AN ANALYSIS OF THE EFFECTIVENESS OF INFLATION TARGETING MONETARY POLICY FRAMEWORK IN SOUTH AFRICA

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ABSTRACT

The aim of this study was to investigate the effectiveness of inflation targeting in South Africa using the Vector Autoregressive method (VAR). The study used monthly data for the period 2000 to 2013 on the following variables: Consumer Price Index Inflation (CPI), money supply (M1), Repo Rate and the Nominal Exchange Rate (NER). The VAR methodology was used to investigate the response of inflation to monetary policy shocks under the inflation targeting framework. The findings from the study revealed that the response of inflation is not consistent with the Taylor rule hence increases in the repo rate meant to reduce inflation actually increase the inflationary pressures in the economy. This is due to the composition of the Consumer Price Index. Housing constitutes the largest weight on the CPI hence this has an impact on how the Repo rate affects inflation. Increases in the repo rate results in increase in the demand for rentals because prospective home owners tend to resort to renting because mortgage loans become expensive as a result of high interest rates. The increase in the demand for rentals pushes the rental price of houses. This results in higher inflation levels. Furthermore, the study established that the inflation targeting framework is effective in reducing inflation persistence because inflation approaches steady state with twelve months after exposure to structural shocks in the VAR system. The autoregression model of inflation showed that the sum of the coefficients is less than one (0.965) showing that inflation targeting has effectively reduced the persistence of inflation of South Africa.

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DEDICATION

I wish to dedicate this thesis to the Almighty for it is not by strength or might but it is by his grace.

DECLARATION

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[Leonard Takunda Makuvaza]

CHAPTER 1: INTRODUCTION

1.1 Background of Study

The ultimate objective of monetary policy in South Africa is to institute a stable financial environment that supports sustainable real economic growth over the medium and long term (South African Reserve Bank (SARB), 2010). This is achieved through maintaining a low inflation rate that has no material effects on the macroeconomic decisions of economic agents. According to Bernanke (1999) financial stability is achieved when people are not concerned about the rate of inflation or any systemic risks in the financial sector when important economic decisions are made. Bernanke asserts that if these preconditions do not prevail, economic disturbances stand in the way of achieving a high and sustainable economic growth.

Friedman (1968) highlighted that there is a consensus on the major goals of economic policy which are high employment, stable prices, and rapid growth. However, there is no agreement on the role that various instruments of policy should play in achieving these goals. In addition, Friedman (1968) stated that the importance of monetary policy in the economy is that it provides a stable background for the economy. When this is achieved, producers and consumers, employers and employees, can proceed with full confidence that the average level of prices will behave in a known way in the future-preferably that it will be highly stable. Inflation has been one of the most important policy objectives of most central banks world over. This has led to the implementation of inflation targeting

in an attempt to give greater assurance to economic decision-makers about the commitment of policy makers in achieving a low inflation rate. This monetary policy framework is predominantly motivated by the desire to provide an anchor for monetary policy that can serve as an effective co-ordination device for the setting of prices of final products (Mishkin, 2008).

The success of inflation targeting in most developed economies motivated South African policy makers to implement inflation targeting as a means of controlling inflationary expectations in the economy. This was done to maintain a stable and low rate of inflation over medium to long term (Ehlers & Steinbach, 2007). The inflation targeting regime is characterised by an announcement of a quantitative target of inflation which monetary authorities aim to achieve. Economic agents are expected to make their decisions based on this announcement and this should be accompanied by adjustments in wage rate and the general price level in line with the announcement (Fromlet, 2010). However, the implementation of inflation targeting in South Africa has raised questions on whether or not such a framework is suitable for emerging market economies.

Mishkin (2004) highlights that the major challenge on implementing inflation targeting in emerging market economies is the frequent occurrence of exogenous supply shocks result in price changes which a central bank has no control and cannot prevent. Petturson (2005) adds that the monetary policy transmission mechanism in emerging market economies is not well understood and there is a weak linkage between inflation and

monetary policy instruments. Mboweni (2003) highlights that the existence of long lags also complicate clear understanding of the transmission mechanism of monetary policy and this represents the single biggest challenge for any inflation-targeting central bank. Bernanke and Woodford (2003) add that a well understood transmission mechanism for monetary policy is one of the prerequisites of a successful inflation targeting framework.

The implementation of inflation targeting is based on the theory of rational expectations. This theory assumes that economic agents set wages and prices based on expectations of future prices (Fromlet, 2010). He adds that the assumption of forward looking monetary policy has also been widely criticized by various scholars who argued that economic agents are not forward looking when making economic decisions. This brings about the main concern among critics who point out that monetary policy instruments under an inflation targeting regime would be ineffective when the necessary preconditions do not prevail (Bonga-Bonga & Kambundi, 2010).

Another criticism against inflation targeting is that it allows too much discretion which may result in an inflationary bias (Kahn, 2010). Others scholars argue that it is inflexible because it does not accommodate for multiple macroeconomic objectives (Mishkin, 2004). This is particularly true in the case of the emerging-market economies such as South Africa where greater flexibility is necessary to deal with exogenous shocks while at the same time paying special attention to other macroeconomic objectives such as output and unemployment (Smal & De Jager, 2001). Given the numerous challenges in

implementing inflation targeting, it is important to investigate whether or not the implementation of inflation targeting in South Africa has given the South African Reserve Bank greater control of inflation as witnessed in other countries which have successfully implemented this framework.

1.2 Statement of the Problem

Inflation control remains one of the priority objectives of South African monetary policy hence inflation targeting was adopted in an attempt to address inflationary pressures within the economy. Inflation targeting has achieved successes in some developed countries where information is readily available to economic agents for making economic decisions. However, South Africa has missed its set inflation targets five times over the past ten years which brings about questions regarding the effectiveness of the inflation targeting as a monetary policy framework in South Africa (Kahn, 2010). There has been an ongoing debate on whether inflation targeting is appropriate for the South African policy framework because empirical studies revealed that inflation targeting in emerging-market economies performed less well than developed economies (Céspedes & Soto, 2005). Inflation targeting is premised on the rational expectations assumption that economic agents are forward looking in setting their economic decisions. However, a survey conducted by the National Bureau of Economic Research revealed that South African economic agents learn about policy objectives with a lag hence they employ a form of adaptive learning mechanism to adjust their expectations (Ehlers & Steinbach, 2007). Milani (2005) identified adaptive learning by economic agents as a crucial source

of persistence. This departure from rationality could render inflation targeting ineffective in controlling inflation persistence or containing inflation within the targets set by monetary authorities. Reduced inflation persistence indicates that the credibility of monetary policy has increased and that inflation expectations are more forward looking. It is in light of this challenges that the study aims to investigate whether or not the implementation of inflation targeting in South Africa has improved inflation control and reduced inflation persistence.

1.3 Research Objectives

The objective of this study is to analyse the effectiveness of inflation targeting as a monetary policy framework in South Africa. In the conduct of this study, the following specific objectives will be addressed:

1. To examine the linkage between the monetary policy instruments and the inflation rate in South Africa.
2. To analyse the effectiveness of inflation targeting in controlling inflation persistence in South Africa.

1.4 Significance of the Study

Since the study will evaluate the effectiveness of inflation targeting as a policy framework in South Africa, the results will be useful to policy makers and monetary authorities in developing targeted policy measures which are efficient in controlling

inflation. The study will contribute to an ongoing debate in academic circles by providing empirical evidence on the effectiveness of the repo rate as a monetary policy instrument.

1.5 Limitations of the study

The major limitation of the study is that expectations are difficult to measure and measurement of expectations has often produced unreliable results. The study will utilize proxy measures of inflation expectations in the form of values of actual inflation realized over a period of time.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter is divided into two sections. Section 2.2 presents the theoretical review of relevant theories relating to inflation targeting. This section covers the definition of inflation targeting, the necessary preconditions required in implementing the inflation targeting framework and other factors which affect the success of this monetary policy framework. Section 2.3 is the empirical literature review. This section presents empirical evidence from studies on inflation targeting by various researchers.

2.2 Theoretical Review

2.2.1 Definition of Inflation Targeting

Kahn (2010) stated that inflation targeting is differentiated from traditional monetary policy frameworks by a publicly announced target for inflation which defines the goal of monetary policy and provides a benchmark for the accountability of the central bank. Kahn (2010) adds that other features which may not be unique to inflation targeting include the use of a number of economic variables for making policy decisions, and a general commitment by society and government that price stability is the ultimate target of monetary policy. Connell (2010) added that in an inflation targeting framework, the central bank commits to the announced numerical range for inflation, subordinates other

intermediate targets, and institutionalizes its commitment through a set of mechanisms that emphasize transparency and accountability for outcomes.

2.2.2 Theoretical Assumptions of Inflation targeting

Keifer (2008) highlighted that the fact that inflation targeting regime is based on the assumption of rational expectations brings in complications in inflation forecasting because rationality is an overwhelming assumption of the economics literature. Keifer (2008) added that the rationality assumption coheres with the notion on well informed maximizing economic agents (Keifer, 2008). Chow (2011) argued that there was insufficient empirical evidence supporting the rational expectations hypothesis when it was embraced in the 1970s. This seems to be true since most expectations surveys fail to show that the expectations of economic agents are sufficiently rational. Mankiw (2003) highlighted that survey data from both consumers and professional economists show significant departures from rationality. Keifer (2008) stated that rational expectations do not conform well to behaviour of economic agents hence economic agents are backward looking in making economic decisions. According to Lyziak (2012), the use of adaptive learning mechanism will make it costly and inefficient to implement policies based on forward looking expectations hence it is debatable whether inflation targeting is an effective monetary policy framework.

Lucas (1963) as cited by Mankiw (2003) postulated that the rational expectations hypothesis implies that every economic agent makes optimal use of information in forming expectations. The rational expectations hypothesis assumes people to use all the information about the process determining a variable when forming expectations. According to Mankiw (2003) the assumption of rational expectations is not backed by strong empirical evidence in the real world. This means monetary policy in an inflation targeting framework can become ineffective when expectations deviate from the rationality assumption.

Łyziak (2012) stated that the degree of rationality exhibited by economic agents has important consequences on macroeconomic performance and monetary policy because backward looking expectations make monetary policy inefficient and costly. Adaptive expectations imply that economic agents form their expectations about the future according to some rule, based on the historic values of the economic variable hence this causes persistence in economic variables and leading to erroneous forecasts. Lyziak (2012) further stated that when expectations are formed rationally, all information available to economic agents is utilised in an efficient manner not only previous values of the economic variable under consideration thereby reducing persistence. Orphanides and Williams (2004) revealed that policies designed to be efficient under rational expectations can perform very poorly when knowledge is imperfect and expectations deviate from the rationality assumption. This presents further evidence that the use of

inflation targeting in South Africa may lead to the impotence of monetary policy given the survey outcomes. In addition, Gasper (2009) revealed that departures from rational expectations increase the potential for instability in the economy; therefore it is important to ensure that monetary policy is effective in anchoring inflation expectations.

Inflation targeting relies on the ability of economic agents to analyse policy decisions which is made impossible by a considerably large proportion of people who are illiterate or who lack access to communication channels such as radios and television as in most African economies. Inflation persistence can arise because private agents have limited information about central bank objectives. Empirical studies show that economic agents learn about policymakers' objectives over time hence inflation tends to be less persistent if agents are more certain about the central bank's inflation objectives (Van de Merwe, 2004). The ability of economic agents to understand monetary policy objectives has significance on the nature of expectations held by the agents. According to Ehlers and Steinbach (2007) there are two sources of survey data for South African inflation expectations which are the Reuters Inflation Expectations (RIE) Survey and the Bureau of Economic Research (BER) Inflation Expectations Survey. The evidence surveys suggest that South African economic agents do not form their inflation expectations rationally. Furthermore, Ehlers and Steinbach (2007) suggested that economic agents employ some form of adaptive learning mechanism which makes use of backward looking expectations. The effectiveness of inflation rate as an anchor for monetary policy is therefore skeptical in light of these survey outcomes.

2.2.3 Preconditions of Inflation Targeting

According to Tumen (2003), the emergence of inflation targeting as a framework for the conduct and evaluation of monetary policy has been accompanied by heated debates on preconditions that a country should satisfy before adopting inflation targeting. Tumen argued that it is easy to set out a long list of elements that are necessary for an inflation-targeting framework to be successful and various authors often disagree on the ultimate list of these prerequisites.

Bernanke and Woodford (2003) stated that it is impossible to say whether a country meets the requirements or not but what is important is the degree to which these preconditions are met. Tumen (2003) argued that an important prerequisite of implementation of inflation targeting is that a situation of fiscal dominance should not exist. Fiscal dominance is a situation where fiscal expenditure is so high to the extent that there is pressure from fiscal authorities to monetize debt. Marcus (2003) highlighted that the monetary authorities have been fortunate in that fiscal issues have not complicated the conduct of monetary policy and situation of fiscal dominance does not exist since there is no pressure on the central bank to finance untenable government deficits. However, the main challenge facing monetary authorities is a clear understanding of the monetary policy transmission mechanism (Mboweni, 1999).

According to Bernanke (2007) the success of an inflation targeting regime depends on the overall level of transparency of the central bank. Transparency, often defined in

terms of the extent of disclosure by the central bank, assists in holding the central bank accountable for its actions ((Céspedes & Soto, 2005). An important responsibility of monetary authorities implementing an inflation targeting framework is to clearly communicate the central bank's objectives. This will reduce uncertainty about the central bank's actions and positively influence expectations in order to improve monetary policy efficiency and macroeconomic performance (SARB, 2012). This precondition can be met through the formation of a monetary policy committee (MPC) before the implementation of the inflation targeting framework. The MPC makes public announcements of the conclusions of policy stance and meetings. The MPC helps the central bank in increasing the amount of information that it disclosed about its operations. In addition, monetary policy forums can be introduced and these enable the exchange of views on monetary policy between the central bank and the public (SARB, 2012).

Mishkin (2004) added that two important preconditions for implementing inflation targeting are instrument and goal independence. Instrument-independence in an inflation targeting framework is usually constitutionally guaranteed. However, most central banks do not have goal-independence, since the goal of monetary policy is set by government in the form of the target. While the institutional requirement is guaranteed, it is not necessarily the case that a high weight is placed on price stability by the public or some politicians (Bernanke, 2003).

Bernanke (1999) highlighted that these preconditions can be viewed as prerequisites for the successful implementation of any monetary policy framework. However, scholars disagree on the list of desirable preconditions for inflation targeting and a more realistic approach should accommodate a degree of learning by doing.

2.2.4 Nature of Inflation Targeting

Handa (2008) highlighted three important stylized facts on the role of central banks in conducting monetary policy. The first stylized fact highlights that the central bank has more than one goal. The main variables targeted by the central bank when conducting monetary policy are output, growth rate, unemployment and inflation. Handa (2008) further stated that many central banks focus on reducing the deviation of output from its full-employment level and on inflation from a target level using the Taylor rule.

The second stylized fact states that the inflation target for most central bank is a low inflation rate, often in a range of 1 percent to 3 percent. Masson (2008) stated that the South African Reserve Bank (SARB) has been using an inflation rate of 3 percent to 6 percent as the main operating guide to setting monetary policy, and the Rand has been floating freely. This target is a much higher and the band wider than most industrial countries that announce inflation targets. According to Bernanke (2007), a high inflation target results in credibility challenges when conducting monetary policy and this unanchors inflation expectations. Another study by Mishkin (2000) revealed that an

inflation target greater than 3% might lead to a decline in central bank credibility and instability in inflation expectations, which could lead to an upward creep in inflation. This shows that the current target range which is an inflation rate between three to six percent can result in the ineffectiveness of monetary policy instruments in controlling inflation.

In the third stylized fact, Handa (2008) added that the instrument of monetary policy can be a monetary aggregate or an interest rate. To illustrate the relationship between the goals and instruments of monetary policy, Handa (2008) highlighted that when the central bank wants to reduce the inflation rate it needs to reduce aggregate demand in the economy. To achieve this, the central bank needs to reduce investment and/or consumption in the economy, which requires an increase in market interest rates. The repo rate is the widely used monetary policy instrument in South Africa. However, the effectiveness of the repo rate has been criticized because there is a substantial lag for monetary policy changes to affect the inflation rate (Bonga-Bonga & Kambundi, 2008). Regardless of this fact, many central banks that practice inflation targeting use the nominal interest rate as their monetary policy instrument.

Handa (2008) concluded that the ultimate object of monetary policy is to achieve certain national goals which often include achieving a low unemployment rate, full-employment output, high output growth rate, a stable price level or a low inflation rate, a stable

exchange rate. To maintain a target range for the inflation rate, the central bank has to operate on the monetary aggregates or interest rates. Handa added that the success or failure of such a policy solely depends on the predictability of the relationships between the rate of inflation and these variables.

The evolution of monetary policy frameworks across the world led to many countries abandoning traditional anchors of monetary policy, such as monetary aggregates and exchange rates. This was mainly because the relationship of monetary aggregates and economic activity broke down in many of these countries (Laubsche, 1999). This led to central banks that targeted monetary aggregates relying more on discretion. Under such circumstances, monetary policy actions often led to an inflationary bias due to the influence of short run economic disturbances. Central banks adopted the inflation rate as their target in an attempt to control inflation to resolve this problem (Bernanke, 1999).

According to Handa (2008), there was a theoretical review in the scope of monetary policy which resulted in many central banks abandoning the multiplicity of goals in favor of a heavy and sometimes sole focus on controlling the rate of inflation. During this period, there was a considerable reduction in the emphasis on using monetary policy to change unemployment and output. The ultimate monetary policy goal became a low inflation rate and this resulted in the birth of inflation targeting as a monetary policy framework.

Fromlet (2010) highlighted that inflation targeting involves the announcement of a quantitative target or target range for the inflation rate over one or more time horizons. Fromlet added that the announcement is often followed by a clear acknowledgement that the principal long-run goal of monetary policy is low and stable inflation.

Since 1990, the state of the art in monetary policies has been inflation targeting (Laubsche, 1999). The inflation targeting framework has been widely regarded as capable of keeping inflation low under fiat money and fluctuating exchange-rate, while simultaneously allowing the flexibility to manage monetary policy (Handa, 2008). Handa (2008) explained that this is achieved through easing credit as an attempt to promote stable growth with a minimum possible unemployment. According to Loanza and Soto (2002), inflation targeting started in New Zealand and Chile as a monetary policy tool aimed to achieve low and stable rates of inflation. The success of this monetary policy framework has led to many countries adopting inflation targeting. In addition, Loanza and Soto (2002) stated that inflation targeting is not a single policy rule because it gives the central bank discretionary powers to achieve inflation target through a variety of monetary policy instruments. Martinez (2008) highlighted that explicit inflation targets control inflation through two principal ways. First, they communicate to the public the objective that monetary policy seeks to accomplish and this serves as a co-ordination device in wage and price setting processes and in forming the public's inflation expectations. By announcing the inflation target, inflation targeting not only

provides a nominal anchor but also a focal point that may anchor inflation expectations. This makes it possible for inflation targeting to have an impact on inflation and on other macroeconomic variables through its effects on inflation expectations and on the expectations-formation process (Martinez, 2008).

Second, they provide a transparent guide to the conduct of monetary policy, whose commitment and credibility can then be assessed on the basis of whether policy actions are taken to ensure that targets are achieved. The move to inflation targeting has seen an increase in the transparency of monetary policy through enhanced credibility, as it allows the public to monitor the central bank's feedback rule (Martinez, 2008).

Bernanke (1999) added that the role of the central bank in implementing an inflation targeting framework is to adopt a strategy of determining directly what the likely path of inflation will be. Under the inflation targeting regime it is important to observe changes in indicators which in the past have affected inflation. The prediction of inflation is very important in the implementation of monetary policy because changes in policy measures are based on likely future price developments. The use of inflation forecasts has led to inflation targeting being criticized because forecasts are inherently unreliable. The fundamental difference between inflation targeting and traditional monetary policy frameworks is that inflation targeting makes forecasting explicit and transparent (Mboweni, 1999).

2.2.5 Rule versus Discretion

Inflation targeting can be seen as a compromise of the 'rules-versus-discretion' as evidenced by Bernanke (1999) who classified inflation targeting as a framework of constrained discretion. In South Africa, the central bank follows an ad hoc procedure, indicating its intentions with respect to the period for bringing inflation back within the range or close to the point target once it has departed. For the same reason the SARB employs an escape clause that specifies the special circumstances in which the central bank should not be expected to achieve its target (SARB, 2012). This form of discretion enables the central bank more flexibility to shocks given than emerging markets are more susceptible to shocks. However, the time-inconsistency theory of optimal monetary policy states that if too much discretion was allowed in the conduct of monetary policy, there would be an inflationary bias in the economy. The problem of time inconsistency arises when an agent has an incentive to promise some action in the future, but when time comes it does not do as promised (Lang, 2012).

According to Gupta and Uwilingiye (2010) when the SARB announces policy decisions in advance, the announcement will be followed by an adjustment of expectations by private decision makers. After the economic agents make their decisions based on the policy announcement, policymakers may be tempted to renege on their announcement. This may result in difficulties in understanding policy announcement because there are inconsistencies in monetary policy over time. Economic agents are led to distrust the

central back, hence expectations tend to be predominantly backward looking. Given the forward looking expectations assumption, monetary policy is only effective when the central bank announcements are credible. This means that the central bank in an inflation targeting framework may commit itself to a fixed policy rule to make its announcements credible.

A study by Ncube and Tshuma (2010) revealed that the South African Reserve Bank (SARB), commits itself to a nonlinear Taylor rule holds. The Taylor rule stipulates that the interest rate adjusts according to the deviation of inflation rate from its target (Taylor 1993). In South Africa the assumption is that the repurchase rate should be raised specific percentage points for each 1 percentage point increase in inflation. However, this commitment of the SARB to the Taylor rule is also questionable given that the repo rate is only changed after long time intervals taken by the MPC to adjust the repo rate in line with the inflation rate. This suggests that the SARB uses short term monetary policy instruments in the short run.

2.2.6 Case for Inflation Targeting

New Zealand was the first country to adopt inflation targeting as a monetary policy framework. Inflation targeting was very successful in controlling inflation in New Zealand because prior to inflation targeting, the inflation rate decreased from 11.6% to 2.3% (Keifer, 2008). Many countries started implementing inflation targeting because

there was growing evidence to suggest that implementation of this framework effectively reduced inflation levels.

According to Van de Merwe (2004) the main advantage of inflation targeting is that it provides an anchor for inflation expectations, price and wage setting, thus reducing the friction which arises from widely divergent inflation expectations. This reduces the cost of disinflation and provides better inflation control to the central bank. Arora (2007) added that inflation targeting also improves the transparency of the central bank through communicating the ultimate policy objective to the public and this objective is translated into an explicit target value. Similarly, Truman (2003) stated that inflation targeting provides improved clarity about the objective of monetary policy, which is conducive to sound planning in both private and public sectors. Furthermore, the framework provides for improved accountability of the Reserve Bank through providing benchmarks for measuring the performance of the central bank.

According to Laubsche (1999), Inflation targets help the central bank achieve long-run price stability thus providing a nominal anchor for monetary policy. The role of a monetary policy framework is to provide a nominal anchor to the economy, that is, a nominal variable that monetary policy makers can use to tie down the price level (Martinez, 2008). Laubsche added that Inflation targets help in improving the transparency and accountability of monetary policy and this enhances the central bank's inflation fighting credibility.

Many scholars agree that low levels of inflation promote economic growth as evidenced by many central banks adopting the inflation-targeting framework. However, literature does not stipulate the absolute inflation level that stimulates economic growth. Ayisi (2013) argued that studies in emerging market countries that focus on estimating the level of inflation that promotes economic growth do not support single-digit inflation level. However, Asino (2013) pointed out that the inflation targeting framework is effective as a growth enhancing tool in both short and long run.

The effect of inflation targeting on key macroeconomic variables is continuously debated by various scholars. Mishkin (2000) argued that inflation targeting regimes are characterized by below-normal output during disinflationary phases in inflation-targeting framework. Mishkin (2000) added that once low inflation levels are achieved, national output return to its previous levels hence once low inflation is achieved. Inflation targeting is not harmful to the real economy. This is evidenced by rapid economic growth experienced after disinflation in many countries that have adopted inflation targeting hence it can be concluded that inflation targeting promotes real economic growth in addition to controlling inflation.

2.2.7 Case against Inflation Targeting

Heintz and Ndikumana (2010) argued that strict rules-based approach to monetary policy, such as inflation targeting, are not desirable for emerging market economies

because of inflation dynamics and structural realities. Monetary policy frameworks should therefore leave enough room for discretion to enable the reserve bank to respond to shocks, especially those originating from the supply side.

Peturson (2005) highlighted that the problem with inflation targeting is the fact that central banks have less control over inflation than their intermediate targets such as narrow money. This is because of the transmission lags of monetary policy that depend on the credibility of monetary policy actions. Kock and Brink (2011) argue that this level of uncertainty surrounding the transmission of monetary policy makes the control of inflation difficult to achieve. Inflation targeting relies heavily on inflation forecasts and when the channels of monetary policy transmission are not well understood, the forecasts become increasingly inaccurate and unreliable (Van de Merwe, 2006). Mishkin (2004) pointed out that emerging market economies are susceptible to sudden supply shocks which impact on inflation hence such countries experience relatively large forecast errors. This results in the central bank losing credibility and ability to anchor inflation expectations. Under such circumstances, many potential benefits of this policy framework may not materialize.

Another argument against the adoption of inflation targeting is the effect of inflation targeting on economic growth with critics pointing out that inflation targeting places great emphasis on inflation at the expense of other economic objectives (Martinez,

2008). Those who tend to interpret inflation targeting as a strict monetary rule argue that inflation targeting can be harmful for growth when interpreting the Taylor rule. Compared with other monetary policy frameworks there is also the risk that inflation targeting could lead to inconsistencies in macroeconomic objectives especially when there are substantial supply shocks (Francisco & Carneiro, 2008). Francisco and Carneiro (2008) added that if an inflation target is taken literally as a rule that is superior to other macroeconomic goals such as output stabilisation; this may result in undesirable variability in national output. When a supply shock occurs and the inflation rate rises and output is lowered, policy makers using inflation targeting as a monetary policy framework may adopt a contractionary monetary policy to achieve a rigidly enforced inflation rate. The result is that output with fall further. Bernarke (1999) highlighted that the adoption of the inflation targeting framework may negatively affect the labour market because inflation may be lowered at the cost of higher unemployment and lower economic growth.

Another requirement for implementing an inflation targeting framework is nominal exchange rate flexibility. Mishkin (1998) stated that large and unanticipated depreciation increase the burden of debt, and this results in a considerable deterioration of balance sheets. When such deteriorations occur, there in an increase the risks of a financial crisis therefore emerging market countries should always pay attention to exchange rate fluctuations when conducting monetary policy under inflation targeting.

2.2.8 Monetary Policy Transmission Mechanism in the Inflation Targeting Framework

Kock and Brink (2011) defined monetary policy transmission mechanism as the different ways in which the economy is affected by monetary policy. Kock and Brink (2011) added that monetary policy is mainly transmitted through the asset-price and credit channels, expectations, risk-taking and international-transactions channels. Bernanke (1999) stated that for a central bank to successfully implement inflation targeting, there is need for a clear understanding of the monetary policy transmission mechanism.

Mukherjee and Bhattacharya (2001) highlighted that a well understood the monetary policy transmission mechanism is a necessary precondition to successfully implement inflation targeting. Mukherjee and Bhattacharya (2001) added that in an inflation targeting framework, changes in the repo rate affect aggregate demand through cost of capital, availability of bank credit, exchange rate, and balance sheets of banks. These are channels of transmission of monetary policy. However, researchers have argued that due to institutional factors in emerging market economies, the interest rate channel of monetary policy transmission is not as effective as in developed economies hence this presents challenges in the effectiveness of short term interest rates such as the repo rate as monetary policy instruments (Mishkin, 2004).

Arora (2007) highlighted that the use of a floating exchange rate system and CPI as a measure of inflation in South Africa provides a close link between inflation and exchange rates. The interest parity condition implies that differences between domestic and foreign interest rates will affect the real exchange rate. This affects the demand of domestic and foreign goods and ultimately aggregate demand. Petursson (2005) added that exchange rate affects domestic currency prices of imported final goods, which are used to calculate CPI bringing about CPI inflation. The exchange rate channel affects actual inflation much faster than the traditional interest rate channel. Petursson (2005) highlighted that monetary policy can affect inflation with a shorter lag under a flexible exchange rate regime. The exchange rate can also affect inflation through disparities in prices of intermediate inputs which are used for producing goods domestically.

2.3 Empirical Literature Review

Numerous scholars have empirically examined the effectiveness of monetary policy and inflation targeting using various econometric techniques. Woglom (2000) conducted a Vector Auto Regression (VAR) analysis on South Africa, New Zealand and Canada to investigate the appropriateness of the inflation targeting framework. The study utilized quarterly data on CPI, real GDP, the nominal exchange rate, and monetary policy instruments for South Africa, Canada and New Zealand. The sample period was 1980 to 2000. The VAR techniques were used to analyse the relative frequencies of different kinds of shocks impinging on the South African, New Zealand and Canadian economies.

The study concluded that South Africa is not a good candidate for an inflation target relative to the other two countries because of the relative importance of foreign shocks and of the weak linkage between monetary policy and inflation. Further this study revealed that weak linkages between monetary policy and inflation will render an inflation targeting system inappropriate. It is therefore important to investigate the link between inflation and monetary policy instruments in South Africa in order to assess the effectiveness of the inflation targeting system.

Smal and De Jager (2001) investigated the evolution of monetary policy in South Africa since the 1980s, through analyzing the various channels of the transmission mechanism. The study used quarterly data on M3, CPI, Nominal Exchange Rate and Real GDP from 1980 to 2000. A VAR model was developed to illustrate the various channels of the transmission mechanism and demonstrate the time lags of monetary policy instruments. The results of the model indicated that there was a fairly long time lag of approximately one year before a monetary policy shock affected the level of real economic activity, and another year before it has an effected on the domestic price level.

A study by Peturson (2005) estimated a panel model for a sample of six inflation targeting countries (Denmark, France, Germany, Italy, Japan and the United States of America). The model was estimated as a seemingly unrelated regression (SUR) with fixed country effects using quarterly data from 1981-2002 for countries considered for this study. The effects of inflation targeting were found to be statistically significant,

even after accounting for the global disinflation trend and domestic business cycle developments. The study revealed that inflation targeting leads on average to more than 3 percentage points fall in inflation.

Apergis and Miller (2005) evaluated the performance of inflation targeting using European Union data. Their focus was on the effects of forward looking monetary policy frameworks on real output. The sample included data covering (1974 to 2001. The data used was quarterly observations on real output (Y) as measured by GDP in 1995 prices; core prices (CPI) as measured by Consumer Price Index, the money supply (M) as measured by M1; and the unemployment rate (u). The countries used for this study were Germany, France, Belgium, the Netherlands, the United Kingdom, Italy, Luxembourg, Spain, Portugal, Denmark, Austria, Finland, Sweden, and Greece. Using ARMA modelling the study investigated the effectiveness of inflation targeting in terms of output losses. The results showed that forward-looking rules encompassed in the inflation targeting framework contribute to macroeconomic stability and monetary policy credibility, and that a positive inflation target, as opposed to zero inflation, leads to higher and less volatile output.

Ehlers and Steinbach (2007) analysed data from both the 2006 Bureau for Economic Research's Inflation Expectations Survey and the 2004 Reuters Inflation Expectations to evaluate the characteristics of expectations formation by economic agents in the South African economy. This study used regression analysis to estimate the adaptive

expectations coefficients on the inflation series. The results did not provide strong evidence to indicate that South African economic agents are exclusively rational or exclusively adaptive in formulating their inflation expectations. The findings of the study showed that economic agents employ some form of learning mechanisms by combining some features of rationality with adaptive behavior in order to minimise their forecast errors over time. Furthermore the evidence from the study revealed that inflation persistence arises because private agents have limited information about central bank objectives. Ehlers and Steinhbach concluded that adaptive learning by economic agents was crucial source of inflation persistence.

Silva and Marcelo (2007) investigated the effectiveness of inflation targeting in Brazil. They used the Taylor rule to model the relationship between monetary policy instruments and inflation. In addition to the Taylor based regression model, the study employed the VAR methodology using quarterly data on M1, CPI, Deposit Rate, Real GDP and the nominal exchange rate. The sample period for this study was 1990 to 2004. The VAR model used in this study had different lag lengths hence the least squares method could not be applied. The Seemingly Unrelated Regressions method was used to estimate the VAR. The two regression models were used to perform an out-of-sample forecasting exercise. The results revealed that inflation targeting was effective in controlling inflation. This was because there was a strong linkage between M1 and CPI revealed from the variance decomposition.

Casmir and Chinaemere (2012) investigated the relationship between inflation and monetary policy instruments in Nigeria and Ghana using the vector autoregression model. The VAR model included money supply, prices, exchange rate and interest rate. The study revealed that prices in the short run are significantly explained by their own shocks rather than monetary policy shocks. This study concluded that monetary policy linkage between inflation and monetary policy instruments is weak hence inflation targeting would perform dismally. The variance decomposition of CPI revealed that only one percent variation in CPI is explained by monetary policy shocks after a period of two months. Own shocks in prices accounted for ninety eight percent variation in CPI in Nigeria and ninety two percent in Ghana. Casmir and Chinaemerem (2012) concluded that in the short run, changes in prices are explained by innovations in its own shocks and that money supply and interest rates have little or no predictive power over price changes in Nigeria and Ghana.

New Zealand was the first country to adopt inflation targeting hence it is interesting to know how successful it has been in implementing this monetary policy framework given its vast level of experience with inflation targeting. Oben (2007) investigated the effectiveness of inflation targeting in New Zealand using quarterly data on the official cash rate, 90-day bank bill rate to represent market interest rates, Gross Domestic Product (GDP), Consumer Price Index (CPI), Expected CPI (EXI), BCR (Bank Credit Ratio) (to represent annual growth rate in bank credit), Spatial Housing Price

(SHP),Trade Weighted Index to represent the annual growth rate in the trade weighted index of the New Zealand dollar foreign exchange rates), and Current Account balance expressed as a percentage of GDP). Quarterly data on these variables were sourced from the website of the Global Financial Data. The methodology used for this study was cointegrating vector autoregression. Using this methodology, the study investigated the dynamic responses of key macroeconomic variables to a sudden increase in the official cash rate for New Zealand. Oben (2007) noted that there is lack of clarity surrounding the magnitudes, direction and duration of changes in the variables instrumental in the monetary transmission mechanism through which interest rate changes enable central banks. The findings of the study revealed that following a shock increase in official cash rate (Monetary Policy Instrument), the other variables involved in the monetary transmission mechanism manifest their maximum responses within three to seven quarters. This finding is consistent with the policy of the Reserve Bank of New Zealand of operating with a horizon of 18 to 24 months. In addition, the response of all variables in the VAR model was consistent with prior expectation. Increase in the official cash reserve led to a persistent reduction in expected inflation suggesting that there was a strong link between the monetary policy instrument (Official Cash Reserve) and inflation expectations. The study revealed that there is a strong degree of rationality exhibited by economic agents thus the central bank could easily control the level of inflation using monetary policy.

A study by Ascari and Florio (2012) using data from Brazil, Russia, India, China and South Africa (BRICS) proved that a higher inflation target unanchors expectations, as feared by Bernanke (1999). This study used quarterly data on inflation, nominal interest rate and real GDP from 1990 to 2005. Ascario and Florio (2012) used a model based on the Taylor rule and their results were that a higher inflation rate decreases the speed of convergence of expectations. In addition, their study revealed that the higher the inflation target, the more the policy should respond to inflation and less to output which may also trigger political interference hence the importance of being transparent diminishes with the level of the inflation target.

Mollick and Torres (2008) examined the effects of inflation targeting on three emerging economies' output growth using the period between 1986 and 2004. Quarterly data on CPI, M3 and nominal interest rate and real GDP were utilized for the study. The countries considered for this study were China, Brazil, India and Chile. Regression analysis based on the Taylor rule was conducted. The findings revealed that there was a systematic positive and significant effects of inflation targeting on real output growth. Furthermore, Molick and Torres (2008) the showed that there is evidence of strong output persistence in these emerging market economies after adopting inflation targeting. However, they argued that in emerging market economies, only full inflation targeting policies have any output effect in the long-run. Mishkin (2000) argued that inflation targeting regimes are characterized by below-normal output during

disinflationary phases in inflation-targeting framework, once. Mishkin (2000) added that once low inflation levels are achieved, national output return to its previous levels hence inflation targeting is not harmful to the real economy. This is evidenced by rapid economic growth experienced after disinflation in many countries that have adopted inflation targeting hence it can be concluded that inflation targeting promotes real economic growth in addition to controlling inflation.

Kim and Chu (2008) in South Korea investigated the effectiveness of inflation targeting in reducing inflation volatility. The study used a sample of 10 years using the period from 1987 to 1997 to represent the period prior to inflation targeting. The sample period 1998 to 2005 represented the inflation targeting period. Using regression analysis, the study revealed that inflation was lower and less volatile after South Korea implemented the inflation targeting framework. This was evidenced by a lower sample mean and standard deviation during the inflation targeting period when compared with the period prior inflation targeting. However, cautions that a lower mean and standard deviation may not be attributed to adoption of inflation targeting but to weaker and less frequent shocks on inflation. An autoregressive model was used to examine the causes of the lower sample mean of inflation and lower inflation volatility. Kim and Chu (2008) concluded that the lower inflation levels and improved price stability was attributed to adoption of inflation targeting.

Poong and Tong (2009) examined the performance of inflation targeting in Malaysia. This study examined the relationship between CPI, money supply (M1), money market rate, and exchange rate of the Malaysian economy using monthly data for the period 1976 to 2007. The Johansen- Juselius (JJ) multivariate cointegration procedure and Vector Error Correction Modelling (VECM) are applied to investigate both short and long run relationships between the variables. The study showed that interest rate changes had significant impacts on the exchange rate but not on money supply. This showed that money aggregates do not significantly explain the changes to the inflation rate.

Gelach and Tillman (2010) explored the success of the inflation targeting framework in Asian countries by looking at the persistence of inflation as measured by the sum of the coefficients in an autoregressive model for inflation using Hansen's (1999) median unbiased estimator. The countries under consideration were India, Chile and Thailand. The study included a sample from 1980 to 2009. The results showed that there was a significant reduction in inflation persistence after the adoption of inflation targeting in the early 1990s. The speed by which persistence falls varied across countries. This study showed that inflation persistence remained unchanged in countries using alternative monetary policies. This is consistent with the views of Kahn (2010) who stated that an important aspect in adopting inflation targeting in a monetary framework is its ability to reduce the prevalence of backward-looking expectations and ultimately inflation persistence. It is however worrying to note that expectations in South Africa predominantly backward looking even when the inflation targeting framework is in

existence. This situation poses potential challenges to policy maker's efforts to reduce inflation persistence. Reduced inflation persistence would also indicate that the credibility of monetary policy has increased and that inflation expectations are more forward looking after the introduction of inflation targeting.

Fromlet (2010) evaluated the effectiveness inflation targeting using ten countries using maximum likelihood estimation. The countries under study were New Zealand, United Kingdom, Australia, Czech Republic, Korea, Canada, Israel, Chile, Poland and Sweden. The study used quarterly data from 1990 to 2009. The data used in this study was the inflation target and the annual inflation rates (CPI). The results showed that inflation targeting was not effective in controlling inflation in six of ten countries. Inflation targeting was found to be successful in developed countries where information dissemination is better than that in emerging economies. Céspedes and Soto (2005) added that inflation targeting yielded less results in emerging-market economies compared to developed economies due to the fact that achieving inflation targeting is more challenging in emerging markets rather than to a lack of commitment to the targets. Cespedes and Soto (2005) argued that merging market economies are also more susceptible to supply shocks presenting further challenges in inflation management. These studies show that inflation targeting cannot guarantee inflation stability in South Africa since it's still a growing economy which is also susceptible to most of these supply shocks.

Another study was conducted in Nigeria by Simeon and Odior (2012). This study examined the inflation targeting in developing countries, using Nigeria as a case study. Using VAR analysis and impulse response functions, the study analysed the effects of policy shocks, where consumer price index (CPI) is presumed to depend upon changes in its determinants. The VAR model included the consumer price index, broad money supply, exchange rate, gross domestic product and government expenditure monthly data over the period 1970-2010. The model investigated the extent in which policy shocks lead to changes in inflation. The results showed that, money supply and past level of inflation had significant impacts on the actual level of inflation in Nigeria.

2.3 Summary

The chapter presented the theoretical and empirical literature on inflation targeting. The chapter revealed that challenges in the monetary policy transmission mechanisms of emerging market economies complicate the implementation of the inflation targeting framework. In addition, the theoretical literature showed that the assumption of rational expectations does not hold in reality and violations of this assumption result in challenges such as inflation persistence and unanchored inflation expectations. These challenges weaken the ability of the central bank to control inflation. The empirical literature showed that inflation targeting has been a successful monetary policy framework world over. However, empirical studies have shown that inflation targeting has yielded better results in advanced economies. This raises questions about whether or not such a framework can have as much success in an emerging market economy. The

next chapter presents the methodology applied to empirically test the whether or not inflation targeting has been an effective monetary policy framework.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter discusses the data and methodology used in this study. The methodology chapter has two sections. Section 3.2 presents the econometric framework and model specification which discusses the preliminary data checks conducted which guided the selection of the appropriate model. In addition the section presents the econometric model used for this study and further diagnostic tests conducted to check the robustness of the model. Section 3.3 presents data, data sources and measurement. This section discusses the data used for this study, sample period and why the data was used in the econometric model.

3.2 Econometric Framework and Model Specification

According to Lütkepohl (2007), stationarity of data is an important consideration in time series analysis because running a regression model using non-stationary data can give misleading parameter estimates of the relationship between variables. Checking for stationarity is important in improving accuracy of results obtained from regression analysis. The data series considered in this research which are the Consumer Price Index (CPI), Repo Rate (RR) Monetary Aggregate (M1) and Nominal Exchange Rate (NER) have a tendency to increase over time and effects of external shocks on these variables tend to persist over time leading to biased standard errors in the series. Preliminary graphical analysis was conducted on each data series to check whether or not the data

was suitable for regression analysis. Afterwards the Augmented Dickey Fuller Tests and the Phillips-Perron test were conducted to test for stationarity. The ADF test has been criticised for having low power if the unit root is close to the non-stationary boundary hence PP test for stationarity was also used because it modifies the ADF t-ratio so that serial correlation will not affect the asymptotic distribution of the test statistic (Banerjee, Dolado, Galbraith, & Hendry, 1993).

After conducting the unit root tests, the researcher selected the appropriate lag length to be used in the Johansen cointegration test and the VAR model. This was because the Johansen test may be affected by the lag length used in the Vector Error Correction Model. According to Enrique and Gutiérrez (2007), the selection of the correct lag order in the vector autoregressive (VAR) model is crucial in ensuring accuracy of the VAR estimates. Lütkepohl (1993) highlighted that selecting a higher order lag length than the correct lag length causes an increase in the mean-square forecast errors of the VAR. According to Lütkepohl (1993), using a shorter lag length often generates autocorrelated errors. Braun and Mittnik (1993) added that using an incorrect lag length also leads to inconsistencies in the impulse response functions and variance decompositions derived from the estimated VAR. The researcher used the information criteria, which include the sequential likelihood modified likelihood ratio (LR), Akaike information criteria (AIC), final prediction error (FPE), Schwarz information criteria (SIC) and the Hannan–Quinn information criteria (HQ). The information criteria gave conflicting lag lengths,

therefore the appropriate lag length selected was the one that eliminated serial correlation.

After selecting the appropriate lag length based on the information criterion, the researcher tested for cointegration among the data series. The necessary criteria for stationarity among non-stationary variables are called integration (Banerjee, Dolado, Galbraith, & Hendry, 1993). According to Johansen and S¨oren (1995) testing for cointegration is important to determine if modelling would yield empirically meaningful relationships. Johansen and Soren (1995) added that if variables have different trends processes, they cannot be modelled in the long run because there are no valid inferences which can be made based on their standard distributions. The Johansen cointegration test was conducted to determine the number of cointegrating vectors. The Johansen method makes use of two test statistics to determine the rank of the Π matrix; the trace statistic and maximum eigenvalue statistic. The Johansen test uses a null hypothesis that the number of cointegrating relations is r against the alternative of k cointegrating relations where k is the number of endogenous variables. The maximum eigenvalue tests the null hypothesis that there are r cointegrating vectors against an alternative of r+1 (Lütkepohl, 2007). After conducting the Johansen test, the researcher concluded that there was no cointegration in the four series hence an unrestricted VAR was estimated.

After conducting preliminary data checks, the VAR methodology was used to analyse the effectiveness of inflation targeting as a monetary policy framework in South Africa. According to Stock and Watson (2011), the Vector Auto Regression (VAR) model is an extension of the univariate autoregressive model to dynamic multivariate time series. The VAR model is very effective in describing the dynamic behavior of economic time series and for forecasting. The VAR model was adopted for analytical purposes because it often provides superior forecasts to those from univariate time series (Stock & Watson, 2011). According to Enrique and Gutiérrez (2007), VAR models eliminate the need for structural modelling by modelling every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system.

The mathematical form of a VAR is shown below:

$$y_t = \beta_{10} + \beta_{11} y_{t-1} + \cdots + \beta_{1k} y_{t-k} + \varepsilon_{1t}$$

Where ϵ_{it} is a white noise disturbance with $E(\varepsilon_{it}) = 0, (i = 1,2),\ E(\varepsilon_{1t}\varepsilon_{2t}) = 0$ and

y_t is a vector of endogenous variables containing M1, Repo Rate, Nominal Exchange Rate and the Consumer Price Index.

Johansen and Soren (1995) highlighted that VAR models are flexible because their forecast can be made based on potential future paths of specified variables in the model. In this research, the causal structure nature of monetary policy instruments on target

variables is investigated and the resulting causal impacts of unexpected shocks or innovations to specified variables on the variables in the model are summarized. These causal impacts are summarized with impulse response functions and forecast error variance decompositions. Generalized impulse response functions (GIRF) were used in this research. This is because the Cholesky technique is sensitive to the ordering of the variables in the VAR hence policy shocks should be placed first in the VAR system under the assumption that policy shocks do not receive feedbacks from innovations. However, if the policy shocks receive feedbacks from innovations, they should be placed last in the system. Each variable in the VAR system is only sensitive to changes in the innovations of those variables that precede it (Mousa, 2010). For this reason, Keating (1992) stated that the results can be sensitive to VAR orderings and may become difficult to interpret. Generalised impulse response functions were used they do not need orthogonalistion of shocks and is therefore not affected by the ordering of the variables used in the VAR model. The generalized impulses are unique and take full account of the historical patterns of correlations between different shocks (Pesaran & Shin, 1998).

The Lagrangean Multiplier (LM) statistic was used to test for serial correlation in the VAR system. The LM test is a large-sample test hence it was because there were more than 30 degrees of freedom which is the minimum requirement to conduct the test. Autocorrelation occurs when the residuals are correlated across time. When residuals are

correlated over time, the t-test on the VAR estimates are invalid hence cannot be used to test the statistical significance of the VAR coefficients. The LM test used in this study revealed that at the selected four lag length, there was no autocorrelation in the VAR model estimated.

The VAR model was used to generate impulse response functions which capture the response of the inflation rate to structural shocks in the economy. According to Stock, James and Watson (2011), impulse responses trace out the response of current and future values of each of the variables to a one-unit increase in the current value of one of the VAR errors. VARs are good at capturing co-movements of multiple time series. The purpose of impulse response functions in this study was to capture the response of CPI to the intermediate monetary policy target (M1) and monetary policy instrument (repo rate). The impulse responses also captured response of inflation to nominal exchange rate fluctuations under an inflation targeting framework.

After generating the impulse response functions, forecast error variance decomposition was conducted in order to consolidate the findings from the vector autoregression analysis. According to Lütkepohl (2007), forecast error variance decomposition reveals how much of the variance in a variable can be explained by exogenous shocks to the other variables in the VAR system. Variance decomposition was carried out to establish

magnitude of response of the Consumer Price Index to innovations within the VAR model.

In addition to VAR analysis, a univariate autoregressive model was estimated to measure the persistence of inflation in South Africa. The sum of the autoregressive coefficients in a univariate process of inflation was used as a measure of inflation persistence. Inflation was assumed to follow an AR (2) process based on the Swartz information criterion. The sum of the coefficients of the AR (2) model of inflation were used as a measure of inflation persistence. Fromlet (2010) highlights that if the sum of the coefficient in an AR model of inflation is greater than one, it can be concluded that inflation is persistent.

3.3 Data, Data Sources and Measurement

The sample considered for this study consisted of monthly data on Consumer Price Index, Repo Rate, Monetary Aggregate and Nominal Exchange Rate data collected from the year 2000 to 2013 by the South African Reserve Bank. The researcher considered monthly data on CPI, M1, Repo Rates and the Nominal Exchange Rate for VAR analysis. The Repo rate served as a policy instrument in the model, M1 and CPI served as target variables. The nominal exchange rate was included to account for the South Africa's trade openness. From literature review, the relationship between CPI, NER and

M1 is expected to be positive. The relationship between CPI and the Repo Rate is expected to be negative.

3.3.1 Money Supply

Monetary targets are widely used as intermediate targets of monetary policy by almost all central banks. The commonly used monetary aggregate by most researchers is broad money supply (M3). However, Mboweni (1999) argued that the relationship between M3 and inflation collapsed between 1990 and 2000 hence M3 is not a suitable intermediate target. Other researchers suggest the use of M1 and M2 as acceptable intermediate targets of monetary policy (Allsop et al, 2006). An intermediate target is any economic variable that is not directly controlled by the central bank but adjust to policy changes and behave in a predictable manner relative to the central bank goals (Allsop, Kara & Nelson, 2006). M1 is used as an intermediate target of monetary policy in South Africa because it is not directly affected by the tools of monetary policy, but rather through the monetary base.

3.3.2 Repo Rate

The SARB uses the repo rate as the policy instrument to steer inflation towards the target band of 3-6%. The repo rate is the rate at which the central bank lends to commercial bank hence it is a measure of cost of credit to the banking sector (SARB, 2010). Changes in the repo rate will result in changes in the interest rates on overdrafts

and other loans. By changing the repo rate, the central bank indirectly affects the interest rates in the economy. Higher interest rates discourage borrowing resulting in reduced aggregate demand in the economy thus lowering the general price level. This study examines the effectiveness of inflation targeting framework in controlling inflation hence the repo rate served as a monetary policy instrument in the estimated VAR model.

3.3.3 Consumer price index Inflation

The Consumer Price Index is a measure of prices of goods and services purchased by consumers. The percentage change in CPI per month measures the monthly inflation rate. The South African Reserve Bank uses the headline CPI as a measure of inflation (SARB, 2010). This measure of inflation was chosen because it is not directly influenced directly by the Bank's monetary policy stance thus it is a suitable monetary policy target. The CPI inflation will serve as a target variable under the inflation targeting framework.

3.3.4 Nominal Exchange Rate

The SARB (2012) defined the nominal effective exchange (NER) rate as a weighted exchange rate of the rand measured against a basket of the currencies of South Africa's twenty most important trading partners. The calculation is based on trade in and consumption of manufactured goods. According to Allsop et al (2006) in an inflation targeting framework, the nominal exchange rate plays a crucial role in transmitting monetary policy actions to the inflation rate. A floating exchange rate provides the

SARB with a platform to directly pursue an inflation target through exchange rate effect of the monetary policy transmission mechanism. Allsop et al (2006) highlighted that the nominal exchange rate acts as a shock absorber in an inflation targeting framework. The NER was included as a variable to examine the relationship between exchange rate fluctuations and inflation.

CHAPTER 4: EMPIRICAL ANALYSIS AND FINDINGS

4.1 Introduction

This chapter presents the empirical analysis and findings. Section 4.2 presents the diagnostic tests conducted on the data. These include the unit root tests, lag length selection and cointegration tests conducted to determine the appropriate econometric model. After these tests are presented, the results from the empirical analysis are presented. Section 4.3 presents results from the econometric model estimates. These include the impulse response functions and variance decomposition. In addition, section 4.3 presents auto regression modelling results which were used to capture inflation persistence in South Africa.

4.2 Diagnostic Tests

4.2.1 Unit Root Tests

Unit root tests were used to test for stationarity of the data used for VAR analysis. Prior to conducting the unit root test, graphical inspection was done on each series. The results from the graphical inspection are attached as appendix 2. Graphical inspection was conducted to investigate suitability of the series for regression analysis. All series considered for this study exhibited variability hence were found to be suitable for regression analysis. Furthermore, graphical inspection was also conducted to provide prior knowledge of the series stationarity in order to complement results from the unit root tests. Preliminary graphical analysis indicated that all the series were explosive.

Formal tests for stationarity were carried out using the Augmented Dickey Fuller (ADF) test and the Philip Perron (PP) test. The results from the unit root test are presented in table 4.1 below:

Table 4.1 Unit Root tests at level

Variable	Test		t-test	t-critical	Probability	Conclusion
CPI	ADF	Intercept	-0.857	-2.886	0.785	Non-stationary
		Trend and Intercept	-0.895	-3.449	0.985	
	PP	Intercept	-0.764	-2.884	0.864	
		Trend and Intercept	-0.848	-3.445	0.985	
NER	ADF	Intercept	-0.655	-2.884	0.753	Non-stationary
		Trend and Intercept	-0.564	-3.446	0.673	
	PP	Intercept	-0.568	-2.884	0.993	
		Trend and Intercept	-0.569	-3.445	0.899	
RR	ADF	Intercept	-0.896	-2.884	0.789	Non-stationary
		Trend and Intercept	-0.756	-3.446	0.846	
	PP	Intercept	-0.577	-2.884	0.635	
		Trend and Intercept	-0.756	-3.445	0.864	
M1	ADF	Intercept	-0.466	-2.884	0.994	Non-stationary
		Trend and Intercept	-0.564	-3.446	0.973	
	PP	Intercept	-0.759	-2.884	0.944	
		Trend and Intercept	-0.576	-3.446	0.845	
		Trend and Intercept	-0.466	-3.445	0.234	

Source: Author's Compilation

The Philip Perron test and the Augmented Dickey Fuller test were conducted on the series above. The two tests use a null hypothesis that the data is non-stationary. The

results above show that CPI, NER, RR and M1 were non stationary at levels since t-test values were greater than t-critical values in all cases. The corresponding probabilities were greater than the value of 0.05 in all the series. The null hypothesis for the data is the series above contain a unit root, meaning they are non-stationary, given the results above; the null hypothesis could not be rejected. The conclusion is that all the series are non-stationary at levels. The differencing method was used to achieve stationarity in the data series.

Table 4.2 Root tests at first difference

Variable	Test	Exogenous	t-test	t-critical	Probability	Conclusion
DCPI	ADF	Intercept	-7.020	-2.886	0.000	Stationary
		Trend and Intercept	-7.106	-3.449	0.000	
	PP	Intercept	-7.854	-2.884	0.000	
		Trend and Intercept	-7.993	-3.445	0.000	
DNER	ADF	Intercept	-9.159	-2.884	0.000	Stationary
		Trend and Intercept	-9.237	-3.446	0.000	
	PP	Intercept	-9.166	-2.884	0.000	
		Trend and Intercept	-9.199	-3.445	0.000	
DRR	ADF	Intercept	-3.266	-2.884	0.019	Stationary
		Trend and Intercept	-3.319	-3.446	0.048	
	PP	Intercept	-10.593	-2.884	0.000	
		Trend and Intercept	-10.644	-3.445	0.000	
DM1	ADF	Intercept	-13.667	-2.884	0.000	Stationary
		Trend and Intercept	-13.682	-3.446	0.000	
	PP	Intercept	-14.368	-2.884	0.000	
		Trend and Intercept	-14.581	-3.446	0.000	
		Trend and Intercept	-9.164	-3.445	0.000	

Source: Author's Compilation

The Philip Perron test and the Augmented Dickey Fuller test were conducted on the data in first difference. The two tests use a null hypothesis that the data is non-stationary. The results above show that CPI, NER, RR and M1 were stationary in first difference since t-test values were less than t-critical values on all cases. The corresponding probabilities were lower than the value of 0.05 in all the series. The null hypothesis for the data is the

series above contain a unit root, meaning they are non-stationary, given the results above, the null hypothesis is rejected. The conclusion is that all the series are stationary at first difference.

4.2.3 Appropriate Lag Length Selection

Table 4.3 Lag Length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2703.316	NA	5.41e+13	42.973	43.063	43.010
1	-1802.585	1729.977	43080153	28.930	29.380	29.113
2	-1757.505	83.72015	27174575	28.468	29.279*	28.798
3	**-1728.017**	**52.89087***	**21980640***	**28.254***	**29.425**	**28.730***
4	-1715.702	21.30576	23390710	28.313	29.843	28.935

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Source: Author's Compilation

Prior to conducting cointegration tests and VAR analysis, the information criterion methods were used to determine the appropriate lag order for both the cointegration tests and VAR analysis. The table above shows the appropriate lag order for the system of

equations selected by each information criteria. Given the results from the information criterion, the researcher selected a lag order of 3 which is the optimum lag length for the Akaike Information Criterion, Final Prediction Error; Sequential modified LR statistic and Hanna-Quinn information criterion. A lag length of 3 was therefore be applied in the Johansen cointegration test and the VAR analysis.

4.2.4 Cointegration Test

Table 4.4: Johansen Cointegration Test

Number of cointegrating equations	Trace Test			Maximum Eigenvalue Test		
	Trace Statistic	Critical Value (0.05)	Probability	Maximum Eigenvalue Statistic	Critical Value (0.05)	Probability
None	23.320	27.584	0.075	23.320	27.584	0.160
At most 1	22.622	29.797	0.265	10.947	21.132	0.653
At most 2	11.676	15.495	0.173	9.593	14.265	0.240
At most 3	2.083	3.841	0.149	2.083	3.842	0.149

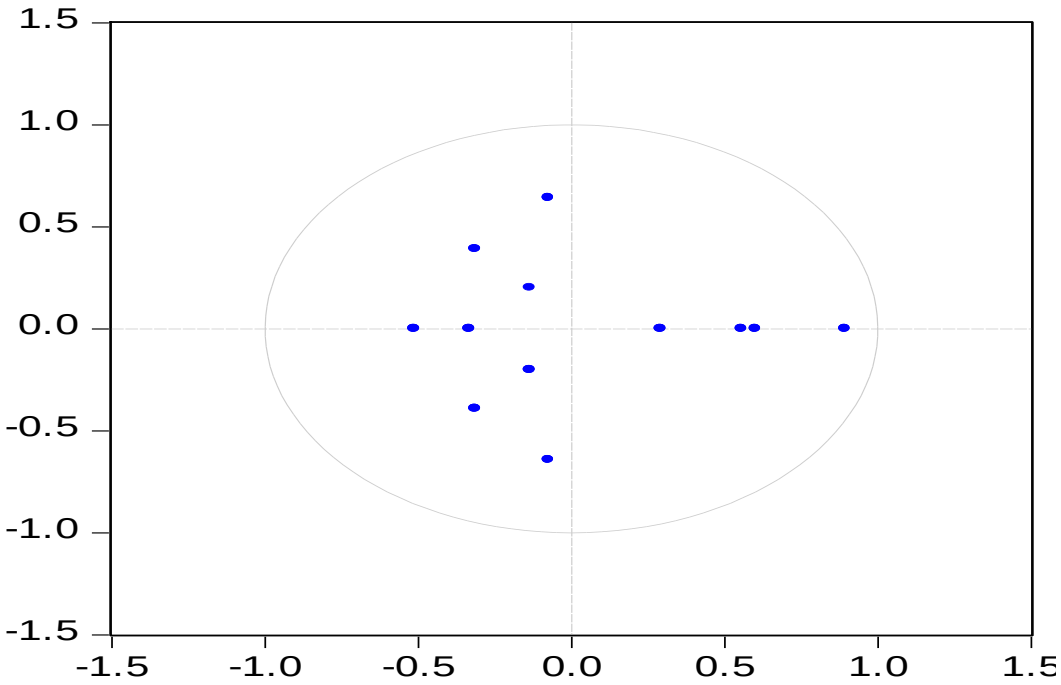
Source: Author's Compilation

Cointegration was conducted to test the existence of a long run relationship between two or more time series. Non stationary series can have a long run equilibrium relationship. The unit root tests showed that the series were integrated of the order one hence there is a possibility that a long run relationship exists among these variables. The Johansen test

developed by Johansen-Juselius (1990) was used to test for cointegration among the CPI, M1, RR and NER series. The Johansen cointegration test uses a null hypothesis that there is no cointegration against alternative hypothesis that there is cointegration of rank 1, rank 2 or rank 3. The t test statistic was less than t critical values in both the maximum Eigen value test and the trace statistic. It was therefore concluded that there was no evidence of cointegration at 5% level. Given these results, it follows that the VAR model was adopted for analytical purposes.

4.2.5 VAR Stability Tests

Figure 4.1 Characteristics of Polynomial Stability condition of the VAR system.



Source: Author's Compilation

To determine whether the VAR model was suitable for analysis, a VAR stability test was conducted. The results of the stability test are shown on the figure above. For the VAR model to satisfy the stability conditions, all roots should lie inside the circle and the modulus has to be less than one. At the chosen lag length, the results showed that all the modulus were less than one. The figure above shows that no root lays outside the unit circle hence the VAR satisfies the stability condition.

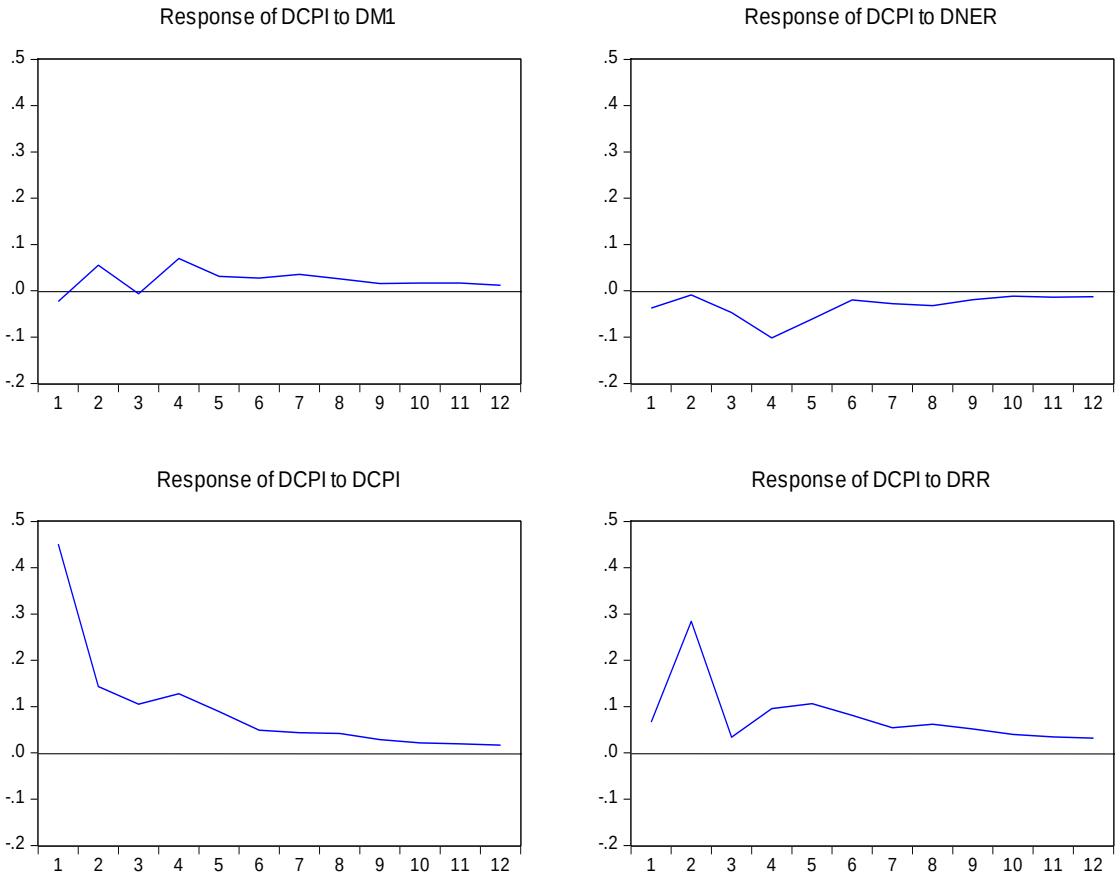
4.3 Econometric Model

4.3.1 VAR Model

After doing the preliminary checks, the previous tests revealed that the VAR model is suitable for analytical purposes since there was no cointegration in the series. VAR models are useful in forecasting economic variables examining the effects of economic shocks (Engle & Granger, 1987). In this research the VAR model was used to examine the effectiveness of policy shocks in controlling inflation. The VAR model was particularly useful in generating impulse response functions of CPI to various economic shocks. The VAR model estimates are attached as an appendix.

4.3.2 Impulse Response Functions

Figure 4.2 Response of CPI to Structural Shocks in the VAR model



The results above show generalized impulse response function of DCPI to DM1, DNER, DRR and DCPI. The effect of a monetary policy shock is transitory because the economy approaches steady state after ten months. This is consistent with the theory of long run money neutrality which states that monetary policy cannot be used to peg the price level in the long run (Friedman, 1968). A one standard deviation shock on M1 causes an increase in CPI inflation in the second period. The full impact of a monetary

policy shock in form of a monetary expansion is realised after four months. This is due to the transmission lag of monetary policy which is the period taken by variables to respond to policy actions. The results are consistent with theory because an increase in money supply is expected to increase the aggregate demand in an economy thus exerting inflationary pressures in the economy.

The response of DCPI to DNER shows the effect of the nominal exchange rate on inflation. The figure shows that a one positive standard deviation on the nominal exchange rate (depreciation) will result in lower levels of inflation from the second to the ninth month. The effect of DNER on DCPI steadily increases from the second month and reaches its peak after four months. After four months, the exchange rate effect on inflation steadily decreases and it approaches steady state after ten months. Mishkin (2008) highlighted that the effect of exchange rate depreciation on inflation is complicated. The exchange rate affects the inflation rate through the effect of depreciation on the price of imported goods. This is termed import inflation. Depreciation makes imported goods more expensive on the local market hence depreciation is expected to result in higher inflation which is in contrast to the result above. Bahmani-Oskooe and Ratha (2004) pointed out that the effect of depreciation depends on the price elasticity of exports and imports. A depreciation results in a greater demand for South African commodities by trading partners since they find them cheaper. South Africa is a predominantly exporting country hence a demand for its

exports induced by a depreciation of the rand will likely result in an increase in the price of commodities (SARS, 2013). The effect of depreciation on inflation is only temporary because the response of DCPI to a one standard deviation shock wears off in the 10th month.

The response of DCPI to DCPI above shows the effect of a one standard deviation shock to DCPI over a year. This impulse response function shows how long inflationary shocks persist in the South African economy. The figure above shows that inflationary shocks have the biggest effect on actual inflation in the first period. Some researchers argue that if inflationary shocks have a great impact on inflation, inflationary pressures in emerging marketing economies can render inflation targeting ineffective (Bernanke, 2004). However, figure two shows that the impacts of inflationary shocks are only transitory because the DCPI approaches the steady state 12 months after the shock to inflation. This suggests that inflation targeting framework is effective in reducing the degree of inflation persistence. Additional autoregressive modelling will be conducted to examine inflation persistence.

The response of DCPI to DRR shows the link between inflation rate and the main monetary policy instrument in South Africa. The figure shows that a one standard deviation to the repo rate will lead to a steady increase in CPI inflation from the first month and reaching a peak in the second month. This increase falls sharply from the

second to the third month as the inflation rate approaches the steady state. After the twelfth month, the monetary policy action will have negligible effect on the inflation rate showing that the effects of DRR on DCPI are only transitory. This is in contrast to the Taylor rule which postulates that inflation should decrease whenever the repo rate is increased. Scholars have however indicated that the composition of CPI has strong bearing on the response of inflation to monetary policy instruments. Increases in interest rates are expected to lead to lower aggregate demand thus lower levels of inflation. According to SARB (2012), housing constitutes the largest proportion of CPI (22.8%). This implies that increases in interest rates tend to discourage prospective home owners from purchasing houses when the cost of credit is high. These individuals may rent houses while waiting for interest rates to fall down so that they could get mortgage loans at cheaper cost. This increase in demand for rentals will push rental prices up hence the inflation level tends to increase as the repo rate is increased. Previous studies have pointed out that the repo rate is an ineffective policy instrument in taming inflation (Bonga-Bonga & Kabundi, 2012). The findings from this study show that the repo rate is moving the inflation in an undesired direction thus it is an ineffective monetary policy instrument.

4.3.3 Forecast Error Variance Decomposition of CPI

Table 4.5: Variance Decomposition of CPI

Variance Decomposition of DCPI:					
Period	S.E.	DCPI	DM1	DNER	DRR
1	0.451	100.000	0.000	0.000	0.000
2	0.5487	74.3677	1.305	0.006	24.322
3	0.560	74.852	1.251	0.474	23.422
4	0.592	71.680	2.774	2.717	22.829
5	0.610	69.727	2.961	3.313	23.999
6	0.617	68.647	3.125	3.289	24.939
7	0.623	68.001	3.440	3.377	25.182
8	0.628	67.293	3.585	3.521	25.601
9	0.631	66.867	3.624	3.554	25.955
10	0.633	66.596	3.684	3.554	26.167
11	0.634	66.374	3.744	3.571	26.311
12	0.635	66.203	3.770	3.588	26.440

Source: Author's Compilation

Variance decomposition refers to the breakdown of the forecast error variance for a specific time horizon. The above variance decomposition indicates which variables have short-term and long-term impacts on the inflation rate. The variance decomposition above shows that fluctuations in inflation in the first period are attributed to shocks on CPI (100%). The effect of CPI shocks to the inflation rate steadily declines over time and they will contribute to 66% of the inflation forecast error variance after twelve

months. However, it is important to note that the CPI series approaches steady state after a period of twelve months as revealed by the impulse response function.

Changes in the monetary policy instrument (Repo Rate) have the second largest impact on the inflation forecast error variance (24% to 26%) from the second to the twelfth period. This indicates that the inflation targeting framework has reduced the monetary policy transmission lag because prior to the implementation of inflation targeting, it took twelve to twenty four months before monetary policy actions could impact on inflation (SARB, 2010). However, the impact of the Repo Rate is not consistent with the Taylor rule where an increase in the Repo Rate is expected to reduce aggregate demand and ultimately the inflation level. The implication is that increases in the Repo Rate in an attempt to halt inflation would increase the inflationary pressures in the economy.

Money supply (3.8% peak in the twelfth month) and the Nominal exchange have the least impact (3.6% peak in the twelfth month) on the inflation rate forecast errors. A shock on M1 contributes very little to inflation and this is consistent with studies done during the period when South Africa was targeting M1. These studies revealed that the relationship between M1 and CPI had weakened hence M1 targeting became ineffective as a monetary policy framework. Similarly a shock on the exchange rate contributes very little to changes in the CPI. The relationship between CPI inflation and NER has been postulated by Fischer (Casmir & Chinamaere, 2012). However, numerous studies

have argued that the Fischer effect does not hold in reality owing to trade barriers and transportation costs (Francisco & Canarneiro, 2005).

4.3.4 AR Estimation of Inflation Persistence

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.540	1.430	2.475	0.0145
AR(1)	1.402	0.079	17.730	0.000
AR(2)	-0.437	0.077	-5.644	0.000

Source: Author's Compilation

The sum of the coefficients of the AR (2) model of CPI inflation is 0.965. Fromlet (2010) stated that if the sum of the coefficients of inflation is less than one, it is an indication that inflation is not persistent. Given the results above, the conclusion is that the inflation targeting framework is effective in controlling inflation persistence.

4.4 Conclusion

This chapter presented the results from the preliminary tests conducted and findings from the empirical analysis. The next chapter concludes the study and presents policy recommendations based on the results from the econometric analysis.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study examined the effectiveness of inflation targeting in South Africa. Successful inflation targeting is expected to result in greater control over inflation through the use of monetary policy instruments. In this regard the linkage between the inflation rate and repo rate was examined using an unrestricted VAR model. In addition Inflation targeting is expected to reduce the persistence of inflationary shocks on the economy. The data set used for this study included CPI (inflation), M1 (Money Supply), Nominal Exchange rate (Stabiliser), Repo Rate (Monetary Policy Instrument). The monthly data covered the period 2000 to 2013.

The conclusions are drawn from the analysis of the impulse response functions, variance decomposition and autoregression modelling. The study revealed that there was a weak positive relationship between the intermediate target of monetary policy (M1) and inflation. This relationship was consistent with theory because an increase in money supply resulted in a higher inflation rate. This is because increases in money supply tend to increase aggregate demand in an economy thus increasing inflation. However, contractionary monetary policy in the form of reducing money supply is not very effective in controlling inflation because money supply only account for a maximum of 3.6% of the changes in the consumer price index. The effect of monetary expansion was

found to be consistent with the theory of long run neutrality of money because the response of CPI to shocks in M1 was temporary.

The findings from the study showed that there is a relatively strong link between the main monetary policy instrument and the inflation rate. The Repo Rate contributes 24% of forecast errors in CPI after a period of 3 months. The contribution of monetary policy shocks increase to about 26% of forecast errors in the CPI in the twelfth month. However, this link between the monetary policy instrument and inflation is not in the desired direction and is inconsistent with the Taylor rule. Increases in the repo rate are expected to reduce aggregate demand and ultimately reduce inflationary pressures in the economy. However, due to the large contribution of housing in the Consumer Price Index, increase in interest rates increase demand for rentals since mortgages become expensive thus prospective home owners resort to renting. The increased demand for housing thus increases price of rentals and this increases the overall inflation rate.

The autoregression estimates showed that the sum of coefficients of the AR (2) model of inflation is 0.965. This shows that the inflation targeting framework has been effective in reducing inflation persistence. This is consistent with the results from the impulse response functions which showed that a one standard deviation shock to CPI persists for a period of about 10 months in the economy. This shows that exogenous shocks on inflation caused by other factors outside the model only impact on the economy for 10 months.

6.2. Recommendations

Given the findings from the study, it is recommended that the monetary policy authorities revise the composition of the Consumer Price Index or to use another measure of inflation rate such as producer price index which eliminates the problem of a high weight being allocated to housing. In addition it is recommended that the Central Bank strengthens the relationship between intermediate monetary policy target (M1) and inflation to achieve greater control over inflation. This can be done through enhancing the public knowledge on monetary policy actions so that a monetary policy stance such as an increase in money supply is followed by an adjustment of public expectations. When the public adjust their expectations in line with policy actions, monetary policy becomes more effective in controlling inflation. The central bank can achieve this through disseminating information on its operations to the general public. It should be noted that the study considered financial factors which impact on inflation. The study could be extended further to include the real sector to establish the impact of changes in output on inflation.

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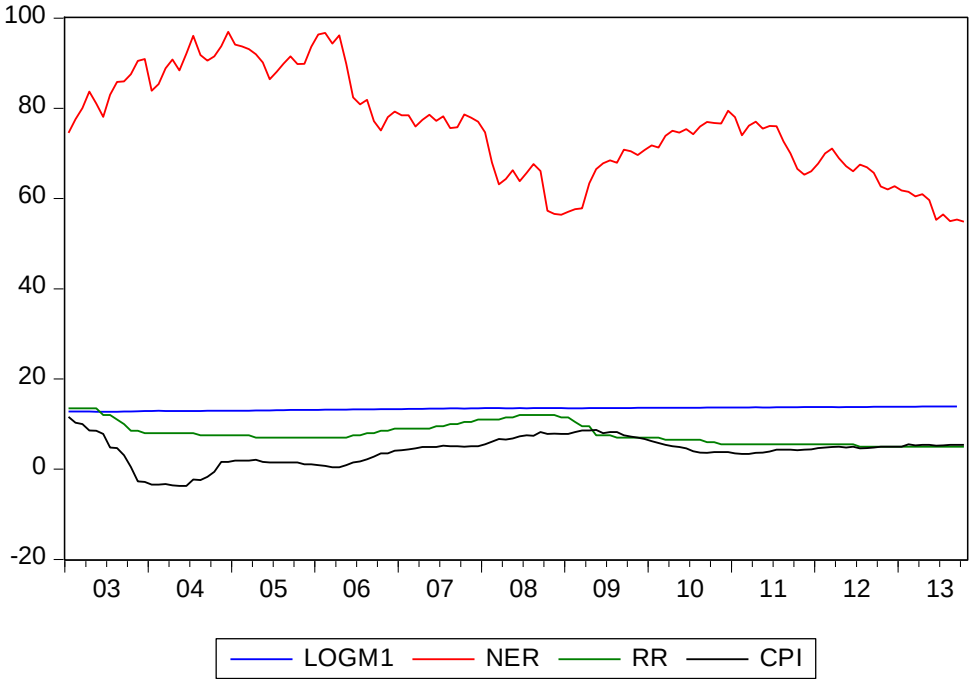
APENDICES

Appendix 1: Graphical Representation of the data series



Appendix 2: Correlation Coefficients

	CPI
M1	0.422370
NER	-0.711802
RR	0.346487
CPI	1.000000

Appendix 3: VAR Estimation

Vector Autoregression Estimates
Date: 11/17/14 Time: 20:27
Sample (adjusted): 2003M04 2013M09
Included observations: 126 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	CPI	NER	M1	RR
CPI(-1)	1.184993	-0.524974	-1344.657	-0.105577
	(0.08920)	(0.44962)	(2919.72)	(0.06140)
	[13.2854]	[-1.16760]	[-0.46054]	[-1.71953]
CPI(-2)	-0.046458	1.292179	-716.5769	0.206654
	(0.13119)	(0.66131)	(4294.45)	(0.09031)
	[-0.35412]	[1.95396]	[-0.16686]	[2.28833]
CPI(-3)	-0.237685	-0.684850	2402.321	-0.121292
	(0.07353)	(0.37066)	(2406.98)	(0.05062)
	[-3.23242]	[-1.84766]	[0.99807]	[-2.39631]
NER(-1)	0.018191	1.050851	-610.1761	-0.008284
	(0.01805)	(0.09097)	(590.715)	(0.01242)
	[1.00806]	[11.5521]	[-1.03294]	[-0.66688]
NER(-2)	-0.027293	-0.448005	1044.831	0.010969
	(0.02505)	(0.12630)	(820.139)	(0.01725)
	[-1.08934]	[-3.54728]	[1.27397]	[0.63601]
NER(-3)	-0.000791	0.187009	-412.6071	0.005878
	(0.01796)	(0.09051)	(587.767)	(0.01236)
	[-0.04406]	[2.06613]	[-0.70199]	[0.47557]
M1(-1)	3.92E-06	-5.06E-06	0.736097	1.76E-06
	(2.8E-06)	(1.4E-05)	(0.09257)	(1.9E-06)
	[1.38469]	[-0.35464]	[7.95158]	[0.90584]
M1(-2)	-6.88E-06	-7.46E-06	0.065887	2.32E-06
	(3.6E-06)	(1.8E-05)	(0.11728)	(2.5E-06)
	[-1.92092]	[-0.41300]	[0.56178]	[0.93977]
M1(-3)	3.72E-06	-1.55E-06	0.192907	-3.46E-06
	(2.9E-06)	(1.5E-05)	(0.09487)	(2.0E-06)
	[1.28219]	[-0.10626]	[2.03328]	[-1.73569]
RR(-1)	0.745866	-0.936519	3449.005	0.994121
	(0.12359)	(0.62299)	(4045.56)	(0.08507)
	[6.03505]	[-1.50327]	[0.85254]	[11.6854]
RR(-2)	-0.837861	0.395059	-3150.482	0.453390
	(0.18596)	(0.93738)	(6087.15)	(0.12801)
	[-4.50565]	[0.42145]	[-0.51756]	[3.54193]

RR(-3)	0.149146	-0.101876	-2010.754	-0.436723
	(0.14588)	(0.73533)	(4775.10)	(0.10042)
	[1.02242]	[-0.13854]	[-0.42109]	[-4.34916]
C	0.210207	30.25592	22948.16	-1.155460
	(1.57528)	(7.94069)	(51565.3)	(1.08437)
	[0.13344]	[3.81024]	[0.44503]	[-1.06556]
R-squared	0.980282	0.964891	0.995983	0.982793
Adj. R-squared	0.978188	0.961163	0.995557	0.980966
Sum sq. resids	22.68532	576.4258	2.43E+10	10.74925
S.E. equation	0.448057	2.258564	14666.69	0.308425
F-statistic	468.1385	258.7994	2335.033	537.8517
Log likelihood	-70.76873	-274.5818	-1380.686	-23.71518
Akaike AIC	1.329662	4.564791	22.12200	0.582781
Schwarz SC	1.622295	4.857423	22.41463	0.875413
Mean dependent	3.938889	75.91270	704592.2	7.714286
S.D. dependent	3.033756	11.46068	220033.1	2.235557
Determinant resid covariance (dof adj.)		19940911		
Determinant resid covariance		12899610		
Log likelihood		-1746.626		
Akaike information criterion		28.54961		
Schwarz criterion		29.72014		

Appendix 4: LM Test

VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Date: 05/19/14 Time: 22:06

Sample: 2003M01 2013M10

Included observations: 126

Lags	LM-Stat	Prob
1	12.01652	0.7428
2	39.31237	0.0010
3	37.92120	0.0016

Probs from chi-square with 16 df.

Appendix 5: VAR Stability Tests

Roots of Characteristic Polynomial

Endogenous variables: DCPI DM1 DNER DRR

Exogenous variables: C

Lag specification: 1 3

Date: 05/19/14 Time: 07:33

Root	Modulus
0.894528	0.894528
-0.074006 - 0.642197i	0.646447
-0.074006 + 0.642197i	0.646447
0.601486	0.601486
0.556656	0.556656
-0.512313	0.512313
-0.313785 - 0.391014i	0.501351
-0.313785 + 0.391014i	0.501351
-0.333210	0.333210
0.291316	0.291316
-0.135516 - 0.201344i	0.242701
-0.135516 + 0.201344i	0.242701

No root lies outside the unit circle.

VAR satisfies the stability condition.

Appendix 6: AR estimation

Dependent Variable: CPI
Method: Least Squares
Date: 11/29/14 Time: 18:05
Sample (adjusted): 2003M03 2013M10
Included observations: 128 after adjustments
Convergence achieved after 4 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.540313	1.430414	2.475027	0.0147
AR(1)	1.402072	0.079079	17.73012	0.0000
AR(2)	-0.436638	0.077361	-5.644140	0.0000

R-squared	0.968100	Mean dependent var	3.997656
Adjusted R-squared	0.967590	S.D. dependent var	3.059630
S.E. of regression	0.550820	Akaike info criterion	1.668341
Sum squared resid	37.92532	Schwarz criterion	1.735185
Log likelihood	-103.7738	Hannan-Quinn criter.	1.695500
F-statistic	1896.760	Durbin-Watson stat	2.254828
Prob(F-statistic)	0.000000		

Inverted AR Roots	.94	.47