In other words, a fall in inflation expectations does not necessarily lower inflation uncertainty.

5.3.0 An Overview of the ARCH/GARCH literature

In this subsection a brief overview of the GARCH literature pertaining to inflation uncertainty is provided. Specific focus is given to those papers that are relevant to the methodology employed later in the chapter.

5.3.1 Literature on Inflation Uncertainty

The empirical literature on the inflation uncertainty relationship can broadly be categorized as being of the ARCH/GARCH (AG) and non AG variety. The early studies by Okun (1971) and Fischer (1981) employ the moving standard deviation or variance of the inflation time series as a proxy for inflation uncertainty. These measures of uncertainty suffer from a critical conceptual drawback, viz., instead of measuring future uncertainty of the variable's values it measures the variability of the time series itself. A higher variability of inflation does not necessarily imply higher uncertainty, since an increase in inflation variance may be caused by fully anticipated changes in inflation; thus it does not necessarily imply an increase in uncertainty. To remedy this drawback Johnson (2002) uses monthly survey data of the

yearly expected inflation predictions of individual respondents to develop three different proxies for inflation variability and finds a significant positive link between current inflation and future uncertainty, consistent with the Friedman – Ball insight. Concerning the three proxies, the first proxy is the deviation between actual and the forecaster's prediction of inflation a year ahead, while the second is the standard deviation of individual forecasts within a calendar year, and the third is the absolute next year forecast error, averaged across individual forecasts within a year.

Before the development of the AG methodology the early studies relied on the traditional proxy for inflation uncertainty which was the variance of different forecasters' prediction of inflation (Holland, 1993). However, Grier and Grier (2006), however, contend that this is a flawed measure of uncertainty, since each forecaster may have a large confidence interval around their point forecast, but that the collective forecasts may show little variability. With the derivation of the mentioned Friedman-Ball and Cukierman-Meltzer hypotheses a new definition of inflation uncertainty resulted which is the variance of the unpredictable component (error terms) of an inflation forecast and is termed the conditional variance of an inflation forecast. The AG methodology fits in snugly with this definition since Engle's (1982) celebrated paper on ARCH and the GARCH extension by Bollerslev (1986) where the conditional variance of the one-step ahead forecast error is employed as a proxy for inflation uncertainty. Engle's ARCH model provides time varying estimates of the conditional variance of inflation, specified as a linear function of current and past squared forecast errors, while Bollerslev developed a generalized ARCH (GARCH) model wherein the time varying estimates of the conditional variance also include past variances, as explained in Enders (2004). Engle used a wage price spiral model to define inflation while the conditional variance was described as a fourth order ARCH process and significant ARCH effects were found to be present. Bollerslev estimates a fourth order autoregressive model for US inflation and estimates a GARCH(1,1) model for the conditional variance and finds that there is no relationship between inflation uncertainty and inflation. Neither the Engle nor the Bollerslev studies explicitly test for the Friedman-Ball and Cukierman-Meltzer hypotheses. However, many subsequent studies have adopted the GARCH approach to test for these hypotheses. Most of the studies which include Chen, Shen and Xie (2006), Daal, Naka and Sanchez (2005), Apergis (2004), Tevnik and Perry (2000), Grier and Perry (1998) appear to support the Friedman-Ball theory, but only those studies, for example, Hwang (2001), Cosimano and Jansen (1988) and Bollerslev (1986), working with US data have refuted the

theory in question. A few studies have also validated the Cukierman-Meltzer hypothesis, these include Apergis (2004), Daal, Naka and Sanchez (2005) and Chen, Shen and Xie (2006).

Grier and Perry (1998), Thornton (2007), Mladenovic (2007) and Jiranyakul and Opiela (2009) have used a two-step procedure of estimating an inflation process (usually AR or ARMA), the residuals of which are then used to estimate inflation uncertainty as a simple GARCH(1,1) model. They then use the generated conditional variances to explore the relationship between inflation uncertainty and inflation through employing a Granger causality test. However some authors have raised objections to using the two step procedure because of the problem of generated regressors arising which may bias the Granger causality tests. Instead they use the multivariate GARCH-in-mean (GARCH-M) model which is estimated via the maximum likelihood method ((Miles (2008), Wilson (2006)), Kontonikas (2004) and Baillie, Chung and Tieslau (1996)). This study will also follow the GARCH-M approach to test for the Cukierman-Meltzer hypothesis . Moreover the study will follow Miles (2008) and Kontonikas (2004) by using the conventional GARCH model augmented by a dummy variable to represent inflation targeting will be used in order to assess the impact of IT on inflation uncertainty. Finally the study will use the simple augmented GARCH model to test the Friedman-Ball hypothesis consistent with the approaches used by Fountas *et. al.,* (2000)) and Thornton (2008).

5.4 Methodology

Most GARCH time series studies that investigate the relationship between inflation and inflation uncertainty first model inflation as an Autoregressive Moving Average of order *p,q* (ARMA(p,q)) or AR(p) (a *p* order Autoregressive) process:

$$\pi_t = \varphi + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{j=0}^{q} \beta_j \varepsilon_{t-j} + \varepsilon_t \qquad 5.0$$

where π_t is the current inflation rate. If $\beta_1 = \beta_2 = ... = \beta_q = 0$, then the model reduces to a *p* order AR process. Suppose that economic agents have rational expectations, then the residuals ε_t represent forecast errors. This study further assumes that inflation uncertainty which is proxied by the time varying variance (h_t) can be usefully described by the following GARCH(p,q) model which was proposed by Bollerslev(1986):

$$\varepsilon_t = v_t h_t^{0.5} \qquad \text{where } \sigma_v^2 = 1; \qquad E(\varepsilon_t / \Omega_{t-1}) = 0; \quad Var(\varepsilon_t / \Omega_{t-1}) = h_t \qquad 5.1$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \qquad 5.2$$

Where $a_0 > 0$; $a_i \geq 0$, i = 1, …q; $\beta_j \geq 0$, j = 1, …,p and Ω_t is the information set available at time t. Additionally v_t is white noise and its variance is unity, so that the residual ε_t still has an expected value of zero based on the information set in the previous period. It can be shown that the conditional variance (h_t) of ε_t is an ARMA process given by equation 5.2, (Enders, 2004). This *generalized* ARCH(p,q) or GARCH(p,q) allows for both autoregressive and moving average components in the heteroscedastic variance (h_t). A high order ARCH(q) model can be represented as a more parsimonious GARCH representation, that is much easier to identify and estimate, Enders (2004).

In regard to evaluating equation 5.0, this study adopted the General-to-Specific modelling approach, which involves specifying an unrestricted, statistically adequate dynamic ARMA(12,12) model, termed the *general model*. This model was then pared down in size on the basis of omitting statistically insignificant variables, thus resulting in a *specific model* that is a more parsimonious, economically sound and statistically valid representation. The study had a choice between an ARMA(1,1) and a AR(2) model. However, on the basis of the minimum values of the Akaike Information Criteria (AIC) and the Schwarz-Bayesian Information Criteria (SBC), the AR(2) model was selected as the best description of the South African inflationary process both over the extended period of 1960M1 to 2010M1 and the restricted period of 1992M9 to 2010M1. Concerning, equation 5.2, after experimenting with a number of GARCH (p,q) functions and observing autocorrelation functions (ACF) graphs of their squared residuals the GARCH (1,1) model was selected as the best functional form to explain conditional variance within the South African context. Equations 5.0 and 5.2 were estimated as Model 1 in Table 21, section 5.7.1 of this chapter.

In IT studies equation (3) has been augmented to derive the following equation:

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta h_{t-j} + \lambda D_t + \delta \pi_{t-1} \qquad 5.3$$

Kontonikas (2004) and Miles (2008) investigated the impact of IT on inflation uncertainty in the UK and Canada, respectively using augmented GARCH models as expressed in equation 5.3. The authors employ a dummy variable (D_t) for the post-IT period, and add this dummy to the conditional variance in equation 5.3. They find a significant, negative impact of inflation targeting on uncertainty in the respective countries, which suggests that the policy has had a significant impact in decreasing inflation uncertainty. Additionally, both the authors also include the lagged level of inflation as a regressor in the conditional variance, so that the negative coefficient on the IT dummy that resulted for both countries indicates that IT has decreased uncertainty, even given the previous period's *level* of inflation.

This study will follow both Kontonikas and Miles, and include a policy dummy (D_t) for IT in the GARCH model to determine the effect of the inflation targeting on inflation uncertainty by estimating equation (5.3) for South Africa. D_t will take on the value of one in the post IT period (2000M2 to 2009M9) and zero otherwise. The study will thus be able to test for the effect of IT by examining the sign and significance of the estimates of λ. The specification in question was modelled as Model 2 in Table 21, section 5.6.1 of this chapter.

A second hypothesis to be tested is the effect of uncertainty on the level of inflation. Recall the Cukierman-Meltzer hypothesis states that a higher level of uncertainty, as measured by the conditional variance GARCH process, should increase the level of inflation. This paper employs the following GARCH-M method, in which the conditional variance affects the conditional mean:

$$\pi_t = \varphi + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{j=0}^{q} \beta_j \varepsilon_{t-j} + \theta h_t \qquad 5.4$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta h_{t-i} + u_t \qquad 5.5$$

A test for the effect of uncertainty on inflation will be undertaken by observing the sign and significance of the estimated parameter θ. As noted in Table 22 the GARCH-M term in Model 3, is insignificant, suggesting that higher uncertainty has no effect on inflation in South Africa.

The third hypothesis to be tested is the Friedman-Ball hypothesis which suggests that a rise in inflation causes inflation uncertainty will be tested using the following model proposed by Fountas (2001) and Thornton (2008):

$$\pi_t = \varphi + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \varepsilon_t \qquad 5.6$$

$$h_t = a_0 + \sum_{i=1}^{q} a_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta h_{t-i} + \delta \pi_t \qquad 5.7$$

π_t is the current inflation rate and where according to the Friedman-Ball hypothesis, $\delta > 0$. As mentioned above the General-to-Specific modelling approach and the minimum value AIC and SBC criterion suggested the choice of an AR(2) model should be used to capture the inflation dynamics. Furthermore equation 5.2, describing the GARCH(p,q) model has been augmented with the current inflation variable to give rise to equation 5.7. Based on the insights gained by observing the ACF of the residuals and as noted above the GARCH(1,1) form of equation 5.8 was evaluated as Model 4 in Table 22. All the mentioned models were evaluated jointly using the maximum likelihood method.

5.5 Inflation Persistence Methodology

In order to examine the persistence of inflationary pressures in the post IT period this study will follow the literature and use the following autoregressive model augmented with a multiplicative dummy variable to capture the post IT period:

$$\pi_t = \gamma_0 + \gamma_1 \pi_{t-1} + \gamma_2 + \gamma_3 D_t \pi_{t-2} + \varepsilon_t \qquad 5.8$$

where, Dt is the IT dummy that takes on the value of one in the post IT period, otherwise zero. Equation 5.8 is a variant of the model used by Kontonikas (2004), where he employed the following model:

$$\pi_t = \gamma_0 + \gamma_1 + \gamma_5 D_t \pi_{t-1} + \gamma_2 \pi_{t-3} + \gamma_3 \pi_{t-6} + \gamma_4 + \gamma_6 D_t \pi_{t-12} + \varepsilon_t \qquad 5.9$$

Variants of equation (5.9) with lagged inflation augmented by dummies which represent policy shifts or other economic events is a popular approach in the inflation persistence literature (see, for example Kontonikas (2004), Siklos (1999) and Alogoskoufis and Smit (1991)). This study estimated equation 5.9 and a few variations thereof; however, the coefficients of lagged inflation greater than two periods proved to be insignificant, hence equation 5.8 was chosen as the best model to assess persistence of inflation in the post-IT period for South Africa. Additionally equation 5.8 was also augmented with a multiplicative dummy attached to the inflation variable lagged by one period; however, its coefficient proved to be insignificant. Thus the study settled for equation 5.8 as the best model to assess post IT inflation persistence. Table 23 reports the results of equation 5.8. If inflation persistence declined during the post-IT period then one should expect $\gamma_3 < 0$ and the sum of $\gamma_2 + \gamma_3 < 0$, this would imply that inflation persistence has indeed subsided in the post-IT era.

5.6 A Structural Break in the Monthly Inflation Data

Siklos (1999), Miles (2008) and Mohr (2008) noted that during the late 1980s and 1990s the world economies registered a sustained disinflationary trend that levelled out to an average of about 2% for industrialized economies. Over this period low inflation levels became a norm in most emerging economies - both IT and non-IT countries - as well, hence studies that do not accommodate for structural breaks when using long data sets may draw erroneous conclusions about the causal factors that contributed to the decline in inflation persistence. Mohr (2008, p.8) argued that the world economy had undergone a structural change since the 1980s and that South Africa joined the global community in the early 1990s when the "international economy itself was in the throes of globalization," where international trade was gaining ascendency in a highly competitive environment which meant that prices were kept low. At the same time South Africa was embarking on trade and financial liberalization programmes which raised the degree of competition that domestic firms were exposed to relative to the Apartheid era. The aforementioned structural change, due to globalization that resulted in low inflation taking root in most economies, was caused by: stronger international competition in the tradable goods sector; downward pressures on wages and prices due to Chinese, Indian and workers from other emerging economies entering the global workforce; exchange rate reform in emerging economies resulting in balance of payment surpluses; productivity gains emanating from improved technology, especially the synergic effects of

digital technology in all other fields; strong political support for low prices and conservative monetary policies and prudent fiscal policies.

A careful examination of Figure 19, Appendix C reveals that post-1990 the monthly CPI inflation rate did indeed follow a downward trend that lasted right up to the credit crunch period (mid 2007-2008). In the light of the above discussion the study opted to undertake a battery of unit root type structural break tests in order to identify the most suitable break date. Section 5.8 below and Appendix C provides a detailed account of the structural break tests that were undertaken.

5.7 Data Issues

This study employs seasonally adjusted monthly consumer price index (CPI) data for the period 1960M1 to 2009M11, obtained from the SARB website. Inflation (π) is measured as the first difference of the seasonally adjusted log CPI ie., $\pi = 100 \times (\ln CPI - \ln CPI_{t-1})$. The 1960M1-2009M11 inflation series was found to have a unit root at the one percent significance level by a battery of unit root tests which included the Augmented Dickey Fuller (1979); Phillips and Perron (1988); Kwiatkowski, Phillips, Schmidt and Shin (1992); Elliot, Rothenberg and Stock (1996) and the Ng and Perron (2001) tests. Maddala and Kim (1998) provides a useful intuitive account of how most of these tests are designed. The series also suffered from a number of structural and trend breaks, and spanned the periods that involved both non-market (1960 to 1983) and market related (1984 to the present) forms of monetary control. In order to make the analysis tractable the study opted for using a shorter data set that ranged from1985m1 to 2009m11, in the hope of acquiring better results. This shorter series covers the period where market related forms of monetary controls involving the interest rates were introduced for the first time which gave the authorities greater control over aggregates such as money supply, bank credit, inflation and exchange rates. In order to both avoid obtaining spurious estimates of the conditional variance as well as preventing the overestimation of the effects of IT on inflation uncertainty, it is critical that the study accounts for structural changes in the data over the period in question. Siklos (1999) and Miles (2008) noted that during the late 1980s and 1990s inflation fell significantly in both IT and non-IT countries and hence the estimated significant impact attributed to IT on expectations, persistence and uncertainty by Kontonikas (2004) and Johnson (2002) may in fact be due to other causes. Although the official policy stance from 1987 to 1999 was that of

a money supply targeting framework but when Chris Stals was appointed governor of the SARB in November 1989, he ushered in the so called eclectic approach which involved using a set of indicators to guide monetary policy stance. These indicators included the money supply, exchange rates, balance of payments, output gap, wage rates, bank credit extensions and the fiscal stance (Stals, 1997a). The eclectic approach marked a significant policy shift, for during much of the Stals era a restrictive monetary policy stance was enforced and inflation assumed a downward trend, which is confirmed by the graphical evidence presented in Figure 19, Appendix C.

5.8 Structural Break Tests

In order to rigorously identify the best possible candidates for structural breaks the study used four commonly used structural break tests to find multiple structural breaks in the South African data. These structural break tests include the Bai-Perron (BP) approach (Bai and Perron, 2003), the Lee and Strazicich (2003), the Andrews and Ploberger (1994) and the Lumsdaine and Papell (1997) unit root tests. This study downloaded the RATS version 6.3 source code for the four structural break tests that was written by T Doan (2003) from the Estima website: *http://www.estima.com/*. The study is grateful to Tom Doan for making the code available.

In view of the justification mentioned above, this study used an AR(2) regression model with a constant as the best description of the South African inflationary process, in order to apply the structural break tests. With reference to Appendix C, these four tests identify the 1990s structural break dates range from 1990M7 to 1993M4, this study opted to follow the more robust BP approach, which uses a dynamic programming algorithm by testing the regression residuals of each observation for a potential breakpoint. Interestingly, for the 1985M1 – 2009M11 data the BP technique identified September 1992 as the best candidate for a break point, this date co-insides with the early phase, of the implementation, of the eclectic approach to monetary policy. Rangasamy (2009) using autoregressive modeling techniques tested for inflation persistence using quarterly data from 1981Q1 to 2008Q4, however his study neglected to consider structural breaks in the data. Additionally the date in question marks the beginning of period when a new political dispensation was being hammered out. Hence this study decided to estimate the GARCH models using the more restricted series of 1992M6 – 2009M11.

5.9 Unit Root Tests

The battery of unit root tests for the 1990M1 – 2009M11 series, which is recorded in Table 21, resoundingly rejects the hypothesis of a unit root for the monthly CPI inflation data in favour of the alternative hypothesis of stationarity irrespective of whether a constant with or without linear trend is assumed.

Table 21. Unit Root Tests for the Monthly Inflation Rate

Panel A - Constant

Test Type	**Levels Test Statistic**		**Critical Statistic**		**1st Difference Test Statistic**	**Critical Statistic**
ADF	-9.014*** (0)		-3.458		-24.453*** (0)	-3.458
PP	-9.158*** (Bw=6)		-3.458		-53.137*** (Bw=37)	-3.458
DF-GLS	-5.680*** (0)		-2.575		-18.949*** (0)	-2.575
KPSS	0.7820 (Bw=9)		0.739		0.1826*** (Bw=85)	0.7390
ERS	1.2079*** (1)		1.9264		0.1632*** (1)	1.9264
Ng-Perron	MZa	-24.542***	-13.800		-104.388***	-13.800
	MZt	-3.4151***	-2.5800		-7.2245***	-2.5800
	MSB	0.1396***	0.17400		0.0691***	0.17400
	MPT	0.2347***	1.78000		0.23472***	1.78000

Table 21 Continued: Panel B - Constant and Linear Trend

Test Type	**Levels Test Statistic**		**Critical Statistic**		**1st Difference Test Statistic**	**Critical Statistic**
ADF	-9.675*** (0)		-3.997		-24.401*** (0)	-3.997
PP	-10.182*** (BW=6)		-3.996		-53.236*** (Bw=37)	-3.996
DF-GLS	-9.000*** (0)		-3.464		-22.602*** (0)	-3.464
KPSS	0.1993*** (Bw=9)		0.216		0.18260*** (Bw=85)	0.2160
ERS	1.5832*** (1)		4.0316		0.60685*** (1)	4.0316
Ng-Perron	MZa	-55.983***	-23.800		-128.24***	-23.800
	MZt	-5.288***	-3.4200		-8.0073***	-3.4200
	MSB	0.0945***	0.1430		0.06244***	0.1430
	MPT	1.640***	4.0300		0.71061***	4.0300

Source: Own Calculations

Notes: *** imply significance at the 1% level.

The numbers within brackets for the ADF, DF-GLS and ERS statistics represent the lag length of the dependent variable used to obtain white noise residuals.

The Numbers within brackets for PP and KPSS statistics represent the bandwidth selected based on Newey-West method using Bartlett Kernel

The numbers within parentheses shown for the ERS statistic indicate the spectral OLS AR based on Schwarz Information criterion.

In the light of the monthly CPI series being stationary the study then proceeded with estimating the GARCH models. If the series was found to be non-stationary then it would have been necessary to have differenced the series until stationary was achieved before GARCH modelling could have been undertaken, alternatively, the Ball and Cecchetti (1990) approach could have been used to decompose inflation variability into long and short run components.

5.10 Results Discussions of the Estimated GARCH and Inflation Persistence Models

Table 22, below, records the results obtained from the GARCH models described in section 5 above. Model 1 estimates a standard AR(2) GARCH(1,1) model for the South African economy, while Model 2 assesses the impact of IT on inflation uncertainty, Model 3 on the other hand is the GARCH M specification that is employed to test the Cukierman-Meltzer hypothesis and finally Model 4 tests the Friedman-Ball hypothesis.

Table 22. Results of the GARCH Models

Variable	Model 1		Model 2		Model 3		Model 4	
Inflation Equation (AR(2))	**Coeff.**	**P-value**	**Coeff.**	**P-value**	**Coeff.**	**P-value**	**Coeff.**	**P-value**
Constant	0.52***	(0.000)	0.54***	(0.000)	0.98***	(0.003)	0.48***	(0.000)
π_{t-1}	0.43***	(0.001)	0.41***	(0.000)	0.41***	(0.000)	0.40***	(0.000)
π_{t-2}	0.18*	(0.074)	0.15**	(0.038)	0.15**	(0.029)	0.18**	(0.015)
h_t	-		-		-1.37	(0.181)	-	
Variance Equation								
Constant	0.077***	(0.018)	0.252	(0.265)	0.019	(0.422)	0.010	(0.608)
ARCH(1) ie., ε_{t-1}^2	0.193*	(0.068)	0.082	(0.241)	0.050	(0.250)	0.100	(0.159)
GARCH(1)ie., h_{t-1}	0.437**	(0.037)	0.726***	(0.000)	0.830***	(0.000)	0.654***	(0.000)
IT Dummy	-		-0.002	(0.737)	-		-	
π_{t-1}	-		0.0128	(0.450)	-		-	
π_t	-		-		-		0.037**	(0.024)
Diagnostics								
$\overline{R}^2$	0.208		0.202		0.222		0.200	
AIC	1 .058		1.055		1.038		1.024	
SBC	1.154		1.183		1.150		1.152	
Q(4)	0.870	(0.647)	0.335	(0.846)	0.315	(0.854)	0.363	(0.834)
Q(12)	6.969	(0.728)	7.430	(0.684)	8.125	(0.617)	9.564	(0.480)
$Q^2(4)$	0.493	(0.781)	0.483	(0.786)	0.711	(0.701)	0.602	(0.740)
$Q^2(12)$	5.319	(0.869)	4.019	(0.946)	2.808	(0.986	5.876	(0.826)

Source: Authors' Calculations

Notes: ***, ** and * imply significance at the 1%, 5% and 10% level, respectively.

Model 4 was achieved by including a dummy variable which took on a value 1 since August (1998) to capture the introduction of the repurchase system of liquidity control. , exclusion of this dummy led to the coefficient on the GARCH coefficient assuming a negative and insignificant value.

The data used to evaluate the four models spanned the period 1992m6 to 2010m1

Q(*k*) and $Q^2(k)$ represents the Box-Pierce statistics for the level and squared residuals respectively.

The numbers in brackets adjacent to the coefficients are the P-values. Akaike Information Criterion and the Schwarz Bayesian Criterion

5.10.1 Discussion

Overall the $\overline{R}^2$, AIC and SBC statistics suggest that all the estimated models are plausible while the Box-Pierce statistics suggest the there is no serial correlation. Moreover the AR(2) model for all the specifications demonstrate similar coefficients for the autoregressive variables. Model 1 demonstrates that there are significant ARCH effects in the inflation data, with all the coefficients being significant at the conventional levels. In Model 2 the IT dummy variable has a negative sign which is consistent with reduction in inflation uncertainty, however the coefficient is not statistically significant, hence it cannot be concluded that IT has caused a reduction in inflation uncertainty in South Africa. This finding reinforces the results obtained by Gupta and Uwilingiye (2007). Model 3 (GARCH-M) demonstrates that the Cukierman-Meltzer hypothesis of higher inflation uncertainty resulting in higher inflation is not found in the South African data, since the uncertainty proxy as measured by the square-root of the conditional variance GARCH process has the incorrect sign and is not statistically significant. Finally in Model 4 of Table 22, the coefficient (δ) on the π_t term is greater than zero and highly significant, suggesting that higher inflation has a significant impact on inflation uncertainty in South Africa, the Friedman-Ball hypothesis is verified for South Africa.

Overall the GARCH effects in all four of the models are highly significant, which is indicative of monthly inflation being persistent in the economy over the period under investigation. The next section will examine with the AR(2) framework together with an IT dummy whether the level of persistence has diminished over the IT period.

5.10.2 Discussion of Results of the Inflation Persistence Model

This section presents and discusses the results obtained from an OLS estimation of equation 5.8. The results are presented in Table 23, below.

Table 23: Results of Inflation Persistence Model

Coefficient	γ_0 = 0.25***	γ_1 = 0.41***	γ_2 = 15*	γ_3 = -0.05
P value	0.0000	0.0000	0.0638	0.5299
$\overline{R}^2$ =0.22; Q(4)=0.25 (0.99); Q(12)=5.55 (0.94) and Q^2(4)=2.65 (0.62); Q^2(12)=11.64 (0.48)				

Source: Authors' Calculations

Notes: *** and * represent 1% & 10% level of statistical significance respectively.

The bracketed values for the Q(k) and $Q^2(k)$ statistics represent the p-values.

The CPI data used to evaluate the AR(2) model spanned the period 1992m9 to 2010m1

The OLS version of the AR(2) model generates identical and statistically significant coefficients for the autoregressive variables as that of maximum likelihood approach used to estimate the GARCH models. The Q(k) and $Q^2(k)$ statistics demonstrate that the error terms do not exhibit serial correlation. Although the γ_3 is negative the coefficient is statistically insignificant, moreover $\gamma_2 + \gamma_3 > 0$ thus implying that there has been no significant decline in inflation persistence since the adoption of the ITMPF. This finding somewhat contradicts the Rangasamy (2009) study which found that inflation persistency declined since the adoption of ITMPF. However, as noted before his study compares persistency from 1981Q1 to 2008Q2 without taking structural breaks into consideration. Additionally this study uses the monthly changes in the inflation rate as a proxy for inflation compared to the Rangasamy (2009) study. The monthly changes tend to be more variable compared to the quarterly measure were effects tend to be averaged out.

Siklos (1999), Miles (2008) and Mohr (2008) pointed out that during the late 1980s and 1990s there has been a global drop in inflation in both IT and non-IT countries and that studies that do not accommodate for structural breaks when using long data sets may draw erroneous conclusions about the causal factors that contributed to the decline in inflation persistence. South Africa's inflation decline has been moving in tandem with global trends, admittedly the inflation differential between South Africa and the United States has progressively declined in the last three decades from 9.05% in the 1980s to, 6.9% in the 1990s and finally to 3.9% since the introduction of ITMF. Nevertheless, compared to the BRIC economies, South Africa's last decade's differential still remains significantly higher than that of India and China which are 3% and -0.8% respectively and closer to that of the inflation prone economy of Brazil at 4.57% but much lower than that of Russia, another inflation prone economy, at 18.36%.

5.11 Conclusion

Firstly the study set out to test whether inflation volatility causes high inflation or whether high inflation causes inflation volatility; the latter hypothesis was proven correct which suggests that it is critical that South Africa operates in a low inflation environment. Secondly, after accommodating for structural breaks in the data in order to avoid erroneous conclusions, the study set out to test whether IT has had a significant impact on inflation volatility and persistence. The results demonstrate that there has been no statistically significant change in inflation volatility and persistence over the pre-and-post IT eras. These findings are consistent with the findings of Gupta and Ulwilingiye (2007) and Gupta, Kabundi and Modise (2010) both of whom employed shorter series. Interestingly these latter two studies employed completely different methods, viz., saphe cracking modelling technique and factor augmented VAR analysis respectively, and arrived at the same conclusions as the current study. These findings were contradictory to the findings of the Rangasamy (2009), where the structural break that occurred in the early 1990s was disregarded in his study; which employed a longer series that stretched as far back as the early 1980s. The findings of this essay tend to support the notion that there are no statistically significant real impacts on the economy as a result of the adoption of the IT framework. However, Kontonikas (2004) and Miles (2008) both of whom conducted similar studies for the UK and Canada respectively found results contrary to that of the present study.

Chapter Six – Forward-looking Monetary Policy Reaction Functions for South Africa

6.0 Introduction

Chapters two and three highlighted the inflation forecast targeting nature of the ITMPF, as well as the practice of IT central banks, to place a higher weighting on the inflation objective, over the other main objectives of employment (or output stabilization around its potential) and exchange rates stabilization. This chapter will attempt to assess whether valid policy reaction functions that are immune to the *Lucas critique,* (explained below) and which includes a forecast targeting component embedded in its dynamics, yield valid results that offer plausible explanations of the monetary policy stances taken by SARB since its adoption of ITMPF more than a decade ago. Should statistically valid results be obtained it would lend support to the claim that the institutional practice of transparency, and accountability, enables monetary policy to be easily understood and predictable which then leads to the benign outcomes of low stable inflation with anchored expectations .

Specifically, this chapter analyses the interest-rate decision-making behaviour of the SARB since the adoption of the ITMPF. The general method of moments (GMM) technique is used to model hybrid Taylor type rules, employing monthly revised data from the period January 2000 to February 2008. This study successfully demonstrates that policy responses are best described by a closed-economy reaction function that incorporates twelve months ahead-expected inflation together with the output gap. However, an open economy specification that includes deviations of real effective exchange rates from its reference value also gives plausible results albeit over a shorter target horizon. Nariadoo and Paya (2011) is the only South African study similar to the present one in that they use the GMM approach, however their study is exposed to the *Lucas critique,* as they use a data set that begins in 1986 long before the IT period. According to Lucas (1976) shifts in economic policy change how policy affects the economy since private agents are forward instead of backward-looking and adapt their expectations and behaviour in accordance with the new policy stance, hence reduced-form econometric models cannot provide useful information on new policies, since the economic structure changes when the policy changes, thereby rendering the reduced form coefficients of the models inconsistent. The important contribution of this study is to confine its analysis to the IT era and to use CPIX inflation (explained below) which was SARB's target variable of choice over most of the IT era. CPIX is the overall CPI (metropolitan and

other urban areas) excluding interest rates on mortgage bonds. However, since January 2009 the target became the overall CPI. As this study considers the period 2000 – 2008, the focus will be on CPIX as the price measure.

The rest of the study is structured as follows: section 6.0 provides a brief summary of the more pertinent issues that were covered in chapters one and three of this study but are of specific relevance to this chapter. Then the Taylor (1993) rule is succinctly described, followed by other international studies on which this study is based. This is then followed by an overview of the South African literature that is associated with policy reaction functions.

6.1 Background

In February 2000, the Minister of Finance, after consultation with the SARB, announced the formal adoption of the ITMPF for South Africa, with an explicit target of 3 - 6 per cent for CPIX inflation to be achieved over a two-year horizon. The introduction of this policy was the culmination of the evolutionary process in monetary policy reform that began in the early 1980s when the De Kock Commission (1985) introduced market-related forms of monetary controls involving interest rates that gave the authorities greater control over monetary aggregates such as money supply, bank credit, inflation and exchange rates. The monetary control system, aimed to control projected GDP and to contain inflation, involved the setting of annual target ranges using a three-month moving average of M3 that was announced in the March 1985 Budget. The target ranges served merely as guidelines; SARB had the discretion to breach targets in the face of macroeconomic shocks. There was no accountability in the sense that there were neither any penalties nor any legal requirements for public explanations when targets were breached. Financial liberalization since the 1980s and the further opening up of the capital account since 1995 weakened the usefulness of M3 targets. SARB implemented an eclectic approach which involved using a set of indicators to guide monetary policy stance. These indicators included the money supply, exchange rates, balance of payments, output gap, wage rates, bank credit extensions and the fiscal stance (Stals, 1997a). However, the degree of influence (ie., the weightings) the various indicators have had in determining the interest rate rule was unclear, thus the rendering policy was quite opaque (Aron and Muellbauer, 2007). Hence the shift to ITMPF is regarded as an advancement due to its transparency and accountability.

Due to the relative infancy of ITMPF and hence the paucity of data, only five published studies exist which examine the response of monetary policy to inflationary pressures under the IT regime. The studies by Woglom (2003) and Saville (2004) use the celebrated Taylor (1993) single-equation "Taylor rule" methodology to assess the interest rate behaviour since the adoption of the inflation targeting (IT) framework. On the other hand, the study by Ortiz and Sturzenegger (2007) uses the open economy Taylor type monetary policy rule within the context of a micro-founded dynamic stochastic general equilibrium (DSGE) model to trace monetary policy behaviour from 1960Q1 to 2006Q4. Naraidoo and Paya (2011) is the only study that uses the GMM technique that is similar to the present study, while Naraidoo and Raputsoane (2011) uses non-linear approaches that is beyond the scope of the present study

6.2 Taylor Rule Literature Review

Taylor (1993) demonstrated that a simple rule, in which the short-term nominal interest rate responded linearly to deviations of inflation and output from their target levels, provided a good description of the actual monetary policy in the United States. The original specification of the rule took the form:

$$i_t^* = r^* + \pi_t + \beta_\pi(\pi_t - \pi^*) + \beta_y y \qquad 6.0$$

where i_t^* is the target short-term nominal interest rate for quarter *t*, r^* is the equilibrium real interest rate, π_t is the inflation rate, π^* is the inflation target, and y_t is the output gap measured by the deviation of real output from its potential level.

When π^* and r^* were set equal to two and β_π and β_y were set equal to half, Taylor (1993) found that equation 6.0 provided a good description of the behavior of the Federal Funds Rate over the 1987–1992 period. He also claimed that this rule could be a useful guideline for future monetary policy.

Many subsequent papers have been written with the aim of obtaining the most appropriate form of the Taylor rule. Clarida, Gali and Gertler (1998, 2000), Woodford (1999) and Levin, Wieland and Williams (1999) generalized equation 6.0 to allow for lagged values of the Federal Funds Rate. These studies found the lags statistically significant, successfully removed all serial correlation from the error terms, and provided convincing evidence that the Federal Reserve Board acts to smoothen the time path of interest rates. Orphanides (2003), Gerdesmeier and Roffia (2003) showed that a forward-looking rule performed better than a

backward-looking rule and that a forward-looking rule was a good predictor of monetary policy. Levin et al. (1999) and Taylor (1999) found the forward-looking rule robust in that it performed well in a number of different macroeconomic conditions.

6.2.1 Review of the South African Literature

Surprisingly, just six studies have been published that estimate Taylor rule type functions for the South African economy. Aron and Muellbauer (2000) estimated both backward-and forward- looking quarterly models for the period 1986 to 1997, using their own inflation and output forecasts. They also augmented their Taylor rules with aggregate money supply, foreign interest rate influences and interest rate smoothing. However, both their models performed poorly. Unfortunately these studies were not updated to incorporate the data since 1997, the period over which significant changes occurred in the monetary policy practice. The Woglom (2004) study employed monthly data to estimate backward-looking, open-economy linear Taylor rules for the pre-and post-inflation targeting sub-periods. The pre IT sub-period ranged from 1990 m1 to 1999 m12 while the post IT period ranged from 2000 m1 to 2004 m12. The following is Woglom's Taylor rule specification:

$$i_t = \alpha + \beta_1 i_{t-1} + \beta_2 \pi_{t-1} + \beta_3 Gap_{t-1} + \beta_4 App_{t-1} + e_t \qquad 6.1$$

Where, App_{t-1} represents exchange appreciation lagged one period.

The study found significant and expected differences in the conduct of monetary policy over the different monetary regimes. In the post IT period, monetary policy response to inflationary pressures appeared to be more aggressive relative to the earlier period. The Saville (2004) study calibrated equation 6.0, using simplifying assumptions based on the mean values of post IT monthly data. The study set π^* equal to four and a half which is the midpoint of the 3-6 percent target range, while r^* was set to eight percent based on the view that the Repo Rate at that time was the same as the prevailing real equilibrium interest rate. Unfortunately, without any sound economic justification, β_π and β_y were set equal to half same as those of the Taylor's model for the USA discussed above. He concluded that SARB is under-reactive in setting the Repo rate, ie., SARB sets the Repo Rate by a smaller margin compared with the dictates of the calibrated Taylor rule. Furthermore, on average, the Repo Rate was much higher than the rate suggested by the calibrated Taylor rule over the post IT period; hence the study concluded that SARB's monetary stance was more restrictive than necessary.

The current study is an improvement on the Woglom study for two reasons. Firstly, the backward-looking versions of the Taylor rule are deemed inappropriate since monetary policy under the IT framework is necessarily forward-looking, ie., the monetary authorities rely on forecasts of inflation over the next year or two to change the Repo Rate in the appropriate direction. Hence this study estimates forward looking models. Secondly, Woglom used interest rate on the 3-month Treasury Bill to proxy the monetary policy instrument (ie the Repo rate), although this rate tracks the Repo Rate very closely over the period in question there are significant differences between the two rates, which can give rise to misleading statistical results.

Moreover this study is superior to the Saville study on two fronts; firstly, it uses the more appropriate forward-looking framework and secondly, it allows the data through the use of advanced econometric techniques to determine the coefficients of the reaction functions instead of merely calibrating them. Finally, this study uses a simpler single-equation framework compared to the complicated systems equations approach of the Ortiz and Sturzenegger paper and, interestingly, achieves results very similar to theirs.

The Naraidoo and Paya (2011) paper is the closest South African study that applies a similar forecasting model, however, they use a monthly dataset spanning 1986M01-2008M12 and they assume that the IT period began two years before the official announcement. While the Naraidoo and Paya study uses some of the most sophisticated parametric and semi-parametric forecasting techniques, their study is exposed to the *Lucas critique*, discussed above, since their model's estimated coefficients is based on pre-2000 data when different policy regimes were in place, which the present study deliberately avoids. Moreover they assume that the implicit IT era began in 1998, the time when SARB was introducing the requisite structural changes before the introduction of the IT regime, these change included the adoption of the repurchase system as well as aligning and reconfiguring their management, communication and media-publication strategies to be in compliance with the transparency and accountability aspects of the IT framework. However this study considers the South African IT era as beginning once the official public announcement was made in February 2000.

Naraidoo and Raputsoane (2011) estimate a nonlinear policy reaction function which captures the optimal responses of the SARB to deviations of inflation and output from their target values over the IT era. Their model allows for SARB's policy responses to be asymmetric depending on whether they are over-or-undershooting the inflation target or

potential output respectively. They found that SARB responds passively when inflation lies within the target band and aggressively when it is outside. In a similar vein they noted that SARB responds more aggressively to negative output deviations from potential compared to positive ones, hence recessionary business cycles are weighted more than expansions. However the Naraidoo and Raputsoane study is beyond the scope of this study, which focuses exclusively on linear type functions.

6.3 Methodology

In estimating the forward-looking Taylor rule, this study adopts what might be termed the 'industry standard' specification first proposed by Clarida *et al.*(1998, 2000) which is widely used in empirical work and which is captured by Equation 6.2. Gerdesmeier and Roffia (2003), and Hayo and Hofmann (2005):

$$r_t^T = r^* + \pi^* + \beta(\pi_{t+n} - \pi^*) + \gamma y_t \qquad 6.2$$

In this specification it is assumed that the SARB's target level of the Repo Rate (r_t^T) is modelled as a function of the deviation of current output from its trend (y_t) and of the expected deviation of n periods-(months)-ahead-inflation from its target level (π^*). This study estimates specifications with n = 3, 6, 9 and 12. Additionally, r* is the long run real interest level which is also termed the optimal interest rate rule in the literature. Moreover it may be noted that $r^*+\pi^*$ is the long run nominal interest rate which arises when inflation is equal to the long run target level and the output gap is zero. Finally, the model accommodates for interest rate smoothening through the inclusion of a lagged interest rate term (r_{t-1}) in its specification. The path of the actual Repo Rate (r_t) is then modeled as a weighted average of the lagged Repo Rate (r_{t-1}) and the target Repo Rate (r_t^T) as depicted in equation 6.3 below:

$$r_t = \rho r_{t-1} + (1-p) r_t^T \qquad 6.3$$

Interest smoothening implies that SARB is averse to large interest rate volatility since it is disruptive to financial markets and the economy as a whole. It also reflects prudent behaviour on the part of the central bankers, since frequent reversals of interest rate usually undermine the credibility of central banks. Furthermore, a policy rule containing lagged interest rate implicitly responds to both contemporaneous/expected inflation and output gap, and also to lagged inflation and output gap. Hence the interest rate smoothening term also incorporates

information about the past behaviour of the economy into the model. In fact, the information contained is lagged; interest rates may include information about other variables not accounted for in the model, for example, the deviation of money from its equilibrium level (Sack and Wieland, 1999).

Moreover, according to Goodfriend (1991), a smooth change in short-term rates provides greater control over long-term interest rates which play an important role in determining long term trends in output and inflation. Woodford (1999) argued that interest rate smoothening enables central bankers to influence economic agent's expectations of inflation due to its behaviour being easily predicted by the public.

When forward-looking rules with smoothening are used, Taylor's original coefficients are kept but they are adjusted to reflect the degree of interest rate smoothening as expressed in the following model which is the main focus of this paper:

$$r_t = (1-p)\alpha + \rho r_{t-1} + (1-\rho)\beta\pi_{t+n} + (1-\rho)\gamma\bar{y}_t + (1-P)\lambda e_t \qquad 6.4$$

Apart from the interest rate smoothening modification, equation 6.4 also accommodates exchange rates effects, as captured by the e_t variable. Equation 6.4 is also referred to as the open- economy Taylor rule specification that was suggested by Ball (1999) to account for central banks increasing their interest rates when its currency depreciates relative to its target level. Ball (1999) argued that the traditional Taylor rule (equation 6.0) describes monetary policy in a closed economy and that small open economies are vulnerable to exchange rate shocks, ie., deviations of real exchange rates from its long run trend. He suggested e_{t-1}=lagged real exchange rates and motivated that, if there was an appreciation in a previous period, then there will be a depreciation of exchange rates by an amount of λe_{t-1} at some point starting in the current period, and this will raise inflation by the same amount.

Some studies (eg., Molodtsova and Papell , 2007), including this study defines e_t as a deviation of exchange rates from its target level, while others (eg., Cote , Lam , Liu and St-Amant, 2002), define it as changes in exchange rates between two successive periods.

Following Clarida *et al*. (1998) the estimates α and β can be used to retrieve the estimate of SARB's target inflation rate (π^*). Although the empirical model (equation 6.4) does not separately identify π^* and r* (long-run real interest rate), it does, however, provide a relationship between the two variables that is a function of α and β. More specifically, by

manipulating equations 2, 3 and 4, it can be established that $\alpha \equiv r^*+\pi^*-\beta\pi^*$, where the $r^*+\pi^*$ terms constitute the long run nominal interest rates and, with further manipulations it can be shown that $\alpha \equiv r^*+ (1-\beta)\pi^*$, hence SARB's estimated inflation target rate may be calculated as:

$$\pi^* = (r^* - \alpha)/(\beta - 1) \qquad 6.5$$

In estimating π^*, this study uses the sample average of real long-term interest rates over the period under consideration. 10-year-and-over bond rate minus the monthly inflation rates were used to estimate the real long-term interest rates. The average of the real long term interest rates over the period under investigation was used to estimate the ***r**** variable in equation 6.5.

The difficulty with estimating forward-looking models is that the contemporaneous variables are correlated with the error terms; hence the estimated coefficients are biased. Furthermore, the t test statistics are unreliable, since the error terms, which invariably violate the normality assumption, also exhibit serial correlation and heteroscedasticity. This study, like most studies, uses GMM (genearlaized method of moments) technique to overcome the mentioned difficulties since GMM does not require the errors to be normally distributed, while serial correlation and heteroscedasticity are easily corrected, through the use of instrumental variables which are correlated with the explanatory variables but are orthogonal to the disturbances (Wooldridge, 2001; Hansen, 1982). See the footnotes to the results contained in Tables 24 and 25 for the list of instrumental variables used, which are similar to those used in Clarida *et al* (1998).

The GMM technique is considered to be a useful within the single equation forward-looking framework, however if the instruments are weak then the results obtained may be unreliable. The maximum likelihood method is considered to be superior in forward looking models however, the approach is demanding since it requires that a structural model be estimated for all explanatory variables other than interest rates, hence GMM is regarded as a suitable alternative since fewer assumptions are required about the structure off the economy. VAR models although useful in generating IRFs to investigate the response of variables to unanticipated shocks or the variance decomposition's ability to indicate which variables contribute to the forecast errors of other variables in the system, also have strong

requirements regarding the ordering of variables or developing assumptions (usually based on theory or common sense) about the structure of the economy. Without such assumptions VAR models are considered as atheoretic models because each variable is the system is a function of all other variables (Stock and Wright, 2000, Stock and Watson).

6.4 Data

Most studies use quarterly data. However, central bank decision-making occurs at a higher frequency eg., SARB meets once every two months. Monthly data are made available with an approximate time lag of about 5 weeks by both the SARB and Statistics South Africa. This study uses monthly data for the period January 2000 to March 2008, which covers the period since the adoption of the ITMPF.

The monthly data on the seasonally-adjusted manufacturing index was retrieved from various editions of the Statistics South Africa Bulletins, and was used as a proxy for output. The output gap (YGP) was estimated as the deviations of the manufacturing index (Z_t) from its trend:

$$YGP_t = 100[\log(Z_t) - \log(Z^*)] \qquad 6.5$$

The trend is commonly regarded as potential output (Z^*) and is estimated through the use of the Hodrick Prescot (1981, 1997) filter. The procedure views time series data as the sum of smoothly varying trend and cycle components, and it involves the filtering out of business cycle fluctuations from the slowly changing demographic and technological factors as well as capital stock that produce per capita output growth (Hodrick and Prescot, (1997). The value of lambda used in the procedure was 14400, which is the recommended value for monthly data.

In a similar vein, equation (6.5) was used to estimate deviations of real effective trade weighted exchange rates (DEER) from its long run trend. The real effective exchange rates, the Repo rate and CPIX indices were downloaded from he SARB website together with the additional instrumental variables that included money supply aggregates (M1, M2, M3, and Notes and coin), short-term interest rates (0 to 3 years bond rates), the per barrel Rand price of Brent crude oil, Real effective exchange rate deviations from trend, output gap and CPIX inflation. In cases where the Repo Rate changed mid-month, the average rate for that month

was used. All variables (X_t) except the interest rates, real effective exchange rates and the output gap were transformed into annual growth rates using the following formula:

$$X_t = 100[\log(X_t) - \log(X_{t-12})] \qquad 6.6$$

6.5. Results

Tables 24 and 25 present the results of the closed and open economy hybrid Taylor rule type monetary policy reaction functions.

Table 24 – Forward-Looking Reaction Functions, excluding Exchange Rate Deviations

π_{t+n}	π^*	ρ	α	β	γ	λ	$\bar{R}^2$	J-statistic
π_{t+3}	9.6	0.86*** (0.012)	2.5*** (0.084)	1.21*** (0.013)	0.43*** (0.016)	—	0.98	0.171
π_{t+6}	5.5	0.96*** (0.011)	0.35 (0.079)	1.76*** (0.01)	0.79*** (0.015)	—	0.98	0.160
π_{t+9}	5.6	0.95*** (0.01)	0.22 (0.078)	1.77*** (0.013)	1.16*** (0.019)	—	0.98	0.165
π_{t+12}	4.7	0.98*** (0.009)	5.32* (0.063)	0.83* (0.012)	1.61** (0.014)	—	0.98	0.158

Notes: ***, ** and * denote significance levels at the 1%, 5% and 10% levels respectively. The bracketed standard errors are those of the composite coefficients, while the reflected coefficients have been estimated using the formulae mentioned in the text.

π_{t+n}, n = 3, 6, 9 & 12 represent the different inflation rate forecast horizons (or expected values), while π^* represents the SARB's target Repo Rate using the estimated coefficients (see equation 5 and footnote 12).

The same instrument set was used to estimate all the above functions which included the short-term interest rates (lags: 1,2,3,6,9 & 12), inflation rate (lags: 1,2,3,6,9 & 12), log of Brent crude oil price (lag:1,2 & 3) monthly annualized growth rate of M1(lags: 1,2,3,6,9 & 12) and YGP (lags: 1,2,3,6,9 & 12).

In regard to all the estimated equations, the J statistic, which has a χ^2 with l-k=23 degrees freedom, indicates that the over-identifying restrictions (ie., when the number of instruments (l=27) is greater than the number of estimated parameters (k=4)) are valid (see Johnson and Dinaro (1997: 337-340) for details). The $\bar{R}^2$ suggests that the 98% of the variation in the Repo Rate is explained by the model. Low Q statistics (not reported) developed by Box and Pierce (1970) - an alternative to DW test - for the regression residuals suggest that the residuals are stationary.

Table 25 - Forward Looking Reaction Functions, including Exchange Rate Deviations

π_{t+n}	π^*	ρ	α	β	γ	λ	$\overline{R}^2$	J-statistic
π_{t+3}	8.1	0.89** (0.008)	2.26*** (0.069)	1.28*** (0.011)	0.35*** (0.012)	-0.102*** (0.0017)	0.99	0.169
π_{t+3}	6.6	0.92*** (0.011)	1.74** (0.079)	1.42*** (0.01)	0.19* (0.015)	-0.145*** (0.0016)	0.99	0.158

Notes: *** , ** and * denote significance levels at the 1%, 5% and 10% levels respectively. The bracketed standard errors are those of the composite coefficients, while the reflected coefficients have been estimated using the formulae mentioned in the text.

π_{t+n}, n = 3, represents the three month ahead inflation rate forecast (or expected value), while π^* represents the estimated coefficients.

The first reaction function was estimated by using the following instrument set: short-term interest rates (lag: 1,2,3,6,9 & 12), inflation rate (lag: 1,2,3,6,9 & 12), log of Brent crude oil price (lag:1,2 & 3), monthly annualized growth rate of M2 (lag: 1,2,3,6,9 & 12), YGP (lag: 1,2,3,6,9 & 12) and DEER (lag: 1,2,3,6,9 & 12)

The second reaction function was estimated by using the following instrument set: short-term interest rates (lag: 1,2,3,6,9 & 12), inflation rate (lag: 1,2,3,6,9 & 12), log of Brent crude oil price (lag:1,2 & 3) monthly annualized growth rate of notes and coins (lag: 1,2,3,6,9 & 12), YGP (lag: 1,2,3,6,9 & 12) and DEER (lag: 1,2,3,6,9 & 12)

Not reported are the results of specifications involving inflation forecasts of six to twelve months ahead, since the coefficients were either of the incorrect signs and/or implausible magnitudes. When using M1 or M3 instruments, similar results were obtained over all four forecast horizons.

A similar interpretation for the J-statistic (degrees of freedom =l-k=33-5) and the $\overline{R}^2$ as mentioned above. Low Q statistics (not reported) - an alternative to DW test- for the regression residuals suggest the residuals are not serially correlated.

6.6 Discussion of the Results

The results confirm that forward-looking, output-gap models with interest rate smoothening adequately describe Repo Rate movements. If the short to medium term forecast horizons are defined as three to twelve months ahead, then the results suggest that the monetary authorities are indeed forward looking in their behaviour. If one considers both the open-and closed-economy models, the response coefficient (β) to expected inflation ranges from 0.83 to 1.77. This implies that a one percentage point increase in the expected inflation rate results in an 83 to 177 basis points rise in the Repo Rate. With the exception of the twelve-month horizon model, all the remaining magnitudes of the expected inflation coefficients (ie., $\beta>1$) are consistent with those of inflation targeting regimes that are required to respond strongly to

expected inflationary pressures by raising the real interest rates by more than the expected rise in the inflation rate.

The range of responses (γ) of Repo Rate to the output gap lies between 0.19 and 1.61. These values suggest that the response of the Repo Rate to a one percentage change in the output gap ranges between 19 and 161 basis points; these findings are consistent with those obtained in the literature. The nine and twelve month ahead models have implausibly high weightings on the output gap which is inconsistent with the values obtained in the literature (see Table 26, below).

The results of Table 25 imply that, over a three-month forecast horizon, the deviation of the real effective exchange rate from its trend value is a significant determinant of the Repo Rate. A one- percent depreciation (appreciation) of the trade weighted real effective exchange rate causes the Repo Rate to rise (fall) by around 10 to 15 basis points.

The closed economy versions of the three-to twelve-months forecast horizon estimated the targeted inflation rate (π^*) ranging from 4.7% to 9.6%. Additionally, the version of the reaction functions involving the six-to twelve-month forecast horizon values are plausible since they lie within three to six percent official target range, thus adding further credence to the validity of these models. The twelve month ahead expected inflation model fares the best since it has an expected targeted inflation rate of 4.7%, and all the coefficients are significant and are of reasonable magnitudes.

The first three-month forward-looking open economy model of Table 25 generates a relatively large value of 8.1% for the targeted inflation rate which lies outside the range of three to six percent. In the second model, the estimated targeted inflation rate lies just outside the boundaries of the targeted inflation rate.

Finally, the coefficient of the Repo Rate lagged one period is significant across all the specifications, and ranges from 0.86 to 0.98. This coefficient signifies that there is a high degree of inertia, perhaps due the monetary authorities' deliberate preference for smoothening or it could also reflect a possible misspecification of functional form.

Overall the three to six month forward looking models appear to be the more plausible models that are consistent with the results of other researchers for both industrialized and emerging market economies, (see table 26, below)

Table 26 Forward looking Taylor Rule obtained by other Studies

Research Paper	ρ	α	β	γ	λ
Hayo and Hofman (2005)	0.85 - 0.92	0.32 - 3.64	1.21-1.48	0.32-0.60	none
Aizenman, Hutchison and Noy (2011)	0.74 – 0.84	0.67 – 4.2	0.22-0.30	0.02-0.03	0.07
Clarida, Gali and Gertler (1998)	0.87 - 92	4.89 -5.76	0.87- 98	0.17 -0.28	0.09
Gerdesmeier and Roffia (2003)	0.32	0.4 – 3.8	0.84 -0.99	0.01-0.66	none
Naraidoo and Paya (2011)	0.92	none	0.47	none	none

Notes: The reported coefficients for the Clarida, Gali and Gertler (1998) paper are those for the UK, however most of the other European countries in that study generated similar coefficients.

The Naraidoo and Paya(2011) used the GMM methodology but unlike the other reported studies in the table, they did not replicate the Clarida, Gali and Gertler (1998) model

In Table 26 the first four studies comprises models that followed the Clarida *et. al.* (1998) specification notice that all the coefficients obtained three and six month-ahead inflation expectations models in Tables 24 and 25 above, are in the same range as these specifications. Although, Nairadoo and Paya (2011) used the GMM approach they did not follow the Clarida *et. al.* (1998). Moreover, contrary to the present study and the reported studies in the table, they used a weighted average of past inflation rates to estimate future inflation; and they employed a composite business cycle indicator as a proxy for output gap. They found that over the IT period SARB did not target output gap, additionally the net[18] inflation smoothening parameter of 0.92 and the weighting on inflation is below 0.5. The interest rate smoothening parameter is similar to that of the present study, it is the view of this study that the weighting of 0.5 on inflation expectations is implausibly low and does not adequately explain the SARB's propensity towards a tight monetary policy stance that dominant feature of monetary policy in South Africa since 1989.

6.7 Conclusion

The analysis has successfully demonstrated that the Repo Rate movements can be usefully described by forward-looking modified Taylor-type reaction functions. Interestingly, the setting of interest rates in the South African context is best described by the closed economy forward- looking reaction function with a twelve-month forecast horizon; this is similar to the European experience where a year ahead forecasting horizon appears to be more appropriate (Clarida *et. al*. (1998), Gerdesmeier and Roffia (2003), Hayo and Hofmann (2005)).

[18] Naraidoo and Paya(2011) used a two period lagged interest rate in their model, hence 0.92 is a summation of the two coefficients corresponding to these variables.

Moreover, these findings are consistent with the practice of SARB where they forecast inflation over a three to twenty four month period and when they notice that in short term inflation is expected to overstep the target they respond with a rate hike. The various issues of the *SARB Quarterly Bulletins between March 2007 and March 2009* record that the MPC arrived at a decision to raise the repo based on the forecast of inflation over one to four quarters ahead despite the official control lag being the two year horizon. This approach makes perfect sense since responding to one year ahead forecast inflation ensures that by the time the second year horizon is reached inflation is well within the target zone. The second three-month ahead open economy models of Table 25 provide plausible fit to the data, with all the coefficients having the plausible magnitudes that are consistent with both economic theory discussed in chapter two and findings of other studies that have investigated small-open economies. Specifically, the results confirm the conclusion derived from the loss function discussed in chapter two, where it was stated that a serious inflation targeter will place a higher weighting on inflation control rather than on the alternative objectives of output and exchange stability. Moreover, the authorities care much about preventing output fluctuations that might arise from large charges in the repo rate and the destabilizing effects of huge output losses, hence the practice of interest rate smoothening is prevalent in practice.

Chapter Seven – Conclusion

7.0 Summary

The underlying basis for this entire thesis is the general consensus among mainstream economists that low, stable inflation is the central goal of monetary policy, more so because price stability is considered to be a necessary precondition for faster sustainable growth. Stability is essential for creating an environment that is conducive for the long-term financing of government and private sector debt including labour intensive industries such as construction and small to medium enterprises. However, long term planning requires agents to view central bank's forecast of inflation and policy stance in curbing inflationary pressures as being credible. This study followed the Greenspan (1994) assertion that price stability is attained when market players do not find the need to factor expectations of changes in the average level of prices into their decisions. Further, the study noted that an IT policy perceived to be credible by market players leads to the anchoring of expectations to a target (or band) that results in a reduction of the variance of relative prices, which in turn reduces the level of inflation (Ball and Mankiw, 1995). Moreover, market players set prices based on expected inflation, hence anchored expectations may lead to less persistent prices and enhances the expectations channel of the monetary transmission mechanism, ie., minimal changes in the policy instrument will be sufficient to steer both inflation and the agents' inflation expectations within target level (band). Additionally the forecast targeting feature, of the IT regime, over the control lag makes monitoring central bank performance easy, for an agent need only observe the outcome of policy action over the target horizon (control lag). This feature together with the added elements of central bank transparency and accountability, enhances credibility and renders monetary policy actions easy to understand and quite predictable. In an attempt to examine the impact that more than a decade of IT has had on South Africa, this study in the form of three essays considered inflation expectations behaviour of the three categories of private agents; the persistence and volatility of inflation; and the policy response functions of the central bank to forecast (or expected) inflation.

7.1 An Overview of Monetary Policy in South Africa: A Synthesis

As noted in chapter three, the debate about the benefits of ITMPF still rages on, the latest studies have employed panel data analysis, Batini *et al.* (2005), Batini and Laxton (2007), Gonclaves and Salles (2008) have found IT to have reduced the persistence and volatility of

inflation and improved on output growth. However the dynamic panel data analysis by Brito and Bystedt (2010) concluded that the 'conservative window dressing' concept of IT has been supported by their findings. The present study found that two important market players, viz., business executives (price setters) and trade unionists (wage setters) have not anchored their expectations to a target level or range. The results showed that these stakeholders are adaptive (backward looking) in setting prices and wages. The implication of this finding is that under benign conditions of low inflation, appreciated exchange rates and low interest rates these agents tend to anchor their expectations to the low inflation rate (which happens to be within the target range). However when unfavourable conditions emerge which include depreciated exchange rates that results in price pressures thus leading to SARB raising the repo rate, these stakeholders revise their expectations based on current and recent past prices (which generally translates to their expectations being out of the target range and in sync with actual and recent past inflation movements). Only financial analysts tend to perceive the central bank as being credible. Since the average price expectations (combined expectations) are heavily weighted by business executives, trade unionists and households (the majority of whom are presumably significantly influence the trade unions) it also exhibits similar patterns to the trade unionists' and business executives' perceptions of future movements of the inflation rate. Moreover the results show that the direction of causality runs from business executives' inflation expectations to that of trade unionists' expectations. Thus implying that there is strong price-wage dynamic which then leads to further wage-price, price-price dynamics operating in the economy that feeds into actual inflation and could possibly derail expectations of inflation or force it to become backward looking as the data reflects.

The ARCH/GARCH and GARCH-M studies have shown that once we account for structural change in the global (and local) economy there is no difference in the persistence and volatility of inflation over the pre-and-post IT periods. These findings are consistent with the findings of Gupta and Ulwilingiye (2007) and Gupta, Kabundi and Modise (2010) both of whom employed shorter series. Interestingly these latter two studies employed completely different methods, viz., saphe cracking modelling technique and factor augmented VAR analysis respectively, and arrived at the same conclusions as the current study. These findings were contradictory to the findings of the Rangasamy (2009), where the structural break that occurred in the early 1990s was disregarded in his study; which also employed a longer series that stretched as far back as the early 1980s. The findings of this essay tend to support the

notion that there are no statistically significant real impacts on the economy as a result of the adoption of the IT framework.

The third essay aptly pointed out that a GMM based derivation of a forward looking policy reaction function can usefully describe the setting of the repo rate over the IT era. The results demonstrated that the SARB has a high weighting on inflation forecasts (or inflation expected to prevail over three to six months down the line) relative to the output and exchange rate objectives, which implies that the South African ITMPF may be categorized as being consistent with the 'conservative window dressing' conception. This view is confirmed by SARB's policy responses over periods of high inflation episodes, for example over 2001-2002 and 2007- 2008 periods where the repo rate through successive increments peaked at around 12% which led to large employment/output losses. Moreover the results showed that over a three to six month horizon, SARB targets the exchange rates as well, in the sense when short-term exchange rates depreciates thereby threatening to add to price pressures the SARB intervenes with a rate hike.

The above results are confirmed by the observations and simulations of the Harvard studies group. They argue that this type of policy stance poses a serious problem to the South African economy for it tends to overvalue the exchange rates, which is detrimental to the manufacturing sector – a sector that has the greatest potential to absorb a significant portion of the unemployed provided that the policy fundamentals are in place. However, diehard IT supporters claim that it is necessary to raise the repo rate when depreciations (or oil price hikes) or relative prices rise (eg., food prices) show signs of further exacerbating the deteriorating inflation outlook, as was the case in 2006, when Brent crude rose to $70 a barrel in April 2006, the MPC kept the repo rate unchanged until June 2006, when it was raised because all indicators were pointing to a further deterioration of the inflation outlook (ie., second round effects of the initial price hikes taking root, thus leading to subsequent upward adjustments in wages, other components of the CPI basket of goods and services and the potential of expectations becoming unhinged (IMF, 2008).

Another feature the results of the policy reaction demonstrated that the SARB follows a policy of interest rate smoothening, for example, in 2008, the MPC noted that inflation is likely to remain above the upper target bound for a much longer period that the control lag of two years, however they merely raised the repo rate by 0.5%, with further increments at subsequent meetings until the inflationary threat subsided.

The second three-month ahead open economy models of Table 25 (see, Chapter 6) provide plausible fit to the data, with all the coefficients having the plausible magnitudes that are consistent with both economic theory discussed in chapter two and findings of other studies that have investigated small-open economies. The short duration of the target horizon is plausible since real effective exchange rate move together with nominal exchange rate movements which are quite volatile and difficult to predict over longer horizons. However, very small weightings are placed on exchange rates and output variability relative to inflation forecast deviations thus implying that the SARB can be considered to be a strict targeter which might then lend some credence to the objections to ITMPF that were raised by Stigiltz (2008) and reinforces the notion that IT is nothing but 'conservative window dressing.' However, Kahn (2008) noted that at the early phases of the inception of the IT regime, monetary policy is typically conservative and as the policy matures and private agents' expectations become aligned to the target, then the central bank becomes a more flexible targeter.

All three essays taken together suggest that although financial analysts find the central bank's IT policy regime to be credible, the vast majority of stakeholders do not find IT to be credible and are adaptive in their inflation expectations formation behaviour. Some researchers erroneously conclude that expectations are anchored when in fact the agents are still behaving adaptively albeit under benign conditions (see the discussions surrounding the Rigobon (2007) paper for example discussed in chapter four). Hence, it then becomes plausible why the inflation volatility and persistence results demonstrate that no statistically significant changes have occurred in the behaviour of inflation pre-and-post IT. Finally it is the tight monetary policy stance (although followed through small fixed increments) of the SARB that has been keeping inflation in check whenever demand and supply shocks threaten to further exacerbate the inflationary outlook. However, using the repo rate to curb effects of supply shocks on inflation destabilizes output.

7.2 Policy Recommendations

The results discussed in chapter four and summarised above clearly point out that unlike financial analysts, firms' and trade unions' expectations are not anchored to a target range; instead they are backward-looking in the sense of viewing the current and recent past behaviour of inflation in forming expectations (forecasting) of inflation over the target

horizon. Moreover the results showed that trade unions take the lead from firms in forming their expectations for future inflation. Thus it might be in SARB's interest, in their communication strategies to specifically target business executives and firms in a structured forum instead of merely inviting them to a bi-annual monetary policy forum meetings held at various centres in the country. It is heartening to note that in November 2011 SARB under the leadership of Governor Marcus, the SARB have forged working relationships that promise to be on-going with the National Economic Development and Labour Council (NEDLAC), which comprises government, business, labour and civil society. It is hoped that these relationships grow and the insights gained filter down to all rank and file members for only then will expectations succeed in being anchored. Moreover, since business executives' expectations shape the expectations of trade unionists it might be strategic for SARB to develop similar on-going working relationships with South African Chamber of Business (SACOB) and COSATU which does not exist at the moment, save for the bi-annual invitations to the monetary policy forum meetings held country-wide.

Government has a role to play in enhancing its competition policies and opening up the economy further to foreign competition in order to minimise the influence of industrial concentration on pricing behaviour. Moreover, inflexible labour policies strengthen trade union bargaining power hence creating an inflation bias and due to wage-wage, wage-price and price-price propagates and strengthens inflationary inertia in the economy.

Aside from inflation volatility and persistence findings discussed above, this study has demonstrated that higher inflation raises inflation uncertainty in the South African context. These findings are a cause for concern since a large body of literature have noted the negative impact of inflation uncertainty on real economic activity. Additionally as mentioned above, since IT entails both costs and benefits, this study should serve as a cautionary note to other emerging economies wishing to implement IT as a policy framework. Moreover, Stiglitz (2008) strongly asserts that IT is a bad policy choice for emerging economies, since imported inflation via food and energy prices – which are a major share of an average consumer's budget – is the major source of inflationary pressures and the use of interest rates to curb price rises only serves to reduce output and employment. He stresses that it is absurd to make inflation the central focus of monetary policy; instead, other factors affecting the economy which includes growth and financial stability should also be considered. Kahn (2008) contends that Stiglitz (2008) assumes that the central bank is a *strict* inflation targeter that

will follow a single-minded goal of price stability to the exclusion of other objectives. However in reality central banks are *flexible* targeters who also place a weighting on output stability as well. Additionally, policy mechanisms like the 'escape clause' and 'interest rate smoothening' prevent excessive interest rises thus ensuring that the economy is not overly stressed. Some economists argue that due to these policy mechanisms, ITMF in practice is constrained discretion.

However from a neoclassical perspective, the results should not be taken to suggest that IT can never be beneficial under any conditions (Miles, 2008). Country circumstances differ, and emerging economies like South Africa have serious structural problems which include industrial concentration, trade union militancy, public sector inefficiencies, administrative pricing, import-shocks-vulnerabilities and skills-and-other-shortages, and hence a formal visible target may be the only means of controlling inflation. Although the Reserve Bank has no control over the mentioned exogenous structural factors, IT is considered to be effective in curbing second round effects of inflation expectations arising from such causal factors. In other emerging economies with fewer structural problems IT adoption might exact much greater benefits.

The inflation smoothening coefficient was found to be statistically significant which suggests that the SARB cares much about preventing output fluctuations, however during the recent financial crisis period, when inflation forecasts indicated higher inflation of the control lag, the repo rate was raised by fifty basis points at successive meetings; perhaps the authorities should consider lower (say, twenty five basis points) increments under dismal domestic and global circumstances.

7.3 Recommendations for Further Research

Propositions 2 (stationarity conjecture) and 3 (cointegration-credibilty conjecture) discussed in chapter four, can be tested using as alternative approach to the one adopted in this study. This alternative approach could involve acquiring paired expectations and inflation data from economies that comprise both IT central banks and non-IT central banks. The data from economies with IT central banks ought to be divided into successful and unsuccessful targeters and then the series should be tested for stationarity. A pattern ought to emerge where successful targeters (credible central banks) will possess stationary data while

unsuccessful targeters (non-credible central banks) ought to possess I(1) paired series which ought to be cointegrated. However it was beyond the scope of this study to acquire such a large and varied dataset.

This study raised objections to the Rigobon (2007) paper concluding that the marked reduction in the pass-through from depreciations to inflation in the 2003 – 2006 period compared to the earlier period of 2000 – 2002 when IT was in its infancy. This study argued that over the 2003-2006 period benign conditions prevailed which included an appreciated exchange rate, low inflation and interest rates. Thus under such circumstances the pass-through rate will necessarily be small and not necessarily due to a gain in central bank credibility. It will be interesting to exam the Rigobon hypothesis over the 2007-2010 period, for purposes of confirming his finding.

Moreover, only bivariate VAR and VECM models involving inflation and expectations were modelled in this study. Richer insights could be obtained by modelling expectations against other sources of inflationary pressures, for example variables like exchange rate movements and import prices; wage rises in excess of productivity increases; indicator of demand pressures like credit extension or money supply; conservative monetary policy stances measured by the repo rate; as well as other sources mentioned extensively in the country case studies of chapter three, sections 3.1 to 3.2, which included oil, food and administrative prices. Holub and Hurnik (2008) undertook similar VAR studies for the Czech Republic and used IRFs to investigate the impact of unanticipated shocks of some of the mentioned variables on the private agents' expectations. Moreover IRFs and variance decompositions can be used to be used to identify the main culprits gives momentum to the various agents' expectations of inflation.

Miles (2008) and Siklos (1999) whose studies were confined to industrialized economies alone were the only two studies that accommodated for structural breaks when investigating the impact of IT. Studies investigating the impact of IT in emerging economies have not accommodated for such breaks in the data. Thus, it might useful to undertake such an investigation for other emerging economies in order to gage the true impact of IT on inflation persistence and volatility.

The recommendation stems from Kahn's (2008) assertion (mentioned above) that as the IT policy matures, the central bank becomes a flexible targeter, thus ongoing research using the type of policy reaction functions estimated in this study as well as the ones estimated by Nairaidoo and Paya (2011) and Qin and Enders (2008) ought to be conducted to monitor subtle changes in monetary policy stances. The linear type models estimated by this study are suitable for rolling fixed-width-windows regressions that are useful for capturing changes in the estimated coefficients through time. This technique involves using a fixed data size (sample size=n) on which regressions are run, then by dropping off the first data point and adding on the next data point and running a new regression gives a new set of coefficients, thus running a series of regressions by moving the fixed window of size n through long time series and by graphing the resulting coefficients, one is able to monitor subtle changes in coefficient values through time.

7.4 Limitations

One of the limitations of this study was that it neglected to focus on the behaviour of output and interest rates over the IT period, hence studies estimating the volatility of output and interest rates over the IT period ought to be conducted in order to derive a richer picture of whether the IT has had beneficial effects on the real variables in the economy.

Another weakness of this study is that it focussed exclusively on South Africa, stronger policy recommendations might have emanated from subjecting the other countries, which were discussed in the case studies of chapter three, to a similar scrutiny.

7.5 Conclusion

Despite the econometric results suggesting that over the pre-and post IT periods there has been no significant changes in the behaviour of inflation (from the perspective of volatility and persistence) and that expectations of most of the private agents are still adaptive in nature and that IT is nothing more than 'conservative window dressing,' it may still be a compelling policy stance for other emerging economies to follow, for foreign investors view the control of inflation as a quintessential barometer that an economy is being well managed. High and volatile inflation has debilitating effects on interest rates, exchange rates, prices and wages which ultimately dissuades investment and reduces economic wellbeing.

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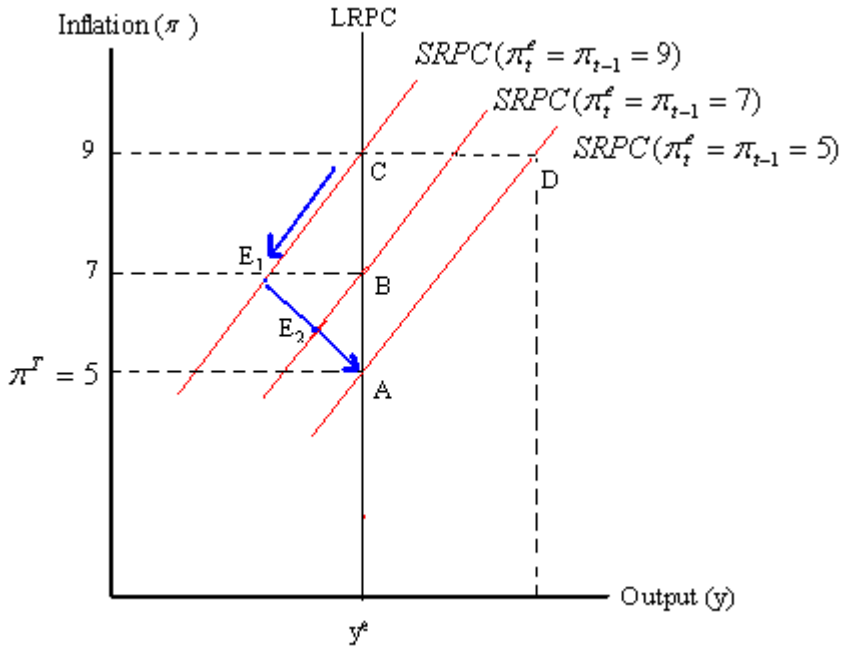
APPENDIX A

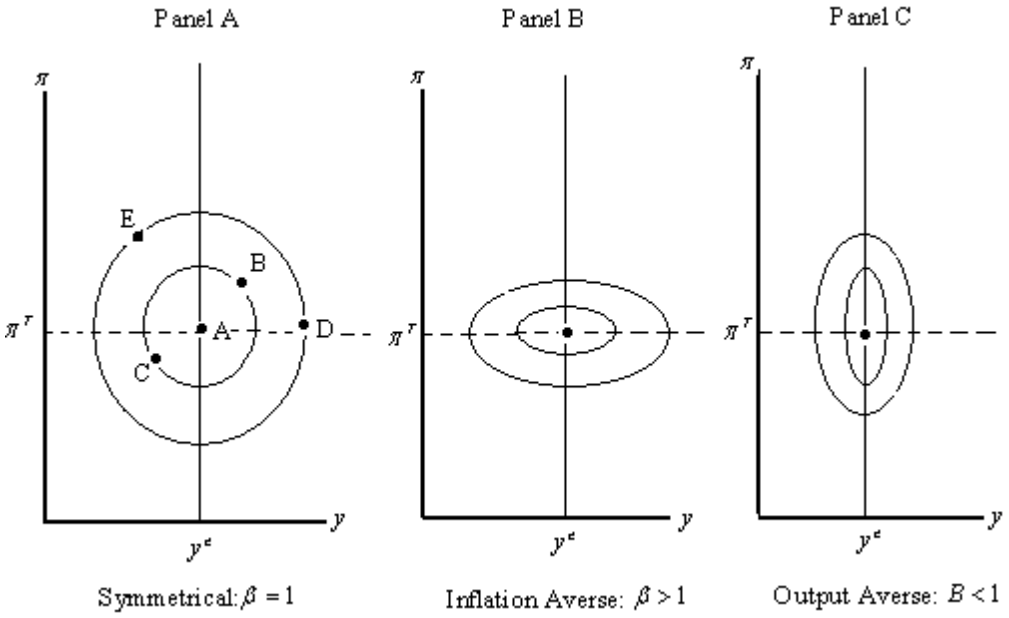
The following diagrams form the basis for the discussions in chapter two of this study. All these diagrams were adapted from Carlin and Soskice (2006).

Figure 1 : Expectations-Augmented Phillips Curve



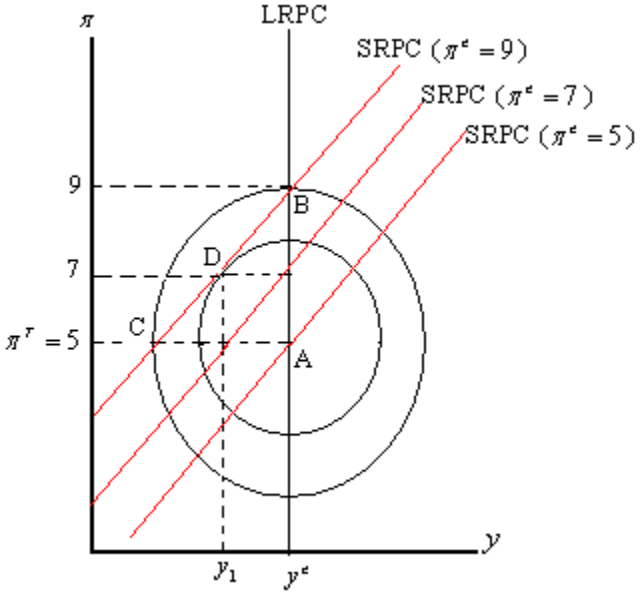
Source: Carlin and Soskice (2006)

Figure 2 : Loss Function Indifference Curves



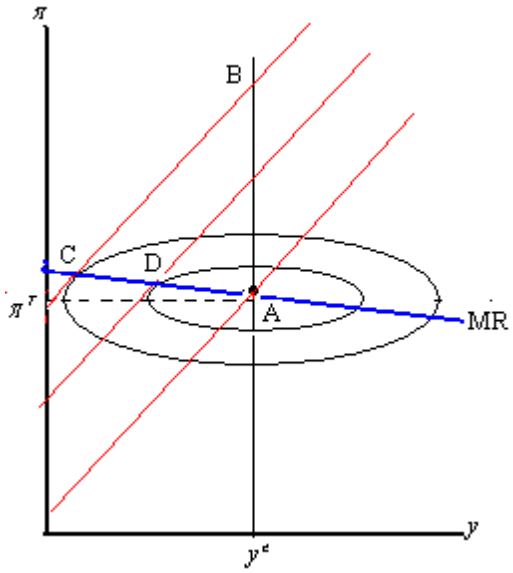
Source: Carlin and Soskice (2006)

Figure 3. Loss Circles and Phillips Curves



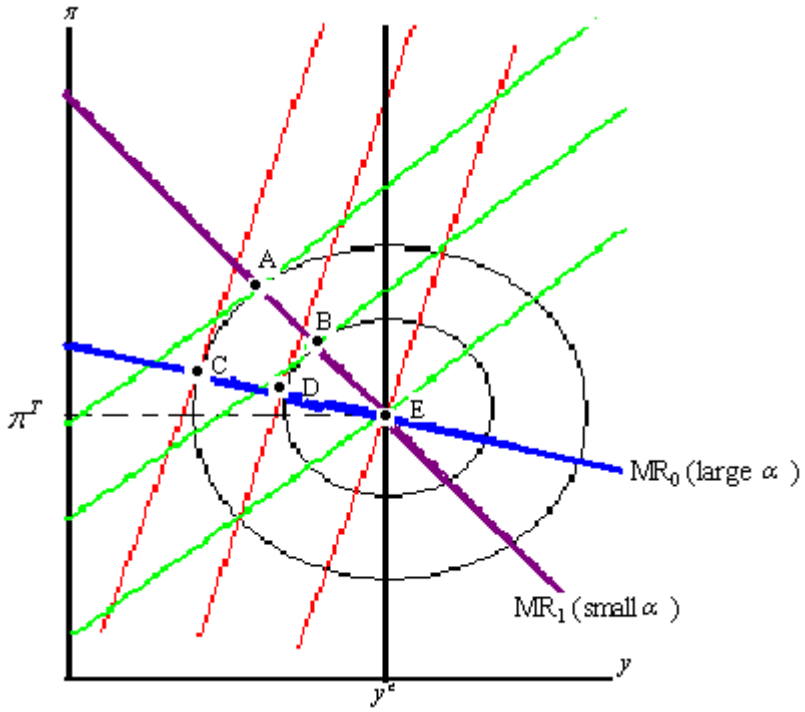
Source: Carlin and Soskice (2006)

Figure 4. Inflation Averse Central Bank & Flat MR



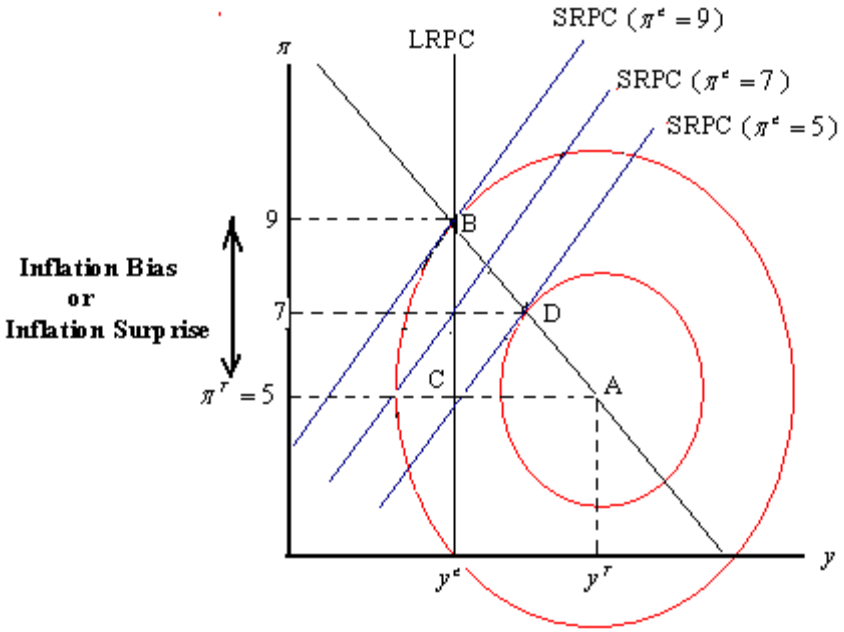
Source: Carlin and Soskice (2006)

Figure 5. Flat and Steep Monetary Rule Curves



Source: Carlin and Soskice (2006)

Figure 6. Inflation Bias and Time Inconsistency Problem



Source: Carlin and Soskice (2006)

The central bank imposes a target a $y^T > y^e$, hence the economy is no longer at point C, the equilibrium position (y^e, π^T). Its ideal position is now point A (y^T, π^T) . Although this point is the government's preferred position hence, the indifference circles (assuming $\alpha = \beta = 1$) emanate from point A the new bliss point, however , it is not optimal since its to the right of the LRPC, implying that it can be liked to a positive demand shock that is not sustainable in the long run. However since expected inflation is the target inflation ($\pi^T = 5$), the central bank minimises its loss by operating at point D with actual inflation ($\pi = 7$). The new MR curve passes both points A and D and also cuts the LRPC at point B. The SRPC will shift upwards and the economy will pass through points along the MR curve until it intersects the LRPC at the Point B. This is the point to which the economy will ultimately return, since it the only equilibrium point, through with the MR curve passes, where inflation is constant when $y = y^e$, the full capacity employment. Thus the net effect of the inflation biased positive demand shock has been a rise in inflation from point C at ($y^e, \pi^T = 5$), to point B ($y^e, \pi = 9$), The inflation differential between these two points is termed the inflation bias. See chapter two for a mathematical definition.

APPENDIX B – Results: Anchoring of Inflation Expectations

This Appendix pertains exclusively to the analysis of the anchoring of inflation expectations in South Africa which was presented in chapter four. Appendix B1.0, below contains the graphs the observed actual (vintage) inflation data and the various expected inflation series.. This is followed by the results of the Cruijsen and Demertzis (2010) type VAR models. While the results for unit root and cointegration tests, as well as the long run cointegrating relationships and the short run adjustments to the long rum relationships are presented in Appendices B 3.0 to B5.0.

Appendix B1.0: Graphs of Vintage and Expected Inflation

This sub-appendix presents Table 1, which summarises the descriptive statistics of various inflation expectations series employed in this study. Furthermore this section presents three graphs of observed vintage inflation and the survey based estimates of combined inflation expectations, the financial analysts' inflation expectations, breakeven estimate of expectations, the business executives' and trade unionists' expectations

Table 1: Expectations Data: Descriptive Statistics

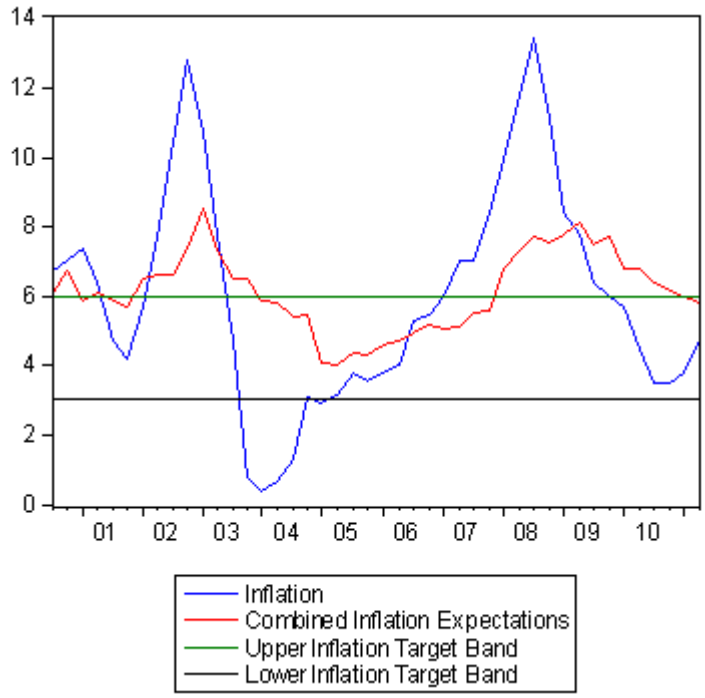
Expectations Variable	Observations	Average deviation from 6% target band	Number of quarters expectations was above 6% target	Variance	RMSE**
Analysts' 1 year ahead	44	-0.5	10	1.02	1.12
Analysts' 2 years ahead	44	-0.7	2	0.28	0.90
Long Term Breakeven*	34	-0.6	7	0.60	1.00
Business Executives'1 year ahead	44	0.6	27	2.58	1.73
Business Executives' 2 years ahead	44	0.6	29	1.90	1.51
Trade Unionists' 1 year ahead	44	0.6	25	3.28	1.89
Trade Unionists' 2 years ahead	44	0.5	26	2.69	1.72
Combined 1 year ahead	44	0.2	23	1.73	1.33
Combined 2 years ahead	44	0.2	23	1.26	1.13

Source: Author's own calculations based on data from SARB, BER and JSE

*Notes: * The monthly data on long term breakeven inflation expectations was appropriately averaged out to generate quarterly series, so the it is comparable to the other series in the table.*

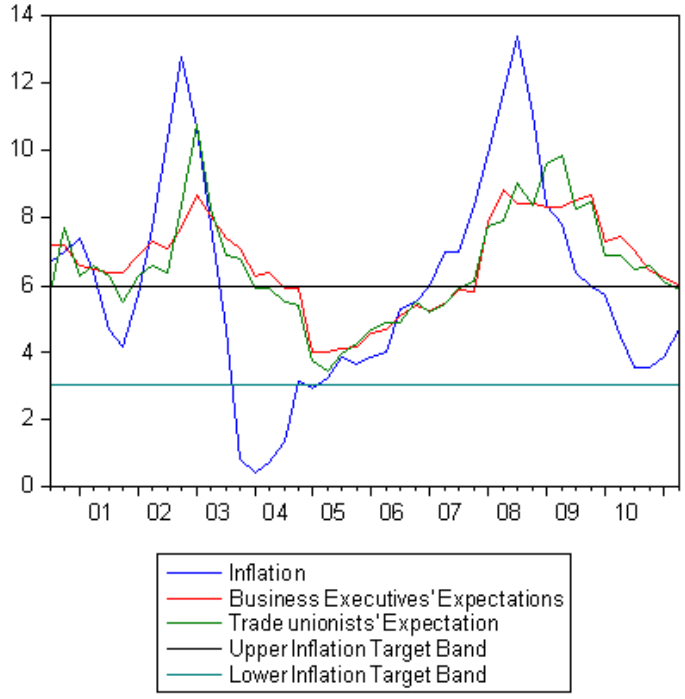
The formula for the root mean square error(RMSE) is as follows: $\sqrt{(\bar{\pi}^e - \pi^T)^2 + \delta^2_{\pi^e}}$ *, where* $\bar{\pi}^e, \pi^T \text{ and } \delta^2_{\pi^e}$ *represents mean expected inflation, inflation target(6%) and variance of the expected inflation series respectively.*

Figure 7. Combined Inflation Expectations



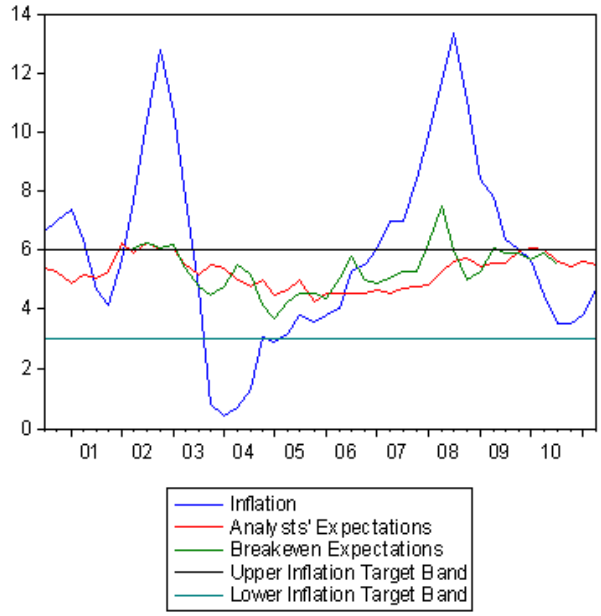
Source: Author's own calculations based on SARB and BER data

Figure 8. Business Executives' & Trade Unionists' Inflation Expectations



Source: Author's own calculations based on SARB and BER data

Figure 9. Breakeven & Financial Analysts' Inflation Expectations



Source: Author's own calculations based on SARB, BER and JSE data

Appendix B2: Unit root Test Results

All the Unit Root Tests for the the inflation series and the various measures of inflation expectations were found to be non-stationary (I(1)) and are reported in tables 2 to 8, below. The results were generated via the *Eviews 6* software, using the intercepts and no trends assumption. The battery of unit root tests, that included the Augmented Dickey-Fuller (1979); Dickey Fuller with general least squares detrending (DF-GLS), by Elliot, Rothenberg and Stock (1996) ; Phillips and Perron (1988); Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992); Elliot, Rothenberg and Stock (1992) and the Ng and Perron (2001) tests. Maddala and Kim (1998) and the Eviews User's Guide II (2007) provides a highly readable account of these tests, while Davidson and MacKinnon, (1993), Hamilton, (1994), Hayashi, (2000) provides a more detailed but more technically challenging accounts of these tests.

Table 2: Unit Root Tests: Quarterly Vintage Inflation(%)

Test Type	**Level Test Statistic**		**Critical Statistic**		**1st Difference Test Statistic**	**Critical Statistic**
ADF	-0.79 ** (5)		-1.950		-2.50** (4)	-1.95
PP	-2.148*** (Bw=2)		-3.458		-3.193** (Bw=0)	-2.933
DF-GLS	-1.859*** (18)		-2.661		-3.204*** (9)	-2.621
KPSS	0.0935 (Bw=4)		0.347[a]		0.0567 (Bw=2)	0.347[a]
ERS	0.1358*** (1)		1.8700		1.1778*** (1)	1.8700
Ng-Perron	MZa	-181.96***	-13.800		-14.725***	-13.800
	MZt	-9.534***	-2.5800		-2.702***	-2.5800
	MSB	0.0524***	0.17400		0.1835***	0.17400
	MPT	0.1388***	1.78000		1.7054***	1.78000

Notes: [a] The KPSS test suggests that the inflation series is stationary while all the other tests suggest that it is nonstationary..

***, ** implies 1% and 5% significance level respectively.

The Band width (Bw) for the kernel density function (see, Andrews, 1991) was chosen automatically by EVIEWS 6 (see Eviews User's Guide II)

The bracketed lag length represents the maximum number of lag differenced terms used in the unit root test. see Eviews User's Guide II)

Table 3: Unit Root Tests: Quarterly Two-Years-Ahead Combined Inflation Expectations (%)

Test Type	Level Test Statistic		Critical Statistic		1st Difference Test Statistic	Critical Statistic
ADF	-1.503 ***(0)		-3.592		-6.235*** (0)	-3.597
PP	-1.805*** (Bw=3)		-3.593		-6.279** (Bw=3)	-3.597
DF-GLS	-1.592*** (0)		-2.620		-5.332*** (0)	-2.621
KPSS	0.131 (Bw=5)		0.347[a]		0.0887 (Bw=3)	0.347[a]
ERS	5.0496***(0)		1.8700		1.857*** (0)	1.8700
Ng-Perron	MZa	-4.648***	-13.800		-21.725***	-13.800
	MZt	-1.518***	-2.5800		-3.225***	-2.5800
	MSB	0.327***	0.17400		0.1531***	0.17400
	MPT	5.284***	1.78000		1.2338***	1.78000

Notes: [a] The KPSS test suggests that the inflation series is stationary while all the other tests suggest that it is nonstationary..

***, ** implies 1% and 5% significance level respectively.

The Band width (Bw) for the kernel density function (see, Andrews, 1991) was chosen automatically by EVIEWS 6 (see Eviews User's Guide II)

The bracketed lag length represents the maximum number of lag differenced terms used in the unit root test. see Eviews User's Guide II)

Table 4: Unit Root Tests: Quarterly Analysts' Two-Years-Ahead Expected Inflation(%)

Test Type	Level Test Statistic		Critical Statistic		1st Difference Test Statistic	Critical Statistic
ADF	-1.979 ***(5)		-3.592		-7.7457*** (4)	-3.597
PP	-2.001*** (Bw=3)		-3.593		-7.749** (Bw=2)	-3.597
DF-GLS	-1.993*** (0)		-2.620(1%)…. -1.947 (5%)		-7.605*** (0)	-2.621
KPSS	0.14896(Bw=5)		0.347[a]		0.09191 (Bw=1)	0.347[a]
ERS	3.4928***(0)		1.8700		1.2216*** (0)	1.8700
Ng-Perron	MZa	-6.822***	-13.800		-26.224***	-13.800
	MZt	-1.839***	-2.5800		-3.6194***	-2.5800
	MSB	0.270*	0.1740 (1%)... 0.2750 (10%)		0.1380***	0.17400
	MPT	3.618	1.7800 (1%)... 4.4500 (10%)		0.9396***	1.78000

Notes: [a] The KPSS test suggests that the inflation series is stationary while all the other tests suggest that it is nonstationary..

***, ** implies 1% and 5% significance level respectively.

The Band width (Bw) for the kernel density function (see, Andrews, 1991) was chosen automatically by EVIEWS 6 (see Eviews User's Guide II)

The bracketed lag length represents the maximum number of lag differenced terms used in the unit root test. see Eviews User's Guide II)

Table 5: Unit Root Tests: Quarterly Business Executives' Two-Years-Ahead Expected Inflation(%)

Test Type	Level Test Statistic		Critical Statistic		1st Difference Test Statistic	Critical Statistic
ADF	-1.463 ***(0)		-3.592		-5.405*** (0)	-3.597
PP	-1.768*** (Bw=3)		-3.593		-5.453** (Bw=3)	-3.597
DF-GLS	-1.426*** (0)		-2.620		-5.473*** (0)	-2.621
KPSS	0.129 (Bw=5)		0.347[a]		0.0954 (Bw=3)	0.347[a]
ERS	6.466***(0)		1.8700		1.154*** (0)	1.8700
Ng-Perron	MZa	-3.863***	-13.800		-22.669***	-13.800
	MZt	-1.361***	-2.5800		-3.3636***	-2.5800
	MSB	0.352***	0.17400		0.1484***	0.17400
	MPT	6.362***	1.78000		1.1.091***	1.78000

Notes: [a] The KPSS test suggests that the inflation series is stationary while all the other tests suggest that it is nonstationary..

***, ** implies 1% and 5% significance level respectively.

The Band width (Bw) for the kernel density function (see, Andrews, 1991) was chosen automatically by EVIEWS 6 (see Eviews User's Guide II)

The bracketed lag length represents the maximum number of lag differenced terms used in the unit root test. see Eviews User's Guide II)

Table 6: Unit Root Tests: Quarterly Trade Unionists' Two-Years-Ahead Expected Inflation (%)

Test Type	Level Test Statistic		Critical Statistic		1st Difference Test Statistic	Critical Statistic
ADF	-2.030 ***(0)		-3.592		-6.871*** (0)	-3.597
PP	-2.185*** (Bw=3)		-3.593		-6.855** (Bw=2)	-3.597
DF-GLS	-2.001*** (0)		-2.620		-4.472*** (0)	-2.621
KPSS	0.128 (Bw=5)		0.347[a]		0.0794 (Bw=3)	0.347[a]
ERS	3.618*(0)		3.91(10%)		3.313* (0)	3.91 (10%)
Ng-Perron	MZa	-6.798***	-13.800		-15.151***	-13.800
	MZt	-1.84***	-2.5800		-2.791***	-2.5800
	MSB	0.271***	0.17400		0.180**	0.233 (5%)
	MPT	3.614***	1.78000		1.735***	1.78000

Notes: [a] The KPSS test suggests that the inflation series is stationary while all the other tests suggest that it is nonstationary..

***, ** implies 1% and 5% significance level respectively.

The Band width (Bw) for the kernel density function (see, Andrews, 1991) was chosen automatically by EVIEWS 6 (see Eviews User's Guide II)

The bracketed lag length represents the maximum number of lag differenced terms used in the unit root test. see Eviews User's Guide II)

Table 7: Unit Root Tests: Monthly Vintage Inflation(%)

Test Type	Level Test Statistic		Critical Statistic		1st Difference Test Statistic	Critical Statistic
ADF	-1.732 ***(0)		-3.592		-5.668*** (0)	-3.496
PP	-1.779*** (Bw=7)		-3.495		-5.903** *(Bw=5)	-3.496
DF-GLS	-1.538*** (0)		-2.588		-5.357*** (0)	-2.588
KPSS	0.199 (Bw=8)		0.347[a]		0.0941 (Bw=7)	0.347[a]
ERS	5.426*(1)		4.18(10%)		0.7345*** (0)	1.949
Ng-Perron	MZa	-4.972***	-13.800		-35.466***	-13.800
	MZt	-1.538***	-2.5800		-4.2119***	-2.5800
	MSB	0.309***	0.17400		0.1187**	0.17400
	MPT	5.025***	1.78000		0.6908***	1.78000

Notes: [a] The KPSS test suggests that the inflation series is stationary while all the other tests suggest that it is nonstationary..

***, ** implies 1% and 5% significance level respectively.

The Band width (Bw) for the kernel density function (see, Andrews, 1991) was chosen automatically by EVIEWS 6 (see Eviews User's Guide II)

The bracketed lag length represents the maximum number of lag differenced terms used in the unit root test. see Eviews User's Guide II)

Table 8: Unit Root Tests: Monthly Breakeven Expected Inflation(%)

Test Type	Level Test Statistic		Critical Statistic		1st Difference Test Statistic	Critical Statistic
ADF	-2.716 ***(0)		-3.497		-9.467*** (0)	-3.496
PP	-2.880*** (Bw=3)		-3.497		-9.459***(Bw=2)	-3.498
DF-GLS	-2.297*** (0)		-2.588		-9.514*** (0)	-2.588
KPSS	0.282 (Bw=8)		0.347[a]		0.0527*** (Bw=7)	0.347[a]
ERS	2.955**(0)		3.11		0.4865*** (0)	1.950
Ng-Perron	MZa	-9.588***	-13.800		-50.0329***	-13.800
	MZt	-2.183***	-2.5800		-5.0014***	-2.5800
	MSB	0.228***	0.17400		0.0999**	0.17400
	MPT	2.580***	1.78000		0.4903***	1.78000

Notes: [a] The KPSS test suggests that the inflation series is stationary while all the other tests suggest that it is nonstationary..

***, ** implies 1% and 5% significance level respectively.

The Band width (Bw) for the kernel density function (see, Andrews, 1991) was chosen automatically by EVIEWS 6 (see Eviews User's Guide II)

The bracketed lag length represents the maximum number of lag differenced terms used in the unit root test. see Eviews User's Guide II

Appendix B3: VAR Model: Results

All the VAR models reported below employ I(1) data, (see unit root results reported in Tables 2-8, above). The lags were selected on the basis of the log ratio (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz Bayesian criterion (SBC) and Hannan Quinn (HQ) information criterion. Where the tests gave different choice, the study selected the majority choices and only selected the minority choice when it gave better results.

Table 9. Results of Bi-variate VAR Model: Inflation – Combined Expectations

Vector Autoregression Estimates
Date: 03/25/12 Time: 23:35
Sample (adjusted): 2001Q2 2010Q3
Included observations: 38 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Inflation	Combined Expt
Inflation(-1)	1.372571	0.265906
	(0.18556)	(0.07323)
	[7.39694]	[3.63132]
Inflation(-2)	-0.742700	-0.238112
	(0.27902)	(0.11011)
	[-2.66178]	[-2.16251]
Inflation(-3)	0.130318	0.144266
	(0.18759)	(0.07403)
	[0.69468]	[1.94878]
Combined Expt(-1)	0.591109	0.524722
	(0.44495)	(0.17559)
	[1.32847]	[2.98835]
Combined Expt(-2)	0.009628	-0.030866
	(0.48325)	(0.19070)
	[0.01992]	[-0.16186]
Combined Expt(-3)	-0.748438	0.157898
	(0.40770)	(0.16089)
	[-1.83574]	[0.98141]
C	2.305175	1.097877
	(1.26008)	(0.49725)
	[1.82939]	[2.20788]
R-squared	0.899447	0.880512
Adj. R-squared	0.879985	0.857385
Sum sq. resids	41.14139	6.406804
S.E. equation	1.152016	0.454611
F-statistic	46.21579	38.07326
Log likelihood	-55.42881	-20.09538

Akaike AIC	3.285727	1.426073
Schwarz SC	3.587387	1.727733
Mean dependent	6.060526	6.157923
S.D. dependent	3.325377	1.203808

Determinant resid covariance (dof adj.)	0.206560
Determinant resid covariance	0.137468
Log likelihood	-70.13646
Akaike information criterion	4.428235
Schwarz criterion	5.031556

Note: All Data used in the VAR

Figure 10: Unit Circle Roots Test: Inflation Combined Expectations VAR

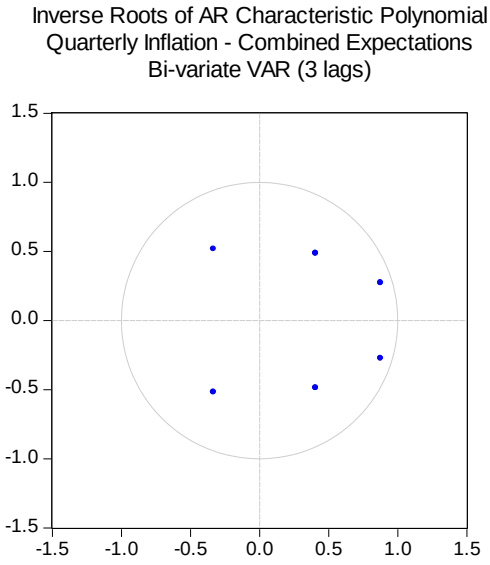


Table 10 Results of Bi-variate VAR Model Inflation –Analysts' Expectations

Vector Autoregression Estimates
Date: 03/25/12 Time: 22:14
Sample (adjusted): 2001Q1 2010Q3
Included observations: 39 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Inflation	Analysts' Expt
Inflation(-1)	1.496572	0.071546
	(0.13433)	(0.06988)
	[11.1409]	[1.02377]
Inflation(-2)	-0.678088	0.004958
	(0.14089)	(0.07330)
	[-4.81294]	[0.06764]

Analysts' Expt(-1)	-0.095584	0.795019
	(0.33744)	(0.17555)
	[-0.28326]	[4.52871]
Analysts' Expt(-2)	0.039656	0.033465
	(0.33625)	(0.17493)
	[0.11794]	[0.19130]
C	1.394334	0.558186
	(0.90594)	(0.47131)
	[1.53910]	[1.18434]
R-squared	0.883149	0.819938
Adj. R-squared	0.869402	0.798755
Sum sq. resids	48.01394	12.99503
S.E. equation	1.188350	0.618229
F-statistic	64.24224	38.70606
Log likelihood	-59.39323	-33.90821
Akaike AIC	3.302217	1.995293
Schwarz SC	3.515494	2.208570
Mean dependent	6.094872	5.787227
S.D. dependent	3.288333	1.378118

Determinant resid covariance (dof adj.)	0.485529
Determinant resid covariance	0.369015
Log likelihood	-91.23731
Akaike information criterion	5.191657
Schwarz criterion	5.618211

Figure 11: Unit Circle Roots Test: Inflation Analysts' Expectations VAR

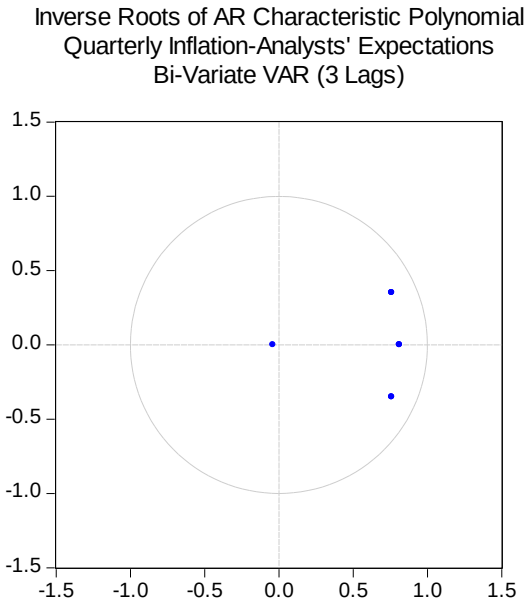


Table 11: Results of Bi-variate VAR Model Inflation – Breakeven Expectations

Vector Autoregression Estimates
Date: 03/24/12 Time: 15:52
Sample (adjusted): 2002M06 2010M08
Included observations: 99 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Inflation	Breakeven Expt
Inflation(-1)	1.462570	0.068971
	(0.08692)	(0.05843)
	[16.8272]	[1.18045]
Inflation(-2)	-0.504468	-0.044903
	(0.08415)	(0.05657)
	[-5.99510]	[-0.79381]
Breakeven Expt(-1)	0.455438	0.927253
	(0.15198)	(0.10216)
	[2.99673]	[9.07610]
Breakeven Expt(-2)	-0.324078	-0.165134
	(0.15563)	(0.10462)
	[-2.08235]	[-1.57842]
C	-0.505439	1.145083
	(0.49613)	(0.33351)
	[-1.01877]	[3.43343]
R-squared	0.977360	0.761896
Adj. R-squared	0.976396	0.751764
Sum sq. resids	34.79417	15.72318
S.E. equation	0.608400	0.408984
F-statistic	1014.480	75.19642
Log likelihood	-88.71425	-49.39571
Akaike AIC	1.893217	1.098903
Schwarz SC	2.024284	1.229970
Mean dependent	5.206061	5.351717
S.D. dependent	3.960051	0.820869
Determinant resid covariance (dof adj.)		0.061734
Determinant resid covariance		0.055656
Log likelihood		-137.9655
Akaike information criterion		2.989203
Schwarz criterion		3.251336

Figure 12: Unit Circle Roots Test: Breakeven Expectations VAR

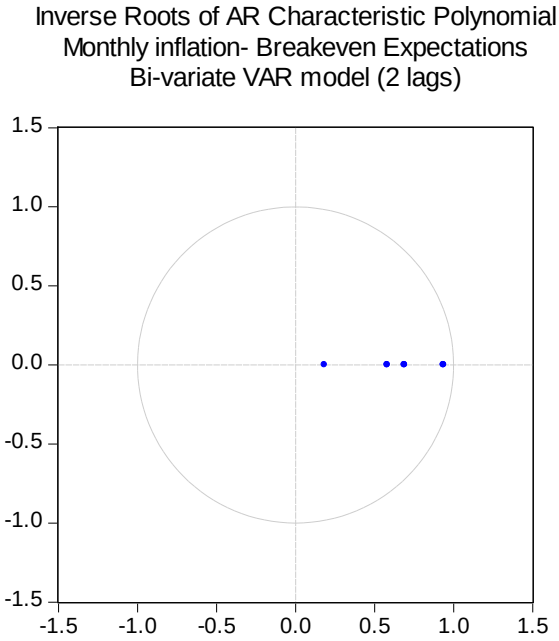


Table 12: Results of Bi-variate VAR Model Inflation – Business Executives' Expectations

Vector Autoregression Estimates
Date: 03/25/12 Time: 22:25
Sample (adjusted): 2001Q2 2010Q3
Included observations: 38 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Inflation	Business Executives' Expt
Inflation(-1)	1.352840	0.198476
	(0.19820)	(0.11717)
	[6.82580]	[1.69399]
Inflation(-2)	-0.622010	-0.117083
	(0.30063)	(0.17772)
	[-2.06903]	[-0.65881]
Inflation(-3)	-0.009365	0.146730
	(0.20716)	(0.12247)
	[-0.04521]	[1.19812]
Business Executive Expt(-1)	0.480958	0.548313
	(0.33366)	(0.19725)
	[1.44146]	[2.77983]
Business Executive Expt(-2)	-0.089826	0.016564

	(0.35686)	(0.21096)
	[-0.25171]	[0.07852]
Business Executive Expt(-3)	-0.376100	0.014606
	(0.28392)	(0.16784)
	[-1.32466]	[0.08702]
C	1.562073	1.393851
	(0.99171)	(0.58626)
	[1.57513]	[2.37753]
R-squared	0.895889	0.846651
Adj. R-squared	0.875738	0.816970
Sum sq. resids	42.59726	14.88655
S.E. equation	1.172222	0.692973
F-statistic	44.45966	28.52552
Log likelihood	-56.08954	-36.11423
Akaike AIC	3.320502	2.269170
Schwarz SC	3.622163	2.570831
Mean dependent	6.060526	6.677267
S.D. dependent	3.325377	1.619778
Determinant resid covariance (dof adj.)		0.485546
Determinant resid covariance		0.323137
Log likelihood		-86.37544
Akaike information criterion		5.282918
Schwarz criterion		5.886239

Figure 13: Unit Circle Roots Test: Business Executives' Expectations VAR

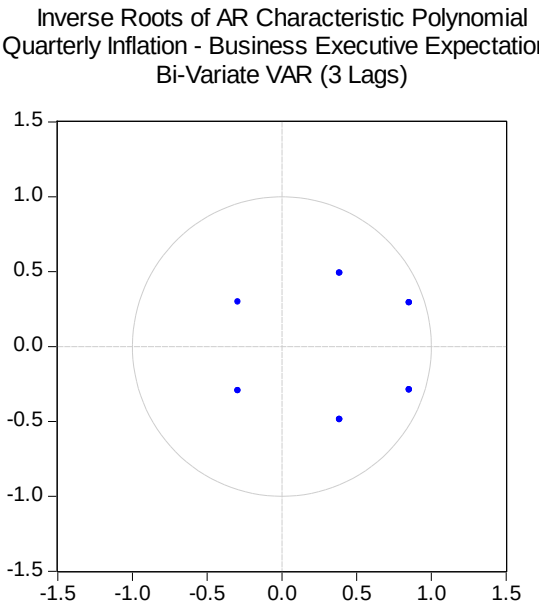


Table 13 Results of Bi-variate VAR Model Inflation – Trade Unionists' Expectations

Vector Autoregression Estimates
Date: 03/25/12 Time: 23:52
Sample (adjusted): 2001Q1 2010Q3
Included observations: 39 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	Inflation	Trade Unionists' Expt
Inflation(-1)	1.454629	0.257069
	(0.14093)	(0.09868)
	[10.3214]	[2.60497]
Inflation(-2)	-0.627525	-0.016781
	(0.16948)	(0.11867)
	[-3.70271]	[-0.14141]
Trade Unionists' Expt(-1)	0.036996	0.440008
	(0.23629)	(0.16546)
	[0.15657]	[2.65937]
Trade Unionists' Expt(-2)	-0.123382	0.122960
	(0.20906)	(0.14639)
	[-0.59016]	[0.83995]
C	1.581326	1.369538
	(0.90658)	(0.63480)
	[1.74428]	[2.15742]
R-squared	0.884138	0.799909
Adj. R-squared	0.870507	0.776369
Sum sq. resids	47.60760	23.34226
S.E. equation	1.183310	0.828575
F-statistic	64.86310	33.98075
Log likelihood	-59.22750	-45.32933
Akaike AIC	3.293718	2.580991
Schwarz SC	3.506995	2.794268
Mean dependent	6.094872	6.564625
S.D. dependent	3.288333	1.752130
Determinant resid covariance (dof adj.)		0.895568
Determinant resid covariance		0.680655
Log likelihood		-103.1756
Akaike information criterion		5.803875
Schwarz criterion		6.230429

Figure 14: Unit Circle Roots Test: Trade Unionists' Expectations VAR

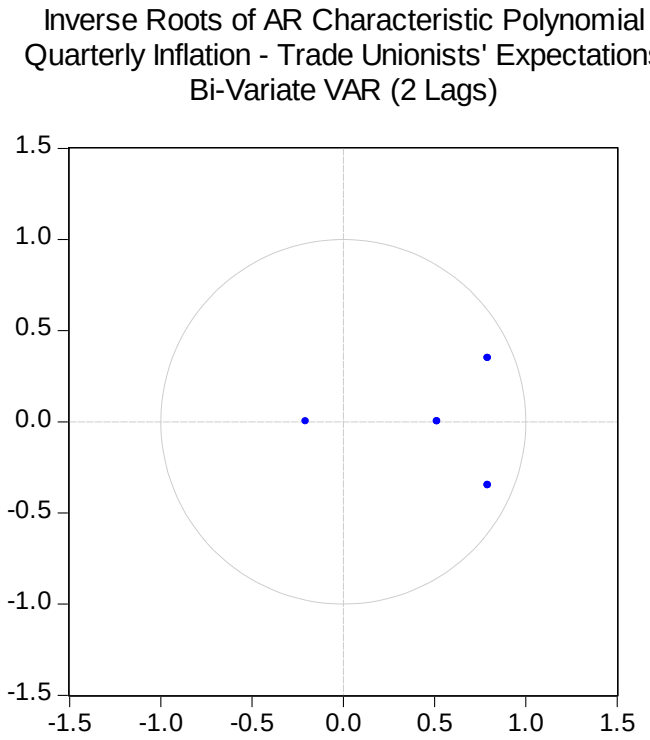


Table 14 Results on Hypotheses 1, 2, 3 and 5

Bi-variate VAR Model	Dependent	Excluded Lags	df	χ^2	P value	Corr e_1e_2
Inflation(π_t) - Expectations of Inflation –Combined(π^e_{Ct}) Quarterly data . 3 lags model	π_t	L π^e_{Ct}	3	5.8	0.12	0.47
	π^e_{Ct}	L π_t	3	18.55	0.0003	
	π^e_{Ct}	L π^e_{Ct} & L π_t	6	94.87	0.0000	
Inflation(π_t) – Analysts' Expectations of Inflation (π^e_{At}) Quarterly data. 2 lags model	π_t	L π^e_{At}	2	1.26	0.53	0.32
	π^e_{At}	L π_t	2	0.28	0.871	
	π^e_{At}	L π^e_{At} & L π_t	4	98.76	0.0000	
Inflation(π_t) – Breakeven Expectations of Inflation (π^e_{TUt}) Monthly data. 2 lags model	π_t	L π^e_{Bt}	2	9.22	0.0100	0.051
	π^e_{Bt}	L π_t	2	3.05	0.22	
	π^e_{Bt}	L π^e_{Bt} & L π_t	4	235.76	0.0000	
Inflation(π_t) – Business Executives' Expectations of Inflation(π^e_{BEt}) Quarterly data. 3 lags model	π_t	L π^e_{BEt}	3	9.79	0.0204	0.35
	π^e_{BEt}	L π_t	3	15.07	0.0002	
	π^e_{BEt}	L π^e_{BEt} & L π_t	6	231.75	0.0000	
Inflation(π_t) – Trade Unionists' (Expectations of Inflation(π^e_{TUt}) Quarterly data. 2 lags model	π_t	L π^e_{TUt}	2	0.954	0.621	0.20
	π^e_{TUt}	L π_t	2	16.88	0.0002	
	π^e_{TUt}	L π^e_{TUt} & L π_t	4	115.71	0.0000	

Notes: The lags were selected on the basis of the log ratio (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz Bayesian criterion (SBC) and Hannan Quinn (HQ) information criterion. Where the tests gave different choice, the study selected the majority choices and only selected the minority choice when it gave better results.

The same lag choices were used for the VAR models estimated in Appendix B3. below.

Appendix B4: Cointegration Tests, Long Run Cointegrating Relationships and VECMS

Table 15.0: Inflation – Financial Analysts' Expectation Cointegrations Test

Bivariate VAR model: Inflation (π) – Analysts'Expectations(π_A^e). VAR lags =2, VECM lags=1 Trend Assumption (ii): No deterministic trend & cointegrating equation has an intercept. Exogenous variable: Credit Crunch Dummy. Adjusted Sample 2001Q1 – 2011Q2 , Observations after adjustments=42				
Ho: Hypothesized no. of C-Vectors	Ha: Alternative Hypothesis	Eigen-value	Statistic	Critical Value 5% level
r = 0	r > 0	$\lambda_{\text{trace test}}$ = 0.335526	19.61676	20.26184
r ≤ 1	r > 1	$\lambda_{\text{trace test}}$ = 0.056640	2.448891	9.164546
r = 0	r > 0	$\Lambda_{\text{max test}}$ = 0.335526	15.28399	15.89210
r ≤ 1	r > 1	$\Lambda_{\text{max test}}$ = 0.056640	3.416646	3.164546

Both the Trace and Maximum Eigen-value statistics suggest that there is no long run cointegrating relationship.

Table 15.1: Inflation – Financial Analysts' Expectation VECM

Long Run Relationship (ECM): $\pi_{t-1} - 0.74\pi^e_{At-1} - 1.37$ (-0.68) (-0.23)				
Short-run adjustment of inflation $\Delta\pi_t = -0.29ECM_{t-1} + 0.72\Delta\pi_{t-1} + 0.43\Delta\pi^e_{At-1} + 0.96CCD$				R^2= 0.56
(-4.25)	(6,17)	(0.81)	(-2.24)	F = 16.27
Short-run adjustment of analysts' inflation expectations $\Delta\pi^e_{At} = -0.008ECM_{t-1} + 0.03\Delta\pi_{t-1} - 0.26\Delta\pi^e_{At-1} + 0.19CCD$				R^2=0.11
(-3.79)	(0.83)	(-1.64)	(1.49)	F = 1.64

Figures in brackets represent t statistics

Table 16.0: Inflation – Breakeven Expectations Cointegration Test

Bivariate VAR model: Inflation (π_t) – Breakeven Expectations(π^e_{Bt}). VAR lags =2, VECM lags=1 Trend Assumption (ii): No deterministic trend & cointegrating equation has an intercept. Exogenous variable: Credit Crunch Dummy. Adjusted Sample 2002M06 – 2010M08 , Observations after adjustments =99				
Ho: Hypothesized no. of C-Vectors	Ha: Alternative Hypothesis	Eigen-value	Statistic	Critical Value 5% level
r = 0	r > 0	$\lambda_{\text{trace test}}$ = 0.143957	18.70064	20.26184
r ≤1	r > 1	$\lambda_{\text{trace test}}$ = 0.033923	3.416653	9.164546
r = 0	r > 0	$\Lambda_{\text{max test}}$ = 0.143957	15.28399	15.89210
r ≤1	r > 1	$\Lambda_{\text{max test}}$ = 0.033923	3.416646	9.164546

Both the Trace and Maximum Eigen-value statistics suggest that there is no long run cointegrating relationship.

Table 16.1 Inflation-Breakeven VECM

Long Run Relationship (ECM): $\pi_{t-1} - 10.20\ \pi^e_{Bt-1} + 47.68$ (-4.82) (4.37)	
Short-run adjustment of inflation $\Delta\pi_t = -0.01ECM_{t-1} + 0.49\Delta\pi_{t-1} + 0.35\Delta\pi^e_{Bt-1} - 0.09CCD$ (-0.994) (5.78) (2.26) (-0.76)	LL=-90.29 R^2= 0.33 F = 15.5
Short-run adjustment of breakeven inflation $\Delta\pi^e_{Bt} = 0.03ECM_{t-1} + 0.05\Delta\pi_{t-1} + 0.18\Delta\pi^e_{Bt-1} + 0.12CCD$ (3.79) (0.09) (1.75) (1.63)	LL=-48.42 R^2=0.13 F = 4.9

Figures in brackets represent t statistics.

Table 17.0: Inflation – Business Executives' Expectations Cointegration Test

Bivariate VAR model: Inflation (π) – Business Executives' Expectations(π^e_{BE}).

VAR lags =3, VECM lags=2.

Trend Assumption (iii): level data have linear trends & cointegrating equation has an intercept.

Exogenous Variable: Credit Crunch Dummy.

Adjusted Sample 2001Q2 – 2011Q2 , Observations after adjustments =42

Ho: Hypothesized no. of C-Vectors	Ha: Alternative Hypothesis	Eigen-value	Statistic	Critical Value 5% level
r = 0	r > 0	$\lambda_{\text{trace test}}$ = 0.511751	39.56325	25.87211
r ≤ 1	r > 1	$\lambda_{\text{trace test}}$ = 0.219662	10.16913	12.51798
r = 0	r > 0	$\Lambda_{\text{max test}}$ = 0.511751	29.39411	19.38704
r ≤ 1	r > 1	$\Lambda_{\text{max test}}$ = 0.219662	10.16913	12.51798

Both the Trace and Maximum Eigen-value statistics suggest that there is a long run cointegrating relationship.

Table 17.1: Inflation – Business Executives' Expectation VECM

Long Run Relationship (ECM): $\pi_{t-1} - 0.86\pi^e_{BEt-1} - 0.005\text{Trend} - 0.18$

(-3.80) (-0.20)

Short-run adjustment of inflation

$$\Delta\pi_t = -0.41ECM_{t-1} + 0.72\Delta\pi_{t-1} + 0.09\Delta\pi_{t-2} + 0.43\Delta\pi^e_{BEt-1} + 0.47\Delta\pi^e_{BEt-2} + 0.62CCD - 0.13$$

(-3.8) (5.22) (0.51) (-1.57) (1.49) (1.28) (-0.65)

R^2= 0.56 F = 16.27

Short-run adjustment of Business Executives' inflation expectations

$$\Delta\pi^e_{BEt} = 0.14ECM_{t-1} + 0.16\Delta\pi_{t-1} - 0.15\Delta\pi_{t-2} - 0.06\Delta\pi^e_{BEt-1} - 0.23\Delta\pi^e_{BEt-2} + 0.2CCD - 0.07$$

(2.44) (2.20) (-1.60) (-0.40) (-1.43) (0.79) (-0.64)

R^2=0.11 F = 1.64

Figures in brackets represent t statistics

Table 18.0: Inflation – Trade Unionists' Expectations Cointegration Test

Bivariate VAR model: Inflation (π) – Trade Unionists' Expectations(π^e_{TU}).

VAR lags =2, VECM lags=1.

Trend Assumption (iii): level data have linear trends & cointegrating equation has an intercept.

Exogenous Variable: Credit Crunch Dummy.

Adjusted Sample 2001Q1 – 2011Q2 , Observations after adjustment =42

Ho: Hypothesized no. of C-Vectors	Ha: Alternative Hypothesis	Eigen-value	Statistic	Critical Value 5% level
r = 0	r > 0	$\lambda_{\text{trace test}}$ = 0.379889	30.58773	25.87211
r ≤ 1	r > 1	$\lambda_{\text{trace test}}$ = 0.212529	10.51777	12.51798
r = 0	r > 0	$\Lambda_{\text{max test}}$ = 0.379889	20.06996	19.38704
r ≤ 1	r > 1	$\Lambda_{\text{max test}}$ = 0.221529	10.51777	12.51798

Both the Trace and Maximum Eigen-value statistics suggest that there is a long run cointegrating relationship.

Table 18.1: Inflation – Trade Unionists' Expectations VECM

Long Run Relationship (ECM): $\pi_{t-1} - 0.70\pi^e_{TUt-1} + 0.02\text{Trend} - 1.92$

(-2.26) (-0.23)

Short Run Adjustment of Inflation

$$\Delta\pi_t = -0.33ECM_{t-1} + 0.82\Delta\pi_{t-1} + 0.01\Delta\pi^e_{TUt-1} + 0.88CCD - 0.21 \qquad R^2 = 0.52$$

(-3.59) (6,12) (0.06) (1.76) (-0.99) F = 9.9

Short-run adjustment of Trade Unionists' inflation expectations

$$\Delta\pi^e_{TUt} = 0.13ECM_{t-1} + 0.22\Delta\pi_{t-1} - 0.27\Delta\pi^e_{TUt-1} + 0.11CCD - 0.05 \qquad R^2 = 0.32$$

(3.79) (0.83) (-1.64) (0.30) (-0.34) F = 4.3

Figures in brackets represent t statistics

Table 19.0 Inflation – Combined Expectations Cointegration Test

Bivariate VAR model: Inflation (π) – Combined Expectations(π^e_C).

VAR lags =3, VECM lags=2.

Trend Assumption (ii): No deterministic trend & cointegrating equation has an intercept.

Exogenous Variable: Credit Crunch Dummy.

Adjusted Sample 2001Q2 – 2011Q2 , Observationsafter adjustments =41

Ho: Hypothesized no. of C-Vectors	Ha: Alternative Hypothesis	Eigen-value	Statistic	Critical Value 5% level
r = 0	r > 0	$\lambda_{\text{trace test}}$ = 0.540376	40.28635	20.26184
r ≤ 1	r > 1	$\lambda_{\text{trace test}}$ = 0.185554	8.415113	9.164546
r = 0	r > 0	$\Lambda_{\text{max test}}$ = 0.540376	31.87123	15.89210
r ≤ 1	r > 1	$\Lambda_{\text{max test}}$ = 0.185554	8.415113	9.164546

Note: Both the Trace and Maximum Eigen-value statistics suggest that there is a long run cointegrating relationship.

Table 19.1 Inflation – Combined Expectations VECM

Long Run Relationship (ECM): $\pi_{t-1} - 0.99\pi^e_{Ct-1} + 0.28$

(-3.88) (0.18)

Short-run adjustment of inflation

$$\Delta\pi_t = -0.40ECM_{t-1} + 0.75\Delta\pi_{t-1} + 0.05\Delta\pi_{t-2} + 0.41\Delta\pi^e_{Ct-1} + 0.54\Delta\pi^e_{Ct-2} + 0.61CCD$$

(-3.48) (5.20) (0.27) (-1.10) (1.42) (1.42)

R^2= 0.55F =8.6

Short-run adjustment of combined inflation expectations

$$\Delta\pi^e_{Ct} = 0.12ECM_{t-1} + 0.15\Delta\pi_{t-1} - 0.1\Delta\pi_{t-2} - 0.25\Delta\pi^e_{Ct-1} - 0.23\Delta\pi^e_{Ct-2} + 0.09CCD$$

(2.60) (2.20) (-1.60) (-0.40) (-1.43) (0.79)

R^2=0.36 F = 3.91

Figures in brackets represent t statistics

Table 20.0: Business Executives' –Trade Unionists' Expectations Cointegration Test

Bivariate VAR model: Business Executives' (π^e_{BE}) – Trade Unionists'Expectations(π^e_{TU}).

VAR lags =2, VECM lags=1.

Trend Assumption (ii): No deterministic trend & cointegrating equation has an intercept.

Exogenous Variable: None

Adjusted Sample 2001Q1 – 2011Q2 , Observations after adjustments = 42

Ho: Hypothesized no. of C-Vectors	Ha: Alternative Hypothesis	Eigen-value	Statistic	Critical Value 5% level
r = 0	r > 0	$\lambda_{\text{trace test}}$ = 0.351399	21.53289	20.26184
r ≤ 1	r > 1	$\lambda_{\text{trace test}}$ = 0.076653	3.349495	9.164546
r = 0	r > 0	$\Lambda_{\text{max test}}$ = 0.351399	18.18339	15.89210
r ≤ 1	r > 1	$\Lambda_{\text{max test}}$ = 0.076653	3.349495	9.164546

Note: Both the Trace and Maximum Eigen-value statistics suggest that there is a long run cointegrating relationship.

Table 20.1 Business Executives' – Trade unionists' Expectations VECM

Long Run Relationship (ECM): $\pi^e_{BEt-1} - 0.90\pi^e_{TUt-1} - 0.72$

(-15.44) (-1.83)

Short-run adjustment of business executives' expectations

$\Delta\pi^e_{BEt} = -0.21ECM_{t-1} + 0.19\Delta\pi^e_{BEt-1} - 0.05\Delta\pi^e_{TUt-1}$ R^2= 0.04

(-0.91) (0.85) (-0.31) F = 0.91

Short-run adjustment of trade unionists' inflation expectations

$\Delta\pi^e_{TUt} = 0.68ECM_{t-1} + 0.11\Delta\pi^e_{BEt-1} + 0.1\Delta\pi^e_{TUt-1}$ R^2=0.12

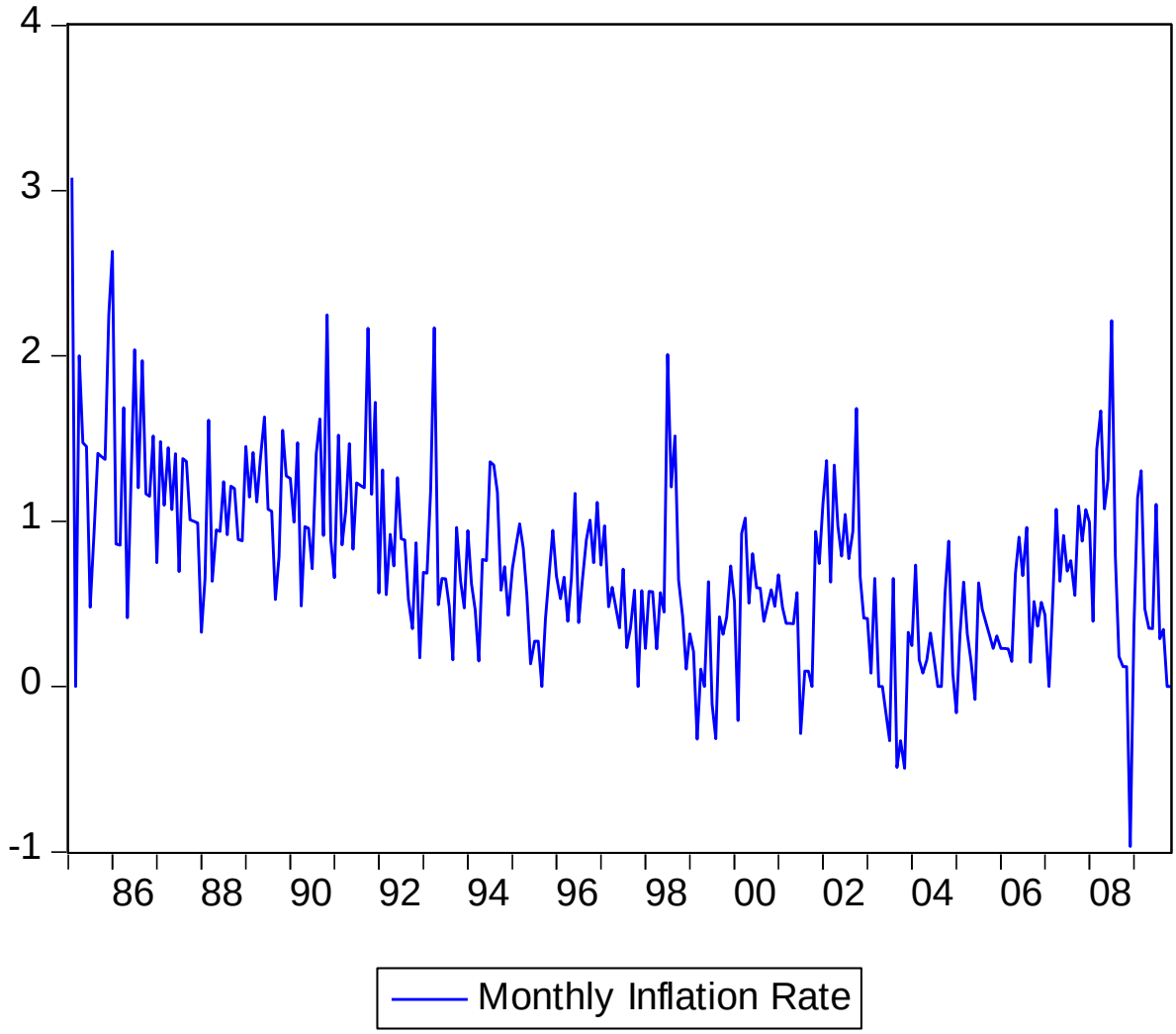
(2.00) (0.32) (0.43) F = 1.64

Figures in brackets represent t statistics

APPENDIX C – Structural Breaks in the Inflation Data

Structural break tests were a key feature of the econometric analysis undertaken in chapter six. This appendix reports the results of the Bai and Perron (2003) , Lee and Strazicich (2004), Andrews and Ploberger (1994) and Lumsdaine and Papell (1997) unit root structural break tests that were conducted using the RATS Version 6.3 software, by employing the source codes written by Doan (2003a, 2003b, 2004 and 2007), which are available on the Estima website (http://*www.estima.com/*). Hansen (2001) provides a useful heuristic account and a survey of the literature involving the structural break methodology.

Figure 19: Monthly Inflation Rate 1985M2-2009M11



Notice That Post-1990 the monthly inflation data exhibit a downward trend

Appendix C1-Bai Perron Structural Break Test Using RATS Code

Linear Regression - Estimation by Least Squares
Dependent Variable INFL
Monthly Data From 1985:03 To 2009:11
Usable Observations 297 Degrees of Freedom 294
Centered R**2 0.999944 R Bar **2 0.999944
Uncentered R**2 0.999991 T x R**2 296.997
Mean of Dependent Variable 134.53562666
Std Error of Dependent Variable 59.04657592
Standard Error of Estimate 0.44382027
Sum of Squared Residuals 57.911070605
Regression F(2,294) 2619464.5003
Significance Level of F 0.00000000
Log Likelihood -178.65344
Durbin-Watson Statistic 1.952441

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.968845834	0.098855478	9.80063	0.00000000
2. X1	1.278531476	0.054633493	23.40197	0.00000000
3. X2	-0.281861419	0.054368279	-5.18430	0.00000040

Best 1 breakpoints
July 1992 (it was identified as the 90th data point)

Sum of Squared Residuals 50.84012
BIC -1.65002*** significant at the 1% level

Best 2 breakpoints
July 1992
March 2008

Sum of Squared Residuals 48.24146
BIC -1.64498*** significant at the 1% level

Appendix C2 – Lee- Strazicich Structural Break Test.

Lee-Strazicich Unit Root Test, Series INFL
Regression Run From 1986:02 to 2009:10
Observations 285
Crash Model with 2 breaks
With 12 chosen from 12

Variable	Coefficient	T-Stat
S{1}	-0.0005	-0.2802
Constant	0.7313	14.3371
D(1995:07)	-0.0842	-0.2004
D(1998:06)	1.6327	3.9048

Lee-Strazicich Unit Root Test, Series INFL
Regression Run From 1986:02 to 2009:10
Observations 285
Trend Break Model with 2 breaks
With 12 chosen from 12

Variable	Coefficient	T-Stat
S{1}	-0.0488	-3.3887
Constant	1.3174	18.9393
D(1993:04)	-0.4475	-1.0735***significant at the 1% level
DT(1993:04)	-0.6045	-10.7780
D(2004:02)	-0.0319	-0.0750
DT(2004:02)	-0.3354	-3.0963

Appendix C3 – Andrews Ploberger Structural Break Test

Linear Regression - Estimation by Least Squares
Robust Standard Error Calculations
Dependent Variable INFL
Monthly Data From 1985:03 To 2008:10
Usable Observations 284 Degrees of Freedom 281
Centered R**2 0.999944 R Bar **2 0.999944
Uncentered R**2 0.999989 T x R**2 283.997
Mean of Dependent Variable 114.81884039
Std Error of Dependent Variable 57.49552452
Standard Error of Estimate 0.43065759
Sum of Squared Residuals 52.115934911
Log Likelihood -162.21705
Durbin-Watson Statistic 1.958858

Variable	Coeff	Std Error	T-Stat	Significance
1. Constant	0.928677459	0.106720524	8.70196	0.00000000
2. X1	1.272770760	0.079594032	15.99078	0.00000000
3. X2	-0.276200022	0.079333598	-3.48150	0.00049861

	Andrews-Quandt		Andrews-Ploberger			
	Test	P-Val	Date	Test	P-Val	
Constant	9.682853	0.030519	1993:04	1.940287	0.056658	
X1	10.187239	0.024162	2005:04	1.887937	0.060429	
X2	10.163579	0.024428	2005:04	1.879169	0.061086	
All Coeffs	17.531013	0.010877	1992:06	7.434675***	0.003746	significant at the 1% level
Resid Var	2.681536	0.622883	1988:09	0.687909	0.319487	

Linear Regression - Estimation by Least Squares
Robust Standard Error Calculations
Dependent Variable INFL
Monthly Data From 1985:03 To 2008:10
Usable Observations 284 Degrees of Freedom 281
Centered R**2 0.999944 R Bar **2 0.999944
Uncentered R**2 0.999989 T x R**2 283.997
Mean of Dependent Variable 114.81884039

Appendix C4 – Lumsdaine and Papell Unit Root Test

Lumsdaine-Papell Unit Root Test, Series INFL
Regression Run From 1986:03 to 2008:10
Observations 273
Breaks in Intercept and Trend
Breaks at 1990:07 2003:08
Estimated with fixed lags 12
Variable Coefficient T-Stat
inflation{1} -0.0300 -4.1551* significant at the 10% (critical t value = -4.239)