A VAR Analysis of South Africa's Monetary Policy with particular reference to Inflation Targeting Policy.

By

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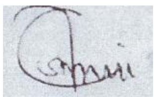
Declaration

I, COMFORT ONI, declare that this dissertation is my original work, save for citation and referencing signify otherwise in the text. The dissertation has not and will not be presented for the award of any degree at any other university.



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Abstract

The aim of this study is to analyze the response of South Africa's key macroeconomic variables to the monetary policy shocks from 1987 to 2009 through the use of variance autoregressive (VAR) technique developed by Sims (1986). The data is analyzed for pre- and post inflation targeting period as the research aims to establish how these macroeconomic variables have responded to the monetary shock under each of the periods. The literature is mixed in regard to the benefits of IT on the South African economy; this study attempted to shed further light on this matter and also explore whether the monetary policy currently used in South Africa is actually the most appropriate policy. Impulse reaction functions (IRF) and variance decomposition in the context of VAR are used to estimate the monetary shocks on the South African economy for the two periods. In addition, cointegration analysis and the vector error correction model (VECM) method was employed in the second phase of the study. The empirical findings from the IRF, variance decomposition as well as cointegration analysis however confirms that the monetary shock has more impact on the nominal variables more than on the real variables.

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List of Acronyms Used

ABRR	–	Assets Based Reserve Ratio
AR	–	(d) d order Autoregressive Model, eg., AR(2) is a Second Order Autoregressive Model
ADF	–	Augmented Dickey Fuller Test
BCB	–	Central Bank of Brazil
CBC	–	Central Bank of Chile
COSATU	–	Congress of South African Trade Unions
CNB	–	Czech National Bank
CPI	–	Consumer Price Index
CPIX	–	underlying CPI that excludes mortgage payments
DF	–	Dickey Fuller
DFGLS	–	DF with Generalized Least Squares Detrending
ECM	–	Error Correction Model (or Mechanism)
ERS	–	Elliot, Rothenberg and Stock Point Optimal Test
ER	–	Excess Reserve
ECB	–	European Central Bank
FAVAR	–	Factor-Augmented Vector Auto Regression Model
FFR	–	Federal Fund Rates
FPE	–	Final Prediction Error
GDP	–	Gross Domestic Products
GMM	–	Generalized method of moments

HPF	–	Hodrick Prescott Filter
HQ	–	Hannan-Quinn Information Criterion
IMF	–	International Monetary Fund
IT	–	Inflation Targeting
ITMPF	–	Inflation Targeting Monetary Policy Framework
LR	–	Likelihood Ratio test
MPC	–	Monetary Policy Committee
MPTM	–	Monetary Policy Transmission Mechanism
M1		Coins and currency; it also includes demand deposits
M2	–	M1 plus short-term time deposits
M3	–	M2 plus large and long-term deposits
NAIRU	–	Non-Accelerating Inflation Rate of Unemployment
OLS	–	Ordinary Least Squares
OMO	–	Open Market Operation
PP	–	Phillips Perron Test
RBCS		Risks based Capital Standard
RBNZ	–	Reserve Bank of New Zealand
SARB	–	South African Reserve Bank
SBC	–	Schwarz Bayesian Criterion
SIC	–	Schwarz Information Criterion
UK	–	United Kingdom
USA	–	United States of America
US	–	United States
VAR	–	Vector Autoregression (model)
VECM	–	Vector Error Correction Model

CHAPTER 1
OVERVIEW OF THE STUDY

1 Introduction

In recent times, the role of monetary policy and the actions of the monetary policy committee have become so important and cannot be taken for granted due to their impact on the economic growth. Different approaches to monetary policy are often debated against one another. Central to this debate are the concerns about how a developing economy such as South Africa meets its growth objectives and addresses the issues of unemployment and economic growth and, at the same time accomplishes a stable macroeconomic environment through price stability. Although, the key function of the monetary policy is to maintain price stability, however this does not mean that the output and economic growth are totally overlooked when making monetary policy decisions. In South Africa, there have been different monetary policy regimes such as liquid asset ratio, mixed system, cash reserve based and daily tenders of liquidity through repurchase. All these systems were faced with one challenge or another. Consequently, South Africa adopted the inflation targeting system in 2000, making the 15th country that adopted inflation targeting.

The main opponent of this system in South Africa is the Congress of South African Trade Unions (COSATU, 1998). In their opinion, the impact of inflation targeting on the economy has been negative and restraining new businesses making the attainment of real economic goals difficult. However, in theory, this should not necessary be the case, as such cut in the level of output and employment are expected to be transitory without long- run consequences. Thus, it is important to ascertain the extent to which inflation targeting policy has affected the key macro economic variables in South Africa in pre and post-inflation targeting periods.

The purpose of this research is to empirically investigate how monetary policy affected the South African economy from 1989 to 2009. The sample is divided into two parts, 1987 to 2000 and 2000 to 2009 respectively. The first part represents the pre-inflation regime while the second part represents post-inflation regime. The two models will be estimated separately; thereafter, the benchmark model which covers the whole period (1987 to 2009) will be estimated to allow for comparison with the two other models. Like most works that have been done in monetary policy analysis, an impulse reaction function (IRF) using unrestricted VAR will be used to estimate the monetary shocks on the economy for the two periods. In addition, cointegration analysis and vector error correction model (VECM) method will be employed in the second phase of the study. The purpose of this is to establish the long - run relationship among the variables. These variables include industrial production, inflation, interest rate, exchange rates and money supply. Its main objective is to estimate the impact of monetary policy on the South African economy in pre and post inflation - targeting era by examining how these variables reacted to monetary policy in the two periods. The work will also attempt to evaluate the impact of monetary policy on the output/inflation variability trade-off. Before the empirical analysis is conducted, the work will first attempt to explain the relevant theories and experiences of other inflation-targeting countries as well as empirical findings in the monetary policy analysis. This will then serve as a basis for examining South Africa's monetary policy and policy prescriptions for the purpose of understanding the South African monetary policy system. It will also assist in choosing the appropriate variables to be used in the analysis chapter.

This area of study has become very important recently especially in those countries that have adopted inflation – targeting monetary policy, South Africa being one of them. This research will compare the impact of monetary policy in pre-inflation targeting and post-inflation targeting period in order to see whether the inflation—targeting policy has contributed positively or negatively to the economic growth of South Africa since its adoption. One of the main critics of inflation- targeting is Stiglitz (2008) who strongly advocated for the abandonment of inflation – targeting with the view that; it brings about a weaker economy and higher unemployment rate and might not necessarily have much impact on inflation but will only make the task of surviving in these conditions more difficult. Also COSATU believes that inflation targeting has been restraining new businesses making the attainment of real economic goals difficult. However, some of the countries that are involved in targeting – inflation policy whether directly or indirectly, have recorded a number achievements and successes from the policy. These countries are Czech Republic, Israel, Brazil, and Chile (Powers, 2005). It is expected that the results of this research will help shed more light on the issues surrounding the inflation-targeting monetary policy in South Africa.

There have been many empirical works on the South African monetary policy framework. However, not too many analyses have been done to compare pre-inflation targeting and post-inflation targeting regimes. The few that were done only considered the short-run relationship among the South African key macroeconomic variables. Such studies include Gupta *et al* (2010), (Kamal, 2010), and Kabundi and Ngwenya (2011). Similar studies outside South Africa include Kim and Roubini (2000), Cheng (2006), Tsangarides (2010).

Holtemoller (2003) found that it is more practical to consider the long run cointegration analysis for the shocks of monetary policy on the macroeconomic variables. For these reasons, this research will attempt to make a contribution to this small body of literature by estimating the unrestricted VAR as well as vector error correction model for the pre-inflation targeting and post inflation targeting periods. Both money supply and short term interest rate will be used separately as a proxy for monetary policy instrument for the pre-inflation targeting period while only short term interest rate will be used as a proxy for monetary policy for the post-inflation targeting period. The reason for this is because, in the pre-inflation targeting period, both monetary base and interest rates were used on different occasions to achieve the monetary policy objective. The monetary base (M2) is chosen in this study as a proxy for monetary base in order to avoid complexity. Only short term interest rate will be used as a proxy for monetary policy in the post- inflation targeting, since monetary policy authority now focus more on the repo rate as a monetary policy instrument which directly reflects the short term interest rate.

The study is divided into six chapters. The purpose of Chapter 2 is to assist in understanding different types of monetary policy regime, as well as the optimal choice of monetary policy, using Poole's analysis of (1970). It will also deal with the theoretical background of the study as well as all relevant theories regarding the monetary policy. Section 2.5 will undertake a brief overview of monetary policy in selected countries, particularly those countries which have adopted inflation targeting policy and have benefited from it one way or another. Furthermore, some empirical evidence of monetary policy transmission mechanism around the world will be explored in the same section. Most of these studies show that the impact of a positive shock of monetary policy on the real macroeconomic variables does not last for long.

Chapter 3 will undertake a review of the South African monetary policy framework. Discussions of the function and objectives of the Reserve Bank including price stability as its main objectives will be discussed in 3.0.1. The chapter will further examine different monetary policy regimes from 1960 till the time of adopting inflation targeting framework in 2000. It will also consider the existing empirical work on the monetary policy in South Africa. The main goal of Chapter 3 is to understand the key monetary policy instruments in South Africa so that relevant explanatory variables may be chosen. Furthermore, it will be used to identify appropriate models that may serve as the bases for quantification in order to better understand the monetary policy process within South African context.

Chapter 4 will be the methodology chapter which serves to outline the statistical techniques and modelling procedures to be followed later. The chapter will be divided into five sections. It is starting with the introduction of the stationarity concept and the relevant integration tests; this will be followed by the discussion of the unrestricted VAR and the necessary identifications. The identification used will be the recursive scheme identification proposed by Sims (1980). The issues of impulse response function and variance decomposition will also be dealt with. The chapter will also deal with the unrestricted VAR model specification and cointegration test, including the error correction mechanism with a brief outline of Johansen’s (1988) VAR approach to cointegration. Lastly, the chapter will set out the VECM model for the South African economy. In addition, the motivation for the choice of variables to enter these models based on the theoretical and practical considerations will be explained in detail.

Chapter 5 gives detailed explanations of the various stages of the estimation procedure. This includes stationarity tests for all the variables, differencing of variables, choice of lag order, identifications, VAR order deterministic components selection procedures, identification and estimations of VAR. Identification and estimation of cointegrating vectors as well as restricted model for the purpose of cointegration is dealt with.

Chapter 6 concludes the study by summarizing the quantitative investigation, discussing the overall significance of the results and its relevance to macroeconomic policy prescriptions and recommendation. It also goes further to indicate strengths and the main weaknesses of this study with suggestions for further research.

CHAPTER 2

MONETARY POLICY THEORY

2 Introduction

This chapter focuses on the theoretical framework of monetary policy. All relevant theories that explain different approaches to monetary policy are discussed in detail. Section 2.0.1 covers the definition of monetary policy and its effect on the level of output and employment. In the past, monetarists have strongly advocated the eclectic system of monetary policy, while the Keynesians believe in the use of interest rates to influence monetary policy through aggregate demand. Accordingly, there is a need to consider an optimal choice of monetary policy rules. Section 2.0.2 deals with these operating rules as well as the choice of problems within monetary policy framework. In connection with this, Poole's (1970) was explored in detail to understand when the use of different monetary policy instruments is appropriate. His analysis was done in the context of the IS-LM framework where both commodity and monetary sectors were subjected to exogenous random shocks. The approach suggests how different types of disturbance in the economy would determine the optimal instrument.

In recent years, a number of countries across the globe have based their monetary policy on an explicit inflation targeting. Section 2.0.3 therefore focuses on the qualitative overview of inflation targeting in Post- Keynesian period. It explores how inflation targeting under Post Keynesians is set using MURI approach. The traditional Phillip's curve shows that there is a permanent trade-off between the rate of inflation and the level of output. A general consensus is that the trade-off only occurs in the short run. However, in understanding this concept, theories such as Taylor (1979), Okun's law (1962), and natural rate of unemployment are explored in detail. Section 2.0.4 explains inflation targeting under orthodox monetary policy which is still seen as an extension of the NAIRU. 2.0.5 Gives an overview of some inflation targeting countries such as Czech Republic, United Kingdom, Brazil and Chile.

The purpose of this section is to show the reasons why these countries have shifted to inflation targeting and also shows how these countries' monetary policy has greatly improved under an inflation targeting approach. In section 2.0.6, the problem of asset price and debt bubbles in inflation targeting is explained while section 2.0.7 discusses in detail, the monetary transmission mechanism, which shows different channel through which the monetary policy influences the economy. The purpose of this section is to assist in explaining how monetary policy works in the South African context and to also select the most suitable variables that will be used for analysis in the later chapters. These channels include bank rates, interest rates, monetary aggregates and exchange rates. Section 2.0.8 covers orthodox monetary target approach as an alternative monetary policy, although more and more countries are moving away from this type of system, but it is still of significance in the Euro area, as monetary supply still plays a major role in their economy.

Lastly, the role of credibility in monetary policy, as well as few empirical findings in both developed and developing nations in the last ten years is looked into in order to fully understand the monetary policy framework of South Africa. The focus will be on those countries which have adopted inflation targeting and also on those studies that employed (VAR) approach which is an approach that is used in this study.

2.0.0. Definition of Monetary Policy

Monetary policy refers to the policy instruments used by the monetary authorities to regulate the money supply and to control the level of interest rates in the economy which, in turn, affect the national income (Haydam 2002 :333). A broader definition of monetary policy covers all actions by the monetary authorities, to control the money supply aggregates, including availability of credit, interest rates and exchange rates, with a view to affect money demand, income, output, prices and the balance of payments. The main objective of any monetary policy is to maintain price stability with the view that benefits from low inflation are large, permanent and the related unemployment costs are smaller and momentary. According to Fortin (2003), most, if not all, central bankers believe that they can raise the level or growth rate of real income by achieving price stability in spite of the associated loss of unemployment that comes, initially with low inflation rate. It can, however, be said that the role of monetary policy in influencing the economy is as important as that of fiscal policy.

The approach of central bankers to monetary policy largely depends on whether monetary authority is looking at things from the monetarists' point of view or the Keynesian point of view. Under the monetarism approach, the focus is on the quantity of money which could only vary the price level but has a neutral effect on the level of output in the long run. Equation 2.1 shows that the price level is dependent on the quantity of money available in the economy.

$$\frac{dp}{dt} \equiv \frac{dM}{dt} \tag{2.1}$$

The core argument of the monetary economists as pioneered by Nobel laureate Milton Friedman is that money supply should be used as the sole monetary policy on the grounds that money supply growth is the key determinant of inflation. High inflation rate is known to be associated with the excess money in the economy and also deflation is associated with too little money in the economy. The assumption here is that money supply is exogenously controlled by the monetary authorities plus that the velocity of circulation is constant and the economy is at full employment. As a result, if there is a high rate of inflation which means there is excess supply of money in circulation, the monetary policy will focus on reducing the money supply by using instruments like open market operations through sales of domestic financial assets.

On the other hand, if there is a limited money supply in the circulation, there will be deflation; the monetary authority will have to raise the level of money supply through purchase of domestic financial assets. The belief here is that the monetary authority is in total control of money supply in the economy, an assumption which has been greatly criticized and the focus is now more on the form of monetary policy which operates through interest rates.

The core element of Keynes' theory is aggregate demand, which states that money is endogenously created by the level of aggregate demand in the economy and that central banks are not in total control of money supply. Nevertheless, the central banks could influence the quantity of money in the economy via interest rates. As seen in equation 2.2, output gap is totally dependent on the level of interest rate and other variables that could influence the aggregate demand (AD). Equation 2.3 indicates that, in order to achieve price stability, it is important that the price level only change in relation to the changes in aggregate demand (AD) and the level of production in the economy.

$$Y - Y^* = \mathrm{h}\,(\mathrm{r}, \mathrm{X}) \tag{2.2}$$

$$\frac{dp}{dt} - \left(\frac{dp}{dt}\right)^* = (Y - Y^*) \tag{2.3}$$

Where Y is the initial output, Y^* is the actual output, r is the interest rate and X represents other variables that could influence the aggregate demand.

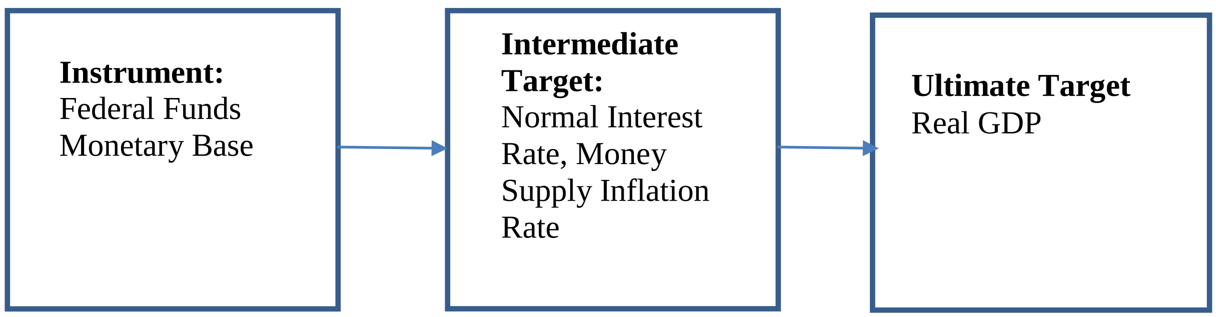
High interest rates is believed to curb spending, choke new investments and discourage the new investors from establishing new businesses, and also that the already existing businesses will have a tough time expanding their production resulting in low levels of output/employment. Most central banks in their defence for raising interest rates claim that such cut in the output/employment only happens at the short run that in the long run the employment will go back to its baseline.

2.0.2.1. Operating Rules of Monetary policy

"The actual implementation of monetary policy involves a variety of rules, traditions, and practices, and these collectively are called operating procedures (Walsh 2003:429)". Operating procedures usually differ according to the actual instrument that is being employed by the central bank in its daily conduct of policy, the operating target whose control is achieved over short horizons i.e., short term interest rates or reserve aggregates. Implementation of monetary policy includes the conditions under which the instruments and operating targets are automatically adjusted in the light of economic developments, and its choice of variables for which it plans to establish its target. For example, the ultimate target of monetary policy is to maintain price stability in order to achieve a high level of real GDP. To achieve this ultimate target, it must decide on which intermediate target to employ i.e., money supply, the nominal interest rates or inflation targeting as its instrument. This process can be illustrated below:

Figure 2.1

Choice of Problem



Source: (Palley, 2006:83).

The monetary policy instruments are those variables that are directly controlled by the central banks. This includes the repurchase rates that are charged on the reserve borrowed by the commercial banks which is later reflected in the short term rates. Also the reserve requirement ratios that determines the level which reserve banks must hold against their deposit liabilities, and the composition of the central banks' own balance sheet (Walsh 2003 :430). Central banks have a way of influencing these instruments such that a pre-specified value of an operating target will be attained. Examples of this operating target are total reserves, borrowed reserves or non- borrowed reserves, and short term interest rates.

Intermediate target variables usually fall between operating targets and the ultimate goals in succession of the links that run from policy instruments to real economic activity and inflation. Most of the time the variables used to measure the ultimate goals i.e., GDP are less frequent than variables such as interest rates, exchange rates and monetary aggregates. The policy makers often make use of these intermediate instruments to make economic decisions. For example, an expansionary money supply indicates that the real output is expanding more rapidly than was previously thought. Consequently, the central bank can decide to tighten the money market to a point believed to be consistent with achieving its ultimate goals. Under this circumstance, money growth serves as an intermediate target variable.

Other examples of intermediate target instruments include the exchange rate where central banks use the nominal exchange rate as an anchor to bring down the rate of inflation. Such system is likened to a fixed exchange rate regime where governments maintain constant values of their currencies against one another. In recent times such system has been abandoned for a more flexible exchange rate regime. Under a flexible exchange rate regime, the exchange rate does not play a direct role in the monetary policy, but it is often used along with the inflation targeting to bring down the level of inflation. An example of the country that has used exchange rate targeting as an intermediate target of the monetary policy is Turkey.

2.0.2.2. Choice of Problem

The Poole analysis (1970) is the most widely used analysis on how a central bank should choose between employing interest rates or money aggregate as its policy tool. The analysis was done in the context of the IS-LM framework where both commodity and monetary sectors were subjected to exogenous random shocks. The approach showed how the stochastic structure of the economy, i.e., the nature and relative importance of different types of disturbance would determine the optimal instrument. The idea was to present under which conditions interest rate policy was to be preferred to a monetary aggregate. Assuming Q_m is the standard deviation of disturbance in the monetary sector and Q_u is the standard deviations of the disturbance in the commodity sector, and B_1 is the income elasticity of demand for money, a sufficient condition for a monetary targeting regime to be superior to interest rate targeting regime is $\frac{Q_m}{Q_u} < B_1$, (Poole, 1970) as quoted by Fontana and Palacio-Vera (2004)

Under Poole's approach, the choice of the monetary policy instrument largely depends on the value of Q_m and Q_u, the structural parameters of the model determining the slopes of IS and Lm functions and covariance of disturbances in the commodity and monetary sector i.e., the values of the behavioural parameters of the model, and the covariance of shocks. A larger variance of disturbances in the commodity sector makes the money sector to be preferred over the commodity sector and vice versa. Also, if the IS is highly variable and the LM is not, the monetary authority should target the money supply to minimize temporary deviations from the equilibrium. On the other hand, if the IS is fixed, and the LM is highly variable, the monetary authority should focus on the interest rate targeting to insulate the real economy and minimize temporary deviations of output (Palley, 2006 :84).

There are shortcomings associated with Poole's approach. Firstly, he did not take into consideration the interdependence between the commodity market and the money market. The increased ability of banks to avert central bank-imposed reserve constraints has led to the view that, under the current institutional framework, the central bank can only affect the money supply growth indirectly through variations in short-term nominal interest rates. In essence, the money is used by the public either as a means of payment or as a liquid store of value representing the liability of private depository institutions. Although central banks have a certain amount of control over the lending activities of commercial banks, they can not entirely fix the stock of money in the economy. As a result, money supply is set by the economic process that involves the income and portfolio decisions of banks and non bank sectors. This situation is known as a process where money is endogenously created. However, this illustration is contrary to Poole's approach because he assumed that the money is exogenously controlled by the apex bank.

Another shortcoming of Poole's approach as noted by Fontana and Palacio(2004) is that, the standard deviations of shocks in the monetary sector (Qm) and covariance of shocks in the commodity and monetary sectors are assumed to be exogenous and independent of monetary policy regime. This is not necessarily true as these parameters are likely to be the functions of the monetary policy regime adopted by the central banks. It can be argued that the implementation of monetary-targeting will raise Qm and vary the covariance terms in such a way to shift the balance in favour of an interest rate targeting regime. Thus, the choice of a monetary targeting regime under this circumstance is likely to be self defeating.

2.0.3. Post Keynesian Framework for Inflation Targeting.

The traditional Keynesian Phillips curve theory shows there is a permanent trade-off between unemployment and inflation. A higher unemployment rate implies a lower wage inflation rate, that is, there is a trade-off between wage inflation and money wage. Thus the rate of wage inflation is defined as:

$$Zw = (W - W_{t-1})/W_{t-1}, \qquad (2.4)$$

Where W is money wage in this period, and W_{t-1} is a one period lag of money wage. If X* stands for the natural rate of unemployment, the traditional Phillips curve may be written as: $Zw = \wp(X-X^*)$, (2.5)

Where $\wp$ measures the responsiveness of wages to unemployment. The equation indicates a fall in the wages, when the unemployment rate exceeds the natural rate, i.e. when Y > Y* and vice versa. This often guides the policy makers in providing a lasting solution to unemployment at the expense of higher inflation rate. However, the Phillips curve may be backward bending if the workers are rational about their decision to ignore inflation at a very low inflation rate. Also the workers in the depressed industries and firms might be willing to accept induced real wage reduction in order to reduce unemployment. But they can only do this, so long as the reductions are not too severe and once inflation rises above the threshold level, workers will resist real wage cut, causing inflation to lose its labour market grease effect (Palley, 2006:90).

Figure 2.2. Backward Bending Phillip Curve

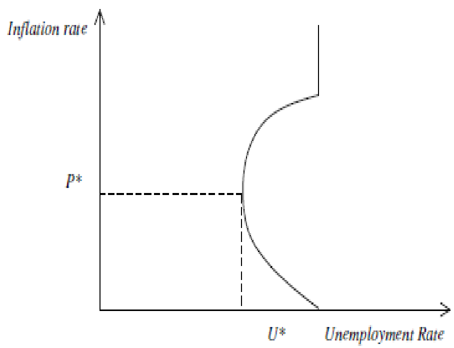


Figure 2.1 is the backward bending Phillip curve which shows the minimum unemployment rate of inflation (MURI) denoted by P* associated with an unemployment rate U*. Post Keynesians believed that the monetary authority should set MURI as its inflation target and interest rate policy should be set to hit this target. If inflation is below the MURI, an increase in inflation will lower the equilibrium unemployment rate, and vice versa. Inflation is, therefore, an adjustment mechanism that can be calibrated optimally to minimize unemployment (Palley, 2006:90). This is not the case under NAIRU approach as, if inflation is increasing, it indicates that the economy is over-heating (below NAIRU) and therefore the monetary authority should tighten money supply. MURI target should, therefore, guide the inflation targeting. However, such target is recommended to be forward looking, and capable of adjusting to temporary supply side shocks.

2.0.3.1. Inflation Output/trade-off variability

In the 1950s and 1960s, economists had thought they could permanently bring down the rate of unemployment by adjusting inflation rates, using the so called Phillip curve. In recent times, the focus has been shifted to a short run unemployment/output trade-off. From the 1970s, economists began to see the trade-off between unemployment rate and inflation from a new perspective. Even though there was scientific support that there existed a trade-off between unemployment and inflation, the new consensus is that this only happens in the short-run. In view of these short term impacts, Chatterjee (2002) suggested that the monetary authorities should refrain from exploiting the temporary trade-off between inflation and unemployment and carry out monetary policy with some desired long-term inflation target in mind.

2.0.3.2. Natural rate of unemployment

The theory of natural rate of employment focuses on the factors that determine the unemployment rate in the economy; it includes fundamental and non fundamental factors. Fundamental factors are those that change slowly over time. These are demography, technology, law and regulations and other social factors. All of these factors are the key determinants of unemployment rate. Non-fundamental factor are those factors responsible for high rate of inflation including those factors that can cause the unemployment rate to deviate from its natural rate. This non-fundamental link can be explained as follows: When people take up an employment, they enter into a contractual agreement with their employers to supply as many hours of work as demanded within reasonable limits at an agreed wage rate. This wage rate reflects the expected rate of inflation which workers expect over the term of their contract and, if inflation turns out to be the way they expected, employers demand and workers supply the normal level of work hours. This way the overall unemployment rate is close to the natural rate.

However, if the inflation rate is higher than anticipated, the employers will demand more hour of labour in order to produce more output so that they can capture the benefit of increase in the price of goods in the good market, while the wage they pay to their workers still remains the same. As a result, the demand for labour will increase and the unemployment rate will fall below the natural rate of unemployment. On the other hand, if the rate of inflation is below the expectation, it means there is a fall in the price level and the prices of their product will be below what is expected while the wages of the workers still remain the same. Consequently, the employers will begin to layoff their workers and this will raise the unemployment rate in the economy.

The people who advocated the natural rate of unemployment believed that when the monetary authority expands the supply of money unexpectedly, the aggregate demand for goods and services will rise faster than aggregate supply and, as a result, actual inflation rises faster above the expected inflation. This will in turn motivate all the firms to utilize all available factors of production to produce more output. This increase in the utilization of resources will eventually lead to a decline in the unemployment rate. Conversely, when the monetary authority decides to reduce the aggregate money supply in the economy, aggregate demand will fall below the aggregate supply. This excess supply will then lead to actual inflation to fall below the expected inflation. The situation will discourage firms from using the resources and factors of production since the actual price will be lower than the expected price. Consequently, the unemployment will begin to rise above the natural rate of unemployment.

The core argument of the natural rate of the unemployment theory is that the monetary authority may initially succeed in creating a higher than expected inflation and get the unemployment rate below the natural rate. “But eventually people will catch on to the fact that the monetary authority is generating more than the expected amount of inflation, and employment contracts will begin to take the new higher inflation rate into consideration (Chatterjee, 2002). Once that difference between actual and expected inflation fades away, the unemployment rate will rise again back to its original state. “Thus, unless the inflation rate is continuously different from what people expect, the unemployment rate will return to the natural rate (Chatterjee, 2002)". The implication of this theory is that, for the monetary authority to be able to keep the rate of inflation permanently below the natural level, it must continuously stay ahead of people's expectation of rising inflation by generating more and more inflation rate.

2.0.3.3. Taylor Rule

Taylor's (1979) theory refers to the permanent trade-off between short run variabilities of inflation and unemployment. Taylor is also of the opinion that there exists an inverse relationship between unemployment and inflation; however, his focus is on the variability of inflation and variability of unemployment. Taylor recognized that there are other non-fundamental factors besides unpredictable changes in monetary policy that could lead to deviation of actual unemployment rate from the natural employment rate. For example, if consumers become unduly pessimistic about the prospect of their future income, they can decide to cut down their spending which could lead to a situation where the aggregate supply will be greater than aggregate demand at prices which firms expected to prevail. Consequently, the downward pressure on prices will lead to a fall in actual inflation below the expected inflation. The utilization of factors of production will also fall which will in turn create unemployment in the economy.

In contrast, if consumers suddenly become optimistic about the future prospect of their income, they will increase their spending, and this will raise the price of goods in the goods market. As a result, producers will utilize more factors of production, and employ more workers in order to supply more goods to meet the increase demand. This situation will lead to creating more job opportunities and a fall in the level of unemployment rate in the economy. The main idea in Taylor's work is the degree to which policy makers can choose the monetary policy to safeguard unemployment against non-fundamental disturbances. For example, in a situation where people become unduly pessimistic towards the expected future income and decide to slow down their spending, there will be a negative impact on employment and the level of output. The monetary authority can expand money supply in the economy in order to correct such deflationary shock.

The monetary authority can also reduce monetary supply to correct the negative unemployment effect of the inflationary shock. In this way, the monetary authority will be acting to offset variability in unemployment caused by a discrepancy between the actual inflation and expected inflation. It can be said that the Taylor theory is consistent with the natural rate of unemployment; under natural rate of unemployment, the monetary authority seeks to bring back unemployment rate caused by non- fundamental factors to the natural rate. Also, under Taylor theory, the monetary authority seeks to offset variabilites in unemployment caused by discrepancies between actual and expected inflation.

Like in the Phillip's curve, a reduction in the variability of unemployment can only be achieved at the expense of more variability in inflation rate under Taylor's theory. This trade-off can be explained as follows: if there is a sudden rise in inflation rate more than expected due to some unforeseen circumstances, this inflation will be much higher in the future. The monetary authority can only correct for this variability in inflation by tightening the monetary sector more than what would have been necessary to keep the unemployment at the natural rate. This additional monetary contraction will raise unemployment above the natural rate and result in more variability of unemployment. Here, a lower variability of inflation is achieved at the expense of more variability in unemployment. In addition, "the more quickly the monetary authority aims to bring inflation rate back down to the pre-shock level, the more variability it will inflict on the unemployment rate (Chatterjee, 2002)". There are two elements that are necessary for such a trade-off to exist. Firstly, there must be disturbances aside the erratic monetary policy actions that cause the actual inflation rate to deviate from the expected inflation rate. Secondly, any change in the inflation rate must tend to be persistent; it is this persistence nature that will lead to a situation where the variability of the inflation rate can be lowered only at the expense of a greater variability in the employment rate.

2.0.3.4. Eckstein- Brinner and Partial Ignorance of Inflation

Eckstein and Brinner (1972) postulated that low inflation is partially ignored by wage and price setters. The assumption was that, if inflation rose from less than 2 percent to greater than 5 percent, workers showed increased awareness and concern with real wage as opposed to nominal wage; so past inflation became incorporated more fully into nominal wage. The argument is that it is near rational for the price setter to ignore the cost of wage inflation, the reason being that, even if the nominal wage is set higher in absolute terms, it will be lower relative to prices when the rate of inflation is positive than they will be when the inflation is zero. Consequently, operating an economy at a low positive rate of inflation will increase the permanent levels of output and employment. Given that, there is a decline in the average wages to prices, it will enable firms to employ more workers and produce more output at a profitable rate in the long run. Also, unemployed workers who were previously without jobs will be able to join the workforce. "Naturally, when inflation increases, as occurred in the 1970s, the cost of being less than perfectly rational will rise, and people will switch their behaviour to take inflation fully into account (Fortin, 2003)". That is, as the behaviour of the wage setters becomes more and more rational, the initial output and employment gains begin to disappear. The implication of this is that further increases in permanent inflation will reduce employment and output permanently. The important note in this theory is that there is an unemployment minimizing inflation rate where permanent output and employment cease to increase and begin to fall.

2.0.3.5. Tobin and Downward Nominal wage Rigidity

Tobin's (1972) analysis is contrary to the previous models above, He explained the effect of downward nominal wage rigidity in an economy in which individual firms keep experiencing unanticipated changes in the demand for their output. As the central bank tries to achieve lower and lower inflation, the percentage of workers refusing to accept the prospect of a nominal wage cut at any point in time increases. Firms are also hesitant to impose absolute wage cuts for fear of losing their best employees and suffering a drop in labour productivity. This general resistance to lower money wages means that the authorities can achieve lower inflation by imposing a permanently stronger dose of unemployment on the rest of the economy.

Under such circumstances, a moderate to high inflation rate with nominal wage constraints would have to be faced, and the long run inflation-unemployment trade-off will be vertical at the traditional unique NAIRU level. But it will become negatively sloped, convex and eventually flat at low inflation rates. “Maintaining price stability or very low rates of inflation in the presence of even a small amount of downward nominal wage rigidity will generate significant permanent losses in employment and output (Fortin, 2003)”.

2.0.3.6. Okun’s Law

Okun (1960) postulated in his original work that there is a negative correlation between output growth and unemployment over time. There are different types of relationships which are referred to as Okun’s law. Firstly, there is difference version of Okun’s law that showed how changes in the unemployment rate from one quarter to the next moved along with the quarterly growth in the real output. This can be represented by the equation below:

$$\Delta \text{ Unemployment rate} = a + b^*(\text{real output growth}) \qquad (2.6)$$

Equation (2.6) captures how output growth varies simultaneously with changes in the unemployment. The parameter (b) is known as Okun’s coefficient. It is expected that Okun’s coefficient (b) is negative such that the rapid growth of output will be associated with a fall in the level of unemployment, and vice versa. Okun’s coefficient also implies that each percentage change in the real output growth is accompanied by a fall in the unemployment rate of (b*) percentage. “(The ratio (–a/b), gives the rate of output growth consistent with a stable unemployment rate or how quickly the economy would typically need to grow to maintain a given level of unemployment (Knotek, II 2007)”. The next relationship is called gap version; here, the focus is on the relationship between the level of unemployment and the output gap (Actual output – Potential output). Okun believed that, when there is high rate of unemployment, it means the resources are not well utilized, in order words; the resources in the economy are idle. Consequently, the actual rate of output will fall below the potential output and vice versa. The Okun gap relationship is shown in equation 2.7.

Unemployment = c + d* (Actual output growth – Potential output growth) ,   (2.7).

Where (c) stands for unemployment at the full employment rate and (d) stands for Okun's gap coefficient. However, as noted by Knotek II, (2007), the problem with full employment and potential output is that, none of these variables are directly observable. Also another problem is the simplicity of the equation itself which could be problematic.

The next relationship is the dynamic version. Dynamic version of Okun's law is an extension of the difference version. One of the arguments of Okun's theory is that, both current and past levels of output can have an impact on the current levels of unemployment. However, considering this ideology, it means that some vital variables could have been omitted from the right hand side of equation (2.6). Due to this omission, a dynamic version has been incorporated which is an extension of difference version that takes into consideration both contemporaneous and past effects of the output and also the past values of unemployment on the current level of unemployment.

The last relationship is the production function version. Another flaw of Okun's law is that, unemployment is assumed to be a proxy for all other forms of idleness of resources in the economy. There are three factors of production which include; labour, capital and technology. Unemployment is just one factor in determining the total amount of labour being used as an input. Other factors include population, fraction of the population that is in the labour force and the number of hours put in by the workers. These production function versions approach combine a theoretical production function which includes all other factors, such as capital and technology in which output are produced. This therefore ensures that all other economic idle resources are assessed. The major setback in this approach is that inputs such as capital and technology are difficult to measure.

The Okun's theory implies that, if there is relatively high level of output growth, it means there is a low level of unemployment which could result in a high rate of inflation. Based on the theories that have been explained previously, a moderate level of inflation rate can only be achieved by giving up a certain amount of employment/output. However, such cut in the level of output is expected to last for a short period of time.

2.0.4. Orthodoxy's Inflation Targeting.

Orthodox economists are known for their non-accelerating inflation rate of unemployment (NAIRU) which has been advocated for many years. The NAIRU is the rate of unemployment at which there is neither upward pressure nor downward pressure on inflation. For example, if the current unemployment rate is below some NAIRU estimate (say, 5 percent), then the Central Bank should tighten monetary policy to head off a coming increase in the inflation (Marco *et al.,* 1997). Such pressure comes from customers taking advantage of the market power given them by excess capacity, and from firms using the market power provided by high unemployment to try to decrease the rate of wage growth. The orthodox economists realized there is a need to shift away from such approach and now coming to terms with inflation targeting, but their own type of inflation targeting is very much rooted within the NAIRU . Many empirical studies have proven that the use of NAIRU is extremely volatile in nature, persuading many countries to gradually withdraw from the practice.

One of the reasons for Orthodox economists advocating inflation targeting is the level of success being achieved by the countries that have practiced inflation targeting. A second justification is that, inflation targeting represents a shift away from quantity - driven policy to price based policy which is easier and more efficient to implement. Within the NAIRU framework, inflation is regarded as a summary statistics of condition of economy (Palley, 2006: 87). i.e., if inflation is increasing, it indicates excess demand and if inflation is falling, it shows that there is an excess supply condition. Inflation is, therefore, a valuable indicator for policy under the NAIRU approach.

The third justification is based on the game - theory versus discretion approach. The game-theory is compatible with the NAIRU model of the real economy, whereby monetary policy does not have any effect on the equilibrium rate of unemployment. It also represents monetary policy in terms of non-cooperative game between the monetary authority and the public at large. However, in spite of this non – cooperative game theory, the monetary authority can still influence the welfare of the society through an increase in the variability of inflation. Secondly, the monetary authority can impact welfare and real outcome if inflation enters as a negative argument in the agent's utility functions (Palley, 2006: 88). Based on this argument, the rule approach implies an adoption of transparent, credible monetary institutions and policy arrangements that serve to discourage the monetary authority from adopting high variable and uncertain inflation. Hence there was a need for such approach as inflation targeting.

A major flaw with the Orthodox inflation targeting is that it is still well rooted within the NAIRU framework. Though, the Orthodox school may have rejected NAIRU as a policy instrument, it still remained attached with the NAIRU theoretical concept. According to Palley, this attachment has an important implication in the sense that the Orthodox school can provide no guidance on what inflation targeting should be under such circumstances. This implies that, inflation is irrelevant as it has no real effects. And, what is important is the rate of change in the inflation. As a result, policy makers should ignore inflation and focus on the change in inflation which is the true indicator of whether there is excess demand or supply under the NAIRU framework.

Furthermore, the Orthodox model suggests that, if there is a cost associated with low inflation, the inflation target should be the current inflation rate and that, if there are disutility costs to inflation, the target should be zero inflation. The Orthodox inflation targeting is actually in line with the Keynesian inflation targeting of maintaining a low inflation rate but it is not capable of justifying this policy recommendation in terms of its own theoretical framework. “This suggests that either their policy recommendation is wrong or their framework is wrong” (Palley, 2006: 89).

Post Keynesians on the other hand see inflation targeting as a form of interest rate policy. The basic guide for the post Keynesians interest rate policy can be explained as follows: full employment should be seen as one of the objectives of the inflation targeting and also that the interest rate should aim at minimizing output gap i.e., (the difference between the potential output and the actual output). It is also important that the interest rate should be targeted on potential output growth. However, the latter guide is an unobservable variable, it also carries the risk that if the economy is initially below full employment, targeting the potential growth rate will result in a permanent future of less than full employment (Palley, 2006:89), since the economy might have never grown fast enough to soak up currently unemployed resources in the economy.

2.0.5. Overview of Monetary Policy in the Inflation Targeting Countries

This section looks at the state of monetary policy framework in some of the countries that have adopted inflation targeting. The focus is on Chile, Brazil, United Kingdom and the Czech Republic. The purpose is to show the reason why these countries have opted for inflation targeting and also, to show how the monetary policy of these countries has greatly improved since the adoption of inflation targeting. The summary is shown in the Table 2.1.

Table 2.1

Inflation Targeting in Selected Countries

Countries	**Chile**	**Brazil**	**United Kingdom**	**Czech Republic**
Current Monetary Policy	Inflation Target (IT)	Inflation Target (IT)	Inflation Target (IT)	Inflation Target (IT)
Inflation Target	2–4%	4.5 %	2%	2%
Target Announcement	Central bank of Chile in consultation with the government	Set by National Monetary Council composed by finance minister, planning minister and Central Bank president	Central bank of United Kingdom	Czech national bank (CNB)
Commencement Date	September 1990	June 1999	January 2004	January 1998
Monetary Policy Objective	Price stability, functioning payment system	Price stability, sound financial system	Price stability and low inflation to support the Government's economic objectives including those for growth and employment.	Maintaining price stability
Other feature	The (CBC)'s Press releases of its monthly monetary policy meeting provide explanation of unforeseen events	Letter from The governor to the minister of finance if the target has been breached	If the target is missed by more than 1 percentage, the Governor of the Bank must write an open letter to the Chancellor explaining the reasons why the target is breached and what the Bank proposes to do to ensure inflation comes back to the target	Escape clause, should there be any deviation from the original inflation target
Inflation Measure	The underlying CPI (the total index excluding fruits, vegetables, and fuels) maintained by the National Statistics Bureau (INE).	Broad consumer price index (IPCA)	Annual rate of inflation based on consumer price index (CPI).	Headline consumer price index (CPI)
Operating target	Real Overnight interbank rate	Overnight interbank rate (SELIC)	Interest rates	
Instrument	OMO	OMO	OMO	

Sources: Bean (2003), Czech National Bank (2000) and Central Bank of Brazil website.

2.0.5.1 Inflation Targeting in Chile

Prior to the time of adopting the IT approach in Chile, its monetary policy framework was characterized by lack of clarity with respect to the objective of monetary policy, incapacity to control fiscal deficit, and inconsistency across foreign exchange, fiscal and monetary policies (Corbo, 2007). This put the central bank in a difficult position in achieving its price stability. From the early 1990s, the central bank shifted its focus to inflation targeting (IT) combined with floating exchange rate, a solvent fiscal sector and a solid financial system. The focus of the policy change was to adjust the interest rates to achieve the target inflation in the price horizon. There are three main channels in which this approach influence the economy, firstly through inflation expectations, secondly through interest rate and financial assets prices and lastly through monetary aggregates and credit trends.

The inflation targeting in Chile came in two-folds. Between (1991) and (1999), there was a partial inflation targeting followed by the annual announcements of CPI inflation targets in September of each year, which usually covers from December to Decemb+er. During these periods the targets were lowered by 1.5 percent points per year on average and inflation performance improved strongly with annual inflation falling from 20 to 30 percent. However, the independence and effectiveness of monetary policy were hampered due to conflicts between exchange rate band commitment, annual inflation targets and capital controls. Consequently there was a need for transition to a fully fledge inflation targeting approach which came in force in 2000 marking the second phase of the inflation targeting in Chile. In the second phase, the focus was now solely on inflation as well as active communication strategy. Between 2000 and 2006, the inflation target range was between 2-4% with monetary policy horizon at 12 to 24 months. From 2007, the target changed to around 3%, with a symmetric tolerance range of one percentage point. Chile’s ability to maintain its inflation target most of the time around 3% with a tolerance range of +/-1% has been successful since its adoption of IT policy. In addition, inflation expectations have been well anchored around the inflation target, but most importantly, there has been low output and inflation variability which has led to macroeconomic stability in Chile.

2.0.5.2 Inflation Targeting in Brazil

Brazil has witnessed a lot of changes in its monetary policy operational procedure since the *real* plan monetary policy rule that was practiced previously, the main objective of this policy rule is to focus on achieving price stability as well as maintaining it. In July 1994, quarterly targets for the monetary aggregates were introduced to build-up confidence that there will be no inflationary financing of the government deficit. Throughout this period, curb in private spending was witnessed together with constraint in credit expansion due to 100% marginal reserve requirements. Thereafter restraints were placed on various forms and maturities of credit operations.

During these periods, the *real* plan approach successfully led to a drastic reduction in the inflation. However, the *real* plan approach was characterized by failure of the Brazilian government to implement much needed fiscal policy reform. This generated a lot of concerns about the fiscal balance, and *real* plan came under speculative attack at the end of 1998 and eventually collapsed in January 1999. Also, there was much pressure on foreign exchange reserves, which forced the BCB to abandon the crawling peg to the dollar. Furthermore, there was a brief attempt to conduct a controlled devaluation; the *real* plan was then left to float in January 15. Consequently, the BCB acknowledged the need to put in place a nominal anchor and introduced an inflation targeting regime on 21 June, 1999, with the inflation target of 4.5% set by the monetary council composed of the finance minister, planning minister and central bank president.

Although, inflation targeting in Brazil has been faced with major challenges such as energy crisis, administered prices, and depreciating exchange rates. The authorities have therefore reacted with significant foreign exchange intervention to prevent vulnerabilities to further shocks resulted from tightening the monetary policy in October 2002. Consequently the Net International Reserves (NIR) have declined by US$ 13 billion.

Amidst these challenges, studies showed that the inflation-targeting mechanism has played a key role in macroeconomic stabilization in Brazil. Also the inflation has been maintained on a low level. Other achievements as noted by Kamal include sharp drop in external debt spread, a reduction in the debt to GDP ratio and an expected recovery of growth.

2.0.5.3 Inflation Targeting in the United Kingdom

Like most central banks, the main objective of the central bank of the United Kingdom was to maintain price stability and low inflation to support the Government's economic objectives including those for growth and employment (Bean, 2003). In the 1970s, there was not much role given to the monetary policy in the United Kingdom, due to Keynesian precept of fiscal policy using interest rates to stabilize the macro economy. Low interest rates were used to encourage investment and credit controls were employed to restrain consumer borrowing. If excess demand pressures showed signs of spilling over into higher inflation and a deteriorating balance of payments, then incomes rather than monetary policy was the chosen tool to keep those pressures in check (Bean, 2003). Also, if they turned out to be unsuccessful, alternative options would be made rather than devaluation of currency in order to restore competitiveness.

During these periods there was a floating exchange rate system which removed balance of payments constraints, but there was increased tendency towards higher inflation in the face of excess aggregate demand. Consequently there was a growing awareness of the importance of monetary control in the management of aggregate demand. This led to adoption of monetary targets in the 70s, but the system failed on an account of unpredictable movements in the velocity of money in the circulation. Thereafter, there was a shift to a flexible exchange rate regime in the 80s. This regime permitted lower interest rates with the prevalence of flexible-rate mortgages while still restraining inflationary pressures. However, the risk associated with this approach became glaring when the economy subsequently slowed sharply at exactly the same time as the pressures of German re-unification were pushing European interest rates upwards (Bean, 2003).

Following a tight policy in order to maintain the exchange rate peg and the desire to limit the domestic slump by lowering interest rates became so great that the government's policy ceased to be credible. Consequently there was a speculative attack on sterling and the decision to quit the exchange rate targeting on 16 September 1992, hence an urgent need for a new monetary policy. The United Kingdom became one of the early inflation targeters in the aftermath of sterling's exit from the exchange rate mechanism (ERM) in September 1992. Since then, it has recorded a number of successes. According to Bean (2003), inflation in the United Kingdom has been both low and remarkably stable compared to its past inflation performance. However, one should be careful not to attribute these achievements solely to the adoption of inflation targeting. Since major structural reforms to labour and product markets were also carried out around these periods which could have also had a positive impact on the real sector of the economy.

2.0.5.4 Inflation Targeting in the Czech Republic

In the beginning of 1998, the Czech National Bank changed to direct inflation targeting. This new monetary policy regime was in replacement of the previous scheme based on an exchange rate peg and money targeting. In comparison with these intermediate targets, inflation targeting implies a direct focus on price stability by targeting inflation. According to (CNB, 2000), the monetary policy regimes applied since the establishment of the Czech Republic can be divided into three stages. In the first period, from the start of the transformation up to the foreign exchange turbulence at the end of May 1997, a strategy was used which combined an exchange rate peg (partially relaxed at the end of February 1997) with a monetary policy based on money targeting. Due to the exchange rate turbulence, towards the end of 1998, the exchange rate peg was replaced by managed floating and money supply became the sole target.

Exchange rate targeting regime in the Czech Republic involved using nominal exchange rate stability via interest rate changes and direct foreign exchange interventions, thereby importing low inflation from the anchor country. Maintaining the exchange rate is an obligation on the fulfilment of which requires certain preconditions. These include above all an appropriate macroeconomic policy mix ensuring a low inflation differential vis-à-vis the "anchor" currency, a sufficient level of international reserves. And also, maintaining of country's competitiveness and overall credibility including its institutional and legislative framework and political stability (CNB, 2000). Exchange rate regime typically entails exchange rate peg, which is the fixing of the nominal rate to the currency of either one or several countries. However such anchor countries must be larger with low inflation and a substantial share in mutual trade, i.e., the United States. The main advantage of this approach was that the imported inflation from the anchor country which was a rule was lower than in the domestic economy. Furthermore, the nominal anchor was quite understandable by the public.

One of the major shortcomings of targeting exchange rate is that it weakens the autonomy of monetary policy in the sense that, the domestic interest rates must in conditions of liberalized capital flows be set in harmony with the interest rates of the anchor country. Also, shocks and events in the anchor countries are automatically transferred to the real economy through the imported monetary policy. Following the abandonment of exchange rate targeting, monetary base targeting was adopted. Monetary targeting does have an advantage over the exchange rate targeting because of possibility of pursuing an independent monetary policy and of reacting accordingly to specific problems arising in the domestic economy. Most importantly, the monetary target in the Czech Republic was able to react directly to specific economic developments. Inflation, the reduction of which was the primary monetary policy task, fell from about 20 percent during 1993 to 10 percent in the first quarter of 1994 on year-to-year terms (CNB, 2000).

Targeting money supply came with a huge challenge, among which was lack of sufficient response of domestic output to the pick-up in demand which resulted to increasing imbalances in the economy. Another major problem was the choice of an appropriate monetary aggregate itself. Such aggregate is expected to be relevant in terms of economic theory and at the same time have an econometrically justified stable link with prices or nominal output (CNB, 2000). In an environment of financial innovation and market computerization and globalization, this relationship is ever more unpredictable and more difficult to predict. Another challenge was that the central bank may not be able to manage the selected monetary aggregate with sufficient precision. It was also observed that the money target was not fully understandable to the public most of the time.

Amidst these challenges the central bank realized that there was a need for a new monetary policy, hence this gave birth to inflation targeting in 1998. So far the inflation targeting in the Czech Republic has been doing incredibly well, even though it has missed its target a couple of times. However, there have been a numerous advantages of the new monetary policy in the Czech Republic, among which are: introduction of a certain order, rules and discipline into the decision-making of the central bank. This has led to better predictability of its reactions to economic developments. In addition, there has been an increase in announcement of the relevant statistical data according to which financial markets and analysts anticipate these decisions and not just of the decisions of the monetary institution itself. Other benefits include increased transparency of monetary policy and CNB, better communication with the public. The public has been more acquainted with the monetary developments and the concrete implementation of monetary policy through quarterly inflation reports.

2.0.6. Inflation Targeting and the problem of Asset price and Debt bubbles

The previous section shows that an increasing number of central bank including South Africa now practice inflation targeting due to its numerous advantages. There is no doubt that inflation targeting is clearly a viable option in bringing down the rate of inflation compared to the orthodox use of monetary aggregates. However, post-Keynesian economists believed that inflation targeting itself might not be a sufficient framework but must be supplemented with financial intermediary balance sheet regulation (Palley, 2006:91). Doing this will help the orderly process of credit creation and allocation, which is the main issue that is usually raised against the inflation targeting framework.

For example the problem of balance - sheet disorder which builds without any immediate effect on inflation can undermine the effectiveness of inflation targeting approach and also inflict huge output and employment costs when they ultimately come to be resolved (Palley, 2006 :91). Hence there is a need for policy makers to guard against such occurrence. The problem of asset price and debt bubbles is well rooted in the endogeneity of money creation by the private sector. And such disorders are more likely to be perverse in the modern monetary sector due to various innovations and financial market deregulation. This results from the fact that innovations and deregulations have increased the elasticity of production of money in the private sector. Consequently, there are rapid changes in balance-sheet and debt positions, in the economy.

The major concern is the possibility of overlooking these problems of balance sheet disorders since inflation is the sole target in the framework. "However, if interest rates policy is directed toward asset market and balance sheet management, it is most likely going to inflict significant collateral damage on the rest of economy. There are four reasons why the build up of balance sheet and asset price disorders may have little impact on inflation. Firstly, asset prices are not included as part of inflation measures and the CPI includes neither equity nor home country prices. This problem could be dealt with by including these prices in the CPI, but will obscure the process of wage setting and inflation indexation for purpose of real income protection. Secondly, in a globalised economic environment, increased spending resulting from asset price and debt bubbles can be accommodated via the deficit trade. As a result, there might be no significant impact on the domestic price level and instead, the private agents might be indebted to banks which might have borrowed from the foreign lenders.

Thirdly, the economic dangers of assets bubble may be unrelated to aggregate demand inflation. For example, increased asset value may be applied as collateral to incur debts which is used to purchase additional assets, which further increases asset price. This might lead to unsustainable debt pyramid that will bring down the entire financial transaction system when it crashes. Lastly, the negative impacts of assets spending may be compositional rather than aggregate. Consequently, asset bubble may prompt investment spending booms that are founded on distorted perceptions and, if these investments do not succeed, it will constitute a negative impact on the financial system which would damn the economy as a whole.

There is also a problem of asymmetric information when it comes to who benefits from asset bubble and who bears the cost of higher interest rates. The primary cause of this problem is that there might be increase in the asset prices when the economy is expanding without necessarily causing inflation and a tightening action from the monetary authority. Once the expansion comes to an end, asset prices stand exposed and a downward correction of the asset prices at this stage will have a negative consequence. And any decrease in the asset prices would freeze markets such that it will result in negative net equity positions where debt- burdened asset holders will find it difficult to sell. Reducing these assets prices also makes it harder to get new loans from the financial markets. Consequently, it will be difficult to embark on new investment projects. One should therefore note that under inflation targeting, the Federal may have no cause to actively prevent asset price inflation on the way up, but then find itself compelled to limit asset price declines on the way down.

An additional policy to supplement inflation targeting as proposed by the Keynesians is the Asset Based Reserve Requirement (ABRR) as a balance sheet regulation to deal with the problem of asset and debt bubble problem. This policy allows monetary authority to target asset markets while leaving interest rates free to target inflation. The main features of such policy are: firstly financial institutions would be required to hold reserve requirements against all assets, even though some asset categories could be zero-rated. Secondly, reserve requirement ratios would be adjustable at the discretion of the bank. Thirdly, requirements would be applied across all financial institutions, showing that earlier business line distinctions have now largely disappeared as a result of deregulation and competitive convergence. Thus, there is a need for functional rather than sectoral regulation where regulations are carried out on the basis of what the companies do rather than what they are called. This is important to ensure a level playing field and avoid having regulation confer unfair competitive advantage.

One of the major advantages of ABRR system is that it enables the monetary policy to change the relative cost of holding different asset categories by adjusting relative requirements without necessarily altering the level of interest rates. For example, if the monetary authority wanted to discourage equity holdings, it could achieve this by raising the reserve requirements on equity holdings. Similarly, if it wanted to discourage commercial mortgage borrowing, it could do so by raising the reserve requirement on new commercial mortgages.

Another benefit of ABRR is that it can be used to promote flows of funds to specific areas that are considered socially deserving. For example, a lower reserve requirement on a particular asset category such as community development loans would increase their relative return and bring about development in such areas. ABRR is also known to have cyclical properties in the sense that, when assets prices and bank lending increase during the boom period, it will raise the demand for reserve which will automatically bring about monetary tightening. Conversely, if assets and bank lending decreases, it will automatically release and contribute to monetary expansion. ABRR however has the potential to strengthen monetary policy predicated upon open market operations by re-building the demand for reserve.

It has been argued that monetary policy could become insignificant due to diminished demand for reserves and a lack of connection between the demand for reserves and economic activity. This notion can be corrected by ABRR because it is capable of establishing a robust and strong link between the demand for reserves and economic activity. This can be attributed to the expansion of financial assets, values and quantities which constitute the central component of the modern economic environment.

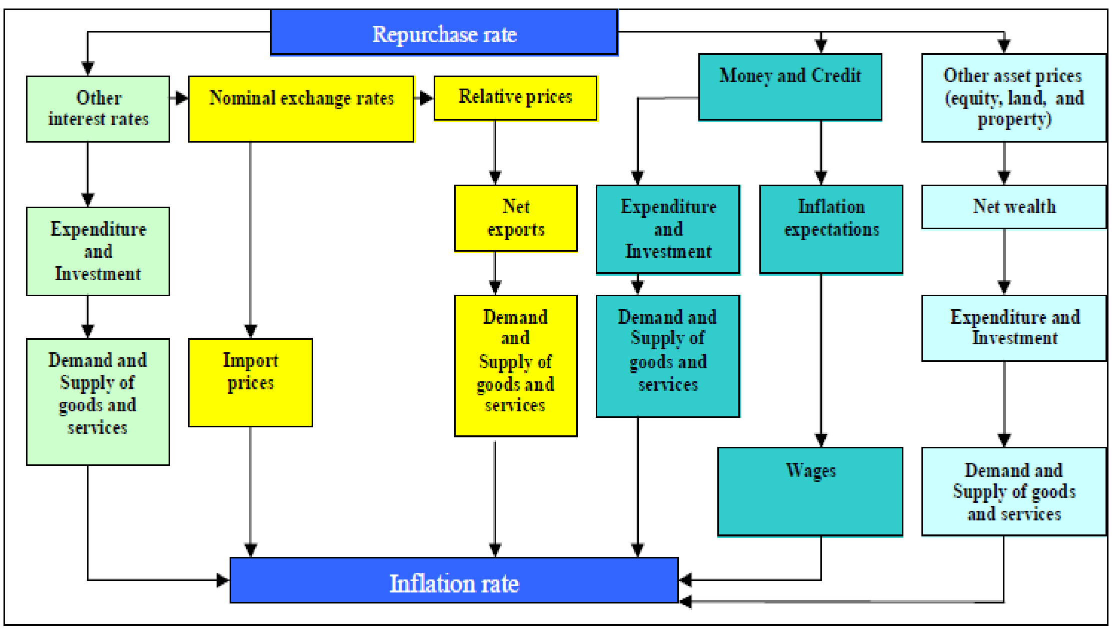
ABRR is different from the current financial regulation known as risks based capital standard (RBCS), because RBCS entails asset-based-liability link, while ABRR relies on the asset-to asset link. Unlike ABRR that is counter-cyclical in nature, RBCS tends to be pro-cyclical. As a result, the quality of assets tends to improve along with the cycle which can free up equity capital while deteriorating in downtowns. The implication of this is that banks will have to find more capital during downturns which is actually the time when it is extremely difficult for the banks to raise capital. This makes financial intermediaries to be stringent on issuing loans during the recession period. Also, under ABRR when an asset is written off, it releases reserve and the process becomes expansionary and the reverse is the case when an asset is written back. In contrast, under RBCS, writing-off an asset eliminates equity, and forces banks to find more equity or cut back on risky asset holding.

2.0.7. Monetary Policy transmission Mechanism

The monetary policy transmission mechanism (MPTM) describes the complex process through which a change in monetary policy stance is transmitted to the rest of economy and through which the goal of monetary policy such as a stable and low inflation rate and economic growth is achieved (De Angelis *et al.,* 2005).The main channels through which monetary policy works itself through the economy are largely indirect, especially, in influencing private-sector expectations and thus long-term interest rates. According to Mollentze, (2009), when a central bank decides on a route or action to be taken, it sets in motion a series of economic events. The impact of these events usually start to manifest through financial markets, which, in turn, slowly works itself through changes in current expenditure levels particularly private consumption and investment. The changes in current expenditure and domestic demand further influence current production levels, wages and employment, and in the process lead to a change in domestic prices, i.e. the rate of inflation. Changes in monetary policy can however be said to have a link with the changes in output, inflation, employment and a variety of economic variables. Actions taken by the monetary authorities have a consequential effect on the real variables such as output, inflation, and prices. Though, these effects are expected to be transitory without long run consequences. According toDe Angelis *et al,* (2005), the essential process through which monetary policy actions affect the rest of economy is through interbank market.

The interbank market is divided into two; namely the central bank-to-private bank interbank market, where the private banks borrow cash reserves from the central bank at the repo rate. Secondly, private bank-to-bank interbank market, where deficit private banks borrow funds from surplus banks at the interbank rate. Changes in monetary policy should first affect the interbank rates, which then transmit a similar effect to other money market rates and finally impact on interest rates in the economy. It is expected that an effective interbank market should respond immediately to changes in the repo rate and will as a result ensure effective pricing in the money market as a whole.

Figure 2.3. Monetary Policy Transmission Mechanism Channels in South Africa



Source: Small and de Jager. (2001)

Looking at Figure 2.3, when the Reserve Bank chooses to influence the change in the repo rate, it sets in motion a series of economic events. In the inflation- targeting regime, the main monetary policy instrument is repo rate. Whenever the Reserve Bank tampers with this repo rate it has a direct effect on other variables in the economy such as interest rates, exchange rates, money and credit, other asset prices resulting in changes in spending and investment. Therefore one can conclude that changes in repo rates affect the demand for and supply of goods and services. However, the pressure of demand relative to the supply capacity of the economy is a key factor influencing domestic inflationary pressures (Kamal, 2010).

De Angelis *et al* (2005)., Mollentze, (2008) asserted that there are two different ways in which repo rate influences market rates, firstly, it directly influences banks' marginal cost of funding and secondly, it reflects the bank's position on monetary policy. Thus, even the interest rates of banks which do not take part in the repo auctions are adjusted when the repo rate is increased. Consequently the cost of capital is affected, causing a decline in investment spending (I) and consumer spending (C), leading to a decline in aggregate demand and real output (y). It is through these channels that demand pressures feed through changes in the output gap to inflation.

Repo rate changes can also influence expectations of the economic agents about the future course of real activity in the economy, and the confidence with which those expectations are held. Such changes will thus affect participants in financial markets, which will in turn affect other sectors in the economy, for example changes in expected future labour income, unemployment, sales and profit. A positive shock to the repo rate could send different signals to different people at a particular period of time. For example an increase in the repo rate could be interpreted as indicating that the monetary policy committee (MPC) believes that the economy may be growing faster than previously thought thereby increasing the expectations of future growth and confidence in general.
It can also be thought of as a need for the MPC to slow down the growth in the economy in order to reach the inflation target, and this could lower expectations of future growth and confidence leading to uncertainties of the impact of a policy change.

A well known channel through which the monetary policy can impact the economy is through broad money channel i.e., the use of open market operation (OMO). If the government embarks on a purchase of government securities in the economy, as an individual the sellers will probably deposit the sale proceeds in the bank, and thus increase bank reserves and the bank's ability to create credit. As an investor, this creates an appetite for more investment opportunities by buying more assets similar to the ones that have been sold. Consequently the prices of the existing real assets will go up relative to the new ones. The increase in the price level of real assets increases wealth relative to the purchase of sources of services. All these combine to raise the demand for current productive services both for producing new capital goods and for purchasing current services. As a result the monetary impulse spreads from the financial markets to the markets for goods and services, thereby increasing aggregate output and spending in the economy.

Transmission through the exchange rate channel is not active in a country where the exchange rate system is rigid due to pegging of domestic interest rates to remain unchanged regardless of any adjustments in the monetary policy. This is in the form of a self-imposed restriction on the use of monetary policy, thus the domestic interest rates are determined by the interest rates in the currency of such country (Uanguta and Ikhide, 2002). In a country with fully flexible rates, the transmission of the interest rates to exchange rates is much deeper. Although in the end the exchange rate is determined by factors such as purchasing power parity, its short run behaviour is the result of the asset equilibrium. In the literature a positive shock to the monetary policy is expected to be followed by an appreciation of domestic currency thereby reducing net export and lowering domestic output.

According to Saizar and Chalk (2008), the monetary policy might not necessarily affect output and inflation through credit and interest rates channel, especially where the majority of the borrowings come from foreign countries. Hence, the effectiveness of changes in policy interest rates in influencing the path of inflation becomes unrelated to the level of credit exchange rate (Saizar and Chalk, 2008). Under such circumstances, exchange rate flexibility turns out to be a very important factor in order for the transmission to take place. Lastly, a contraction in total demand will reduce output relative to its potential level, and this will, in turn, slow the rate of increase in the price level relative to its trend. And this will also have a negative effect on the wage increases in the labour market and the overall effect of this transmission will ultimately lower output and inflation.

2.0.8. Orthodoxy's Monetary targeting Policy

The use of a monetary aggregate as a monetary policy rule is no longer seen as a viable option in monetary economics, as more and more central banks are now moving toward interest rate policy rule as proposed by Keynesians. It is important to highlight the difference between this orthodox approach and Keynesian theory. Keynesian theory is a policy rule in which inflation and output respond to interest rate. Monetarists, on the other hand, consider aggregate supply of money the sole source through which the monetary authority can influence the economy. However, post Keynesians see monetary targeting as an undesirable option if not infeasible **(**Fontana and Palacio-vera 2004; Palley, 2006: 84). The new Keynesian model is based on three principles; firstly an aggregate supply principle relates inflation to expected inflation and the output gap, (i.e., the difference between the actual and potential real output); secondly, the output gap is related to the expected short term interest rates, (through this principle, monetary authority can influence the aggregate spending in the economy) and thirdly, short term interest rates are usually set from time to time by the central banks. As a result, central bank can minimize fluctuations in the output from potential inflation emanating from policy makers' implicit or explicit inflation objective.

The above three models form the basis of many central banks to influence output and inflation in the modern day monetary policy without much attention being given to the money supply. Thus central banks provide an anchor for inflation through their long-run inflation objectives and their commitment to influence short term interest rates in order to achieve their objective over a given period of time.

However, the role of monetary aggregate is still significant for the European Central Bank (ECB). The main ECB strategies in achieving its monetary goal are money supply and economic analysis. These tools are used in organizing, evaluating, and cross-checking the information relevant for assessing the risks to price stability. Although their monetary aggregate consists of a detailed analysis of the implications of money and credit developments for inflation and economic activity. In the Euro area, the reference value for M3 growth is usually set by the ECB at a point believed to be consistent with maintaining price stability over the medium term. Any deviation of money growth from this reference point serves as a trigger for further analysis to identify the source of deviation and its implication for future inflation. The ECB uses a range of money demand models, all assumed to have a stable long-run relationship in which money demand depends on such fundamental factors such as GDP, spread between short-term market interest rates and, also interest rate paid on M3 assets. Money demand is also assumed to increase with real GDP and decline as market rates rise relative to the rate of return on M3.

According to Kahn and Benolkin (2007), the money demand model of ECB is used in different ways; firstly they help confirm signals from the economic analysis stake of the ECB's policy strategy. For instance, a strong money growth might be attributed to a low-interest-rate environment and rapid real GDP growth. Under this circumstance, both monetary analysis and economic analysis would be sending complementary signals about current economic conditions. Secondly, the analysis of money demand models is used to make a distinction between the transitory movements in money growth from longer-run trends. For example, money demand models suggested in 1999 that the steep Euro area yield curve was temporarily holding down money growth so that the observed M3 growth rate was understating the underlying monetary stimulus.

Thirdly, money demand models serve as a yardstick for evaluating the cumulative effect of past money growth on overall liquidity in the economy. They also provide an estimate of the long-run equilibrium level of money demand that can be compared with the outstanding stock of money. For example when M3 is significantly above its equilibrium, the model suggests a possibility of a build up of inflation pressures.

Findings by Kahn and Benolkin (2007) also showed that one reason why ECB relies more heavily than the Federal Reserve on monetary aggregates is that, the historical relationship between money growth and inflation has been stronger in the Euro area than in the United States. Even though money growth and inflation are correlated over the long-run in both countries, the correlation is higher in the Euro area. Another explanation for the ECB relying more heavily on money growth than the Federal Reserve is the greater stability of the relationship between nominal spending and money in the Euro area at least until recently (Kahn and Benolkin, 2007). Money is also seen as a predictor of inflation in ECB due to a high explanatory power in the ECB reduced- form modeling for monetary aggregates. However, the use of monetary aggregates as a predictor of inflation sharply diminished in 1990s and 2000s when money growth became insignificant as a predictor to inflation two quarters ahead and had the wrong sign (Kahn and Benolkin, 2007).

According to Fontana and Palacio-vera (2004), there are two conditions that must be met before monetary targeting could be successful. Firstly, central banks must be in total control of money supply, and secondly, there must be a stable relationship between the money supply and the nominal income. There must also be two other added conditions before the first condition can be met. Firstly, central banks must be in total control of monetary base or bank reserves, and secondly there must be a stable relationship between monetary base and money supply.

It is believed that, if central banks tried to run a system of monetary base control, it would fail. The reason being that most of the time it will be accommodating the day-to-day demand of the banking system for reserves at a penal interest of its own choice whenever its monetary base target is below the system's demand for reserves. Moreover, when its target is above the system's demand, overnight rates would fall to near zero. Another condition necessary for central banks to have a total control of money supply is stability of money multiplier. This condition is however not feasible because of endogenity of money supply, it relies on the idea that the money supply in the modern monetary economics is credit-driven and demand determined. That is, credit is created when loans are given out to the non bank sector comprising firms and households. As a result, the level and the rate of expansion of the money supply largely depends on the decisions of the private sector. This forms the basis of Keynesian theory of aggregate demand, which is the rate at which monetary expansion is determined by the level of planned aggregate deficit-spending net of loans repayment.

In a situation where central banks decide to increase money in circulation through open market operations; this decision will not be feasible if the banking sector deliberately reduces the amount of credit given out due to failure to identify profitable outlets. This will however increase the banks' excess reserve ratio (ER). In the same way the non - bank sector can decide to dispose off any unwanted money balances in the form of loan repayment. Under such circumstances, an increase in money supply will be offset by the increase in the aggregate reserve deposit ratio, and an attempt by the monetary authority to increase the money supply will be ineffective. Equally, an attempt by the central banks to reduce the level of bank reserves below the level of required ratio will only encourage the bank sector to seek reserves elsewhere. They can either do this through the discount window or through interbank with additional cost through higher interest rate. Acquiring more funds means their lending ability will increase; as a result they will increase their loans reserve and deposit reserve ratio. As banks continually seek to raise their deposit/reserve ratios by discovering new financial products and procedures, money multiplier and money velocity will exhibit an upward trend (Fotana and Palacio-vera, 2004).

On the other hand, when there is an increase in the interest rate and returns on non-reserves; it will encourage the banks to keep minimum excess reserves and also search for alternative sources of fund yielding a lower reserve requirement. The second condition under which money targeting can be a feasible option is through income and money supply. However, there seems not to be a stable relationship between money supply and income due to financial market deregulations, and improved financial technology and financial innovations. In the case of financial regulation, bank sectors have devised a way to overcome the challenge of restrictive balance requirement by seeking alternative non-deposit funds at penal interest rates. However, the way these non-deposit funds alter the structure of liability side of banks' balance sheet can be uncertain and unpredictable.

In practice, money supply could be a good indicator of economic performance. For instance, if the economy's long-run real growth rate was 3 percent and velocity growth was zero, a steady 5 percent growth rate of the money supply would be associated with a 2 percent rate of inflation in the long run. A pick-up in money growth from 5 percent to 7 percent would then be associated over the long run with a pick-up in inflation from 2 percent to 4 percent. In addition, the growth rate of money supply, in theory could possibly help policymakers predict nominal spending growth over the short to medium term, provided velocity growth could be predicted over that time frame. Moreover, given a reliable model of how aggregate nominal spending growth is divided between inflation and output growth, and the policymakers could use money growth to help understand the short- to medium-term outlook for inflation and output. However, the fundamental argument why a lot of countries are moving away from monetary aggregate target remains that the relationship between money, nominal GDP growth, and inflation rate had completely broken down. This is primarily due to financial innovations that have made the money velocity to be unpredictably volatile.

2.0.9. Role of Credibility and transparency in Monetary Policy

The success of any monetary policy in maintaining a low inflation level relies on credible policy. One of the main reasons why many central banks have shifted to inflation targeting approach is to achieve a more transparent and credible monetary policy. Lack of credibility or failure of central banks to maintain price stability has been greatly attributed to private sector's lack of confidence in the monetary authority's commitment to maintain a consistent set of policies over time. This can be explained by using rational expectations model. Rational expectations are essentially forward-looking. In essence, current decisions depend not only on the current and past states of the environment, but also on the entire expected future outline of events, including expected economic policy.

Private agents form these expectations by making best possible use of all relevant information currently available to them which, in turn, influences their decisions.

Anchoring private agents' inflationary expectations around a credible monetary policy will facilitate a more moderate approach to shocks by the central bank as agents will discount short-term volatility (Aron and Muellbauer, 2006). There could be a great economic benefit resulting from a credible monetary policy, for example, if private agents believed that the monetary authority will be able to achieve their low inflation targeting policy, their inflation expectations are more likely to be anchored around the inflation target. As a result, price and wage setting will be less responsive to temporary fluctuations resulting in stability in the economy.

Furthermore, an increase in the predictability of interest rate policy will cause market interest rate volatility to be reduced, and reduce the overall uncertainties in the economy. According to Blackburn and Christensen (1989), there are three different factors that affect monetary policy's credibility; these include technological factors, administrative/political and strategic constraints. The technological factors include economic data on which the monetary authorities base their judgment and forecasts. It also includes controllability of the policy instruments and the feasibility of policy makers' objective, accuracy and relevance of the economic theory employed by the monetary authority.

Political factor has to do with the ability of an incumbent government to execute any required legislation and whether an incumbent government will have sufficient time to carry out its program or it will be tempted to modify it due to political pressure, or pressures from social unions such as trade unions and labour unions. This factor is important because the heightened degree of independence granted to monetary authorities has been crucial in providing central banks flexibility to pursue a low inflation objective. The last one is the strategic constraints, which results from the interdependence between the behavioural patterns of private agents and centralized policy makers. The players in this game are the policy makers and the private agents who are forward-looking and always trying to predict the economic policy to be applied. The problem arises if there is an incentive for the policy makers to pursue a strategic advantage and seek short-run gains by breaking the previously announced policies.

2.0.10. Empirical Evidence

Kim and Roubini (2000) investigated the exchange rate anomalies in industrial countries using structural VAR. These industrial countries include U.K, Italy, Canada, Germany, Japan and Germany. The variables under examination were short term interest rates, monetary aggregates, consumer price index (CPI), and industrial production as a proxy for GDP, world price of oil, federal fund rate and exchange rate. The focus was on the impact of monetary contraction on key macroeconomic variables as well as exchange rate.

The results showed that the monetary shock in all the countries led to a decline in the price level smoothly and significantly at least over some quarters except France, where there was an increase in the price level after the monetary contraction for a few months but later declined significantly. In Germany, the U.K, Italy and Canada, the fall in the price level was persistent over the full 48 months, but in Japan, the price level fell persistently for 24 months and later rose above the baseline but was statistically significant. The result was consistent with the theory because, a contraction in the money supply led to a fall in the level of output for some quarters for all the countries except for Italy where the fall in output was insignificant. The findings also showed that an increase in the interest rate, i.e., a contraction in the monetary aggregate led to an appreciation of domestic currencies relative to the U.S. dollar in all the countries. Such appreciation impact was statistically significant in all countries.

However, when real exchange rate was substituted in the place of a nominal exchange rate variable, the results showed that initially there was an appreciation of domestic real exchange rates for sometimes, but reverted itself back to the original state before the shock. "This mean-reverting behaviour of the real exchange rate is consistent with the long term implication of a monetary shock in overshooting and liquidity models that envisage an initial appreciation of the exchange rate and before returning to its original baseline.

Lovrinovic and Benazic (2004) used the VAR technique to analyze the European Union monetary transmission mechanism, using data from 1992 to 2003. The focus was on the impact of interest rates on real and monetary macroeconomic variables. The assumption made was that an increase in short term interest rates would lead to a reduction in industrial production, increase in retail prices, appreciation of real exchange rate and reduction in quantity of money supply. However, the results show that the interest rates influenced only the industrial production and not other variables.

Siok Kun (2008) investigated the interaction between monetary policy and exchange rate in three inflation targeting Asian countries, Korea, Philippines, and Thailand in both their pre - crisis and post - crisis periods. The two periods also represent the pre and post inflation targeting periods. The structural VAR and GMM methods were adopted in carrying out their study. The variables under examination included interest rates, monetary aggregate (M1), CPI, and industrial production as a proxy for output, world oil price in USD, Federal Fund Rate (FFR), and the exchange rate in units of US dollars.

The results showed that the reactions of the domestic variables to the monetary shocks were consistent with the theory in the three countries. For example, the monetary shock led to an increase in interest rate, but a contraction in the money supply, CPI and appreciation in the exchange rate. Also, the increase in CPI and output as well as depreciation in exchange rate led to the increase in the interest rate, but in Korea, an increase in the interest rate was followed by its decline afterward in period two. In Thailand, an increase in output growth was not followed by the tightening in the interest rate. The policy reaction function in Korea before the crisis did not react significantly to exchange rate but in Thailand, after the crisis, the policy reaction function significantly reacted to exchange rate.

Generally, the results suggest that the exchange rate does not have significant effects on the policy reaction function, i.e., the impact of the exchange rate on the policy function is very small with the exception of Thailand where the policy reaction function is strongly impacted by the exchange rate. The result also showed that there is a contractionary action of the monetary policy to the inflationary pressure in the three counties under examination; this finding is in line with Kim and Robini (2000).

Furthermore, the magnitude of the change in the policy reaction in response to a domestic shock has declined after the financial crisis in 1997 (Siok Kun, 2008). This could be because there is a decline in the effect of the shocks or lower persistence of the shock in period two after recovering from the crisis. However, the result of the forecast error variance shows that the maximum explanatory power of CPI or inflation shock of the three Asian countries has increased after the adoption of inflation targeting. This implies that there is a need for the monetary authority to be concerned about price stability in the period two. Also, the determination power of exchange rate on policy reaction function remained low in Korea and Philippines but increased sharply in Thailand.

Tsangarides (2010) also used VAR techniques to investigate the transmission of monetary policy on output and prices for Mauritius using data from 1999 to 2009. The results showed that unexpected monetary policy tightening, i.e., an increase in the Bank of Mauritius interest rate led to a decline in prices and output. However, the effect on the output was much weaker compared with prices. The findings also showed that an unexpected decrease in the money supply or an unexpected increase in the nominal exchange rate resulted in a decrease in prices. Variations of the policy variables were found to account for a small percentage of the fluctuations in output and prices. The overall results showed a weak monetary policy transmission mechanism particularly for output in Mauritius.

Cheng (2006) used vector auto-regressive analysis to investigate the effects of monetary policy on the Kenyan economy. The focus was on the impact of monetary policy shocks on output, prices, short term interest rates and the nominal effective exchange rates. The data used were from 1997 to 2005. He found that the effect of monetary policy on output seems to be insignificant. However, a monetary shock had a significant and persistent impact on prices. A shock on monetary policy was found to be followed by the decline in prices, with the effect peaking at 9 to 12 months after the shock. There was also an appreciation of the domestic exchange rate with the impact lasting for 9 to 12 months in response to the shock of the monetary policy.

Aleem (2010) investigated the transmission mechanism of monetary policy in India using the VAR approach. The focus was on examining the effects of an unanticipated monetary policy tightening on GDP, prices and overnight call money rate. Variables used included GDP, prices, interest rates as the indicator of the monetary stance of India, world commodity price index, Federal Fund rate and the United States GDP. The results showed that a rise of 1.5% in the overnight call rate led to a decline in GDP and prices. Three channels through which monetary policy affects the output were identified: i) Through bank lending channel; the result showed that the prime lending rate responded immediately to an overnight call money rate shock. "A positive overnight call money rate shock creates an initial increase in the prime lending rate to 0.24% above the baseline. After the second quarter, it converges toward the baseline (Aleem 2010)". The result confirmed the importance of the bank lending channel in the transmission of monetary policy to the real economy of India. ii) Through asset base channel, the results showed that the asset base channel was not important in the monetary policy transmission to the real sector of India. iii Through the exchange rate channel. In order to examine the exchange rate channel, the focus was on the effects of a positive overnight call money rate shock on GDP that passes through the exchange rate. The results suggest that, in response to an unanticipated increase in the overnight call money rate, the real effective exchange rate appreciated initially and shows a short-lived reaction to a positive overnight call money rate shock, and that a weak response of the real effective exchange rate to a positive monetary policy shock weakens the first step in the exchange rate channel.

Shibamoto (2007) analyzed the monetary policy shock of Japan using factor augmented vector autoregressive analysis. He found that the time lags with which the monetary policy shocks are transmitted vary between the various macroeconomic time series. These series included housing and employments indices. Also, the study showed that monetary policy shocks have a stronger impact on real variables such as employment and housing, than it had for industrial production. Also a study using VAR by Wayne and John (1997) for Jamaican economy showed that the impact of monetary policy was found to be immediate and pervasive, albeit short lived, lasting between two to eight months. Subsequently, a unit shock to the reverse repo, the inflation rate decelerates within two months by approximately 0.1 percent per month. Whilst the rate of depreciation declines significantly over the space of five months following a unit shock to the repo rate. At the same time there are very strong, albeit temporary, real sector effects, as real economic activity declines by approximately 2.0 percent in four months.

Other works include the work of Cortes and Cruz (2007) who also used (VAR) model to investigate the impact of monetary policy in Philippines. The results of the study showed that monetary shocks produced impulse responses that showed transitory cyclical fluctuations on macroeconomic variables that dissipated over time. Monetary shocks had the following properties:

- They were associated with a fall in domestic liquidity or M3 stock;
- They led to a transitory increase on the inflation rate or the price level as observed with the price puzzles and
- They generated sharp but temporary decline on the output of the manufacturing sector.

2.0.11. Conclusion

The chapter covered all the relevant theories in understanding monetary policy framework. From these theories, appropriate variables required for analysis are chosen. These include; short term interest rates, level of output, money supply, price (CPI), and exchange rate. Furthermore, this chapter discussed the output/variability tradeoff as postulated by Taylor (1970). The approach is consistent with the Phillip`s curve in the sense that, there is also an inverse relationship between the output and inflation. However, Taylor believed that such relationship is only temporary and not permanent.

Few empirical findings from developed nations as well as developing nations in which South Africa falls into were considered. These findings show that the impact of increase in the short term interest rates on the level of output is transitory. Also, that the impact of positive shock in the monetary policy is more significant on the price level compared to that of output. Finally, this chapter confirmed that most countries are now moving toward an interest rate rule of monetary policy in the form of inflation targeting as advocated by the Keynesians. However, inflation targeting its self is said not to be enough due to the asset price and debt bubble. This can be overcome by asset based reserve requirement (ABRR). Whichever case, interest rate policy rule monetary policy seems to be the best approach and the impact of positive monetary policy shock on the level of output might not be so significant.

CHAPTER 3

SOUTH AFRICAN MONETARY POLICY

3 Introduction

The purpose of this chapter is to examine the South African monetary policy framework over different time periods marking policy shifts and to determine its effectiveness as well as its shortcomings. This includes a historical account of application of monetary policy in South Africa prior to the inflation targeting regime. Also the current monetary policy of inflation targeting will be considered extensively. The functions and objectives of the South African Reserve Bank as well as the goals and objectives of monetary policy in South Africa will be explained in detail. The controversy over the use of short interest rates as a monetary policy tool within the framework of inflation targeting will also be discussed.

3.0.1. Functions and Objectives of the South Africa Reserve Bank

The South African Reserve Bank (SARB) was established in 1921 under the currency and Bank Act, Act No.31 of 1921 (Castelejin, 2001). The current legislation pertaining to the South African Reserve Bank is contained in the South African Reserve Bank Act 1989 (Act No.90 of 1989) as amended. The Reserve Bank is listed on the Johannesburg Securities Exchange (JSE) and its shares are held privately. The Bank consists of 14 directors of which seven are appointed by the shareholders, and the other seven including the governor and the three deputy governors are appointed by the president.

The primary objective of the South African Reserve Bank as stated in the Constitution of the Republic of South Africa Act 108, (1996) is to protect the value of currency in the interest of balanced and sustainable economic growth in the country. Secondly, the SARB in the pursuit of its primary objective must perform its function without the influence of any external bodies section, i.e., the Reserve Bank must be able to operate independently without fear, favour or prejudice. However, there must be regular consultations between the Bank and the cabinet members especially the Minister of Finance. Deviations from the primary objectives of the Reserve Bank could be contested in a court of law. The objectives as formulated in the Constitution can only be amended by a two-third majority vote in the parliament. The governor of the Reserve Bank, after consultation with the deputy governors and the monetary policy committee can decide on the main monetary policy tool to be adopted. Although the minister of finance may be consulted, monetary policy changes do not require the ministerial approval. In addition, the minutes of the minister's meetings with the management of the South African Reserve Bank are not supposed to be publicly published.

The Reserve Bank also functions as a bank of issue, custodian of gold and foreign-exchange reserves, banker to the government, lender of last resort, controller of credit, bank of central clearance and the supervisor of banks. The Reserve Bank has the sole right to issue bank notes and coins. The cash is circulated through purchases of assets from the government and the commercial banks, thus making credit available to the sellers of financial assets. This process is limited by the public cash requirements. The SARB as a banker to the government serves as a custodian of gold and foreign-exchange reserves and also handles all the financial receipts and payment of the state. The Reserve Bank also deals with the weekly issue of Treasury bills on behalf of the Treasury and also advises government on monetary and financial matters including the administration of exchange controls. They are also involved in the coordinating and management of public debt in an advisory capacity.

The Reserve Bank also serves as a lender of last resort. The bank plays this role by making up cash balance shortage experienced in the money market through the Corporation for the Public Deposits (CPD), the discount houses and commercial banks. The discount houses are responsible for obtaining these required cash balances for any shortfalls from the Reserve Bank on behalf of commercial banks. This is done through rediscounting Land Bank bills, treasury bills, and bankers' acceptances. The Reserve Bank as a banker of bankers serves as the controller of credit, bank of central clearance and supervisor of banks.

It is also the responsibility of the Reserve Bank to control the composition and the levels of required reserves; as a result it is able to control the supply of money in the economy. Commercial banks use these reserves to clear mutual claims and obligations, rendering the Reserve Bank as a clearing agent. The research section of the Bank is responsible for data collection, analyzing and publishing economics statistics and also conducting research on topics relating to the Bank and monetary policy. In the face of all these responsibilities, the main goal of the Reserve Bank remains to maintain price stability.

3.0.2. Monetary Policy in the pre inflation targeting regime

According to Casteleijn (2001), the South Africa monetary policy framework since 1960s can be divided into five broad categories as shown in Table 3.1. Firstly, there were liquid asset requirements with quantitative controls over interest rates and credit between 1960s and early 1980s. Under this regime, the interest rates played a minor part as a corrective instrument; the main form of monetary control was achieved through liquid asset requirements. Commercial banks were required to hold specific assets known as minimum deposits requirements. The rationale behind this was that the limited supply and low yield of financial assets would limit banks' lending and money supply growth. The liquid asset requirement was also used as an instrument for protecting the interest of depositors requiring commercial banks to hold 3 to 10 percent against demand and time deposits.

Table 3.1.Evolution of South Africa's Monetary Policy Framework

Year	**Monetary Policy Framework**
1960 - 1981	Liquid asset ratio-based system with quantitative controls over interest rates and credit
1981 - 1985	Mixed system during transition
1986 - 1998	Cost of cash reserves – based system with pre-announced monetary targets (M3)
1998 - 1999	Daily tenders of liquidity through repurchase transactions (repo system) plus pre-announced M3 targets and informal targets for core inflation
2000	Formal inflation targeting

Source: (Casteleijn, 2001).

In 1965, the Bank Act was amended resulting in an additional credit policy instrument as a supplementary reserve for the purpose of monetary stability. The Act provided for commercial banks to deduct from supplementary reserve balance they were required to hold with the Reserve Bank. They were also allowed to deduct from any net increase after a specified date in the aggregate amount of their holding of Treasury Bills, government stock with a maturity not exceeding 3 years of advances to the Land bank and other approved assets. Shortly after this period, the Bank Act was amended to allow the Reserve Bank to reduce commercial banks' minimum asset requirement balance against demand liabilities to not less than 6 percent in order to stimulate the economic growth.

In the past, other financial institutions which were mainly competitors of commercial banks were never included in the minimum reserve requirements. This made it difficult for the Reserve Bank to control the supply of money effectively. However, the recommendations of the Technical Committee as contained in the Reserve Bank Act of 1965 gave birth to a uniform set of legal requirements for all banking institutions and not just commercial banks.

In addition, the use of credit ceilings and other credit controls became prominent around this time. The period was also associated with the inflationary financing of government expenditure which could not be curbed by restrictive policies based on minimum asset requirements. The use of interest rates as a monetary policy tool also became ineffective due to high rates of inflation, since they could no longer give an indication of the real cost of borrowing. This incidence supported the fundamental view of Quantity Theory of Money as the sole cause of inflation (Casteleijn, 2001).

In the early 1970s, ceilings on the bank credit were abolished and liquid asset requirements were amended. Commercial Banks were also given more freedom to extend credit, although, they were recommended by the Reserve Bank to concentrate more on production and export sectors. This led to a rapid growth in the monetary aggregates especially M2, and a deficit on the balance of payments during 1975. The prime overdraft rate flunctuated around 8 percent and 12.5 percent between 1970 and 1979 respectively. It later fluctuated between 9.5 percent and 24 percent after 1979.

There was much dissatisfaction with the liquid asset system and, following the recommendations of the De Kock Commission, a range of reforms was introduced in 1980s (De Kock, 1985). There were lots of changes in the existing system such as removal of direct control on deposit rates and bank credit ceilings. This gave birth to a new policy known as a cost of cash reserves-based system, with pre-announced targets for M3. The pre-announced monetary targets were to be achieved indirectly by using interest rates. Under the cash reserve system, the SARB influenced the cost of overnight collateralized lending and hence market interest rates (Casteleijn, 2001). The system came into full operation in 1985. Under this regime, the supply of credit was influenced by open market operations and various policies acting on the overall liquidity, resulting in persistent money market shortage and relatively high bank rates. The monetary authorities were able to control the supply of money indirectly through slowing down of money the demand.

The system also involved setting targets annually, using three month average of broad money growth. The primary reason for implementing this policy was to have room for projected real GDP growth and also to curtail inflation (Aron and Muellbauer, 2006). The main shortcoming of the approach was lack of transparency. The SARB could breach the targets whenever there was a need to do that without any penalty; for example, in the face of external trade and financial shocks. The usefulness of these targets was sharply diminished by extensive financial liberalizations beginning in the 1980s and larger capital flows from 1994 (Aron and Muellbauer, 2006).

Between 1998 and 1999, there were daily tenders of liquidity through repurchase transactions, with pre-announced M3 targets and informal targets for core inflation. Money supply guidelines were still announced but received less attention than before. During this regime, there was much transparency aiming at greater credibility and a more pronounced effect on inflation expectations. Repo rate was allowed to be determined by the market in daily tenders of liquidity through repurchase transactions. This, therefore, put SARB in a neutral position. Significant over – or under provision of liquidity signalled a preference for movement in the repot rate under this system (Aaron and Muellbauer, 2006).

When the level of liquidity failed to adjust to the equilibrium, there would be a need to alter the movement of the interest rates. The system was not sustainable due to poor functioning of the money demand market that was dominated by a few large banks. Rates also proved inflexible, and the interbank market rate did not always clear effectively (Aron and Muellbauer, 2006). There was also little difference between this system and the previous ones as the commercial banks still remained heavily influenced by the SARB-directed preferences for the level of interest rates.

3.0.3. Monetary policy in the inflation target regime

The use of inflation targeting was first adopted by New Zealand in 1990. Before this time, New Zealand practiced the monetarist approach which was associated with a very high rate of inflation. In 1988, the minister of Finance Roger Douglas made it clear to the Reserve Bank governor Donald Brash that the inflation rate must be brought down to the range of 0-2 percent and must be kept there (RBNZ, 2000). However, since the introduction of inflation targeting, New Zealand's inflation performance has moved from being among the worst in the developed world to being around the middle of the pack. For example, the initial target range of 0-2 percent was achieved in 1991. As a result of this success, an increasing number of central banks has since adopted the same approach as their preferred monetary policy.

Initially, most of the countries that practiced inflation target monetary policy framework were mainly industrialized countries. More and more countries including developed and newly emerging markets countries have however shifted to inflation targeting. Nevertheless, there are still many who are yet to adopt inflation targeting. These countries include United States, India and Russia. The United States still uses different tools to achieve its monetary goal. These instruments include open market operations, discount rate, reserve requirement, interest required reserve balances and excess balances and lastly term asset-backed security loan facilities. The major tool that is usually used by the Federal Reserve Bank is open market operation, i.e., buying and selling of government securities in the open market.

Supposing the Federal Reserve Bank wants the fund rate to fall, it buys government securities from a bank, and then pays for it by increasing that bank's reserves. Thus the bank now has more reserves than it wants and the bank can lend these unwanted reserves to other banks in the federal fund markets. Consequently, there will be overall increase in the supply of reserves to the banking system and federal fund rate will fall. Also, if the Federal Reserve Bank feels there is a need to tighten the monetary supply, it does the reverse.

South Africa formally adopted inflation targeting as its monetary policy in February 2000. This happened shortly after Governor Tito Mboweni assumed office in August 1999. The use of inflation targeting monetary policy is a replacement of the eclectic approach that was used in the 1980s and 1990s under Dr de Kock and Dr Stals. During these periods money supply along with exchange rates were being targeted in order to maintain a low level of inflation rate.

The formal adoption took place after discussions with National Treasury, trade unions and business organizations, and consultations with other central banks that were already engaged in the formal inflation targeting. The target was to achieve a consumer price index (CPIX) inflation rate between 3 and 6 percent. This CPIX includes the average rate of increase in the overall consumer price index but excludes the mortgage interest costs. A price measure that would be acceptable to all South Africans as being inclusive as possible in terms of both items and geographical coverage was chosen. The authorities also realized that there were potential disadvantages in opting for overall CPI, and this led to the exclusion of mortgage costs. The CPIX was initially defined for metropolitan and urban areas and has a wider coverage of households (80 percent) than CPI (metropolitan), with only 40 percent coverage (Aron and Muellbauer, 2006).

In February 2009 the measure was changed to the continuous inflation target range for headline CPI between 3 and 6 percent (SARB, 2009). The 3 percent width allows for limited variability in the inflation rate and at the same time it is not too wide to reinforce divergent inflationary expectations. Some of the inflation targeting countries (e.g, New Zealand, United Kingdom and Sweden) have used the same approach. Furthermore, a two year time horizon was also chosen since a typical lag of 1, 5 to 2 years (i.e., in the case of South Africa) arises between a change in the short term interest rates and its impact on inflation. Thus the chosen time length is a realistic period in which the authorities can be expected to achieve the target (JP Van Den Heever, 2001).

3.0.3.1. Characteristics of South Africa' inflation - Targeting Framework

A major characteristic of South Africa's inflation targeting policy is the public announcement of official target range of inflation rate over a specified period of time. This is done to enhance the Reserve Bank's transparency and accountability. Before this public announcement, the SARB consults with the government and the National Treasury and then sets the inflation target. This process reflects that the Reserve Bank does not have autonomy in choosing the inflation target, but has the sole responsibility to choose the monetary policy tool that will be used to achieve the target. Under inflation targeting policy, the main objective is to target inflation in order to achieve price stability. This implies that all other goals are subordinated. For example, a variable such as exchange rate is not directly targeted under inflation targeting (Mboweni, 2002).

Recent economic thinking suggests that greater transparency of policy may influence the effectiveness of monetary policy (Aron and Muellbauer, 2006). An important component of inflation targeting in South Africa is the increase in monetary policy transparency and accountability. Essentially inflation targeting improves accountability through an explicit publication of a known benchmark that must be reached over a specific period of time. A greater level of transparency is achieved through better communication with the public and the markets about the objectives of monetary policy on a regular basis. This also includes informing the public about the rationale for decisions taken by the monetary authority. The medium through which the SARB conveys information includes publications of monetary policy statements and press releases and live television broadcast after each MPC meeting, six times a year. Monetary policy forum also takes place twice a year in South African major cities, which is usually attended by stakeholders, businesses, government and academic institutions. There is no doubt that the Reserve Banks has achieved a greater level of transparency since its adoption of inflation targeting. For example, the transparency level has improved from a score of 5 in 1994 to 9 in 2004 out of a possible 15 (Aron and Muellbauer, 2006). It has also been projected that this score will improve as the institutional design of the system matures.

Table 3.2.- Inflation Rate

Year	Inflation Rate
1984	**12.0%**
1985	**16.1%**
1986	**19.2%**
1987	**15.5%**
1988	**12.8%**
1989	**14.9%**
1990	**14.2%**
1991	**15.5%**
1992	**13.7%**
1993	**9.8%**
1994	**9.2%**
1995	**8.6%**
1996	**7.3%**
1997	**8.6%**
1998	**6.8%**
1999	**5.1%**
2000	**5.4%**
2001	**5.8%**
2002	**9.1%**
2003	**5.8%**
2004	**1.4%**
2005	**3.4%**
2006	**4.6%**
2007	**7.2%**
2008	**11.5%**
2009	**7.1%**
2010	**4.3%**

Source: Statistics South Africa (2010).

3.0.3.2. Arguments in favour of Inflation Targeting in South Africa

Table 3.1 shows the trend for changes in the inflation rates (CPI) in South Africa from 1984 to 2010. High rates of headline consumer price inflation were experienced between 1985 and 1987. The monetary target that was practiced this period was able to bring down the rate of inflation significantly from between 12 and 20 percent to an average of below 10percent between 1994 and 1999. The main reason for targeting money supply was based on the underlying assumption that there existed a relationship between money supply and inflation. The monetary target was used as an intermediate objective, with low inflation rate and price stability as the primary objectives.

After the formal adoption of inflation targeting precisely in 2002, the inflation rate went outside the target range. The SARB in their defense blamed this on the increases in the price of food, oil and administered prices (SARB, 2009). Also between the last quarter of 2007 and first quarter of 2009, inflation rate stayed well outside the inflation target range of 3 to 6 percent (SAStats, 2010). The Reserve Bank succeeded in bringing down inflation rate under informal inflation targeting and yet inflation rate stayed well outside the target range after the formal adoption of inflation targeting. This raises the questions as to why the Reserve Bank adopted inflation targeting policy and whether inflation targeting is the most appropriate approach for monetary policy in South Africa. According to Van Der Mewe (2004), the rationale for adopting inflation targeting can be divided into four categories.

Firstly, there were uncertainties among the public about the monetary policy stance adopted by the monetary authorities before the formal adoption of inflation targeting. For example, the growth in money supply and bank credit extension in the 1990s were well above the guidelines of the authorities for a considerable period of time, and the public had expected an increase in the short term interest rates. However, the authorities realized that the excess money growth was mainly due to the structural change in the economy; as a result, they did not apply more stringent monetary policy measures. This situation was difficult for the public to understand, and there was a need for a specific approach such as inflation targeting.

Secondly, it is believed that inflation targeting co-ordinates monetary policy and other economic policies in as much as the target is consistent with other objectives. Thirdly, the inflation targeting serves as a discipline measure for the monetary policy, thereby increasing the central bank's accountability. The primary reason for this notion is that application of inflation targeting affects inflation expectations which in turn facilitate a reduction in inflation. Furthermore, a credible inflation targeting is expected to form a basis for future price and wage settings. Moreover, an important part of the rationale for adopting inflation targeting is the direct focus on the inflation objectives and a clear commitment to achieving the objectives (Mboweni, 2002)**.** This, therefore, helps to anchor the public inflation expectations, thereby improving planning for the economy as a whole.

Other justifications for adopting inflation targeting include redistribution of income and wealth. Generally, the wealthy individuals are in a better position to hedge against inflation, whereas the poor populations are vulnerable to the impact of high inflation rates. The wealthy are often in possession of assets which can be protected against inflation, the poor on the other hand hardly have assets to protect against inflation. Also, high inflation rate leads to a regressive form of taxation, and the burden is usually carried mostly by the poor population of the economy (Corbo, 2007). However, the ability of the working poor to protect themselves against inflation depends on their bargaining power with their employers. In the case of non-working poor, their ability to protect themselves depends on the degree to which any social benefit is linked with inflation.

The current inflation faced by South Africa is driven primarily by higher food prices. And since the poor have a higher weight for food in their consumption basket, the inflation rate facing the poor has been significantly higher than that faced by the high income earners. Furthermore, inflation is known to be associated with distortion in the tax system, even if income rises together with inflation, this often leads to a higher tax bracket which eventually leads to disproportional increases in tax payments. Inflation also poses difficulties when making economic decision as high inflation is usually accompanied by greater price variability. These difficulties could make the price system less efficient which could result in low levels of investment and growth (Mboweni, 2002).

3.0.3.4. Inflation Targeting and economic growth in South Africa.

The underlying reason for controlling inflation is that a low inflation rate will provide an appropriate basis for sustainable economic growth. The SARB believes that there is no long-run trade-off between unemployment rate and inflation rate; however there is a trade-off between inflation variability and output variability in the short-run. There are two types of inflation targeting viz., strict and flexible inflation targeting. Strict inflation targeting focuses on inflation as its sole objective while flexible inflation targeting takes into consideration other variables such as output. In reality, most inflation targeting countries practice flexible inflation targeting. A strict inflation targeting tries to hit the target as quickly as possible under any circumstances, while a flexible targeting will gradually push the inflation towards its target.

It is believed that the stricter the inflation targeting is, the more variable the output is. Also, if there is too much focus on economic growth, there will be greater inflation variability and lower credibility for the whole inflation-targeting framework especially at the early stage of the approach. Thus, it is important to maintain an appropriate tradeoff between rigid adherence to the inflation targeting on one hand and a steady path of output on the other hand, with credibility as a crucial element. It cannot be said that South Africa is a strict inflation targeter because, in the initial and subsequent stage of the framework, targets were set on the basis of what was attainable without putting too much pressure on the output.

According to Mboweni (2002), if South Africa were to be a strict inflation targeter, it would have attempted, perhaps vainly and at a high cost, to achieve the 2002 targets. There would also have been a much tighter schedule for reaching the inflation targets. Even if the primary goal of inflation targeting in South Africa is to reduce inflation, this does not mean that the Monetary Policy Committee is not conscious of the fact that an excessive fast reduction of inflation will involve high costs.

Moreover, whether or not inflation targeting policy is being used, any monetary policy that is adopted would still have to focus to some extent on inflation. For example, if a variables such as exchange rate is being targeted, and the economy is subjected to exchange rate shocks, there is a possibility that in an attempt to defend the exchange rate, the interest rates would have to go up significantly. Likewise, if monetary aggregates were being targeted, there can be no presumption that it would have resulted in a lower interest rate outcome (Mboweni, 2002). It has been argued that it is not unlikely that the inflation targeting will have a negative impact on the economy. Nevertheless, such negative impact is expected only in the short run.

3.0.3.5. Criticisms of Inflation Targeting

One of the limitations of the inflation targeting is that it is a complicated approach to implement as noted by Mboweni (2002). It is believed that all monetary policy frameworks should be forward looking; however, this is not the case in South Africa’s inflation targeting due to its reliance on the forecast. The implication is that, if there are inaccurate forecasts, it could obscure the objectives of the central bank and reduce its credibility. Another shortcoming of inflation targeting is that the Reserve Bank does not have a total control over inflation because of factors that may arise which are beyond the control of the monetary policy. These factors include natural disasters, international oil price hikes, administered prices and depreciation of the exchange rate. There is also the risk that inflation targeting could lead to an inefficient stabilization of output in the face of these unexpected events.

Other arguments against inflation targeting are that there is too much attention being given to inflation target range and neglects other important factors such as growth and unemployment. Furthermore, it is believed that inflation targeting can produce weak central bank accountability due to the long lags from the monetary policy instruments to the inflation outcome (Mishikin, 2000). Another shortcoming is in connection with exchange rate flexibility which is required for a successful inflation targeting as such circumstance can cause financial instability especially in the emerging-market-country context.

In addition, inflation targeting may not be efficient to ensure fiscal discipline or prevent fiscal dominance, i.e., inflation targeting system does not prevent the authorities from pursuing irresponsible fiscal policy which could in the long run dampen the inflation targeting approach. Such actions will lead to a situation where the fiscal deficit will eventually be monetized or the public debt eroded by a large devaluation, and result in a high inflation rate. "Absence of outright fiscal dominance is therefore a key prerequisite for inflation targeting, and the setting up of institutions that help keep fiscal policy in check are crucial to the success of the strategy (Mishkin, 2000)." Other shortcomings as explained in the Mishikin (1999) and Bernanke *et al*., (1999) which are considered not to be serious objections to a well designed inflation targeting approach include; the potential to increase output instability, the ability to lower economic growth and allowing discretions on the part of the monetary authorities.

3.03.6. Escape Clause and Explanation Clause

In order for inflation targeting to be flexible and also for the Reserve Bank to be more accountable, there was an Escape Clause which recognized that there might be some economic supply shocks or unexpected events which are beyond the control of the monetary policy and which can have a major impact on the CPIX inflation rate. This includes a sharp rise in international oil prices, drought, and changes in direct taxes and international contagion which can affect the exchange rate. These shocks might not be related to the domestic economic fundamentals and domestic monetary policy. Reacting to such events could lead to loss of jobs and output. Under such circumstances where the target for CPIX inflation will not be met, it will be indicated so in the monetary policy statement and the Monetary Policy Committee will, therefore, set out the path and time horizon over which the inflation rate will be brought back in line with the target.

The Escape Clause was later replaced by an Explanation Clause. Under the Explanation Clause, if the economy experiences supply shocks, affecting the currency and could take the CPIX outside the target range as envisaged under the Escape Clause. It is the responsibility of the Reserve Bank to inform the public fully of the nature of the shocks, the anticipated impact on the CPIX inflation rate and the monetary policy response to ensure that inflation returns to the target and the time framework over which this will occur.

In order to overcome problems that could be encountered under inflation targeting policy, it is important that the central bank is free to pursue financial stability. The inflation targeting may also be jointly set by the government and the central bank, but the Reserve Bank should be free to choose any tool they consider to be appropriate for achieving the objective once the target has been set. It is also important that there should be co-operation between monetary policy and other policies with the objectives of inflation as one of the goals of the overall policy. In addition, there is a need for well-developed financial markets. In general, monetary authorities require effective money, capital and foreign exchange markets. If financial markets do not react quickly to the instruments applied; it obviously reduces the effectiveness of monetary policy and leads to a delay in impacting on inflation (Mboweni, 2002).

Other preconditions for inflation targeting include availability of human and technological resources; this is because the inflation targeting approach involves using sophisticated forecasting models, which need advanced computer hardware and software. This could be a major constraint in most developing countries which want to embark on inflation targeting. As noted by Mboweni, in the case of South Africa, the Reserve Bank seems to be well equipped for inflation targeting compared with other developing countries.

3.0.3.7. South Africa's Experience in the early stage of Inflation targeting compared with other emerging market countries.

The emerging economics countries (EEC) which have adopted inflation targeting over the years include the Czech Republic, Poland, Israel, Brazil, and Chile. There are quite a number of challenges that are commonly found in these emerging economies in the early stage of adopting inflation targeting, with South Africa being no exception. Many of these emerging economies have undergone structural changes which, therefore, make them susceptible to unexpected shocks and exchange rate volatility compared with the developed nations. Challenges faced by these emerging economies include lack of information on economic development due to less frequently availability of data on economic variables. Lack of credibility and constant deviations from inflation target range are also mostly common among the emerging economies as compared with the developed nations. This results from the fact that developing countries find it more challenging to commit themselves to their target compared with developed nations.
These challenges could be a result of volatile macroeconomic environments and weaker institutions usually found in the emerging market countries.

When comparing South Africa's inflation targeting with those of other newly emerging countries, particularly in the area of stress tests, response and success or failure of inflation targeting, they all had similar experiences. For example, South Africa, like Israel, did face a stress test in its early stage of inflation targeting, precisely in the third year (Powers, 2005). This resulted from increases in housing prices, fruits and vegetable prices which led to a large deviation from the target range. The Israeli authorities reacted to this by tightening monetary policy decisively; this decision was based on the expansionary fiscal policy, demand pressures and a rise in inflation expectations (Powers, 2005). Also, in terms of credibility, institutional and policy adjustments to the framework, the experience was quite similar for most of the newly emerging economies that adopted inflation targeting.

South Africa is similar to Israel, Poland and the Czech Republic in the sense that they all faced a government policy which was contrary to the inflation-- targeting principles in terms of rigidity in administered prices and wage settlements (SARB, 2002). In the case of South Africa, administered prices and wage settlements largely constitute a large proportion of inflation rates as was the case in Israel. Furthermore, South Africa like its counterpart experienced a stress test in the early years which include high international oil prices, 30 percent currency depreciation and rigidities in administered prices. South Africa like Poland, Czech Republic missed its targets at the beginning of its inflation target. This is due to a major rise in food prices and increase in the price of oil as well as high wages (SARB publications, 2004). Czech Republic was different because, instead of overshooting its target, it undershot its target due a drastic fall in the prices of food and commodities. However, the effect of undershooting must not be overlooked as the consequence of undershooting is just as serious as overshooting.

Institutional and policy adjustments were also not unusual among the emerging economies in the beginning of their inflation targeting years. For example, during Israel's first three years, very narrow target ranges were set to focus on expectations but the inflation target was exceeded by 650 basis points (Powers, 2005). Consequently, the target range was replaced by the target range between 200 and 300 basis points wide without impacting on inflation expectations. Also in the Czech Republic, the initial target was 1 percent point band between 1998 and 1999; this was later changed to 2 percent from 2000. The decision was informed by the accuracy with which the bank thought it could achieve the targets as well as the historical volatility of the targeted net inflation pressure. Like these countries, South Africa experienced major changes in its institutional adjustment. For example, it changed its target measure from net inflation to headline CPI from April 2001 onwards due to the SARB's consideration that the CPI headline reflects price development more comprehensively and is also more relevant for economic decisions (SARB, 2002). However, there were arguments against targeting headline CPI due to uncertainty about the development of regulated prices and the effects of changes in administered prices. In addition, the CPIX was initially defined for metropolitan and urban areas and has a wider coverage of households (80 percent) than CPI (metropolitan), with only 40 percent coverage (Aron and Muellbauer, 2006). This was later changed to a targeted measure with the headline of CPIX for all urban areas in February 2009, with the continuous inflation target range for headline CPI between 3 and 6 percent (SARB 2009). Furthermore, the initial Escape Clause that was provided for to accommodate unforeseen events was also changed to An Explanation Clause. Unlike the Escape Clause, it clearly indicates that it is the responsibility of the Monetary Committee to announce to the public fully the nature of the shocks and the anticipated impact on the CPIX inflation rate. It also includes the monetary policy response to ensure that inflation returns to the target and the time framework over which this will occur. There were not many adjustments to Brazil inflation's targeting framework in spite of the difficulties it faced within the first 18 months under inflation targeting, yet they were able to successfully address the continued assault in its inflation targeting framework.

It is impossible to have a successful inflation targeting without credibility on the part of monetary policy makers. Central banks that have adopted inflation targeting have placed a premium on transparent monetary policy Aron and Muellbauer (2006). There are different factors that could affect credibility under the inflation targeting framework. For instance, not meeting inflation targets could impair the credibility of the monetary policy framework, resulting in a lack of confidence in the framework on the part of private agents. According to Powers (2005), supportive government policy is key to both the credibility of the process as well as the success in meeting the targets. However, meeting inflation targeting is largely determined by the government policies. For instance, an increase in wage settlements and administered prices in Israel and South Africa both had negative impact on their inflation targeting approaches in their early years of inflation targeting. In both countries, the inertial inflation expectations were partly a result of high wage settlements and increase in administered prices that led to their missing of targets.

There has been much argument against constant changes and adjustment to inflation target due to its negative impact on credibility. Others have argued that, even if credibility is lost through changes to inflation target, transparency and communication could still be gained in the process. However, “it can be said that the frequent modifications and adjustments to the inflation targets do not necessarily mean that the monetary authority lacks credibility (Powers, 2005)”. Instead, the most important thing is the steadfast commitment on the part of the central bank to the principle of inflation targeting and open communication to the public.

3.0.4. Empirical Evidences from South Africa

Aron and Muellbauer (2002) used multi forecasting technique to investigate the effect of interest rates on output in South Africa. A general - to- specific testing procedure on quarterly data for the period of quarter 1 of 1963 to quarter 2 of 2002 was used. They found that both the rise in nominal interest rates and the level of the real rates had strong negative effects on subsequent output growth. The effect of real interest rates on output was found to persist up to three years; this could be a result of its effect on investment, and hence on capital formation. However, the shifts towards more market-oriented monetary policy in the 1980s appear to have weakened their influences (Aron and Muellbauer, 2000). It was also found that households and firms were able to refinance more easily after the shift in the monetary regime, suggesting that high nominal interest rates did not have much impact on expenditure after the shift in the regime.

It could also be that the effects of high nominal rates prior to market-oriented monetary regime could have been exaggerated due to the new regime leading to a more liberal credit market, which allowed the borrowers to easily refinance even at a high nominal rate. This, therefore, helped to weaken the impact of high nominal rates. Their findings emphasized on focusing on other tools such as competition policy, labour market policies, improved measurement of housing cost in bringing down inflation rather than using interest rates.

Bonga-Bonga and Kabundi (2009) investigated how monetary policy instruments affect inflation in South Africa using structural vector error correctional model approach. The findings employed seasonally unadjusted monthly data for South Africa from February 2000 to September 2007. The variables used were manufacturing as a proxy for GDP, consumer price index, credit extension and interest rates. Impulse response function (IRF) analysis was also used in a vector autoregressive framework. The results showed that a positive shock to interest rates increases total production for the first 6 to 7 months while the negative response of total GDP to interest rate shocks became apparent after 9 months. This however is contradictory to most VAR literature.

A positive shock to interest rate also increased prices for more than 18 months and for a period of at least 20 months; however, there was no evidence that prices are likely to decrease after a positive monetary policy shock. This suggests that a positive monetary shock might not necessarily decrease the price level or that there might not be a substantial lag in the effect of monetary policy on prices. They concluded that there might be a need for a change in monetary policy stance from a simple inflation-targeting to a dual target of inflation, and employment and output growth. The very important channel through which repo rate could influence inflation is through credit demand which, in turn affects total demand and the price level. The results found in their study were contrary to this notion; there was only a slight positive response of credit to positive monetary shock. An increase in the repo rate by 1.5 percentage point from June 2006 to March 2007 was followed by an increase in the credit demand by the private sector. This suggests that an increase in interest rate, in general, is not effective enough to decrease the demand for credit in South Africa. They also found that the impact of interest rate on its own shocks is persistent, i.e., an initial increase in repo rate was found to be followed by subsequent increase in the repo-rates during the period of the analysis.

Khabo and Harmse (2005) evaluated the impact of monetary policy on the economic growth of a small and open economy of South Africa using ordinary least squares regression (OLS). They found the structuralist's argument (i.e., post Keynesians' argument) that the monetary authority does not have a total control on the supply of money to be true. The study confirmed that the money supply as well as CPI do have a significant effect on the economic growth of South Africa, also that the current supply of money is highly correlated with the past supply of money, i.e., the performance of the past money supply has influence on the current money supply.

A study by Gupta *et al.*, (2009), using factor augmented vector autoregressive analysis, to assess how effective monetary policy has become after the adoption of inflation-targeting showed that there was a shrink in the real variables and nominal variables as a result of a contractionary monetary policy in inflation targeting regime. The work also showed that the ability of monetary policy to influence the real macroeconomic variables is more pronounced in the post-inflation targeting regime but that the effect is insignificant. The most significant part of this work is that there was no presence of puzzles as seen in most VAR literature.

Similarly Kabundi and Ngwenya (2011) used FAVAR to assess the monetary policy in South Africa in a data rich environment and found no price puzzle which is contrary to most existing VAR work. They found that the impact of monetary shock on the real variables such as production is more significant than that on inflation. The result showed a drastic fall in the level of production in response to an increase in the short term interest rate; this impact became more glaring after 12 months. All of these studies have used different data in their first differenced form which amounts to establishing short-run relationships among the variables. This research will take things further by looking at the long-run relationships among the variables in order to investigate the impact of monetary policy in the pre-inflation and post-inflation targeting.

3.0.5. Conclusion

This chapter started by looking at the functions and objectives of the Reserve Bank of South Africa and the main objective of the Reserve Bank which is to maintain price stability such as to have room for economic growth. Sections 3.0.2 - 3.0.3 gave a broad overview of the South African monetary policy framework in pre-inflation and post-inflation era, as well as macroeconomic management policies, instruments and methods employed from the 1960s. Some of the rationales for adopting inflation targeting include a need for a specific approach and increase the Reserve Bank's accountability and credibility. Nevertheless, some of the major obstacles to inflation targeting include unexpected supply shocks like exchange rate depreciation and oil price shocks, increase in administered prices and increases in wages and salaries.

These unforeseen circumstances can put an economy in an inefficient level of output, and thus gave birth to introduction of an Escape Clause which was later replaced by an Explanation Clause. In addition, South African inflation targeting was compared with those of its counterpart newly emerging markets, and it was found that they all underwent similar experiences in the early stage of the approach. These countries included Brazil, Israel, Chile, Poland and the Czech Republic. Some of the things they shared in common were stress tests, missing of targets and institutional changes.

Section 3.0.4 gave a brief outline of the relevant empirical findings that have been conducted within the South African monetary policy framework. In particular, the focus is on those findings that are related to the impact of increase in interest rates on the level of output. These findings show a negative impact of increase in interest rate on the level of output, with the exception of Bonga-Bonga and Kabundi's work that first showed an increase in the level of output in response to increase in interest rate for a few months before output started declining. Furthermore, recent works on South African monetary that were considered in this review revealed a negative impact of monetary policy shock on the level of output, such studies include Gupta, *et al.*, (2009), Kabundi and Ngwenya (2011).

Most of the works that have been done so far focussed on the impulse response function (IRF) using VAR and FAVAR analysis. This work will take things further by looking at the cointegration analysis and error correctional model (VECM) within the context of VAR in order to look at both short run and long run consequences of the impact of monetary policy on these macroeconomic variables.

CHAPTER 4

METHODOLOGY AND MODEL SPECIFICATION

4. Introduction

The purpose of this chapter is to outline all the relevant statistical estimations and techniques that will be employed in this study, discussing in detail the models to be estimated in Chapters 5. After discussing the concept of stationarity, this study will look into VAR , cointegration and VECM analysis which will be used to investigate the relationship between South Africa's key macroeconomic variables. This chapter is divided into the following five sections:

Section 4.0.1 undertakes a detail discussion of the issues surrounding stationarity, which include its definition, spurious regression issues, the procedure for testing for stationarity and various types of stationary tests that include Dickey Fuller (DF),
Augmented Dickey Fuller (ADF) and Philip Perron (PPT) stationarity tests.

Section 4.1 discusses the VAR methodology that includes its definition, estimation and identification, Impulse Response Function (IRF) and variance decomposition. The purpose of this is to identify the shock of monetary policy on South African macroeconomic variables in pre and post- inflation targeting periods.

Section 4.2 outlines the VAR model to be estimated for the South African economy in chapter five. This also includes the identification of a five variable VAR model for South African economy.

Section 4.3 discusses the concept of cointegration that includes its definition, the Engle Granger (EG) and the Johansen Vector Error Correction Model (VECM) for cointegrated data. Thereafter, the steps involved in determining cointegration and the estimation of a VECM model will be succinctly outlined.

Section 4.4 specifies the vector error correction to be estimated in Chapter 5 and also discusses the choice of variables to be used for the unrestricted VAR and cointegration models on the basis of the theoretical and practical considerations of Chapters 2 and 3.

4.0.1. Stationarity in Time Series

A random walk is a process where the current value of a variable is composed of its past value plus an error term . It can be shown that the mean of a random walk process is constant but its variance is not. Therefore a random walk process is non-stationary, and its variance increases with t. For example $x_t = x_{t-1} + \varepsilon_t$. Where variable x_t current value is composed of its past past value of x_{t-1} and error term ε_t with zero mean and one variance. Most macroeconomic time data series exhibit random walk[1] behaviour and or trends, and, therefore, are known to be non- stationary. Since the work of Dickey and Fuller (1979), it is known that the estimation of such non- stationary time series equations maybe subject to spurious regression results.

A stochastic process is said to be stationary if its mean, variance and covariance remain constant over time. The value of the covariance between two time periods depends only on the distance or lag between the two time periods and not on the actual time at which the covariance is computed. These conditions can be summarized as follows;

i) E (X_t) = Constant

ii) Var (X_t) = Constant

iii) (X_t , X_t + k) = Constant for all t and all k $\neq$ 0.

Thus the above definition is said to be weakly stationary (Thomas 1997:374; Gujarati 2006: 497). A time series is, however, non-stationary if it fails to satisfy any of the above conditions. In general, a stationary time series tends to return to its mean and fluctuates around it with reasonable constant amplitude, while a non-stationary series will have different means at different points in time. According to Engel and Granger (1987), one can distinguish between stationarity and non-stationarity time series using the following table:

Table 4.1- Difference between Stationarity and Non-Stationarity

Stationarity	**Non-Stationarity**
i) Exhibition of mean reversion in that, it fluctuates around a constant long-run mean ii) It possesses a finite variance that is time-invariant. iii) It has a theoretical correlogram that diminishes as lag length increases	i) There is no long-run mean to which the series returns. ii) The variance is time-dependent and goes to infinity as time approaches infinity. iii) The theoretical autocorrelations do not decay but, infinite samples; the sample correlogram dies out slowly.

Source: Engel and Granger, (1987)

The implication of the second point in Table 4.1 is that the full impact of random changes of every lag or past values of the time series will be carried forward into the current and futures values of the series. Consequently, the variance of this variable will become infinitely large as time approaches infinity. Furthermore, the time series disturbances will be perfectly correlated with itself over time, thus indicating the presence of autocorrelation. This will result in a variability of time series mean across the time and the length of the time lapse between the series returning to one of its original mean values. The problem with non-stationarity of variables is that, it results in spurious regression or spurious correlation problems; “the reason being that, the classical regression model was devised to handle relationship between stationary variables and not non- stationary variables (Thomas 1997: 377)".An example of non stationarity is random walk model as shown in equation 4.1.

$$x_t = x_{t-1} + \varepsilon_t \ , \tag{4.1}$$

where x_t is determined by the process, and ε_t is white noise. Taking expectations from both sides, $x_t = x_{t-1}$, implies that the mean of the process is constant. To check whether the variance is constant over time and assuming that the initial value of X is X_0,

It gives :

Period 0, X_0 (4.2)

Period 1, $X_0 + \varepsilon_1 = X_1$ (4.3)

Period 2, $X_1 + \varepsilon_2 = X_0 + \varepsilon_1 + \varepsilon_2 = X_2$ (4.4)

Period 3, $X_2 + \varepsilon_3 = X_0 + \varepsilon_1 + \varepsilon_2 + \varepsilon_3 = X_3$ (4.5)

All together, we have; $X_t = X_0 + \varepsilon_1 + \varepsilon_2 + \varepsilon_3 \ldots + \varepsilon_t$ (4.6)

The equations above show that, as the variable grows from its base: it is accompanied by a stochastic distance ε_t. If the variable continues to grow indefinitely, it will drift further away from its base. For example, the foreign exchange rate today equals to the foreign exchange rate of yesterday plus a random shock.

4.0.2. Stationarity testing

In modern macroeconomics, it has become a common practice to test for stationarity when dealing with time series data, as the estimation of non-stationary time series maybe subject to spurious regression results resulting from stochastic or deterministic trend that runs through the data. As this must not be presumed by the researcher, testing for unit root becomes very important (i.e., testing for unit roots is the same as testing for stationarity).

$$x_t = \phi x_{t-1} + \varepsilon_t \qquad (4.7)$$

The most commonly used formal method for testing for a unit root was proposed by Dickey and Fuller (1979, 1981). Dickey- Fuller approach was based on using critical values to test for unit roots. The test involves running a simple random walk regression in (4.7) above for all time series variables defined by the econometric model. The key object is to check whether ϕ is equal to 1 (i.e., there is unit root). The equation can also be written as in (4.8) and (4.9) if X_{t-1} is subtracted from both sides.

$$x_t - x_{t-1} = (\phi - 1)x_{t-1} + \varepsilon_t, \qquad (4.8)$$

$$\Delta\ x_{t-1} = \gamma x_{t-1} + \varepsilon_t, \qquad (4.9)$$

where $(\phi - 1) = \gamma$. Having estimated γ or ϕ via OLS, one can test the null hypothesis- $H_0 : \gamma = 0$, or ϕ=1 (i.e., there is presence of unit root) and the alternative hypothesis $H_1 : \gamma < 0$ or $\phi < 1$. (i.e., the series is stationary).

The significance test is achieved by comparing the computed tau ('t') against the critical ('t) statistic. The computed't' statistics (i.e Dickey Fuller statistics) is the normal't' test on the coefficients of the dependable variables. This is achieved by dividing γ or ϕ coefficients by their respective standard errors to obtain $t\gamma$ or $t\phi$, and then compare them with the tabulated critical tau statistics. If the computed sample values are more negative than the critical value't' statistics, it leads to the rejection of the H_0 in favour of the alternative H_1. If there is a positive or less negative critical value, it means that the null hypothesis should not be rejected and hence the series is I(1). (i.e., non stationary).
However, MacKinnon (1991) provided more appropriate critical values as an alternative to the DF critical statistics which is often used in most macroeconomics models. The Eview 6 software package generates the MacKinnon critical values which will be used in this study.

Dickey and Fuller also proposed two other alternative regression equations that can be used for testing for the presence of a unit root. The first contains a constant in the random walk process which is often the case for most macroeconomic variables. This is shown in the equation below:

$$\Delta x = \alpha_0 + \gamma x_{t-1} + \varepsilon_t \qquad (4.10)$$

This case is important when one is not sure about the nature of the series and hence, it is safer to include a constant.

The second regression allows a non-stochastic time trend in the model so as to have;

$$\Delta x = \alpha_0 + a_2 t + \gamma x_{t-1} + \varepsilon_t \qquad (4.11)$$

where t is the time trend variable. This regression is very important when there is a possibility of a deterministic trend being present in the data or when the underlying data generation process (DPG) is unknown.

The methodology is precisely the same, regardless of whether the equation is in the form of a pure random walk, a random walk with constant or a random walk with both constant and trend. However, the critical values of the t-statistics do depend on whether an intercept and/or time trend is included in the regression equation. Dickey-Fuller (1979) also found that the critical values of $H_0 : \gamma = 0$, or ϕ =1 depends on the form of the regression and the sample size.

Usually, error terms are unlikely to be white noise. Thus Dickey and Fuller (ADF) (1979, 1981) extended their test procedure suggesting an augmented version of the test which includes extra lagged terms of the dependent variables in order to eliminate autocorrelation in a model. To illustrate Augmented Dickey Fuller (ADF) test, consider equation (4.12).

$$\Delta\ x_t = \alpha_0 + a_2 t + \gamma x_{t-1} + \sum_{i=1}^{p} \beta_i \Delta x_{t-p+1}\ +\ \varepsilon_t \tag{4.12}$$

where $\Delta x_{t-1} = (x_{t-1} - x_{t-2})$, $\Delta x_{t-2} = (x_{t-2} - x_{t-3})$ ….to $\Delta x_{t-p+1} = (x_{t-p+1} - x_{t-p})$. However, one uses n lagged difference terms, the number of which are empirically determined by either Akaike Information Criterion (AIC) or Schwartz Bayesian Criterion (SBC). The reasons for including as many lagged terms as possible is to ensure that the error term (ε_t) in the Augmented Dickey Fuller test as contained in equation 4.12 becomes white noise (i.e., they are serially uncorrelated). As is the case in Dickey Fuller test, the usual Dickey Fuller tau statistics is also applicable to the Augmented Dickey Fuller test, and the testing hypothesis still remains the same. Therefore, if the 't' statistics estimated in equation (4.12) has a high negative number, then the correspondence time series will be stationary.

Another unit root testing procedure that is commonly used is Phillips-Perron test (PPT) which was developed in 1988. Philip-Perron test supports the Dickey-Fuller tests in that, it assumes that the errors are statistically independent and have a constant covariance. They, however, used a generalization of the Dickey-Fuller procedure that allows for fairly mild assumptions concerning the distribution of the errors. The procedures are modifications of the Dickey-Fuller t-statistics that take into consideration less restrictive nature of the error process. To illustrate Philip – Perron (PP) approach, consider equation:

$$\Delta x_t = \alpha_0 + \sigma x_{t-1} + \varepsilon_t \tag{4.13}$$

In the case of ADF test, it corrects for higher order serial correlation by adding lagged differenced terms on the right-hand side of the equation. The PP test, on the other hand, makes a correction of the coefficients σ in the equation (4.13) in order to account for the correlation ε_t . The asymptotic distribution of the PP 't' statistics is the same as that of the ADF 't' statistics, and thus the MacKinnon (1991) critical values are also applicable which is calculated by eview software. Also, in the same way as with DF, ADF tests, the

PP test can be performed by including a constant, constant and trend or neither of the two in the regression.

4.0.3 Transforming Non-stationary time series to Stationary Time Series.

Once non-stationarity has been established through those tests that have been explained in the previous section, such data must be differenced in order to conduct a VAR analysis, especially since VAR models routinely assumes that the data are stationary (Enders, 1995:266). In order to difference a data series, one must first check whether the order of integration is one (i.e., x_t ~I(1),). The results are usually displayed by eview software, showing whether a series becomes stationary at first differencing or not based on the 't' statistics; if the series is not stationary at first differencing, one can proceed to differencing the series the second time (i.e., x_t ~I(2),). However, this analysis is not expected to go this far because most macroeconomic time series data are usually ~ I(1).

To illustrate how stationarity is achieved by differencing, consider a first order process $x_t = \alpha + \beta t + \phi x_{t-1} + \varepsilon_t$, if β = 0, and ϕ =1, where there is a problem of unit root due to the exhibition of upward or downward trends depending on the sign of ϕ. This situation is known as stochastic trend. Stationarity can be achieved by removing Y_t from both sides of the equation which results in the equation below

$$\Delta x_t = \alpha + \varepsilon_t \tag{4.14}$$

The equation is constant and stationary. Hence the process is known as difference stationary process (DTP). Differencing process involves calculating the difference between successive observations, and if required, the first differences of the first differences (second differencing) maybe computed to achieve stationarity. As explained before, if after taking first differences the series are rendered stationary, then it is referred to integration of the order 1 designated by I(1) . Similarly, if the original series needs to be differenced twice before stationarity is achieved, then the series is integrated of order 2 of I(2). Also, if the series has to be differenced d number of time before stationarity is achieved, the series is integrated of order d of I(d) .

The second way of converting non-stationarity series to stationarity is through detrending of time series that exhibits trends. The trend /time variable (t) is usually included in such series in order to avoid spurious regressions. This process is known as trend stationary process (TSP). Nelson and Posser (1982) asserted that it is acceptable to include the deterministic time/trend into the regression in order to render non-stationarity to stationarity time series. To illustrate this process, assuming one has a regression equation Yt = $\alpha + x_{t-1} + \beta t + \varepsilon_t$ and if $\beta \neq 0$, such a trend is known as a deterministic trend. A deterministic trend, therefore, cannot be removed by first differencing, since it will not remove t from the process. If Yt is subject to such a trend, it is said to be a trend stationary process where ε_t is regarded as a stationary variable since $\varepsilon_t = xt - \alpha - \beta t$

However, since most macroeconomic time series generally display upward trends and increasing variances, they are best described as being non-stationary with a stochastic drift trends instead of being stationary with a deterministic time trend. This is because non stationary time series show signs of stochastic drift trends as a result of the stochastic trends influence; hence they do not follow constant variance and covariance. Stationary time series on the other hand, are characterized by deterministic trends which continue to revert back to its mean as times progresses, and exhibit finite variance and covariance.

4.1.0 VAR Analysis

VAR methodology has been used extensively in analyzing monetary policy transmission mechanisms as well as other macroeconomic models due to its ability to handle multiequation models. This methodology seems to be the best method for the kind of analysis that is done in this study because it enables one to consider interrelationships among South Africa's key macroeconomic variables. The discussion of VAR methodology in this section is drawn from Enders, (1995: 264-280).

VAR models have the form of simultaneous-equation modelling in the sense that it takes into consideration a number of variables at a time, and also all the variables in the model are treated symmetrically. This approach was based on the fact that sometimes it is difficult to separate the endogenous from exogenous variables. Assuming that an economic theory suggests a relationship between variable x and y, modeling each variable may involve autoregressions of x on lagged values of x and y on lagged values of y.

Nevertheless, such a separate approach would not capture the interactions that might exist between the two variables. For example, suppose variable x is interest rate and y is GDP, it is likely that variable x and y are related. Thus, modelling these variables should take place in a multivariate framework (bivariate in this case, since we are looking at two variables). In a VAR system, variable x is not just related to its own lagged value but also to the lagged value of y. In the same way, y is also related to its own lagged value as well as lagged value of x.

In the primitive system of VAR, each equation is assumed to be white-noise disturbance, i.e., they are uncorrelated. However, there is autocorrelation in the reduced form of the equation, since each variable is meant to be affected by the lagged value of itself as well as the contemporaneous and lagged values of other variables in the model. There are two dimensions in the VAR analysis, the length or order of the autoregression p and the number k of the variable that are jointly modelled. For instance, for a bivariate equation, k=2, while for a multivariate equation, k=3. To illustrate the VAR analysis, assuming that the time path of variable x is affected by current and past realizations of y will yield the following bivariate equations;

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} - \begin{bmatrix} b_{12} \\ b_{21} \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix} + \begin{bmatrix} \Pi_{11} & \Pi_{12} \\ \Pi_{21} & \Pi_{22} \end{bmatrix} \begin{bmatrix} x_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{xt} \\ \varepsilon_{yt} \end{bmatrix}, \qquad (4.15)$$

Where x_t and y_t are stationary, and error terms (ε_{xt} and ε_{yt}) are white-noise disturbances with standard deviations of σ_x and σ_y respectively where ε_{xt} and ε_{yt} are uncorrelated. This equation is known as structural VAR or primitive VAR system.

Equation (4.15) is not a reduced form equation, since the variable x_t has a contemporaneous effect on y_t and y_t has a contemporaneous effect on x_t. However, one can transform the equation to obtain VAR in a standard and reduced form by using the matrix algebra, say (Note: Eviews perform the matrix algebra calculations automatically)

$$z_t = A_0 + \Pi_1 z_{t-1} + e_t \tag{4.16}$$

Hence, one can rewrite 4.16 in the equivalent form:

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} x_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \tag{4.17}$$

4.1.1 Estimation and Identification

The VAR equation in (4.15) cannot be estimated directly as x_t is correlated with the error term εy_t and y_t is correlated with the error term εx_t. Such equation cannot be estimated via OLS, as the standard estimation techniques require that the regressors be uncorrelated with the error terms in order to recover all the information in the primitive system in (4.15). However, equation (4.15) remains unidentified unless one is willing to restrict one of the parameters. A popular way of identifying restrictions is to use a recursive system as proposed by Sims (1980). Assuming one imposes a restriction on the primitive system in (4.15) such that the coefficient b_{21} equals to zero, imposing restriction, B^{-1} is given below;

$$\begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \tag{4.18}$$

Again, by premultiplying the original VAR by B^{-1} and estimating the system by using OLS results in the following equation as in (4.17):

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} x_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix},$$

where $e_1 = \varepsilon_{xt} - b_{12}\varepsilon_{yt}$ and $e_2 = \varepsilon_{yt}$. If however, the restriction has been made such that b_{12}=0, one would have arrived at $e_{1t} = \varepsilon_{xt}$ and $e_{2t} = -b_{21}\varepsilon_{xt} + \varepsilon_{yt}$.

This type of restriction assumes that y_t has a contemporaneous effect on x_t but that x_t affects y_t sequence with a one-period lag. Also, the error terms ε_{xt} and ε_{yt} both affect the contemporaneous values of x_t, but only ε_{yt} shocks affect the contemporaneous value of y_t. Thus the observed values of e_{2t} are completely attributed to the pure shock to the y_t sequence. This restriction can be used to represent a particular economic model. When one variable is restricted in the case of a bivariate model above, the system is said to be exact identified. In general, in an n-VAR, B is an n X n matrix since there are n regression residuals and n structural shocks.

Therefore, the exact identification requires that (n^2- n)/2 restrictions be placed on the relationship between the regression residuals and the structural innovations (Enders, 1995: 272). This refers to decomposing the residuals in a triangular fashion known as Cholesky decomposition. In practice, one decides which of the decomposition is most appropriate (i.e., either to put a restriction such that b_{21} =0 or b_{12}=0) based on the assumption that one variable has no contemporaneous effect on the other. For example, one can assume that the output performance does not have immediate effects on the monetary policy.

4.1.2 Impulse Reaction Function (IRF)

In order to further understand how VAR works, it is important to consider how macroeconomic variables respond to different kind of shocks. This response is known as Impulse Reaction Function (IRF). It is possible to identify each shock or innovation associated with a particular variable in the model. Such shocks can be said to be a path whereby variables move away from and then return to their equilibrium point within a specific period of time. Again, one needs to impose an additional restriction on the VAR system in order to identify the impulse responses by using Cholesky decomposition through the use of matrix algebra which eviews software automatically generates. To illustrate IRF, consider the bivariate systems expressed in matrix form in (4.17) which can also be written in the form of a moving average representation, if u_x and u_y are mean values of x_t and y_t respectively:

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} u_x \\ u_y \end{bmatrix} + \sum_{p=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} e_{1t-p} \\ e_{2t-p} \end{bmatrix} \tag{4.19}$$

Again, one must impose an additional restriction in order to identify Impulse Response Function as explained earlier through matrix algebra; hence one can re write the moving average representation in (4.19) in terms of ε_{xt} and ε_{yt}:

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} u_x \\ u_y \end{bmatrix} + \sum_{p=0}^{\infty} \begin{bmatrix} \phi_{11}(p) & \phi_{12}(p) \\ \phi_{21}(p) & \phi_{22}(p) \end{bmatrix} \begin{bmatrix} \varepsilon_{xt-p} \\ \varepsilon_{yt-p} \end{bmatrix} \tag{4.20}$$

To be more compact, 4.20 can be written as:

$$z_t = u_t + \sum_{p=0}^{\infty} \phi_p \varepsilon_{t-p} \tag{4.21}$$

where u_t is a vector of moving average $\lfloor u_x \quad u_y \rfloor$.

The coefficients of $\phi_{11}(p)$, $\phi_{12}(p)$, $\phi_{21}(p)$ and $\phi_{22}(p)$ are called the impulse response functions (Enders, 1995: 274). Their purpose is to generate the effects of ε_{xt} and ε_{yt} shocks on the entire time paths of the x_t and y_t sequence. For example, the coefficient $\phi_{12}(0)$ is the immediate impact of a one-unit change in ε_{yt} on x_t. Likewise, the elements $\phi_{11}(1)$ and $\phi_{12}(1)$ are the one-period responses of unit change in ε_{xt-1} and ε_{yt-1} on x_t respectively. Also, updating by one period indicates that $\phi_{11}(1)$ and $\phi_{12}(1)$ represent effects of unit change in ε_{xt} and ε_{yt} on x_{t+1}. Therefore, the accumulated effects of unit impulses in ε_{xt} and ε_{yt} can be obtained by the appropriate summation of the coefficients of the impulse response functions. Accordingly, after n periods, the cumulated sum of the effects of ε_{yt} on the sequence of x_t is given as:

$$\sum_{p=0}^{n} \phi_{12}(p) \tag{4.22}$$

Furthermore, by letting n approach infinity will yield the long run multiplier. Since the x_t and y_t sequences are assumed to be stationary, thus it must be the case that for all j and k, it be given as follows:

$$\sum_{p=0}^{\infty} \phi^2 jk(p) \tag{4.23}$$

4.1.3 Variance Decomposition

The unrestricted VAR are usually not so good in estimating short- term forecasts since they are overparameterised. However, the understanding of the properties of the forecast errors is extremely helpful in estimating interrelationship among the variables in the system (Enders 1995: 278). Assuming the matrix coefficients of A_0 and Π_1 in (4.16) are known and one wants to forecast the various values of z_{t+i} conditional on the observed value of z_t. Updating (4.16), with one period ahead (i.e., $z_{t+1} = A_0 + \Pi_1 z_{t-1} + \varepsilon_{t+1}$) and taking the conditional expectation of z_{t+1} gives:

$$E_t z_{t+1} = A_0 + \Pi_1 z_t \tag{4.24}$$

The equivalent forecast error is defined as:

$$e_{t+1} = z_{t+1} - E_t z_{t+1} \tag{4.25}$$

In general, n step- ahead forecast is defined as:

$$E_t z_{t+n} = (I + \Pi_1 + \Pi_1^2 + ... + \Pi_1^{n-1})A_0 + \Pi_1^n z_t \tag{4.26}$$

The associated forecast is defined as:

$$e_{t+n} + \Pi_1 e_{t+n-1} + \Pi_1^2 e_{t+n-2} + ... + ...\Pi_1^{n-1} e_{t+1} \tag{4.27}$$

The purpose of forecasting error variance decomposition is to show the proportion of the movements in a sequence due to its own shocks to other variables. It is also possible to write these forecast errors in terms of the ε_{xt} and ε_{yt} shocks. If ε_{yt} shocks explain none of the forecast error variance of x_t at all forecast horizons, one can conclude that x_t sequence is exogenous. Thus, x_t sequence would progress independently of the ε_{yt} shocks and of the y_t sequence. On the other hand, if ε_{yt} shocks could explain all the forecast error variance in the x_t sequence at all forecast horizons, x_t would be entirely endogeneous. This study will examine how monetary policy (short term interest rate) impacts on industrial production through the use of variance decomposition mechanism.

4.1.4. Stationarity and Stability in the VAR

Usually, in the first-order autoregressive equation i.e. $x_t = \beta_0 + \beta_1 y_{t-1} + \varepsilon_t$, the stability condition can only be achieved if β_1 is less than 1. If this condition is met, the equations are stationary and do not have a unit root. As discussed earlier, when data - generation process exhibits a random walk with infinite memory to shock, such model is said to have a unit root and the series is non-stationary. AVAR process is not different, because the presence of a unit root in the VAR model will render it unstable. Such problems can be overcome by first differencing as explained earlier. Also, when a group of variables are cointegrated, a linear combination of such variables will yield a stationarity result under VAR analysis provided the are I(1). Such combination provides more information about the long run relationship among the variables.

In other words, in the first-order autoregressive equation, all the eigenvalues of β_1 must have a modulus less than 1. The eigenvalues (Φ_1) of β_1 are the roots of the kth order characteristics polynomial $|\beta - \phi|$ obtained by solving the characteristics equation below:

$$|B| = |\beta_1 - \phi_1| = 0, \qquad (4.28)$$

where $|B|$ is the determinant of matrix B. However, if the roots (Φ_1) < 1, it implies that the model is stable.

To further explain the stability of VAR, consider equation 4.25 which can be written in the form of lag operator as shown in 4.26:

$$x_t = b + Ax_{t-1} + \varepsilon_t \qquad (4.29)$$

$$(I - AL)x_t = b + \varepsilon_t \qquad (4.30)$$

Assuming error term is omitted from the equation above, it will result in $(I - AL)y_t = b$. The necessary stability condition requires that equation (4.26) must lie outside the unit circle. $(I - AL)y_t = b$ can then be written as a polynomial in order to see the stability conditions in terms of the eigenvalues:

$$G(L)y_t = b, \tag{4.31}$$

where $G(L)=I-AL$, $\Rightarrow G(L) = (1-\lambda_1 L)(1-\lambda_2 L)$. $G(L)y_t = b$ is nothing but a matrix polynomial in the lag operator. In reality, a number of econometrics software are available to calculate the eigenvalues such as e-view, stata and microfit software.

4.2.0. VAR Model Specification for South African Economy

This section presents the VAR model that will be specifically made use of in Chapter 5. VAR methodology also known as unrestricted VAR as proposed by Sim (1980) will be used in the first part of this analysis.

4.2.1. VAR Model Specification for South African Economy

There are three unrestricted VAR models to be estimated. The first model is the pre-inflation targeting period model (1987m01 -2000m01), and the second model is post-inflation targeting period model (2000m 02-2009m 12). The third is a benchmark model that covers the whole period (1987m01-2009m12) against which the pre and post-inflation targeting models will be compared.

There are quite a number of researchers who have used VAR to analyze the monetary transmission mechanism. To mention a few; Lovrinovic and Benazic (2004) for the European Union, Arnostova and Hurnik (2005) for Czech Republic, Cheng (2006) for the Kenyan economy and Tsangarides (2010) for Mauritius.

The South African economy in the context of VAR is represented by the equation below:

$$Y_t = A(L)Y_t + B(X_t) + \varepsilon_t \tag{4.32}$$

The equation above is a reduced- form equation which is derived from the structural equation. It shows the relationship between all the endogenous variables: industrial production, Inflation rate, money supply (M2), short term interest rate, and nominal exchange rate.

The structural equation for this model can be explained as:

$$GY_t = AY_{t-1} + BX_{t-1} + \varepsilon_t \tag{4.33}$$

where, G represents all the coefficients describing the contemporaneous relationship among the variables. Matrix A includes all the coefficients describing the lagged relationship among all the variables, while matrix B shows all the coefficients describing the relationship between the endogenous variables and the exogenous variable, and ε_t encompasses the residuals. If equation 4.35 is multiplied by $G^{(-1)}$, it results in the equation below:

$$Y_t = G^{(-1)}AY_{t-1} + G^{(-1)}BX_t + G^{(-1)}\varepsilon_t \tag{4.34}$$

This can then be written in a more reduced form as in 4.32 above.

$$Y_t = A(L)Y_t + B(X_t) + u_t$$

In the empirical analysis, the Brent Crude oil price will be used as a proxy for the world oil price while global manufacturing index will be used as a proxy for global commodity price. The two variables are assumed to be exogenous to the South African economy.

Dummies such as transition of regime in 1994, adoption of inflation targeting monetary policy in 2000 and credit crunch in 2008 are included in the model to account for possible structural break in the system. These are represented by the following vector:

$$X_t = [DOP \quad DPR \quad D94 \quad D2000 \quad DCC] \tag{4.32}$$

where DOP is the differenced world oil price and DPR represents differenced global commodity price, D94 represents dummy for the transition of political regime in 1994, D2000 represents change in monetary policy that took place in 2000 and DCC represents credit crunch that occurred in 2008. D94 assumes the value of 1 from January 1994 onwards. The second dummy is D2000 which assumes the value of 1 from February 2000 on ward. The lastly dummy is D2008 assuming the value of 1 from August 2007 to March 2009. Usually, there are no exogenous variables in the VAR model, but these variables are included to eliminate the price puzzle that is commonly found in VAR.

The endogenous variables include industrial production, 12 month percentage change in CPI, short term interest rates, nominal exchange rate and money supply (M2). These are shown in the vector Y_t :

$$Y_t = [\ DY \quad DINFL \quad DI \quad DX \quad DM2\ ], \tag{4.33}$$

where DY stands for differenced industrial production, DINFL for differenced 12month percent change in CPI, DX for differenced nominal exchange rate and DM2 for differenced money supply (M2).

Note: All the dummy variables will enter into the bench mark model that covers the 1987 to 2009 period, while the D94 dummy will enter the pre VAR specification only and the DCC dummy will enter the post VAR specification only

4.2.2. Identification for South African Economy

As explained in section 4.1.1, the primitive VAR cannot be estimated using OLS because of the cross-correlation of error terms and regressors between the various equations in the system. Hence, to identify the coefficients in the system, this study will invoke the orthogonal recursive assumption that was introduced by Sim (1980), to model the South African economy. The assumption is based on the identification of original shock ε_t using the vectors of residuals u_t. This can only be achieved if an assumption is made such that there exists an exact relationship of $n^2 - \{(n^2 - n)/2\}$ simultaneous relationship among the variables, where n is the number of endogenous variables. The implication of this is that the recursive assumption will require $\frac{n\chi(n-1)}{2}$ additional restrictions for this model.

This is achieved by imposing the matrix G as a lower triangular one, i.e., by setting all the coefficients above the diagonal equal to zero. This represents the assumption made on the structure of South African economy by choosing an ordering of the variables explained in 4.33. This type of ordering of variables follows that of Hurnik and Anostova (2005) with a slight modification to suit the South African economy. The ordering of endogenous variables is very important in Cholesky decomposition, For example, the ordering of variables in a particular way reveals what is observed by the monetary policy at the time, which decision is made and also which variables do not respond contemporaneously to the policy action. Hence one makes an assumption that there exists simultaneity among these variables.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ G_{21} & 1 & 0 & 0 & 0 \\ G_{31} & G_{32} & 1 & 0 & 0 \\ G_{41} & G_{42} & G_{43} & 1 & 0 \\ G_{51_{51}} & G_{52} & G_{53} & G_{54} & 1 \end{bmatrix} \begin{bmatrix} u_t^{YGAP} \\ u_{DINFL} \\ u_t^{DI} \\ u_t^{DX} \\ u_t^{DM2} \end{bmatrix} = \begin{bmatrix} \varepsilon_t^{YGAP} \\ \varepsilon_t^{DINFL} \\ \varepsilon_t^{DI} \\ \varepsilon_t^{DX} \\ \varepsilon_t^{DM2} \end{bmatrix} \qquad (4.37)$$

The ordering of variables in equation 4.33 assumes that the first variable responds to its own shock, the second variable responds to the first variable as well as the shock of itself. The last variable in the equation responds contemporaneously to all other variable as well as the shock of itself. Also, in this model, it is assumed that the Monetary Policy Committee in its decisions take into consideration the current stage of variables such output (DY), inflation (DINFL), exchange rate (DX) as well as money supply (DM2).

Furthermore, the ordering assumes that the monetary policy does not have a contemporaneous effect on output and prices and that the interest rate is said to have an immediate effect on the exchange rate, but that the interest rate does not respond in the same period to changes in the exchange rate. The last assumption has been argued not to be applicable to a small and open economy but only applicable to a large and relatively closed economy. However, the recursive assumption made in this model does not allow for a contemporaneous effect of exchange rate on the interest rate. Even though South Africa is a small and open economy, the monetary policy is expected not to react contemporaneously on the exchange rate, as the current monetary policy is inflation targeting. It is therefore expected to be more concerned about the ultimate effects of the inflation forecast. Consequently one can argue that this type of ordering is well suitable for an economy such as South Africa. (See Anostova and Hurnick 2005 who used similar model for the small and open economy of Czech Republic).

4.3.0 Cointegration and Error Correction Model

This section focusses on cointegration and error correction model. The previous section dealt with unrestricted VAR methodology which takes into account the short-run relationship among the variables only and which was estimated through differencing the I(1) variables. However, this approach loses important long run information. Hence, this study will endeavour to exploit the information contained in the levels of the variables by estimating long run cointegrating relationships among the variables and incorporating them into a VECM via the Johansen (1988, 1991) method.

This section will outline the concept of cointegration and the VECM model which estimates both short and long- run relationships among the variables. The section begins with the definition of cointegration, followed by discussion of VECM, and the steps involved in estimating cointegration and VECM using Johansen method.

4.3.1Cointegration and Error Correction Model

Since the data series employed in this study are found to be non-stationary (See Chapter 5 Table 1-7), such series can meander without any tendency to return to a long run level. Such regression will, therefore, yield spurious results if modelled in levels. As explained earlier, the solution to such problem is to difference the series in order to make it stationary. However, the problem with using differenced data is that it only gives a short-run relationship, in differencing data series; much long-run relationships information among variables is lost in the process. Hence, cointegration approach is more effective in dealing with non-stationary data since it gives short - run and long-run relationships. [2]

Cointegration theory asserts that there exists a linear combination of these non-stationary variables that are stationary (Enders, 1995: 320). “If each element of a vector of time series x, first achieves stationarity after differencing, but a linear combination β'x, is already stationary, the time series x, are said to be co-integrated with co-integrating vector β, (Engle an Granger, 1987)”. However, there may be a number of such co-integrating vectors so that (β) becomes a matrix. Interpreting β'x, = 0 as a long run equilibrium, cointegration implies that deviations from equilibrium are stationary, with finite variance, even though the series themselves are non- stationary and have infinite variance (Engle and Granger, 1987). The major advantage of cointegration and error correction model is that it gives short-run and long – run relationship between the variables.

Assuming a linear function of 3 non-stationary variables as in equation 4.38, each of these variables can wander without any tendency to return to a long-run level, cointegration analysis asserts that the combination of these 3 variables is stationary. Thus solving for the error term, equation 4.38 can be re-written as 4.39.

$$z_t = \beta_0 + \beta_1 p_t + \beta_2 y_t + \beta_3 r_t + \varepsilon_t \qquad (4.38)$$

Since (ε_t) must be stationary, it follows that the linear combination of integrated variables given by the right side of the equation (4.38) must also be stationary.

$$\varepsilon_t = z_t - \beta_0 + \beta_1 p_t - \beta_2 y_t - \beta_3 r_t \qquad (4.39)$$

Accordingly, the theory necessitates that the time paths of all the 3 variables must be linked. A more formal description of cointegration analysis can be explained thus: consider a set of economic variables in long-run equilibrium when;

$$\beta_1 x_{1t} + \beta_2 x_2 + \ldots + \beta_n x_{nt} = 0 \qquad (4.40)\backslash$$

Let β and x_t denote the vectors ($\beta_1, \beta_2, \beta_3 \ldots \beta_n$) and ($x_{1t}, x_{2t}, \ldots, x_{nt}$). The system is in long-run equilibrium when $\beta x_t = 0$. The deviation from long-run equilibrium is called equilibrium error, such that $\varepsilon_t = \beta x_t$. See Enders 1995: 322.

Also, according to Engle and Granger, (1987), the components of the vector ($x_{1t}, x_{2t}, \ldots, x_{nt}$) are said to be cointegrated of order d, b, denoted by x_t ~ CI(d,b) if

i. All components of x_t are integrated of order d

ii. There exists a vector $\beta = (\beta_1 x_{1t} + \beta_2 x_{2t} + \ldots + \beta_n x_{nt})$ which is integrated of order (d-b) where b > 0.

where β is known as the cointegrating vector.

4.3.2 Error Correction Model

When variables are cointegrated, it is important to note that such variables are highly influenced by their time paths and the extent to which any deviation from long-run equilibrium occurs. Before the system can return to its long run equilibrium under such circumstance, there must be movements of at least some of the variables responding to the magnitude of the disequilibrium (Enders, 1995:328).

To illustrate this, assuming a bivariate model with the assumption that the two variables (x and y) are both I(1). Error correction model is also included in the system.

$$\begin{bmatrix} \Delta x_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \Delta x_{t-1} \\ \Delta y_{t-1} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \end{bmatrix} \left[y_{t-1} - \beta x_{t-1} \right] + \begin{bmatrix} \varepsilon_{xt} \\ \varepsilon_{yt} \end{bmatrix}, \tag{4.42}$$

where ε_{xt} and ε_{yt} are white-noise disturbances terms which may be correlated. The variable (x_t) and (y_t) change in response to stochastic shocks represented by ε_{xt} and ε_{yt} as well as the response to stochastic deviation from long-run equilibrium. For example, if this deviation happens to be positive such that the error correction $\left[y_{t-1} - \beta x_{t-1} \right]$ is greater than zero, the variable (y_t) would rise and the variable (x_t) will fall. Long-run equilibrium is, however, attained when $y_{t-1} = \beta x_{t-1}$.

δ_1 and δ_2 have interpretations of speed of adjustment parameters which can also be termed as short-run adjustments, i.e the larger δ_1, the greater is the response of x_t to the previous period's deviation from long – run equilibrium. Small values of δ_1 imply that x_t is unresponsive to the last period's equilibrium error. However, at least one of the speed adjustments (δ_1) and (δ_2) must be non-zero and, if they are both zero, it implies that the long – run equilibrium relationship does not exist and that the model is not of error correction or cointegration.

4.3.3. Testing for Cointegration using Johansen Method

The concept of cointegration and vector error correction (VECM) was formalized by Engle and Granger (1987) by introducing a simple test procedure to analyze the existence of long-run relationships. However, there are major setbacks with this procedure. For example, when there are more than two variables there may be more than one cointegrating relationship which cannot be handled by Engle-Granger procedure using residuals from a single relationship. Consequently, it is impossible for such approach to give the number of cointegrating vectors (Asterious and Hall, 2007: 317). A more advanced technique to correct such flaw is provided by Johansen (1988). Johansen's work was based on testing for Π as shown in equation 4.43 which provides estimates of α and β through a procedure known as a reduced-rank regression. There are 3 steps involved in Johansen's methodology:

$$\Pi = \alpha\beta' , \qquad (4.43)$$

Where α is represents the speed of adjustment coefficients and β is the matrix of the long-run coefficients.

- **Testing the Order of Integration**: The first step involves testing for the order of integration of the variables under examination. Most economic time series are non-stationary and therefore integrated. However, the most desirable case for cointegration is a situation where all the variables of interest are integrated of the same order. Testing for the order of integration is very crucial especially in cases where we have a mix of I(0), I(1), I(2) variables. It is still possible that contegrating relationship might still exist but if such mixed variables are included in a model, it can lead to a spurious regression. However, in general, most economic variables are integrated of I (1)

- **Setting the appropriate lag length of the model**: The second step for Johansen method is setting the appropriate lag length of the model. If the lag length of a particular model is different from the true lag length, the results of such estimation will be inconsistent, and so will the impulse function and error decomposition of the model (Baun and Mittnik, 1993).

According to Astriou and Hall (2007), in order to choose an appropriate lag length, VAR model including all non-stationary variables in question are estimated with a large number of lags, then reducing down by re-estimating the model for one lag less until we reach zero. In each of these models, values of Akaike information criterion (AIC) and Schwarz information criterion (SIC) criterion are compared. Also diagnostics concerning autocorrelation, heteroskedasticity, possible ARCH effects and normality of the residuals are compared. Generally, the model which minimizes AIC and SBC and which also passes all diagnostic checks are selected as the one with the optimal lag length. Statistical software such as e-view provides different appropriate lag lengths based on different criterion (i.e., AIC, SIC, and FPE).

- **Choosing the appropriate Model regarding the deterministic components in the multivariate system:** The next step of Johansen method is to check whether an intercept or trend should be included in the model. Generally there are 4 stages involved in determining this process , according to Asteriou and Hall (2007), This process can be summarized below:

  i. No intercept or trend in CE (cointegration and error correction model), or VAR. Though this rarely occurs in the real sense. Since intercept is generally needed to account for adjustments in the units of measurement of the variables.
  ii. Intercept but no trend in CE, no intercept or trend in VAR (i.e., no linear trends in the data). This implies that the first differenced series have a zero mean.

iii. Intercept in CE and VAR, but no trends in CE and VAR. It is assumed that the intercept in CE is cancelled out by the intercept in the VAR leaving just one intercept in the short-run.

iv. Intercept in CE and VAR, linear trend in CE but no trend in VAR.

v. Intercept and quadratic trend in the CE, and intercept and linear trend in VAR, i.e., including a linear trend in the short-run model and a quadratic trend in CE model.

However, as is the case in stage (i), stage (v), it is also not a feasible option because it is implausible in terms of economic theory. And this leaves us to choose between options (ii), (iii) and (iv). This is known as pantula principle. The pantula principle involves estimation of all the (3) models and the presentations of their results from the most restrictive model through the least restrictive hypothesis. Comparison will be made through moving from the most restrictive model to the least restrictive model (i.e., comparing the trace test statistics to its critical values for each of these models, stopping only when hypothesis of no cointegration is not rejected).

- **Determining the rank of the number of cointegrating vectors (Π) –** The fourth step of cointegration analysis is to determine the number of cointegrating vectors Π. According to Johansen (1988), the number of cointegrating vector k x k matrix with rank r can be determined by (i)test statistics and (ii) trace statistics.

i. **Test statistics**- This test is based on the maximum eigenvalues, and it is usually called the maximal eigenvalue statistics. The null hypothesis is that the rank $\Pi =$ r, and the alternative hypothesis is that there is $\Pi =$r+1vectors.The tests involve ordering of the largest eigenvalues in descending order and considering whether they are significantly different from zero. For example, if we obtained n characteristics roots denoted by $\eta_1 > \eta_2 > \eta_3 >_4 ... > \eta_n$, and if the variables of interest are not cointegrated, the rank of Π is zero and all the characteristics will also be equal to zero (Asteriou and Hall,2007: 323-325). Conversely, if the rank of Π is equal to 1, then 0 <η_1<1, for a cointegration relationship. Thus to test how many of the numbers of the characteristics roots are significantly different from zero, it makes use of the following equation:

$$\lambda \max(r, r+1) = -T \ln(1-\lambda_{r+1}) \quad (4.44)$$

ii **Trace Statistic-** Trace statistic is based on the likelihood ratio test about the trace of the matrix. It takes into consideration whether the trace is increased by adding more eigenvalues beyond the rth eigenvalue. The null hypothesis under trace statistics is that the the number of cointegrating vectors is less than or equal to r. As is the case with test statistics, when η_i =0, then the trace statistics is equal to zero. Also, the closer the characteristics roots are to unity, the larger the test statistics. The trace statistics is usually calculated as:

$$\lambda_{trace}(r) = -\Gamma \sum_{i=r+1}^{n} \ln(1-\lambda_{r+1}) \quad (4.45)$$

The practice involves estimating downwards and then stopping at the value of r which is associated with a test statistics that exceeds the critical value.

- **Testing for weak exogeneity:** The next step after determining the rank of the cointegrationg vector is to test for the weak exogeneity. Π matrix consists of $\alpha\beta$, which indicates the speed of adjustment coefficients and the matrix of the long run coefficients. Thus, we can say that there are r$\leq$n-1 cointegrating vectors in β, and at least n-r column of α are equal to zero. Hence, if we have determined the number of cointegrating vectors, one can move on to testing the weakly exogeneous. However, if a variable is found to be weakly exogenous, it can be dropped as an exogeneous variable but can still be included as an endogenous variable (Asteriou and Hall, 2007:326).

- **Testing for linear restrictions in the cointegrating vector-** The last stage in Johansen methodology is to test for linear restrictions in the cointegrating vector. Johansen approach allows for inclusion of possible linear restrictions after estimating α and β. The reason for this is to allow testing for specific hypotheses regarding various economic theories and predictions.

4.4.0 Model Specification for South African- Cointegration Analysis

The South African monetary policy cointegration analysis to be estimated in the next chapter is based on the statistical framework for the cointegrating VAR which is estimated via the Eviews version 6 software. The cointegrating VAR can be expressed as a general vector error correction model (VECM) which was adapted from Johansen (1991).

$$\Delta z_t = \beta_0 + \beta_{i1} t - \prod z_{t-1} + \sum_{i=1}^{p-1} \Gamma iz \Delta z_{t-1} + \psi Dt + \varepsilon_t \qquad (4.46)$$

β_0 and $\beta_1 t$ represents the intercept and trend coefficients, $\prod$ is a k X k long run multiplier matrix and Γiz are k X k coefficients capturing the short-run dynamic effects. z_t is a k X 1 vector of jointly determined (endogenous) I (1) variables. In the context of this work, these variables include industrial production (LY), change in CPI (INFL), short term interest rates (I), nominal exchange rate (LX) and money supply (LM2).

Dt represents a vector of dummies which are included to capture the structural break that could cause a shock to the system. Harris (1995) noted that dummy variables such as structural break can be included into the model, which will, in turn, affect the underlying distribution of the test statistics; as a result, the critical values for these tests will be different depending on the number of dummies included. The dummies are the same as those used in the unrestricted VAR. In addition, as was the case for unrestricted VAR, the cointegration and VECM analysis will be estimated for both pre and post-inflation targeting periods, and the results will be compared with the benchmark model.

4.4.1 Theoretical and Practical Basis for the Choice of Variables

The variables that are considered in this work were chosen based on the theoretical background contained in Chapter 2, the South African monetary policy framework, empirical studies from South Africa, as well as studies from other countries as reviewed in Chapter 2.

The industrial production was used as a proxy for GDP; according to the IMF definition, industrial production consists of manufacturing, electricity and mining. Industrial production is believed to be the most appropriate proxy for GDP because it comprises three major sectors in the economy (manufacturing, mining and utilities). These three variables were rebased up to 2005 (the current base year) base year and then added together to yield variable of industrial production. The second variable in this model is inflation rate. The percentage change in the CPI over 12 months period was directly used as an indicator for the inflation rate in this study since it is readily available on monthly bases. The percentage change in the CPI directly measures the inflation rate in the economy; hence it is one of the standard international macroeconomic variables. In addition, it has become a popular choice for the price level indicator in the South African economy.

One of the main variables used in the standard macro-economic theory is short term interest rates. Although Repo Rate is the main tool used by the SARB to carry out its operation, any change in the Repo Rate is directly reflected in the short term interest rates. If the SARB feels that there is a need for a monetary contraction in the economy due to high rate of inflation, they will increase the repo rate which will result in an increase in the lending rate and the short term interest rate, thereby reducing the money demand in the private sector of the economy. Hence, the 91 day Treasury Bills will be used as a proxy for short term interest rates in this study. The interest rates are meant to capture the yield curve effects, since during high economic growth, short term interest rates are expected to trend downward while the trend of long term interest rates is expected to be opposite. A narrow spread between the long term and short term interest rates implies that the economy is slowing down and the future inflation is thus expected to be low while a large spread indicates an increase in economy activity with the expectation of higher inflation rates in the nearest future.

Furthermore, an important variable that is included in the second model of this work is repo rate, which is the main tool used by the Reserve Bank to carry out its monetary policies. The main reason for including the repo rate is to also examine its direct transmission to real output and inflation rate. The choice of money supply (M2) variable for both pre-inflation targeting and post – inflation targeting periods is due to the monetarists' conception that an increase in the money supply is the primary cause of inflation and output in the short run, while the effect will manifest fully on prices in form of high inflation rate in the long run. The last variable is nominal exchange rate which measures the amount of rand per dollar. The reason for including this variable is to examine the response of monetary policy to the exchange rate shocks in the South African economy.

Sek (2008), and Kim and Roubini (2000) asserted that the recession and inflation in the economy can be as a result of monetary contraction and supply shock. Thus world oil price and global commodity price were included in the model as exogenous variables in order to help isolate exogenous monetary changes brought as a result of supply shock. The Brent crude oil price is used as a proxy for world oil price while global industrial materials index is used as a proxy for global commodity price.

4.0.5 Conclusion

The chapter started with the concept of stationarity. The knowledge of stationarity in the time - series analysis is important because most economic time- series data are non-stationary and, therefore, give spurious regression results if not differenced. The understanding of the concept of stationarity has no doubt helped to gain insight into how economic time series behave over time. The research methods that will be employed in Chapter 5 were also discussed in detail. This is divided into two, viz, (i) Unrestricted VAR and (ii) Cointegration Analysis. The unrestricted VAR is mainly used to establish the short-run relationship among variables. The cointegration analysis ,on the other hand, is used to analyze both short-run and long-run relationships. However, in cointegration analysis, non-stationarity is not a threat since the methodology allows the combination of two or more non-stationary variables to be cointegrated, yielding a long – run relationship among the variables. The next chapter will focus on the detailed analysis of the techniques that will be employed in this study.

CHAPTER 5

EMPIRICAL ANALYSIS

5 Introductions

This chapter deals with the detail account of the empirical estimation procedure that was undertaken, as well as the presentations and interpretations of the results.

As explained previously, the focus of the research is to empirically investigate the South African monetary policy in the pre-inflation targeting and post – inflation targeting period and compare it with the whole period which serves as the benchmark for this study. In order to achieve this aim, the response of South African's key macro economic variables to the shock of the monetary policy will first be estimated, followed by the Cholesky variance decomposition of industrial production and inflation rate variables. The last stage of the investigation will be to look into the long-run relationships that exist among the said variables using Johansen cointegration methodology. The macroeconomic variables in question include; industrial production, inflation, interest rate, exchange rate and money supply. Exogenous variables include commodity price world oil price and the dummies. The dummies in this study are dummy (D94) to capture the shift in the political regime in 1994. Furthermore, there is dummy (D2000) to capture change from an eclectic approach of conducting monetary policy to the adoption of the inflation targeting monetary policy framework. Lastly there is dummy credit crunch (DCC) which serves to capture the global eco nomic recession that took place in 2008.

As explained previously, the primary aim is to estimate how the South African's main macroeconomic variables reacted to the monetary policy behaviour over the years, through the use of model covering three periods ; firstly pre-inflation targeting period, secondly post-inflation targeting period and thirdly the whole period model which serves as the benchmark model. In addition, the model will exploit the Impulse Response Function (IRF) and the variance decomposition model offered within the VAR framework to study the short – term relationships. Moreover, the long – run cointegrating relationships will be investigated using the Johansen (1991) VECM methodology.

Section 5.0 deals with the choice of variables based on the theoretical background in chapter two as well as the empirical studies that were reviewed in chapter two and three. Subsequently based on the discussions in chapter 4, the estimation procedure which is divided into 6 stages is discussed as follows:

Stage one (Section 5.1) involves calculations of the industrial production variable as well as the transformation of all the data which includes the log transformation of all the variables except for those data which already exist in percentage form.

Stage two (Section 5.2) covers the estimation procedures of stationarity test based on the Dickey Fuller, Augmented Dickey Fuller and Philip Perron tests. The tests are meant to separate out the 1(1) variables from 1(0) variables. It discusses fully all the results concerning stationarity.

Stage three (Section 5.3) presents the VAR model which includes the lag selection thereby using the Akaike Information Criterion (AIC).

Stage Four (Section 5.4) presents the identification scheme of the recursive VAR discussed in detail. In addition the assumption that is made in the model is further represented in matrix form. This process gives rise to the estimation of the short- run relationships of the five variables in the model. The procedure also included unrestricted VAR in order to estimate the impulse reaction function (IRF) among the variables.

Stage Five (Section 5.5) further explores the Unrestricted VAR estimations with the focus on the variance decomposition of industrial productions and inflation rate variable. In line with the objective of this study, variance decomposition technique will show the relative importance of other three macroeconomic variables in explaining variations in the industrial production and inflation rates.

Stage Six (Section 5.6) is the final stage of this research which is cointegration test. The previous stage discusses the short-run relationship among the variables. This section is the cointegration model which outlines the long - run interactions among the variables through error correction models. The steps involved in cointegration test include selection of the deterministic components, and VECM. Here again the estimation procedure is outlined and the results will be reported as discussed.

5.0.1. Choice of Variables

The main data source for this work is the South African Reserve Bank web site (http//www.resbank.co.za). However, some data are not available on the website, and are only available in hard copies from the various issues of the Statistics South Africa Bulletin. The following variables are included in the study:

The seasonally adjusted monthly industrial production at market prices in millions of rand, at constant 2005 prices was used as a proxy for output. The industrial production is the weighted sum of the manufacturing, mining and electricity variables. The variable is used to calculate excess demand variable.

Inflation was represented by the monthly index of percentage change in the price level over 12 months; it has been generated from 1923. It is arrived at using this formula; inflation = $\ln CPI_t - \ln CPI_{t-12}$. This measures the changes in the price level over the period of 12 months. It is denoted by DINF. The weights used were based on the respective contribution of each sector to GDP.

The short term interest rates represented the discount rates on 91-day Treasury Bills. It is used as an indicator for short term interest rate which serves as a proxy for monetary policy actions. It is available on a weekly basis. The monthly series has been obtained by averaging out the data over 4 weeks and where the months has 5 weeks, the average is obtained by averaging it out the data over 5 weeks. The letter I represents interest rates in level form while DI represents interest rates in first difference of interest rates.

The money supply variable is represented by the M2 monthly monetary aggregates measured in million rands. It comprises of M1 plus money outside the banking system and checking deposits plus short and medium term deposits. (i.e. notes and coins plus money outside banking system plus short and medium term deposits. The data is available in monthly basis. The first difference of M2 is denoted by DM2.

The study used the monthly nominal exchange rates measured in cents (South African cents) per US $ (dollar). The series impacts on inflation since depreciations affect inflation through imported prices, while appreciations have a downward pressure on imported prices. X represents nominal variable while DX represents the first difference of nominal variable (X),

The world oil price is represented by the Brent crude oil prices which are in US dollar; the data is available on monthly basis. The variable is included in the model as an exogenous variable. It is meant to capture the impact of changes in world oil the prices.

The materials price index is used to represent the commodity prices. This variable was included in the study for the purpose of improving the performance of the model. The variable was included in the model as an exogenous variable.

5.1.0 Stage One- Data Transformation and Calculations of Industrial Production and Potential Industrial production.

This section covers the calculations of the industrial production variable, calculation of potential industrial production variable and the transformation of the variables into the natural log.

5.1.1 Calculations of Industrial Production Output

Industrial production consists of variables such as manufacturing, mining and electricity. The data for the industrial production is not readily available and had to be constructed by summing up the manufacturing, mining and electricity data which is available in the bulletin of statistics South Africa (various issues). The procedure for calculating industrial production variable is explained below:

I) Electricity is available in kilowatts, therefore the index of electricity was calculated using the formula below:

$$\frac{Monthly\ Electricity\ Generation}{Electricty\ Generation\ \ 2005\ Base\ Year} \times \frac{100}{1}$$

II) The respective indices of manufacturing and mining, were rebased to the 2005 base period through the use of the following formula:

$$\frac{Monthy\ Index}{2005\ Base\ Year\ index} \times \frac{100}{1}$$

5.1.2 Natural Log Transformation

It is important to transform macroeconomics time series data into natural log form due to the fact that, non-transformed data usually tends upwards and unit root tests often diagnoses the series to be non-stationary. Transforming these data to logarithm form means that the series (Z_t) remain roughly constant thus their percentage growth may be considered as:

$$(Z_t - Z_{t-1}) / Z_{t-1} \tag{5.0}$$

However, the short term interest rate and percentage change in price levels are already in percentage form and there is no need to transform them into natural logarithm since the elasticity of these variables can be interpreted directly.

5.2.0 Stage two- Stationarity Test and Selection of Order of Integration

This section deals with the testing for the order of integration of the data, as well as reporting and discussing of the results. It is important to test the stationarity of all the series before progressing to the specification and estimation of models. Three different unit root tests were conducted (ADF, DF and PPT). It is expected that all the South African macro-economics variables employed in this study are I (1). Dickey and fuller (1979) recommended that there are two alternative regression equations that should be used for testing for the presence of unit roots (This has been explained in details in the previous chapter). The first one is the inclusion of constant in the equation; this process is considered to be extremely important because it exhibits a definite trend in the series which is common among most macroeconomic time series. The second model is the inclusion of constant and non-stochastic trend in the equation. Both models were conducted, and they yielded similar results test for the unit root tests. The results for both models are reported in table 5.1 to 5.7.

Table 5.1

Results of unit root tests for log of industrial production Note: (All unit root test at 1% significance level)

Panel A- Constant

Test Type	**Levels Statistics**	**Critical Statistics**	**1ST Difference Statistics Test**	**Critical Statistics**
ADF	-0.091313	-3.455096	-5.266234	-3.455096
PP	-1.424521	-3.453997	-34.09217	-3.454085
DF-GLS	1.125570	-2.573784	-4.245194	-2.573818

Panel B- Constant and Linear Trend

Test Type	**Levels Statistics**	**Critical Statistics**	**1ST Difference Statistics Test**	**Critical Statistics**
ADF	-1.933804	-3.993335	-5.318628	-3.993335
PP	-5.905326	-3.991780	-34.21099	-3.991904
DF-GLS	-1.814745	-3.466300	-5.040640	-3.466300

Table 5.2

Results of unit root tests for change in price level

Note: All unit root test at 1% significance level

Panel A- Constant

Test Type	**Levels Statistics**	**Critical Statistics**	**1ST Difference Statistics Test**	**Critical Statistics**
ADF	-1.593178	-3.455096	-7.212245	-3.455193
PP	-2.470614	-3.453997	-12.89676	-3.454085
DF-GLS	-0.044801	-2.573784	-5.245957	-2.573818

Panel B- Constant and Linear Trend

Test Type	**Levels Statistics**	**Critical Statistics**	**1ST Difference Statistics Test**	**Critical Statistics**
ADF	-1.102970	-3.993335	-7.248418	-3.993471
PP	-2.949459	-3.991780	-12.88497	-3.991904
DF-GLS	-0.974418	-3.466300	-6.666851	-3.466200

Table 5.3

Results of unit root tests for Short term interest rates. Note: (All unit root test at 1% significance level)

Panel A- Constant

Test Type	Levels Statistics	Critical Statistics	1ST Difference Statistics Test	Critical Statistics
ADF	-1.998931	-3.454443	-6.133800	-3.454443
PP	-1.733876	-3.453997	-9.898358	-3.454085
DF-GLS	-1.610742	-2.573555	-6.103311	-2.573555

Panel B- Constant and Linear Trend

Test Type	Levels Statistics	Critical Statistics	1ST Difference Statistics Test	Critical Statistics
ADF	-3.409179	-3.992411	-6.216173	-3.992411
PP	-2.843291	-3.991780	-9.855483	-3.991904
DF-GLS	-1.741496	-3.467000	-6.115874	-3.467000

Table 5.4

Results of unit root tests for the log of money supply (M2)

Note: All unit root test at 1% significance level

Panel A- Constant

Test Type	Levels Statistics	Critical Statistics	1ST Difference Statistics Test	Critical Statistics
ADF	4.285084	-3.454263	-2.010230	-3.455096
PP	5.692698	-3.453997	-16.05168	-3.454085
DF-GLS	0.489820	-2.573784	-1.696752	-2.573784

Panel B- Constant and Linear Trend

Test Type	Levels Statistics	Critical Statistics	1ST Difference Statistics Test	Critical Statistics
ADF	0.466291	-3.992156	-8.063196	-3.992156
PP	0.638682	-3.991780	-16.32677	-3.991904
DF-GLS	-1.480385	-3.466300	-1.472377	-3.466300

Table 5.5

Results of unit root tests for the log of Exchange rate. Note: (All unit root test at 1% significance level)

Panel A- Constant

Test Type	Levels Statistics	Critical Statistics	1ST Difference Statistics Test	Critical Statistics
ADF	-1.676586	-3.454719	-4.553099	-3.454719
PP	-1.349522	-3.453997	-11.19057	-3.454085
DF-GLS	-0.570002	-2.573652	-4.473341	-2.573652

Panel B- Constant and Linear Trend

Test Type	Levels Statistics	Critical Statistics	1ST Difference Statistics Test	Critical Statistics
ADF	-2.607830	-3.992801	-4.560958	-3.992801
PP	-2.095870	-3.991780	-11.17597	-3.991904
DF-GLS	-2.669431	-3.466700	-4.517599	-3.466700

Table 5.6

Results of unit root tests for Global Commodity Price

Note: All unit root test at 1% significance level

Panel A- Constant

Test Type	Levels Statistics	Critical Statistics	1ST Difference Statistics Test	Critical Statistics
ADF	-1.826807	-3.454174	-7.582154	-3.454174
PP	-0.725841	-2.573460	-11.91874	-3.454085
DF-GLS	-1.683428	-3.453997	-6.235642	-2.573460

Panel B- Constant and Linear Trend

Test Type	Levels Statistics	Critical Statistics	1ST Difference Statistics Test	Critical Statistics
ADF	-2.409694	-3.992029	-7.572333	-3.992029
PP	-2.106994	-3.991780	-11.90044	-3.991904
DF-GLS	-2.439619	-3.467300	-6.992021	-3.467300

Table 5.7

Results of unit root tests for the log of World Oil Price

Note: All unit root test at 1% significance level

Panel A- Constant

Test Type	Levels Statistics	Critical Statistics	1^{ST} Difference Statistics Test	Critical Statistics
ADF	-0.801719	-3.455096	-6.400840	-3.455193
PP	-1.223421	-3.453997	-10.28648	-3.454085
DF-GLS	-0.482887	-2.573784	-2.495504	-2.573751

Panel B- Constant and Linear Trend

Test Type	Levels Statistics	Critical Statistics	1^{ST} Difference Statistics Test	Critical Statistics
ADF	-2.137698	-3.993335	-6.434321	-3.993471
PP	-2.555535	-3.991780	-10.26782	-3.991904
DF-GLS	-1.623115	-3.466300	-4.589027	-3.466300

Table (5.1) – (5.7) show the ADF, PP and DF tests for all the variables. The test results were based on the Akaike information Criteria (AIC). To generate statistics under these tests, one has to choose the appropriate lag length. This study chose 12 lags, however other lag lengths were considered but yielded similar results. The result based on ADF, DF-GLS and PP test indicate that all the variables are integrated of the first order, i.e. I(1), except for the variable money supply (DM2). However, after including a constant and a trend (See Table 5.6, Panel B), all the results demonstrate that M2 is I(1) and upon first differencing it becomes stationary.

5.2.1 Differencing of Variables for Unrestricted VAR

As discussed in the previous chapter VAR models can only comprise of stationary variables, hence for the purpose of unrestricted VAR, all the variables were first differenced. This took place after variables have been transformed into natural log with the exception of short term interest rates and percentage change in the price level that were already in percentage form. Based on the results of the unit root tests in the table 5.1 – 5.7 above, all the variables are integrated of one order. i.e., I(1), hence they were differenced only once to achieve stationarity

5.3.0 Stage Three- VAR Model Selection

This section deals with the selection of the order (p) VAR model. Numerous models were estimated and hence in the interest of brevity only some of the detailed results will be reported to show how the VAR (p) order was generated.

5.3.1 Selection of VAR order (p), Presentation and Discussion of the Results.

It is standard practice to first determine the selection of VAR order (p) before proceeding to its estimation. According to Baun and Mittnik (1993), if the lag length of a particular model is different from the true lag length, the results of such estimation will be inconsistent, and so will the impulse function and error decomposition of the model. According to Lütkepohl (1993), selection of higher order lag length than the true length will result to an increase in the mean square forecast errors, while under fitting the lag length will lead to autocorrelated errors. However, there is no particular way of selecting an appropriate lag length in VAR models. In the literature there are two distinct strategies that have been suggested, one by using likelihood ratio test generally used in conjunction with stepwise strategies. Many researchers have criticized the stepwise strategy that it lacks the theoretical rationalization for the sequence of variable selection. In the case of likelihood tests, it has been argued that the tests are usually subjective and could be problematic, especially if many tests are to be made at a time.

Ivanov and Kilian (2005) recommended six criteria for lag order selection: the Schwarz Information Criterion (SIC), the Hannan–Quinn Criterion (HQC), the Akaike Information Criterion (AIC), the general-to-specific sequential Likelihood Ratio test (LR), a small-sample correction to that test (SLR), and the Lagrange Multiplier (LM) test. However, the most widely used criteria in choosing the (p) lag order are AIC and SBC. Studies by Seddighi *et al* (2000: 301) and Patterson (2000: 623) also suggest that the AIC and SBC tests should be used in selecting the order (p) of the VAR model. However, SBC penalizes heavily larger model orders, and for moderate and large samples, AIC are essentially equivalent. Also FPE may outperform AIC for very small sample sizes while HQ penalizes high model orders more heavily than AIC but less than SBC (Lütkepohl, 2006: 148). In the light of this, for these models to be stable, FPE criterion was employed in selecting the lag order, since the sample became relatively small after being divided into samples (pre-inflation targeting and post- inflation targeting period).

5.4.0 Unrestricted VAR: Presentations and Discussions of the Result

As explained earlier, the study will be divided into pre and post IT period sample respectively and its results will be compared to the whole period sample which will serve as a benchmark. The pre – IT period extends from January 1987 to January 2000. The post IT period extends from February 2000 to December 2009. Between 1987 and 2000, there was eclectic monetary policy approach where monetary base was targeted in order to achieve a moderate level of inflation. In February 2000, there was a formal adoption of inflation targeting, where repo rate is directly used to achieve a target of inflation rate between 3 to 6 percent. This forms the basis of this sample division.

As explained in the previous sections, all the variables were expressed in the logarithm except the interest rates, and percentage change in prices, that are already in percentage form. Various unit root tests were conducted and the results showed that all variables were integrated of order one in levels, that is; they are 1(1), and 1(0) in differences. However, all data were transformed into a stationary form for the purpose of estimating unrestricted VAR models which only explain the short-run relationship among the variables. The long run relationship which is better explained by the cointegration and error correctional model will be dealt with in the second part of this work.

As mentioned before, industrial production was used as a proxy for output at a monthly frequency; this comprises other variables such as manufacturing, mining and electricity. For the monetary policy rate, the 91-day Treasury Bills was used as a proxy for the monetary policy stance since it shares a strong correlation with the repo-rate. The lag orders for the two models were chosen using Final Prediction Error (FPE). This was found to be of the second lag for the pre IT model and third lag order for the post IT model. See appendix 1, Tables (A-1 - A-3). for the reported results.

5.4.1 Discussions of Results for Impulse Reaction Function (IRF) for Pre-Inflation Targeting

The presentation and discussion of the results begin with the sample from (January 1987 to February 2000) which represents the pre-inflation targeting period. Impulse responses of a one-standard deviation monetary policy shock is employed (that is, the response of other variable to the unexpected temporary rise in the interest rate).

In the same vein with Arnostova and Hurnik (2005), as shown in equation (5.1), the following assumptions are made in arriving at an unrestricted VAR model that is suitable for the South African economy:

i). That the monetary policy does not have a contemporaneous effect on output and prices

ii). Interest rates have an immediate effect on the exchange rate but does not respond in the same period to changes in the exchange rate.

iii). The last assumption has been argued not to be applicable to a small and open economy but only applicable to a large and relatively closed economy. However, the recursive assumption we follow here does not allow for a contemporaneous effect of exchange rate on the interest rate.

Though South Africa is a small and open economy, the monetary policy is expected not to react contemporaneously to the exchange rate, since the main focus of IT is to steer actual inflation to be within the 3 to 6 percent range through the use of changes in repo-rate. Consequently one can argue that this type of ordering can be well suitable for an economy such as South Africa.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ G_{21} & 1 & 0 & 0 & 0 \\ G_{31} & G_{32} & 1 & 0 & 0 \\ G_{41} & G_{42} & G_{43} & 1 & 0 \\ G_{51_{51}} & G_{52} & G_{53} & G_{54} & 1 \end{bmatrix} \begin{bmatrix} u_t^{YGAP} \\ u_{DINFL} \\ u_t^{DI} \\ u_t^{DX} \\ u_t^{DM2} \end{bmatrix} = \begin{bmatrix} \varepsilon_t^{YGAP} \\ \varepsilon_t^{DINFL} \\ \varepsilon_t^{DI} \\ \varepsilon_t^{DX} \\ \varepsilon_t^{DM2} \end{bmatrix} \qquad (5.1)$$

Usually in a VAR system, the structural innovations of the monetary policy variable are generally taken as the monetary policy shocks, which represent the unanticipated changes in monetary policy stance. Two different approaches are used for the short term behavior of the variables in the pre – IT period. Firstly, interest rates were used as an indicator for the monetary policy shock, and secondly, the monetary base (M2) was used as an indicator for the monetary policy shock. This approach was employed because in the pre-inflation targeting period, there were different types of monetary policy system ranging from liquid asset ratio-based system to pre-announced monetary targets (M2), as well as mixture of both systems during pre-inflation targeting system, thought the pre-inflation targeting was mainly dominated by monetary targets (M2). As a result it will be best if both interest rates and monetary base (M2) are used differently as a proxy for monetary policy action during this period.

5.4.1.1 Pre-Inflation Targeting Period Model using interest rates as monetary policy Indicator

The results showed there is no considerable effect of monetary policy shock on the real output in the pre-inflation targeting using 91 days Treasury Bill rates as an indicator for the monetary policy. A positive shock to the interest rate has a small and insignificant impact on the output by 0.02 percent and remained volatile for a considerable period of time of over twelve months before it eventually evened out and returned to its base. This result is contrary to the findings of Bonga-Bonga and Kabundi who found output to first rise for the period between six and seven months before it experienced a decline. Also, price level rose significantly in response to the monetary shock but for a very short period of time. This is not unusual, as this could be due to the increase in expected inflation rate by the economic agents. The same result was found in (Cheng, 2006) and also a similar result was found by Bonga-Bonga and Kabundi (2009) where a positive shock to the interest rate increased the prices more than 18 months.

There was immediate overshooting of exchange rate in response to the monetary shock; an increase in the short term interest rate led to immediate appreciation of rand but remained volatile for more than fifteen months before it became stable. The reason for the immediate fall in the level of output can be explained through exchange rate channel, an appreciation of exchange rate will make the export of South Africa to be more expensive and become less competitive in the international market. This will have a negative effect on the total production in the economy as a whole. The impact of monetary policy on money supply is not so significant and quickly returned to its origin after ten months.

5.4.1.2 Pre-Inflation Targeting Model using Monetary base (M2) as a monetary policy Indicator

As explained before, the monetary base was predominantly used by the monetary policy committee in the pre-inflation targeting era, thus money supply M2 was chosen in this study as a proxy for the monetary base. As indicated by the unrestricted VAR cholesky IRF (See Appendix A, figure A2). A monetary policy shock during pre-inflation targeting period based on monetary (M2) as an indicator for monetary policy showed an increase in inflation rate but, this increase starts to fall at 5 months and the effect dies out after 10 months. Following the monetary policy shock (i.e., increase in the monetary growth based M2), there was an increase in the industrial production. This results from the low level of interest rate (i.e., the interest rate falls by 0.5% after following an expansionary shock of M2 monetary base) brought about by the excess money in the economy, leading to more investment and business opportunities. The shock generated about 0.02% response and remained volatile for 15 months before the effect dies out. This shows that money does not have impact on the real variables in the long run.

Note: See Figure A1 to A4, appendix A for the full results of the impulse response function for the Unrestricted VAR for pre-inflation targeting, post-inflation targeting period and the benchmark model.

5.4.2. Presentation of Impulse Reaction Function (IRF) Results for Post-Inflation Targeting

In the post-inflation targeting unrestricted VAR, short term interest rate is used as a proxy for the monetary policy resulting from the fact that, under inflation-targeting there is no role for monetary base . Looking at the impact of the monetary policy on the South African's key macroeconomic variables in the post - inflation era; the results showed that there is a significant fall in the output in response to the positive shock of monetary policy as compared to the pre-inflation era. The elasticity of this fall is about 0.06 percent as compared to 0.02 in the pre-inflation period. The reason being that, under inflation targeting, the interest rate is targeted directly to control the inflation rate which could have a direct negative effect on the level of output. However, the effect is less volatile as compared to the pre- inflation period. The volatility only lasted for about six months before stability returned, unlike under pre-inflation era where the effect lasted for more than fifteen months. This is in line with Taylor (1979)'s work, which envisaged short run variability between unemployment and inflation without any permanent loss of output.

The results from pre - and post - inflation targeting period revealed that the price puzzle which mostly found in the VAR literature did not occur in the two models. Also, the interest rates and monetary base models in the pre-inflation periods responded to the monetary policy shock by 1.7 percent and 1 percent respectively. Nevertheless, the inflation rate under post-inflation period responded by 2.1 percent to a positive monetary shock compared with 1.7 percent and 1 percent respectively in the pre-inflation period. The result suggests that the expected inflation rate over a short horizon is higher under post-inflation targeting period compared with the pre-inflation targeting period model. It was also found that it took a little bit longer for the inflation rate to start declining in the pre-inflation targeting period compared with post-inflation era. This implies that in the post inflation targeting period, inflation exhibits less inertia, perhaps an indication that the inflation targeting monetary policy framework has succeeded in convincing economic agents that their policy actions are credible.

5.4.3 Benchmark Model - Presentation of Impulse Reaction Function (IRF) Results for the whole period (1987-2009)

The result of the benchmark model for the unrestricted impulse reaction function (IRF) is shown in the (see Fig A4, Appendix A). The graphs display the impact (the impulse response) of a one-standard deviation monetary policy shock defined as an exogenous, unexpected, temporary rise in the interest rate on industrial production output, inflation rate, exchange rate, and money supply, together with a 95 percent confidence band.

The effect of a monetary policy shock on industrial production output appears to be insignificant as it quickly returns to the equilibrium after 3 months. Specifically, the impact is not statistically distinguishable from zero, given that the negative elasticity of 0.04 percent response of industrial production the shock of monetary policy. However, the monetary shock seemed to have more significant impact on the inflation rate compared with the effect on industrial production. An unexpected and temporary rise in the short-term interest rate is followed by a sharp decline in prices, with the effect peaking at 5 to 6 months after the shock. This is the typical humped shape that many previous studies have noted (See Kim and Roubini, 2000). Similarly, the exchange rate variable responds to a monetary shock, an unexpected and temporary rise in the short-term interest rate tends to be followed by exchange rate appreciation, though the impact only lasted for about 5 months after the shock. Money supply also responded to the shock of monetary policy by a sharp decline over few months before it returned to its equilibrium position.

The benchmark model gave overall results as expected in the theory. The results for the pre-inflation targeting model and post-inflation targeting models are not that different from the benchmark model. Comparing the pre-inflation targeting model and post-inflation targeting model with the benchmark model, the results suggest that the transmission mechanism impact of the repo rate on the South African's key macroeconomic policy variables is not very strong, particularly for the industrial production variable. The transmission from the monetary policy is stronger for nominal variables such as inflation rather than real variable (industrial production output). This result is supported by Cheng (2006) and Tsangarides, (2010).

This lack of transmission to real variables could be attributed to neutrality of money, although it is expected that money would be neutral in the long-run, at the same time, money would still be expected to affect output in the short-run. However, the lack of a transmission to real variables may reflect bottlenecks and structural problems in financial markets (Tsangarides, 2010). Conventionally, it is assumed that markets are completely free of frictions. This is not always the case as various models in the credit channel and bank lending literature suggest that financial market frictions and rigidities may be manifested in a number of ways that are likely to introduce uncertainty into the magnitude and timing of the economy's response to changes in the monetary policy.

5.5.0 Estimation of Cholesky Variance Decomposition for the South African's Key Macroeconomic Variables.

The previous section undertook the estimation of impulse response function of the key South African macroeconomic variables to the shock of monetary policy in pre and post inflation targeting periods. The results showed that the response of these macroeconomic variables to the response of monetary policy have not really changed overtime, and the impact of monetary policy shocks on inflation died down after a short period of time in the inflation targeting period. This section will further look at the variance decomposition of industrial production and inflation variables relative to other variables in the system.

The variance decompositions as explained in the previous chapter (see chapter 4, section 4.3.1) measures the contribution of each type of shock to the forecast error variance. Estimating the variance components of the South African key macroeconomics variables allows one to determine the relative importance of the variables in the system in explaining variations in industrial production and inflation. The variance decomposition exploited in this section is 24-months periods of industrial production and inflation relative to other variables in the model. Accordingly, the analysis starts with pre-inflation targeting model, followed by post-inflation targeting period model which are then compared with the benchmark model (whole period).

5.5.1 Discussion of the Variance decomposition of industrial Production and Inflation rate Variables in the Pre-Inflation Targeting Period.

Table A4 and A5 (Appendix A) show the (Cholesky) variance decomposition for the variables industrial production and inflation under pre-inflation targeting period. The results show that, in the pre-inflation targeting period, the M2 explained about 2.33 percent of variations in the industrial production while the interest rate accounted for 3.55 percent variation in the industrial production. Other variables such as inflation explains industrial production with a negligible amount in the first period but grows bigger overtime, however, on average, the inflation rate does not seem to play a significant role in explaining industrial production output in the pre-inflation targeting period.

The role played by interest rate and money supply seems to increase over time but the interest rate variable appears to have an upper hand in influencing industrial production, in all, the role played by these two variables is insignificant. In the case of exchange rate, it could only explain a negligible amount of 0.25 percent of industrial production.

The result shows that the money supply (M2) contributes just a little bit more than interest rate to the forecasted variance decomposition of inflation during the pre-inflation targeting period, however, the difference is negligible. The implication of this is that the money supply (M2) explains the inflation rate better than the interest rate during the expansionary monetary policy operation. In addition, the exchange rate variable could only explain inflation rate with a negligible amount of 0.24 percent.

5.5.2 Discussion of the Variance decomposition of industrial Production and Inflation rate Variables in the Post-Inflation Targeting Period.

Table A6 and A7 (Appendix A) show the (Cholesky) variance decomposition for industrial production and inflation under post-inflation targeting period. The situation is similar to that of pre-inflation targeting period, in the post-inflation targeting in the sense that, under variance decomposition of industrial production, it started by explaining itself by 100 percent and began to shrink over time. As it was the case under pre-inflation targeting model, the variables that have largest share in explaining industrial production are interest rate and money supply with interest rates having an upper hand. The situation under post-inflation targeting period also reflects an effect of monetary policy transmission mechanism through interest rates. Moreover, variables like inflation and exchange rate could only explain the industrial production variable with negligible amounts of 0.04 and 0.22 on average respectively.

The variance decomposition of inflation rate under post-inflation targeting model in Table A7 revealed that interest rate variable is more important than money supply (M2) in explaining the inflation rate. Interest rate and money supply accounted for 32 percent and 0.36 percent respectively compared to 5 percent and 8 percent under pre-inflation targeting period. The investigation also shows that the ability of money supply to explain inflation rate decreased in the 2000s (post-Inflation targeting period).

5.5.3 Variance decomposition of Industrial Production and Inflation rate Variables (Comparison between Pre and Post Inflation Targeting Period with the Benchmark Model)

Table A8 and A9 (Appendix A) present the variance decomposition of industrial production and inflation rate variables for the whole period (1987m01- 2009m12) which is used as a benchmark model for this work.

In the pre IT period, changes in the interest rate explained about 3 to 4 percent in forecast error of the forecasted variable from 8 months onwards while changes in money supply explains about 2 percent of the variation in the forecast error. Money supply seems to explain a longer portion of the variation in inflation forecast error, this is understandable since money supply targeting was the main policy in the pre IT period. However, monetary policy only explains about 5 percent of the variation in the inflation over the whole period compared to around 33 percent in the post IT period. The post IT variance decomposition suggests that money supply plays an insignificant role in forecasting inflation.

Interestingly, changes in monetary policy explains about 2 percent of the variation in industrial production in the post IT whereas it used to explain about 4 percent in the pre IT era. Moreover, changes in money supply also explains less of the variation in forecast error variance of output compared to the pre IT period, thus implying that factors within the industrial production sector itself and not monetary policy has been the main factor in explaining industrial production. Viewing all the results together in the pre IT period, monetary policy, money supply explain about 6 percent of output variation in the post IT period, this fell to less than 3 percent in the post IT.

In the case of the post IT period model, specifically from 8 months onward, the monetary policy explains between 32 percent of the variation forecast error variance inflation rate changes while industrial production explains between 2 to 3 percent of the variation in the forecast error variance of inflation. In the post IT period, monetary policy plays a much more significant role in explaining inflation forecast compared to the pre IT period, where only 11 percent of the variation in inflation forecast was explained. The results from the benchmark model shows that from about 8 periods after the shock, interest rate and the money supply only explains about 4 percent of the variation in industrial production. The overwhelming variation in the forecast error is explained by industrial production changes itself. Furthermore, changes in money supply explains about 4 percent of the inflation forecast error variance about changes output and exchange rates explains 2 and 1 percent of the error variance respectively. The result of the role of money supply was found to be negligible in the post IT period model and the benchmark model, while monetary policy (interest rates) explains 33 and 10 percent of the variation in the inflation in the post IT and the benchmark models respectively.

5.6.0 Stage Four- Cointegrating Vectors and Vector Error Correction Model (Long-Run Relationships)

The second part of this work is cointegration analysis which seeks to examine the long-run of all the variables in questioned. As discussed in the previous chapter, in cointegration analysis, there is no need for differencing the non-stationary variables as differencing causes important information about the long - run relationship between variables to be lost, hence data can be used in their level forms. Recalling table 5.1 - 5.7 unit root tests, all the variables are integrated with $I(1)$; therefore, there may exists some cointegration between the variables under examination. Thus, cointegration tests using Johansen's technique can be conducted. However, before the Johansen cointegration test can be conducted, there are steps that must be followed. The first step is transformation of variables into log form; this has been discussed in details previously. This is followed by the selection of the VAR order (p). The third step is the selection of the deterministic components in the VAR model, and the identification of the cointegrating vectors. The last step is the identification of restrictions and lastly the main cointegration test itself.

5.6.1 The VAR Order (p) Selection for Cointegration Analysis, Presentation and Discussion of the Results

As discussed in the previous chapter (Chapter 4 section 4.3.2), that before cointegration relationships are estimated, some certain procedures must be followed. These include selection of appropriate VAR order (p). This was done following the same approach that was used in the first part of this work. As explained before, the choice of the lag length is critical for obtaining models whose disturbance terms exhibit white noise. And for these models to be stable, FPE criterion was employed in selecting the lag order, since the sample became relatively small after being divided into samples (pre-inflation targeting and post- inflation targeting period) as was done in the first part of the work. This procedure led to selection of order (p) = 6 for pre-inflation targeting model, order (p) = 2, for the post - IT and order (p) = 4, for the whole period model. See the reported results in the tables B-1-B-3 appendix B.

5.6.2 Selection of the deterministic components in the VAR model

The next important step that must be undertaken before the Johansen (1991) VAR model is estimated is the necessary requirement of making assumptions about the deterministic in the cointegrating relationships. These assumptions according to Eviews 6 users Guide II (2007) are that the data:

i) Have no deterministic trends and the cointegrating equations and do not have Intercepts
ii) Have no deterministic trends but the cointegrating equations have intercepts
iii) Have linear trends but the cointegrating equations only have intercepts

iv) Have linear trend and that the data;
v) Have quadratic trend and the cointegrating relationships have linear.

Most macroeconomic relationships tend to follow (ii) and (iii) assumptions. Assumption (i) is too trivial and is unsuitable for most econometrics investigations while the use of assumption (iv) and (v) is usually based on having a prior knowledge of the nature of the relationships between the variables. This study estimated both (ii) and (iii), model (iii) produced the most plausible results in regard to the long – run relationships between the variables.

Table B-4 – B-6 (Appendix B) reports the results of the trace and maximum eignevalue. The trace and maximum eigenvalue tests utilize a sequential testing procedure. For example if the null hypothesis of at most zero cointegrating relationships is rejected in favour of at most one cointegrating relationship, then in the next step the null hypothesis of at most one cointegrating relationship is tested against the alternative of at most two cointegrating relationships, and so on. Therefore if p is the number of variables (i.e., industrial production, inflation rate, interest rate, exchange rate and money supply variables) and r is the rank (number of cointegrating equations), then the trace statistics will test the hypothesis that $r \leq p$ against the alternative. The null hypothesis will fail to be rejected when the test statistic is smaller than the trace test's critical values. The maximum eigenvalue test on the other hand tests the null of r cointegrating equation against the alternative of r+1 cointegrating equations. The null hypothesis fails to be rejected when the test statistic is smaller than the maximum eigenvalue test's critical values.

The hypothesis of the existence of at most one cointegrating equation (Ho: $r \leq 1$) is not rejected in all the models except post-inflation targeting period model, whilst the hypothesis of no cointegration (Ho: $r = 0$) is rejected at a 5 percent level of significance for both pre-inflation targeting period and the benchmark model (Whole period). Hence, the analysis concludes that a long-run cointegrating relationship exists among all the variables in the pre-inflation targeting period model and the whole period model.

From Table B-4, the trace test statistics rejects the hypothesis of no cointegrating relationship between the variables (i.e r $\leq$ 0) in favour of the alternative (i.e., Ha: r=2) at 95 percent degree significance level. The maximum eigenvalue on the other hand rejects t the hypothesis of no cointegrating relationship among the variables (i.e r $\leq$0) in favour of the alternative (i.e., Ha: r=1) at 95 percent significance level. Since the maximum eigenvalue and trace statistics were not in agreement, this study opted for the maximum eigenvalue of r=1.

Note that this was the only case where this approach had to be employed since the eigenvalue and trace statistics contradicted each other in the pre-inflation targeting model and the benchmark model (Whole period) thus the study had to resort to the above trial and error (or arbitrary approach) method in the absence of proper guiding principles.

5.6.3.0 Vector Error Correction Model (Long-Run Relationships)

The cointegration analysis in this work sets out to identify one long-run cointegrating relationship among the variables under examination. All the variables that are considered are I(1) as was the case in Johansen (1988). This will further lead to estimation of the vector error correction model. However the trace and maximum eigenvalue statistics suggest that the long – run relationship only exists in the pre-inflation targeting and the whole period models. The post-inflation targeting models is not identified, hence this study will only estimate the two identified models.

5.6.3.1 Estimation of Vector Error Correction Model for Pre-Inflation Targeting Period.

The results for the vector error correction model for the pre-inflation targeting model are reported in Table B-7. The magnitude and the signs of the adjustment coefficients prove to be plausible. The $\alpha\beta$ forms the error correction mechanism, α is the term which shows the speed at which the independent variables (inflation, interest rates, exchange rate and money supply) shift to eliminate shocks in the industrial production output within one month. While β indicates the long run adjustment coefficient, the α coefficient indicates how quickly the system re-establishes its long-run equilibrium position (Asterious and Hall, 2007).The vector error correction model shows the industrial production moving 35 percent in the same month to eliminate the long-run disequilibrium. Other variables such as inflation, exchange rate and money supply moved more than 100 percent to correct for disequilibrium at the long-run.

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From Table B-7, the following short form of long-run equation can be obtained:

$$LY = 2.565 + 0.011(INFL) - 0.001(I) + 0.077(LX) + 0.101(LM2) \quad (5.4)$$

The β (long-run coefficient) for inflation is 0.011, -0.001 for interest rate, 0.0771 for exchange rate and 0.101 for money supply. By comparing the t-statistics in the reported result (Table B-7, Appendix B) against the t-critical value of (1.96), the values can be said to be statistically significant. This suggests that inflation and industrial production move in the same direction but less than unity. The results also revealed that the industrial production and interest rates move in opposite direction, that is if there is increase in the interest rates by the Reserve Bank, the industrial production tends to go the other direction (i.e., decline in the level of output) however the effect is considered to be weak at the long-run since the coefficient is much less that unity. This view is in support of Taylor's hypothesis. The only variable that did not seem to give a plausible sign is the exchange rate which could be as a result of too much noise in the data and the shortness of the data sample. This is further explored in the benchmark model.

5.6.3.2 Estimation of Vector Error Correction Model for the Benchmark Model (Whole Period)

A post IT VECM was not estimated since the maximum eigen value and trace statistics suggest no long – run cointegrating relationships in the post IT period. The analysis went straight to the benchmark model which covers from 1987 to 2009 and the results are reported in Table B-8, Appendix B. The results are reasonably successful because all the variables gave the expected signs for the long-run adjustments indicating a stable long-run relationship among the variables (industrial production, inflation, interest rate, exchange rate and money supply).

For the benchmark model, the vector error correction model shows the industrial production moving only 0.04 percent in the same month to eliminate the long-run disequilibrium whereas inflation shifted more than 100 percent to correct for disequilibrium in the long- run. Other variables such as interest rates, exchange rate and money supply adjusted by 29 percent, 0.6 percent and 0.005 percent respectively to correct for long –run equilibrium.

Again, the following long-run equilibrium equation is obtained:

$$LY = 0.251 + 0.049(INFL) - 0.017(I) - 0.046(LX) + 0.332(LM2) \qquad (5.5)$$

The β (long-run coefficient) for inflation is 0.049, -0.017 for interest rate, -0.006 for exchange rate and 0.332 for money supply. Also by comparing the t-statistics in the reported result (Table B-8, Appendix B) against the t-critical value of (1.96), the values can be said to be statistically significant suggesting that inflation and industrial production move in the same direction but less than unity. The negative sign on the exchange rate that occurred in the pre-inflation targeting period was corrected in the benchmark model which further explains that the benchmark model is a more stable model. As it was the case with pre-inflation targeting model, results revealed that the industrial production and interest rates move in opposite direction, that is if there is a shock in the monetary policy (interest rate), the industrial production tends to go the other direction (i.e., decline in the level of output) . However, it is also confirmed in the benchmark model that that the effect tends to be weak at the long-run since the coefficient is much less that unity.

5.6.4 Interpretations of the Results

The cointegration tests and VECM analysis suggest that a long-run cointegrating relationship exists among all the variables. The results from the pre-inflation targeting model were similar to the benchmark model except that the sign on the exchange rate was positive whereas it was expected to be negative.

An appreciation of the domestic currency is expected when there is an upward swing in the level of production; therefore, the benchmark model gave a more plausible result in this regard.

It is also expected that the industrial production variable and inflation should move in the same direction. This was the case for both pre-inflation targeting model and the benchmark model, implying that an increase in the industrial production causes a boom in the economy making it to reach its peak which eventually results in inflation. Also, as it was expected, the long-run coefficient of interest rate was negative in both pre-inflation targeting model and the benchmark model. From the equation in (5.2) and (5.3) above the coefficient of interest rate is less than unity, implying that the long-run relationship between the industrial production and interest rate is weak and the effect is transient contrary to the insinuation that much output is lost due to increase in the interest rates. Similar result has been found for South African economy. See Gupta *et al* (2009).

Lastly, the long-run relationship between the industrial production and the money supply also gave an expected positive sign. It is expected that the money supply and industrial production should move in the same direction, the estimated results confirmed this for the South African economy. It is unfortunate that the post IT VECM could not be estimated for comparative purposes, however in the future, it will be possible when longer data sets will be available.

5.6.5 Conclusion

All the variables in this study are non-stationary in levels and stationary in first difference based on the combination of visual inspection and three formal unit root tests (ADF, DF and PP tests). The main objective of this study was to evaluate South African monetary policy, and based on the economic theory and literature, the study, decided to employ the South African's key macroeconomic variables. These include industrial production, inflation, short term interest rates, exchange rate and money supply. The study was able to evaluate the response of each of this variable to the shock/increase in the monetary policy mainly the interest rates.

The analysis started by transforming the non-stationary variables to stationary for the purpose of modeling the first part of the study which is the unrestricted VAR leading to estimations of impulse response function for the three models. The three VAR models estimated includes pre-inflation targeting (1987-2000), post-inflation targeting (2000-2009) and the benchmark model which covers from 1987 to 2009. The main findings are that in the post – IT, industrial production declines in response to a shock in the monetary policy, however this decline is short lived. Furthermore, it appears that there is an instant response of inflation to the monetary policy shock in the post-inflation targeting as compare to the sluggish response in the pre-inflation targeting period. Also the effect of the shock of monetary policy on industrial production is quite sharp but does not last for a long period before it returns to the equilibrium. Nominal variables such as inflation; exchange rates and money supply seem to be more affected by the actions of monetary policy compare with the real variables. Overall, it appears that there is no much difference in the way these variables response to the monetary shocks in both pre and post inflation targeting period.

Thereafter, the study further estimated the variance decomposition for all the three models. The main findings were that, in the, both money supply and interest rate had the larger share in explaining industrial production variable. However, the interest rates had an upper hand in explaining the industrial production variable in the post-inflation targeting period compare with money supply, though the proportion of this variation were negligible. The results also showed that, overall the interest rate variable was an important variable in explaining the inflation which justifies the use of interest rate as a monetary policy tool.

The second objective of the study was to look at the long-run relationship among these variables using Johansen cointegration test analysis. Since all the variables existed in a non-stationary form, it was easy to proceed to cointegration analysis. The cointegration test was carried out for all the three models (pre-inflation targeting, post-inflation targeting and the benchmark model). Unfortunately, the estimation could not establish any cointegration relationship for the variables in the post-inflation targeting period. Hence, a VECM could not be estimated for comparative purposes.

However the results demonstrate that plausible long – run cointegrating relationships exist for both pre – inflation targeting and the benchmark model. In the pre-inflation targeting model, not all the signs were correct, for example the sign on the exchange rate was positive contrary to the negative sign that was expected, however this was corrected in the benchmark model which shows that the benchmark model is a more stable model. This reinforces the view that meaningful long – run analysis can only be conducted with long data series. Thus the short 2000 – 2009 post IT data set showed that no cointegrating relationship was identified. Hence, the Johansen VECM technique can only be applied in the future to investigate the long – run impact of IT.

CHAPTER 6
CONCLUSION

6 Introduction

This chapter will summarize the key findings of this study, draw conclusions and make recommendations based on the study's quantitative and qualitative outcomes. Furthermore, comments will be made on some of the study's strengths and weaknesses.

6.0.1 Summary

The aim of this research was to investigate the South Africa's monetary policy framework through the use of unrestricted VAR technique. It set out to do this by considering the impact of monetary policy on the country's main macroeconomic variables. These variables include industrial production, inflation, exchange rate and money supply, the main monetary policy instrument used in this study is short term interest rate. A central focus of this study was to examine how these key macroeconomic variables reacted to the impact of monetary policy in pre and post-inflation targeting period. This was done by dividing the data sample into two sub-samples representing pre and post-inflation targeting period, and each of them was estimated separately, also the benchmark model which covers the whole period was estimated to allow for adequate comparison. The first sub sample covered 1987 to 2000 period; this was the period when South Africa monetary policy was based on eclectic approach to achieve its monetary policy goal. The second sub sample covered 2000 to 2009 periods representing the period when the inflation- targeting approach was adopted, while the benchmark model covers the whole period under investigation from 1987 to 2009.

The study carefully selected the main macroeconomic variables that have been considered in theory as well as other international studies in this area of study. These include; industrial production as a proxy for output, inflation (CPI), 91 days Treasury bills as a proxy for short term interest rates, nominal exchange rates, and M2 to represent monetary base. Usually there are no exogenous variables in VAR models but this study included some exogenous variables as well as dummies to control for the external impact and the effect of the structural break on South African economy. One of the uniqueness of this study is the construction of the industrial production variable which consisted of manufacturing, mining and electricity, which is different from South Africa studies, i.e . Khabo and Harmse (2005), Gupta *et al.,* (2009) and Kabundi and Ngwenya (2011). Other variables were also carefully selected in accordance with the various economic theories as well as other international studies of monetary policy models.

Firstly, the results on the various unit root tests were presented (See Table 5.1-5.7), followed by the results on the unrestricted VAR technique, through impulse function response (IMF) and variance decomposition. All these results only considered the short-run relationships among the differenced variables; hence the research went further to estimate the cointegration analysis which considers both short - run and long- run relationships. The result for the unit root showed that all the variables were integrated of first order i.e., I(1) but become I(0) after first differencing, and this makes it easier to conduct the cointegration analysis within the ordinary unrestricted VAR framework.

After examining the unit root tests for all the variables and found that they are all integrated of first order, they were all differenced and became stationary. The study thereby proceeded to the estimation of the unrestricted VAR which gave rise to IRF and the variance decomposition analysis. Additionally the cointegration analysis was used since all the variables were integrated of the order 1. Hence, the analysis was done using variables in their levels form without having to transform them to stationary form through differencing, which has the disadvantage of loss of long – run information contained in the data. However, out of the three models that were estimated under cointegration analysis, only two showed that the long-run relationship exists among the variables. The two models are the pre-inflation targeting model and the benchmark model. The overall result showed that there has not been much difference in the way these macroeconomic variables handle monetary policy shock in the pre and post-inflation targeting. The price puzzle that is commonly found in most VAR literature however did not feature in the research; a similar result was achieved in the Kabundi and Ngwenya (2011). The result in this work showed that the monetary policy had more impact on the inflation rate than the real variable especially during the post-inflation rate period suggesting that inflation - targeting policy is an effective policy to curb the inflation rate. See other similar results in Cheng, (2006) and Tsangarides, (2010).However, this result is contrary to the work of Kabundi and Ngwenya who found that the monetary policy did have a significant effect on the real variables more than the nominal variable such as inflation.

The results from variance decomposition found that both money supply and interest rate had the larger share in explaining industrial production variable. However, the interest rates had an upper hand in explaining the industrial production variable in the post-inflation targeting period compare with money supply. Though the proportions of this variation were negligible, factors in the industrial production sector itself explained much of the variation in its forecast error variations. The results also confirmed that, overall the interest rate variable was an important variable in explaining the inflation which justifies the use of interest rate as a monetary policy tool, especially in the post IT.

Furthermore, the studies proceeded to using Johansen cointegration analysis to establish the long-run relationships among the variables. This was made possible because all the variables exhibited I(1) properties. The estimation could not establish any cointegration relationship for the variables in the post-inflation targeting period. However, the results of the trace and maximum eigen value statistics tests suggest an existence of a long-run cointegration for the pre-inflation targeting model and the benchmark model. In the pre-inflation targeting model, not all the signs were correct, for example the sign on the exchange rate was positive contrary to the negative sign that was expected, however this was corrected in the benchmark model which implies that the benchmark model is a more stable model, perhaps due to the long data set that are used to evaluate these models.

The main finding is that even though there is a long – run relation between the industrial production and interest rates, the long-run relationship coefficient is less than unity and the result appears to be significant.

6.0.2 Policy Recommendations

The results of the impulse response function (IRF) for pre and post-inflation targeting periods (Figure A1 and A3) noted that the impact of monetary policy on the South Africa's key macroeconomic variables is more pronounced on the nominal variables compared with the real variables. Furthermore, the combined evidence from the variance decomposition result showed that the monetary policy transmission to the real sector is not as strong as many people believe. The monetary policy authority of South Africa embarked on the inflation - targeting policy since 2000 to achieve the monetary policy goal which is to bring down the rate of inflation in the economy. The same policy has been practiced by a number of first world economies such as New Zealand, United Kingdom and Australia, thus these countries have achieved a tremendous result making the policy to be attractive to their developing countries counterparts such as Brazil, Israel and South Africa. A major reason that can be attributed to some of the successes achieved by these developing countries especially Israel and South Africa, are well developed financial market and independent central banks, which succeeded in maintaining inflation at low single digit levels for most of the period under consideration.

In the case of South Africa, the issue of central bank independent as well as the financial market development is not that much of a problem as the Reserve Bank's independent is protected by the constitution; hence the monetary authority seems to be committed to its primary goal. However, a major area in which South Africa needs to worry about is the increases in the wage settlements as well as increase in the administered prices. This could jeopardize the objective of the monetary policy committee if care is not taken, thus there is a need for the authorities to convince the politicians and the labour union that the inflation targeting is the best policy prescription for the South African.

From the results of the impulse response function IRF in (Figure A1 - A4), the output variability that occurs in response to the monetary policy shock lasted for less than five months before it returned to its base. This implies that that the output variability is not so significant under inflation targeting approach. The discussion from chapter two, section (3.0.3.4) noted that there are two types of inflation targeting; strict inflation targeting and flexible inflation targeting. It is believed that the stricter the inflation targeting is, the more variable the output and if there is too much focus on economic growth, there will be greater inflation variability and lower credibility. Thus, it is important for the South African monetary policy to continue to maintain an appropriate tradeoff between rigid adherence to the inflation- targeting on one hand and a steady path of output on the other hand such as to maintain its credibility.

One of the main issues that is usually raised against inflation targeting is the problem of credit creation and allocation by the private agents as explained in chapter two (section 2.0.6). Post Keynesian economists believed that inflation targeting itself might not be a sufficient framework but must be supplemented with financial intermediary balance sheet regulations. For example the problem of balance - sheet disorder which builds without any immediate effect on inflation can undermine the effectiveness of inflation- targeting approach and also inflict huge output and employment costs when they ultimately come to be resolved (Palley, 2006 :91). Hence there is a need for policy makers to guard against such occurrence. Doing this will help the orderly process of credit creation and allocation.

Lastly, the experience of South Africa inflation targeting approach can encourage other emerging market economies to adopt such a framework because it has been able to control the inflation to a reasonable range since its adoption. Based on the empirical findings in this study, the output variability has been kept to a minimum judging from the impulse response function and the cointegration analysis results.

6.0.3 Limitations and Future research

Firstly this study compared and contrasted the two periods leading to the division of the data sample into two sub groups; pre and post-inflation targeting periods, hence the data sample became relatively short especially the post-inflation targeting data after the division. Consequently there is possibility of data limitations given the short period of analysis. Therefore, the findings may not serve as a best guide as to how the South African inflation targeting policy works, hence this leaves room for future research when the data on the period of inflation targeting will have become relatively longer.

Secondly, this study largely focused on the impact of IT on industrial production. Future studies ought to extend the analysis to include other variables such as current account, fiscal policy, credit extension and so on.

For the sake of concluding this work on a positive note, it is therefore worthwhile to mention some of the strengths of the research. Firstly, the study made use of industrial production output variable as a proxy for income which is not available on the SARB website or anywhere else but has to be constructed for the purpose of this work. Most variables that have been used as a proxy for income for similar works are manufacturing and GDP.

Secondly, the study enjoyed comparison of pre and post-inflation targeting under three different methods all in the context of VAR framework, namely; IRF, Variance decomposition and cointegration analysis. However, all the three methods seem to be pointing to the same direction, i.e., that output is stable under IT and the predictable long – run relationships exist among the macroeconomic variables under consideration.

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Appendix A – Results Appendix:

This appendix records section 1,2 and 3. Section 1 contains table A-1 to A-3 which takes record of the selection of AIC and FPE statistics that are used to demonstrate how the VAR orders (p) of the various models were chosen. This includes the pre-inflation targeting model, post-inflation targeting model and for the whole period model respectively for the unrestricted VAR.

Section 2 comprises of figures A-1 to A-3 . Figure A1 record the impulse responses to innovation of interest rate as a monetary policy indicator in the pre-inflation targeting period. Figure A2 shows the responses to the innovations when money supply (M2) is used as a monetary policy indicator in the pre-inflation targeting period. Figure A3 is the responses to the innovation in D1 in the post-inflation targeting period. This last figure in this appendix is the responses to the innovation in DI for the whole period which is used as the benchmark for this study.

The last section in this appendix is section 3 which records the variance decomposition of industrial production and inflation rate variables in the pre-inflation targeting period, post-inflation targeting period and the whole period. Table A-4 and A-5 show the variance decomposition of industrial production and inflation rate variables in the pre-inflation targeting period. Likewise table A-6 and A-7 account for the variance decomposition of industrial production and inflation rate variables in the post-inflation targeting period, while table A-8 and A-9 account for the variance decomposition of industrial production and inflation variable in the whole period.

Selection of the Order of the Unrestricted VAR Model

Table A-1 - Pre-Inflation Targeting Period (1987M1-2000M1).

VAR Lag Order Selection Criteria
Endogenous variables: DY DINFL DI DX DM2
Exogenous variables: C DOP DPR D94
Date: 08/29/11 Time: 12:14
Sample: 1987M01 2000M01
Included observations: 149

Lag	LogL	LR	FPE	AIC	SC	HQ
0	563.8644	NA	4.65e-10	-7.300193	-6.896979	-7.136374
1	753.2303	355.8555	5.12e-11	-9.506447	-8.599215*	-9.137854
2	794.0792	74.02143	4.15e-11	-9.719184	-8.307934	-9.145816*
3	834.0613	69.76741	3.41e-11*	-9.920286*	-8.005018	-9.142144
4	854.8181	34.82681	3.63e-11	-9.863330	-7.444044	-8.880414
5	869.2609	23.26362	4.23e-11	-9.721623	-6.798319	-8.533933
6	894.6274	39.15637*	4.28e-11	-9.726542	-6.299221	-8.334078
7	914.4448	29.26056	4.69e-11	-9.656977	-5.725638	-8.059739
8	937.2456	32.13545	4.96e-11	-9.627458	-5.192101	-7.825446

* 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

[3]

Table A-2 - Post-inflation Targeting Period (2000M02 -2009M12).

VAR Lag Order Selection Criteria
Endogenous variables: DY DINFL DI DX DM2
Exogenous variables: C DOP DPR DCC
Date: 08/31/11 Time: 11:00
Sample: 2000M02 2009M12
Included observations: 107

Lag	LogL	LR	FPE	AIC	SC
0	336.5514	NA	1.85e-09	-5.916849	-5.417255
1	520.1034	336.2262	9.59e-11	-8.880438	-7.756351*
2	555.9433	62.30108*	7.87e-11*	-9.083053*	-7.334473
3	568.5499	20.73607	1.00e-10	-8.851400	-6.478328
4	590.2581	33.67810	1.09e-10	-8.789871	-5.792306
5	598.7925	12.44270	1.53e-10	-8.482103	-4.860045
6	621.5065	30.99289	1.67e-10	-8.439373	-4.192823
7	636.4159	18.95032	2.14e-10	-8.250765	-3.379721
8	662.4681	30.67830	2.28e-10	-8.270432	-2.774896

* 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

[3] Based on 107 observations from 2000M2 to 2009M12 (Post-inflation targeting). Order of VAR= 2 based on AIC and FPE Criterion

Table A-3 – Whole Period (1987M1-2009M12).

VAR Lag Order Selection Criteria
Endogenous variables: DY DINFL DI DX DM2
Exogenous variables: C DOP DPR D2000 D94 DCC
Date: 08/29/11 Time: 12:21
Sample: 1987M01 2009M12
Included observations: 256

Lag	LogL	LR	FPE	AIC	SC	HQ
0	810.5286	NA	1.55e-09	-6.097879	-5.682429	-5.930787
1	1173.748	695.2247	1.10e-10	-8.740219	-7.978560*	-8.433882
2	1237.912	120.3066	8.11e-11	-9.046184	-7.938316	-8.600604*
3	1271.754	62.13264	7.58e-11*	-9.115266*	-7.661189	-8.530441
4	1293.474	39.02792	7.79e-11	-9.089640	-7.289354	-8.365572
5	1305.035	20.32257	8.67e-11	-8.984650	-6.838156	-8.121338
6	1327.183	38.06727*	8.90e-11	-8.962370	-6.469668	-7.959815
7	1343.725	27.78456	9.55e-11	-8.896288	-6.057377	-7.754489
8	1357.576	22.72424	1.05e-10	-8.809187	-5.624066	-7.528143

* 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

[4]

[4] Based on 256 observations from 1997M1 to 2009M12 (Whole Period). Order of VAR= 3 based on AIC and FPE Criterion

Section 2- Impulse Response Function (IRS)

Figure A1- Impulse Response Function to the Innovation of interest rate (DI) in the Pre-Inflation Targeting Period (1987M1-2000M1).

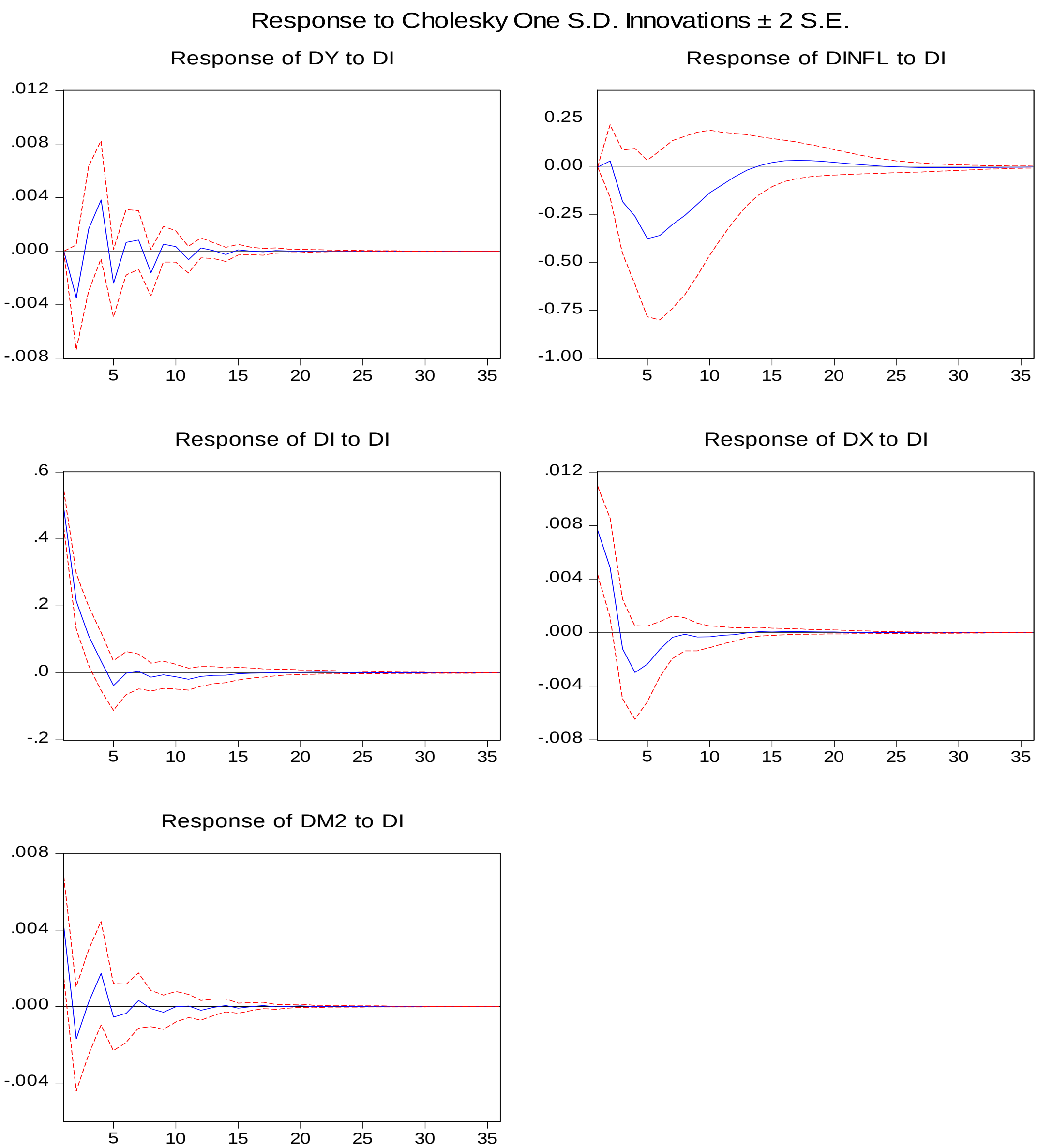


Figure A2- Impulse Response Function (IRS) to the Innovation of M2 (DM2) in the Pre-Inflation Targeting Period (1987M1-2000M1).

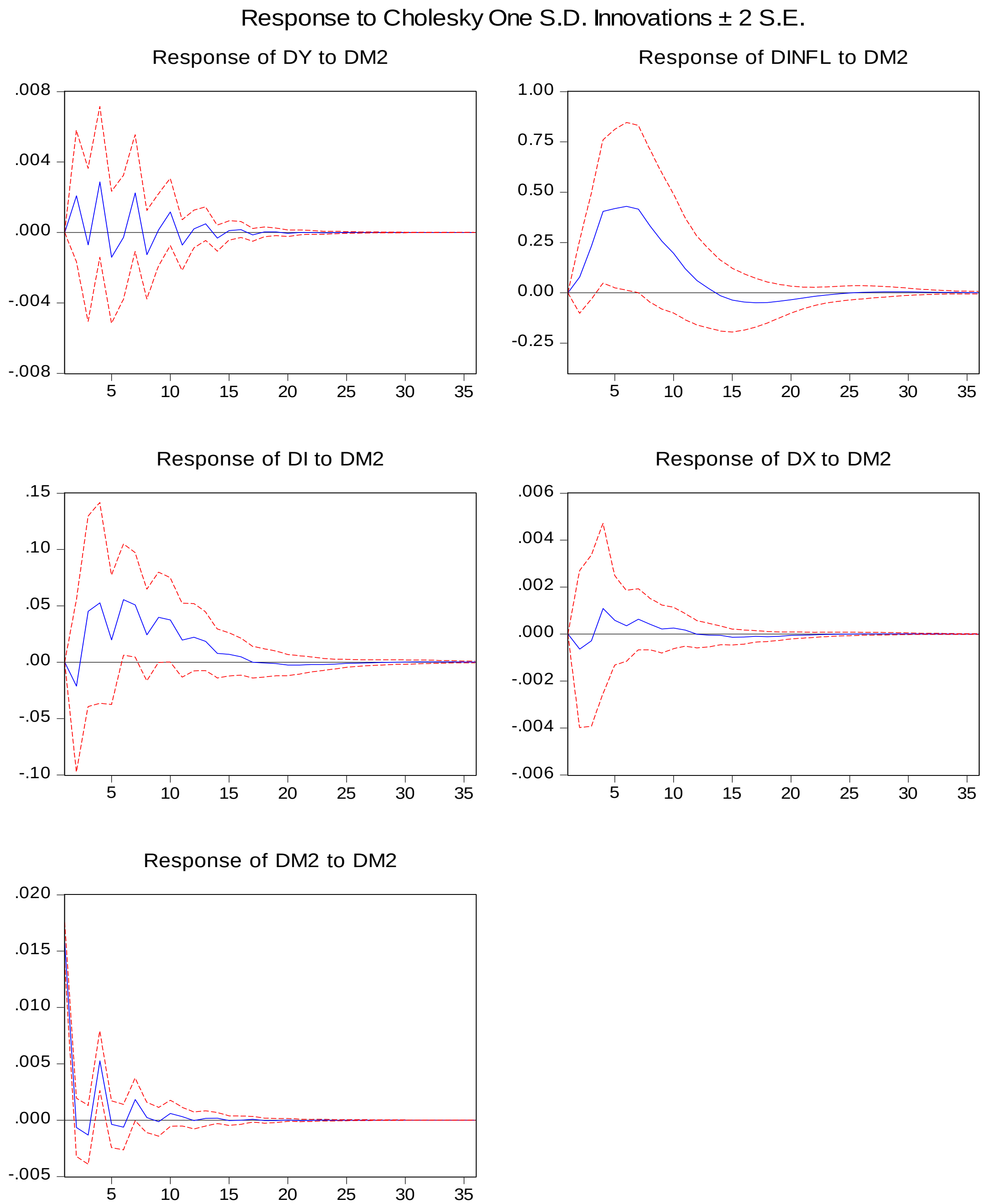


Figure A3- Impulse Response Function (IRS) to the Innovation of interest rate (DI) in the Post-Inflation Targeting Period (2000M02-2009M12).

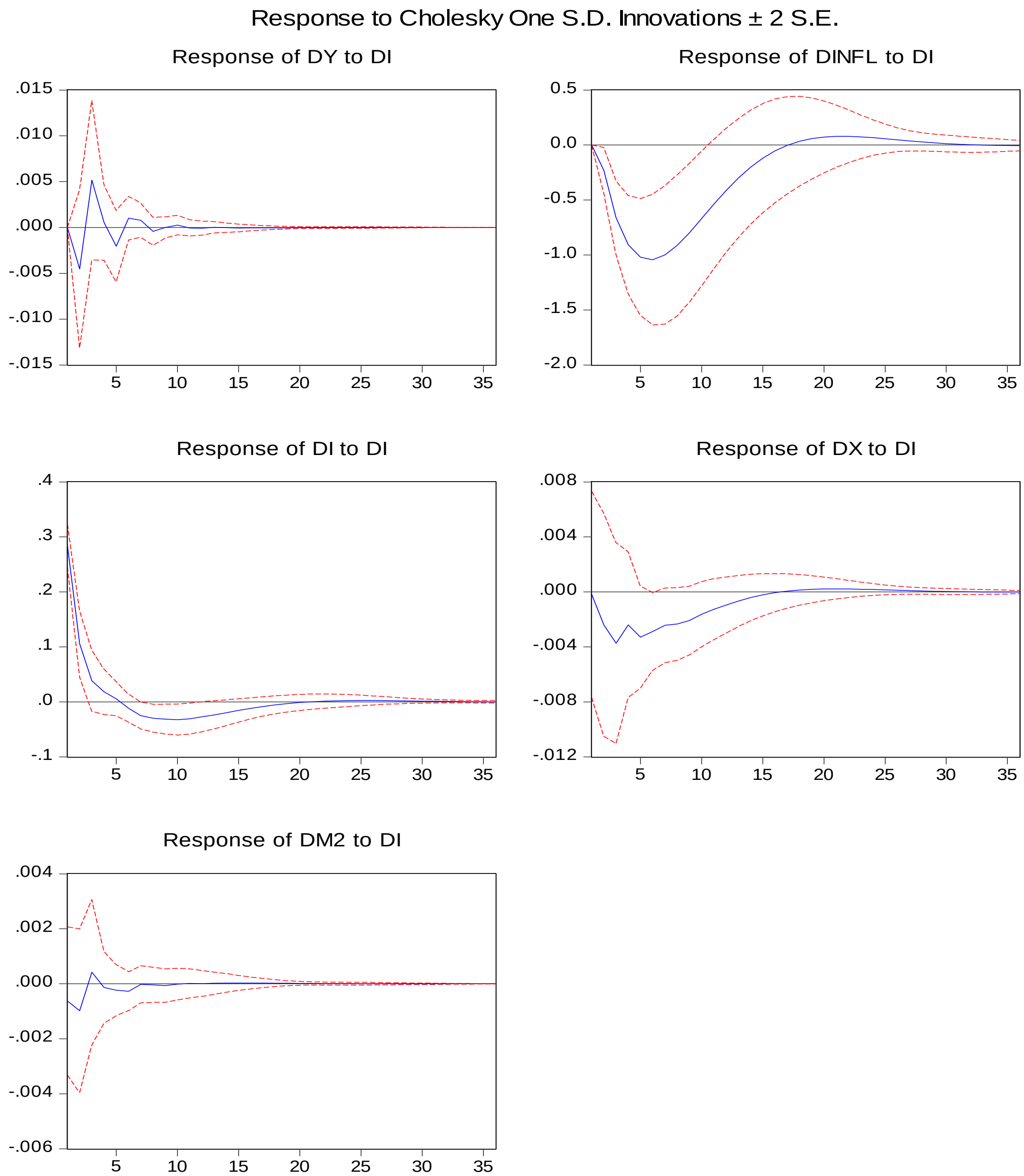
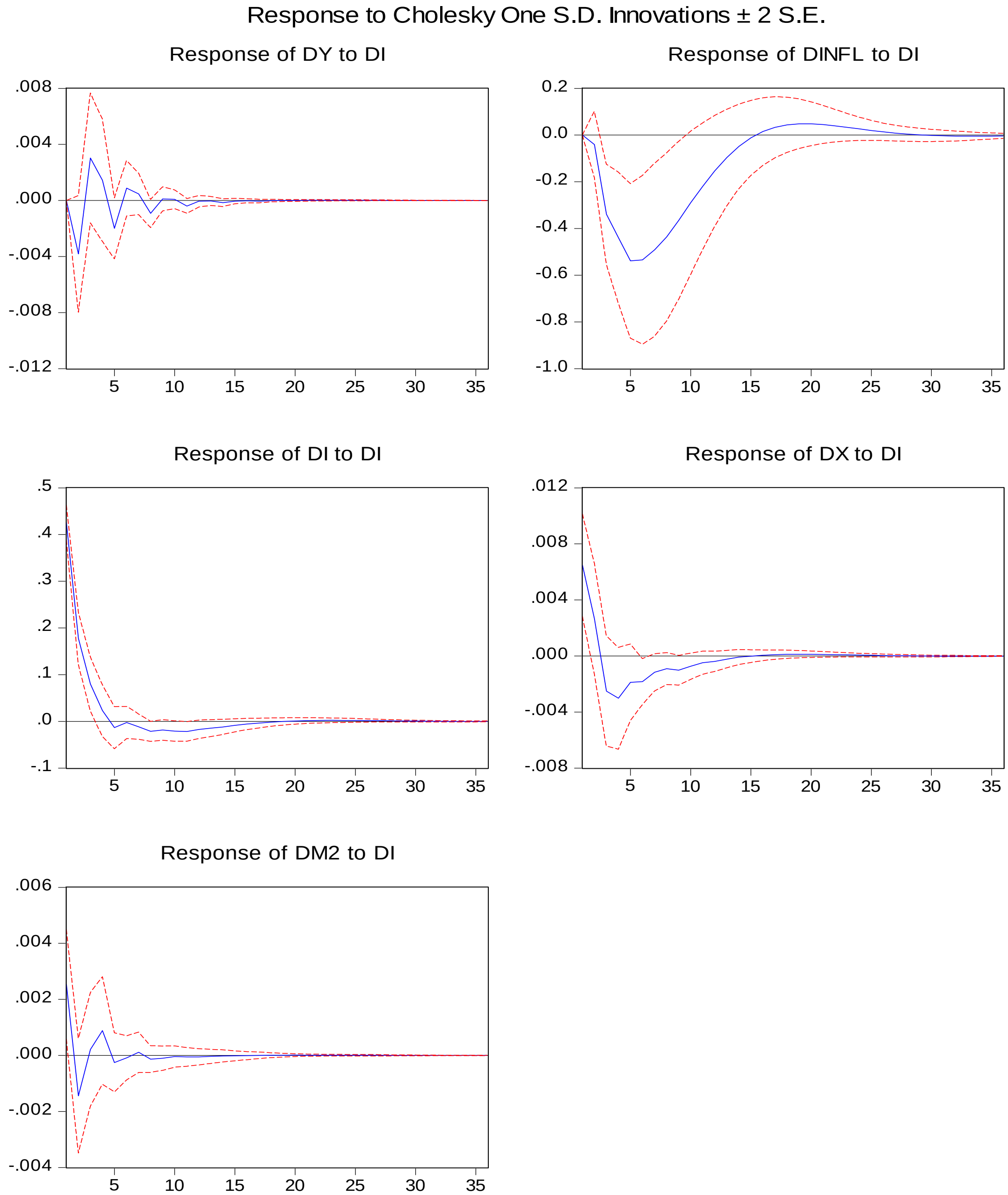


Figure A4- Benchmark Model - Impulse Response Function (IRS) to the Innovation of interest rate (DI) for the whole Period (1987M1-2009M12).



Section 3- Variance Decomposition

Table A-4: 24 months period Variance Decomposition of Industrial Production (DY) in the Pre-inflation targeting period (1987M1 – 2000M1)

Period	S.E.	DY	DINFL	DI	DX	DM2
1	0.023990	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.029236	97.99155	0.001023	1.406872	0.095943	0.504608
3	0.029321	97.44965	0.097594	1.719204	0.174808	0.558744
4	0.030734	95.23702	0.105898	3.113783	0.164179	1.379115
5	0.031572	94.31460	0.147916	3.532540	0.499108	1.505837
6	0.031621	94.22723	0.160414	3.564250	0.539257	1.508849
7	0.031793	93.54475	0.161532	3.592737	0.713295	1.987687
8	0.031963	93.08398	0.203369	3.810300	0.779867	2.122488
9	0.031979	93.04988	0.207435	3.832338	0.787914	2.122435
10	0.032008	92.88937	0.210140	3.836593	0.813743	2.250149
11	0.032034	92.76622	0.219706	3.870017	0.848017	2.296043
12	0.032038	92.75546	0.219764	3.874734	0.850575	2.299469
13	0.032043	92.72632	0.220093	3.873559	0.857352	2.322674
14	0.032047	92.70498	0.220801	3.878809	0.862962	2.332443
15	0.032047	92.70219	0.220962	3.879536	0.863731	2.333583
16	0.032048	92.69896	0.220966	3.879363	0.864610	2.336105
17	0.032049	92.69593	0.220972	3.879575	0.865609	2.337908
18	0.032049	92.69535	0.221248	3.879695	0.865699	2.338004
19	0.032049	92.69507	0.221339	3.879681	0.865796	2.338118
20	0.032049	92.69462	0.221413	3.879653	0.865906	2.338407
21	0.032049	92.69450	0.221520	3.879665	0.865911	2.338403
22	0.032049	92.69445	0.221555	3.879670	0.865918	2.338402
23	0.032049	92.69439	0.221576	3.879670	0.865928	2.338438
24	0.032049	92.69437	0.221588	3.879670	0.865927	2.338442
Cholesky Ordering: DY DINFL DI DX DM2						

Table A-5: 24 months period Variance Decompositions of Inflation (DINFL) in Pre-inflation targeting period (1987M1 – 2000M1)

Period	S.E.	DY	DINFL	DI	DX	DM2
1	0.023990	0.004373	99.99563	0.000000	0.000000	0.000000
2	0.029236	0.178056	99.24838	0.037071	0.307968	0.228525
3	0.029321	0.131516	97.52915	0.715520	0.362491	1.261318
4	0.030734	0.120832	94.67644	1.533014	0.269355	3.400361
5	0.031572	0.181354	91.75784	2.943403	0.242435	4.874970
6	0.031621	0.374676	89.17171	3.950007	0.259807	6.243802
7	0.031793	0.552871	87.12104	4.549823	0.291982	7.484284
8	0.031963	0.737577	85.74965	4.981878	0.297833	8.233059
9	0.031979	0.905809	84.85220	5.240507	0.304715	8.696764
10	0.032008	1.015747	84.31642	5.368188	0.315824	8.983825
11	0.032034	1.084590	84.07221	5.432910	0.320964	9.089331
12	0.032038	1.124630	83.99359	5.448833	0.323647	9.109301
13	0.032043	1.140078	83.99420	5.442155	0.325042	9.098527
14	0.032047	1.142324	84.01843	5.431982	0.324600	9.082668
15	0.032047	1.140532	84.03454	5.425320	0.323928	9.075682
16	0.032048	1.138451	84.03655	5.424489	0.323383	9.077129
17	0.032049	1.137958	84.02581	5.427152	0.323182	9.085902
18	0.032049	1.138744	84.00927	5.431343	0.323255	9.097388
19	0.032049	1.140339	83.99323	5.435799	0.323384	9.107252
20	0.032049	1.142289	83.98020	5.439255	0.323581	9.114674
21	0.032049	1.143877	83.97148	5.441434	0.323774	9.119437
22	0.032049	1.144987	83.96672	5.442608	0.323892	9.121793
23	0.032049	1.145689	83.96465	5.443053	0.323959	9.122654
24	0.032049	1.146019	83.96413	5.443096	0.323990	9.122767

Cholesky Ordering: DY DINFL DI DX DM2

Table A-6: 24 months period Variance Decomposition of Industrial Production (DY) in the Post-inflation targeting period (2000M2 – 2009M12)

Period	S.E.	DY	DINFL	DI	DX	DM2
1	0.042253	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.047329	97.50210	0.000867	0.917265	0.111224	1.468549
3	0.048439	96.44397	0.000852	2.008915	0.111612	1.434652
4	0.049812	96.21608	0.039643	1.911124	0.205256	1.627895
5	0.049863	96.02974	0.040197	2.073217	0.204927	1.651918
6	0.050035	95.98501	0.040492	2.100139	0.220090	1.654273
7	0.050074	95.95037	0.042363	2.121627	0.220236	1.665409
8	0.050085	95.94356	0.042757	2.127804	0.221138	1.664736
9	0.050095	95.94228	0.042931	2.126987	0.221491	1.666312
10	0.050096	95.93951	0.042947	2.129486	0.221517	1.666539
11	0.050097	95.93933	0.042950	2.129468	0.221557	1.666691
12	0.050097	95.93890	0.043095	2.129692	0.221565	1.666747
13	0.050097	95.93875	0.043247	2.129691	0.221577	1.666737
14	0.050098	95.93861	0.043342	2.129711	0.221578	1.666759
15	0.050098	95.93837	0.043449	2.129846	0.221577	1.666755
16	0.050098	95.93823	0.043546	2.129891	0.221578	1.666752
17	0.050098	95.93814	0.043609	2.129927	0.221577	1.666751
18	0.050098	95.93804	0.043653	2.129981	0.221577	1.666750
19	0.050098	95.93798	0.043683	2.130016	0.221577	1.666749
20	0.050098	95.93794	0.043699	2.130035	0.221577	1.666748
21	0.050098	95.93792	0.043707	2.130050	0.221577	1.666747
22	0.050098	95.93791	0.043711	2.130059	0.221577	1.666747
23	0.050098	95.93790	0.043712	2.130063	0.221577	1.666747
24	0.050098	95.93790	0.043712	2.130065	0.221577	1.666747

Cholesky Ordering: DY DINFL DI DX DM2

Table A-7: 24 months period Variance Decomposition of Inflation (DINFL) in the Post-inflation targeting period (2000M2 – 2009M12)

Period	S.E.	DY	DINFL	DI	DX	DM2
1	0.042253	0.078579	99.92142	0.000000	0.000000	0.000000
2	0.047329	0.072030	96.72038	1.875685	0.631399	0.700506
3	0.048439	0.744754	88.57379	9.048025	0.657596	0.975839
4	0.049812	1.220320	81.96772	15.50815	0.513480	0.790337
5	0.049863	1.554511	77.05613	20.36685	0.393423	0.629083
6	0.050035	1.863436	73.32317	23.97502	0.318969	0.519409
7	0.050074	2.082491	70.54986	26.64229	0.274799	0.450555
8	0.050085	2.233028	68.48805	28.62192	0.249318	0.407681
9	0.050095	2.348867	66.97933	30.05366	0.235666	0.382473
10	0.050096	2.431994	65.91697	31.05215	0.229605	0.369279
11	0.050097	2.485988	65.20295	31.71909	0.228181	0.363785
12	0.050097	2.519941	64.75235	32.13553	0.229209	0.362967
13	0.050097	2.539619	64.49360	32.37094	0.231258	0.364582
14	0.050098	2.549222	64.36475	32.48548	0.233462	0.367079
15	0.050098	2.552749	64.31547	32.52691	0.235333	0.369539
16	0.050098	2.553121	64.30854	32.53018	0.236670	0.371496
17	0.050098	2.552213	64.31898	32.51854	0.237474	0.372795
18	0.050098	2.551141	64.33215	32.50537	0.237847	0.373492
19	0.050098	2.550419	64.34114	32.49678	0.237925	0.373737
20	0.050098	2.550183	64.34403	32.49425	0.237834	0.373694
21	0.050098	2.550363	64.34164	32.49681	0.237674	0.373507
22	0.050098	2.550809	64.33585	32.50255	0.237509	0.373279
23	0.050098	2.551367	64.32861	32.50958	0.237374	0.373072
24	0.050098	2.551918	64.32143	32.51646	0.237280	0.372914
Cholesky Ordering: DY DINFL DI DX DM2						

Table A-8: 24 months period Variance Decomposition of Industrial Production (DI) in the Whole period (1987M1 – 2009 M12)

Period	S.E.	DY	DINFL	DI	DX	DM2
1	0.032901	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.037147	98.72782	0.099990	1.055287	0.110923	0.005978
3	0.037607	97.98807	0.102518	1.681634	0.139940	0.087840
4	0.039249	96.77201	0.098303	1.679008	0.224276	1.226407
5	0.039621	95.89825	0.132107	1.899169	0.520928	1.549549
6	0.039681	95.82242	0.133150	1.942421	0.532006	1.570004
7	0.039857	95.38408	0.134493	1.938823	0.581292	1.961316
8	0.039912	95.15803	0.164998	1.986735	0.639924	2.050310
9	0.039918	95.15114	0.169456	1.987030	0.640530	2.051843
10	0.039938	95.06660	0.173736	1.985387	0.646677	2.127603
11	0.039947	95.02624	0.184338	1.994275	0.655385	2.139759
12	0.039948	95.02413	0.186389	1.994404	0.655388	2.139688
13	0.039950	95.01186	0.187824	1.994228	0.655878	2.150209
14	0.039952	95.00632	0.189586	1.995739	0.656890	2.151464
15	0.039952	95.00596	0.189812	1.995882	0.656887	2.151463
16	0.039952	95.00481	0.189890	1.995907	0.656916	2.152475
17	0.039952	95.00437	0.189932	1.996056	0.657002	2.152641
18	0.039952	95.00434	0.189948	1.996066	0.657003	2.152640
19	0.039952	95.00426	0.189988	1.996064	0.657007	2.152679
20	0.039952	95.00417	0.190042	1.996062	0.657008	2.152721
21	0.039952	95.00406	0.190139	1.996065	0.657010	2.152723
22	0.039952	95.00397	0.190229	1.996072	0.657011	2.152722
23	0.039952	95.00387	0.190303	1.996080	0.657010	2.152735
24	0.039952	95.00379	0.190368	1.996090	0.657011	2.152738
Cholesky Ordering: DY DINFL DI DX DM2						

Table A-9: 24 months period Variance Decomposition of Inflation (DINFL) in the Whole period (1987M1 – 2009M12)

Period	S.E.	DY	DINFL	DI	DX	DM2
1	0.032901	0.040574	99.95943	0.000000	0.000000	0.000000
2	0.037147	0.017893	98.64064	0.057853	0.931413	0.352202
3	0.037607	0.156461	95.03252	2.287635	1.317283	1.206102
4	0.039249	0.390162	91.77141	4.157851	1.255229	2.425350
5	0.039621	0.708266	88.84353	6.209817	1.148962	3.089428
6	0.039681	1.082660	86.53231	7.715860	1.115972	3.553198
7	0.039857	1.348821	84.80537	8.785871	1.108726	3.951211
8	0.039912	1.570168	83.54489	9.592271	1.123481	4.169196
9	0.039918	1.758296	82.65300	10.16156	1.135748	4.291395
10	0.039938	1.887515	82.06490	10.53472	1.142105	4.370759
11	0.039947	1.970804	81.71147	10.76709	1.147231	4.403399
12	0.039948	2.021608	81.52486	10.89083	1.149795	4.412908
13	0.039950	2.046971	81.44672	10.94201	1.150337	4.413964
14	0.039952	2.056112	81.42875	10.95317	1.150001	4.411961
15	0.039952	2.057008	81.43651	10.94618	1.149223	4.411078
16	0.039952	2.054717	81.44964	10.93511	1.148439	4.412099
17	0.039952	2.052210	81.45798	10.92693	1.147812	4.415069
18	0.039952	2.050796	81.45892	10.92379	1.147415	4.419085
19	0.039952	2.050672	81.45381	10.92516	1.147246	4.423105
20	0.039952	2.051566	81.44519	10.92936	1.147221	4.426665
21	0.039952	2.052992	81.43566	10.93463	1.147278	4.429441
22	0.039952	2.054511	81.42706	10.93971	1.147368	4.431357
23	0.039952	2.055853	81.42030	10.94384	1.147454	4.432548
24	0.039952	2.056883	81.41562	10.94679	1.147520	4.433195

Cholesky Ordering: DY DINFL DI DX DM2

Appendix B –The Johansen Cointegration Procedure

This appendix gives a succinct account of the Johansen method of cointegration. Section 1 gives the details report of model selection criteria in VECM which includes the choice of lag length. Section 2 shows the various statistics that are employed to show how the numbers (r) of cointegrating vectors were selected. Section 3 is the reports of the VECMs' results for the different models in this study.

Table B-1- VAR orders (p) for the cointegrating analysis- Pre-Inflation Targeting Period

VAR Lag Order Selection Criteria
Endogenous variables: LY INFL I LX LM2
Exogenous variables: C D94
Date: 10/26/11 Time: 13:52
Sample: 1987M01 2000M01
Included observations: 149

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-143.7924	NA	5.42e-06	2.064327	2.265934	2.146237
1	841.9154	1878.799	1.36e-11	-10.83108	-10.12545*	-10.54440*
2	879.6294	69.35339	1.15e-11	-11.00174	-9.792095	-10.51028
3	909.5234	52.96647	1.08e-11	-11.06743	-9.353768	-10.37120
4	940.1662	52.23669	1.01e-11	-11.14317	-8.925492	-10.24216
5	966.4886	43.10521	9.98e-12	-11.16092	-8.439225	-10.05514
6	993.1511	41.87258*	9.90e-12*	-11.18324*	-7.957522	-9.872682
7	1007.458	21.50804	1.16e-11	-11.03970	-7.309970	-9.524373
8	1028.208	29.80218	1.26e-11	-10.98266	-6.748906	-9.262554

* 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

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[5] Based on 149 observations from 1987M1 to 2000M1 (Pre-inflation targeting). Order of VAR= 6 for cointegrating analysis which was also chosen based on AIC and FPE Criterion.

Table B-2 - VAR orders (p) for the cointegrating analysis- Post-Inflation Targeting Period

VAR Lag Order Selection Criteria
Endogenous variables: LY INFL I LX LM2
Exogenous variables: C DCC
Date: 10/26/11 Time: 13:55
Sample: 2000M02 2009M12
Included observations: 119

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-179.4637	NA	1.66e-05	3.184264	3.417804	3.279097
1	620.1980	1505.246	3.69e-11	-9.835261	-9.017872*	-9.503345
2	677.1116	102.3488*	2.16e-11*	-10.37162*	-8.970385	-9.802624*
3	696.8891	33.90430	2.38e-11	-10.28385	-8.298762	-9.477769
4	712.8377	26.00022	2.80e-11	-10.13173	-7.562788	-9.088561
5	736.5788	36.70889	2.91e-11	-10.11057	-6.957780	-8.830320
6	746.5699	14.60887	3.85e-11	-9.858317	-6.121681	-8.340987
7	762.4748	21.91941	4.66e-11	-9.705459	-5.384973	-7.951046
8	778.4658	20.69421	5.72e-11	-9.554047	-4.649712	-7.562551

* 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

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[6] Based on 119 observations from 2000M2 to 2009M12 (Post-inflation targeting). Order of VAR= 2 for cointegrating analysis which was also chosen based on AIC and FPE Criterion.

Table B-3 - VAR orders (p) for the cointegrating analysis- Pre-Inflation Targeting Period for the Whole Period

VAR Lag Order Selection Criteria
Endogenous variables: LY INFL I LM2 LX
Exogenous variables: C D94 D2000 DCC
Date: 08/29/11 Time: 19:36
Sample: 1987M01 2009M12
Included observations: 268

Lag	LogL	LR	FPE	AIC	SC
0	-632.0513	NA	8.93e-05	4.866054	5.134038
1	1349.304	3829.635	4.08e-11	-9.733613	-9.130649
2	1430.134	153.2155	2.69e-11	-10.15026	-9.212312*
3	1466.076	66.78650	2.48e-11	-10.23191	-8.958984
4	1495.049	52.75725*	2.41e-11*	-10.26156*	-8.653655
5	1513.639	33.15733	2.53e-11	-10.21373	-8.270841
6	1532.207	32.42368	2.66e-11	-10.16572	-7.887856
7	1544.934	21.75100	2.93e-11	-10.07414	-7.461292
8	1562.476	29.32273	3.11e-11	-10.01847	-7.070649

* 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

[7]

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[7] Based on 268 observations from 1987M1 to 2009M12 (Post-inflation targeting). Order of VAR= 4 for cointegrating analysis which was also chosen based on AIC and FPE Criterion.

Section 2- Selection of Johansen number (r) of Cointegrating Vectors

Table B4 - Selection λ max and λ trace Statistics for Pre-inflation Targeting Period

Date: 10/26/11 Time: 14:04
Sample (adjusted): 1987M07 2000M01
Included observations: 151 after adjustments
Trend assumption: Linear deterministic trend
Series: LY INFL I LX LM2
Exogenous series: D94
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 5

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.235661	88.47410	69.81889	0.0008
At most 1 *	0.145835	47.89380	47.85613	0.0496
At most 2	0.101665	24.09161	29.79707	0.1966
At most 3	0.047760	7.902500	15.49471	0.4759
At most 4	0.003391	0.512881	3.841466	0.4739

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.235661	40.58030	33.87687	0.0068
At most 1	0.145835	23.80219	27.58434	0.1418
At most 2	0.101665	16.18911	21.13162	0.2140
At most 3	0.047760	7.389620	14.26460	0.4441
At most 4	0.003391	0.512881	3.841466	0.4739

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

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Table B-5 -– Selection λ max and λ trace Statistics for Post-inflation Targeting Period

Date: 10/26/11 Time: 13:59
Sample: 2000M02 2009M12
Included observations: 119
Trend assumption: Linear deterministic trend
Series: LY INFL I LX LM2
Exogenous series: DCC
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.199450	66.70056	69.81889	0.0864
At most 1	0.142950	40.22825	47.85613	0.2144
At most 2	0.111861	21.87136	29.79707	0.3057
At most 3	0.062598	7.754788	15.49471	0.4920
At most 4	0.000523	0.062262	3.841466	0.8029

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.199450	26.47231	33.87687	0.2927
At most 1	0.142950	18.35688	27.58434	0.4657
At most 2	0.111861	14.11658	21.13162	0.3555
At most 3	0.062598	7.692526	14.26460	0.4108
At most 4	0.000523	0.062262	3.841466	0.8029

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

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[8] Cointegration with unrestricted intercepts and no trends in the VAR- 151 observation after adjustmenst from 1987m01 to 2000m01.
Trace statistics suggested 2 cointegrating relationships, while max-eigen test suggested 1 cointegrating relationship.

Table B-6 – Selection λ max and λ trace Statistics for the whole Period

Date: 02/14/12 Time: 18:00
Sample (adjusted): 1987M05 2009M12
Included observations: 272 after adjustments
Trend assumption: Linear deterministic trend
Series: LY INFL I LX LM2
Exogenous series: D2000 D94 DCC
Warning: Critical values assume no exogenous series
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.123544	85.80451	69.81889	0.0016
At most 1 *	0.095799	49.93629	47.85613	0.0315
At most 2	0.067086	22.54482	29.79707	0.2691
At most 3	0.012743	3.656544	15.49471	0.9293
At most 4	0.000618	0.168253	3.841466	0.6817

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.123544	35.86822	33.87687	0.0286
At most 1	0.095799	27.39147	27.58434	0.0529
At most 2	0.067086	18.88828	21.13162	0.1001
At most 3	0.012743	3.488292	14.26460	0.9090
At most 4	0.000618	0.168253	3.841466	0.6817

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

[9] Cointegration with unrestricted intercepts and no trends in the VAR- 119 observation from 2000m02 to 2009m12. Both Trace statistics and eigen statistics suggested no cointegrating relationship

Section 3

This section records the VECM results for the Pre-Inflation Targeting Period model and the Whole Period model

Table B-7- Results of the Pre-Inflation Targeting Period Cointegrating Vectors

Vector Error Correction Estimates
Date: 08/31/11 Time: 13:42
Sample (adjusted): 1987M07 2000M01
Included observations: 151 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1			
LY(-1)	1.000000			
INFL(-1)	-0.010545 (0.00355) [-2.97270]			
I(-1)	0.000525 (0.00223) [0.23516]			
LX(-1)	-0.077109 (0.05941) [-1.29785]			
LM2(-1)	-0.101860 (0.03340) [-3.04999]			
C	-2.565719			
Error Correction:	**D(LY)**	**D(INFL)**	**D(I)**	**D(LX)**
CointEq1	-0.354005 (0.10299) [-3.43742]	5.639948 (2.81919) [2.00055]	5.689464 (2.03388) [2.79734]	0.112934 (0.09007) [1.25383]
D(LY(-1))	-0.369878 (0.11715) [-3.15729]	-2.374254 (3.20694) [-0.74035]	-2.963183 (2.31362) [-1.28076]	-0.002125 (0.10246) [-0.02074]
D(LY(-2))	-0.269644 (0.11940) [-2.25824]	-4.494185 (3.26865) [-1.37494]	-1.619222 (2.35814) [-0.68665]	-0.061575 (0.10443) [-0.58963]
D(LY(-3))	0.130133	-3.451059	-2.897778	-0.176850

	(0.12196)	(3.33866)	(2.40865)	(0.10667)
	[1.06699]	[-1.03367]	[-1.20307]	[-1.65795]
D(LY(-4))	0.059672	-5.634069	-6.853273	-0.201234
	(0.11330)	(3.10149)	(2.23755)	(0.09909)
	[0.52668]	[-1.81657]	[-3.06285]	[-2.03082]
D(LY(-5))	0.044181	-4.104398	-2.785820	-0.078158
	(0.09336)	(2.55564)	(1.84375)	(0.08165)
	[0.47324]	[-1.60601]	[-1.51095]	[-0.95722]
D(INFL(-1))	-0.002425	0.004927	0.026454	-0.000871
	(0.00311)	(0.08517)	(0.06144)	(0.00272)
	[-0.77949]	[0.05785]	[0.43055]	[-0.32012]
D(INFL(-2))	-0.000377	0.295137	0.122573	0.002071
	(0.00295)	(0.08089)	(0.05835)	(0.00258)
	[-0.12749]	[3.64881]	[2.10050]	[0.80145]
D(INFL(-3))	-0.000576	0.045459	0.000653	0.001369
	(0.00307)	(0.08413)	(0.06070)	(0.00269)
	[-0.18749]	[0.54032]	[0.01076]	[0.50918]
D(INFL(-4))	-0.002651	-0.250717	0.051752	0.003772
	(0.00296)	(0.08102)	(0.05845)	(0.00259)
	[-0.89554]	[-3.09438]	[0.88535]	[1.45719]
D(INFL(-5))	-0.004054	-0.000226	-0.018178	-0.003253
	(0.00305)	(0.08353)	(0.06026)	(0.00267)
	[-1.32864]	[-0.00270]	[-0.30164]	[-1.21881]
D(I(-1))	-0.004740	0.376197	0.389720	0.007675
	(0.00498)	(0.13646)	(0.09845)	(0.00436)
	[-0.95089]	[2.75690]	[3.95873]	[1.76051]
D(I(-2))	0.001478	0.133639	-0.021617	-0.006458
	(0.00534)	(0.14625)	(0.10551)	(0.00467)
	[0.27669]	[0.91375]	[-0.20487]	[-1.38199]
D(I(-3))	0.006813	-0.223395	0.028920	-0.001895
	(0.00510)	(0.13956)	(0.10068)	(0.00446)
	[1.33644]	[-1.60071]	[0.28723]	[-0.42506]
D(I(-4))	-0.007800	0.005005	-0.327098	-0.011555
	(0.00480)	(0.13139)	(0.09479)	(0.00420)
	[-1.62521]	[0.03809]	[-3.45083]	[-2.75278]
D(I(-5))	0.008530	0.394471	-0.045782	0.006089
	(0.00485)	(0.13288)	(0.09586)	(0.00425)
	[1.75726]	[2.96866]	[-0.47757]	[1.43437]
D(LX(-1))	0.098582	-1.418129	1.551322	0.332201
	(0.10689)	(2.92596)	(2.11091)	(0.09348)
	[0.92231]	[-0.48467]	[0.73491]	[3.55364]
D(LX(-2))	-0.051847	3.673164	3.494156	-0.146740
	(0.11129)	(3.04640)	(2.19780)	(0.09733)

	[-0.46589]	[1.20574]	[1.58984]	[-1.50765]
D(LX(-3))	0.147263	2.478280	-4.238939	0.087150
	(0.11471)	(3.14018)	(2.26546)	(0.10033)
	[1.28377]	[0.78922]	[-1.87112]	[0.86866]
D(LX(-4))	-0.028726	0.699077	0.419164	-0.114505
	(0.11325)	(3.10029)	(2.23668)	(0.09905)
	[-0.25365]	[0.22549]	[0.18740]	[-1.15601]
D(LX(-5))	0.040406	1.404876	4.016165	0.024305
	(0.10729)	(2.93713)	(2.11897)	(0.09384)
	[0.37659]	[0.47832]	[1.89534]	[0.25901]
D(LM2(-1))	0.100072	-3.156016	-1.203751	-0.043935
	(0.12832)	(3.51273)	(2.53423)	(0.11223)
	[0.77986]	[-0.89845]	[-0.47500]	[-0.39148]
D(LM2(-2))	0.019675	-7.907964	1.698081	-0.124099
	(0.12839)	(3.51452)	(2.53552)	(0.11229)
	[0.15325]	[-2.25008]	[0.66972]	[-1.10520]
D(LM2(-3))	0.268143	-2.542168	0.760807	0.043692
	(0.12007)	(3.28698)	(2.37137)	(0.10502)
	[2.23315]	[-0.77341]	[0.32083]	[0.41605]
D(LM2(-4))	0.127070	-0.042021	-3.563337	0.100292
	(0.12896)	(3.53021)	(2.54685)	(0.11279)
	[0.98535]	[-0.01190]	[-1.39912]	[0.88921]
D(LM2(-5))	0.138544	7.484972	1.521970	0.319885
	(0.12760)	(3.49299)	(2.51999)	(0.11160)
	[1.08577]	[2.14285]	[0.60396]	[2.86639]
C	-0.337497	3.965389	-2.752870	0.098354
	(0.11803)	(3.23105)	(2.33102)	(0.10323)
	[-2.85939]	[1.22727]	[-1.18097]	[0.95277]
LOP	0.011274	0.646497	-0.397425	-0.015099
	(0.01146)	(0.31367)	(0.22629)	(0.01002)
	[0.98388]	[2.06107]	[-1.75623]	[-1.50670]
LPR	0.067638	-1.351340	0.880270	-0.012205
	(0.02786)	(0.76253)	(0.55012)	(0.02436)
	[2.42818]	[-1.77217]	[1.60013]	[-0.50097]
D94	-0.006994	0.174665	0.067735	0.003708
	(0.00462)	(0.12639)	(0.09118)	(0.00404)
	[-1.51475]	[1.38199]	[0.74287]	[0.91838]
R-squared	0.514682	0.378300	0.521826	0.364297
Adj. R-squared	0.398366	0.229298	0.407222	0.211939
Sum sq. resids	0.066011	49.46661	25.74633	0.050493
S.E. equation	0.023357	0.639386	0.461280	0.020428
F-statistic	4.424857	2.538889	4.553311	2.391052
Log likelihood	369.7486	-130.0031	-80.70115	389.9816
Akaike AIC	-4.499982	2.119246	1.466240	-4.767968

Schwarz SC	-3.900522	2.718706	2.065700	-4.168509
Mean dependent	0.000619	-0.095364	0.009205	0.007333
S.D. dependent	0.030113	0.728317	0.599127	0.023011

Table B-8 - Results of the Whole Period Cointegrating Vectors

Vector Error Correction Estimates
Date: 02/14/12 Time: 18:04
Sample (adjusted): 1987M05 2009M12
Included observations: 272 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LY(-1)	1.000000
INFL(-1)	-0.048952
	(0.00811)
	[-6.03624]
I(-1)	0.017503
	(0.00834)
	[2.09923]
LX(-1)	0.045635
	(0.11699)
	[0.39007]
LM2(-1)	-0.332412
	(0.05967)
	[-5.57039]
C	-0.251172

Error Correction:	D(LY)	D(INFL)	D(I)	D(LX)	D(LM2)
CointEq1	-0.004384	1.878153	0.295514	0.062059	0.004833
	(0.02144)	(0.40874)	(0.27372)	(0.01979)	(0.01021)
	[-0.20454]	[4.59496]	[1.07961]	[3.13562]	[0.47337]
D(LY(-1))	-0.535986	0.842530	-0.001556	-0.119865	0.003039
	(0.06578)	(1.25443)	(0.84005)	(0.06074)	(0.03133)
	[-8.14759]	[0.67165]	[-0.00185]	[-1.97338]	[0.09698]
D(LY(-2))	-0.388177	-0.721386	2.172477	-0.137494	-0.012294
	(0.06897)	(1.31509)	(0.88068)	(0.06368)	(0.03285)
	[-5.62853]	[-0.54855]	[2.46683]	[-2.15920]	[-0.37426]
D(LY(-3))	-0.006634	-0.444572	1.619671	-0.114035	-0.016692
	(0.06447)	(1.22936)	(0.82327)	(0.05953)	(0.03071)
	[-0.10291]	[-0.36163]	[1.96737]	[-1.91568]	[-0.54356]
D(INFL(-1))	0.002106	0.167657	0.019127	0.000538	0.001924
	(0.00320)	(0.06099)	(0.04084)	(0.00295)	(0.00152)

	[0.65859]	[2.74899]	[0.46831]	[0.18210]	[1.26287]
D(INFL(-2))	0.001612	0.209939	0.125769	0.002047	-0.000535
	(0.00321)	(0.06129)	(0.04105)	(0.00297)	(0.00153)
	[0.50165]	[3.42515]	[3.06407]	[0.68970]	[-0.34933]
D(INFL(-3))	-0.000373	0.075855	-0.049741	0.004199	0.000918
	(0.00315)	(0.06005)	(0.04021)	(0.00291)	(0.00150)
	[-0.11849]	[1.26319]	[-1.23691]	[1.44403]	[0.61178]
D(I(-1))	-0.009674	0.337401	0.415604	0.001784	-0.004229
	(0.00500)	(0.09541)	(0.06389)	(0.00462)	(0.00238)
	[-1.93359]	[3.53650]	[6.50499]	[0.38627]	[-1.77446]
D(I(-2))	0.005656	-0.042707	-0.017409	-0.003327	0.001436
	(0.00543)	(0.10362)	(0.06939)	(0.00502)	(0.00259)
	[1.04091]	[-0.41215]	[-0.25089]	[-0.66306]	[0.55475]
D(I(-3))	0.001169	-0.012828	0.004048	-0.004773	0.000496
	(0.00495)	(0.09432)	(0.06317)	(0.00457)	(0.00236)
	[0.23630]	[-0.13600]	[0.06408]	[-1.04503]	[0.21071]
D(LX(-1))	0.012498	-0.824575	1.124680	0.343171	0.099286
	(0.06897)	(1.31509)	(0.88067)	(0.06368)	(0.03285)
	[0.18122]	[-0.62701]	[1.27707]	[5.38914]	[3.02250]
D(LX(-2))	-0.010340	1.986353	1.032462	-0.165752	-0.007662
	(0.07194)	(1.37171)	(0.91860)	(0.06642)	(0.03426)
	[-0.14374]	[1.44808]	[1.12396]	[-2.49551]	[-0.22361]
D(LX(-3))	-0.034059	-0.499401	-1.824325	0.051815	-0.005687
	(0.06882)	(1.31237)	(0.87885)	(0.06355)	(0.03278)
	[-0.49487]	[-0.38053]	[-2.07581]	[0.81539]	[-0.17349]
D(LM2(-1))	-0.010253	-4.632374	0.668267	0.018714	-0.045449
	(0.12834)	(2.44733)	(1.63890)	(0.11850)	(0.06113)
	[-0.07989]	[-1.89283]	[0.40775]	[0.15792]	[-0.74346]
D(LM2(-2))	-0.010635	-2.085570	3.476108	-0.208885	-0.011111
	(0.12874)	(2.45490)	(1.64397)	(0.11887)	(0.06132)
	[-0.08261]	[-0.84955]	[2.11446]	[-1.75726]	[-0.18120]
D(LM2(-3))	0.243221	-4.137779	3.544703	0.031964	0.309448
	(0.12813)	(2.44330)	(1.63620)	(0.11831)	(0.06103)
	[1.89822]	[-1.69352]	[2.16642]	[0.27017]	[5.07040]
C	-0.001115	0.042065	-0.104734	0.006547	0.010456
	(0.00498)	(0.09487)	(0.06353)	(0.00459)	(0.00237)
	[-0.22400]	[0.44337]	[-1.64846]	[1.42517]	[4.41198]
D2000	0.002521	0.285319	0.030278	-0.001007	0.000874
	(0.00581)	(0.11070)	(0.07413)	(0.00536)	(0.00277)
	[0.43417]	[2.57738]	[0.40842]	[-0.18785]	[0.31620]
D94	0.000959	-0.143883	-0.020201	-0.003242	-0.002768
	(0.00565)	(0.10773)	(0.07215)	(0.00522)	(0.00269)
	[0.16972]	[-1.33556]	[-0.28000]	[-0.62144]	[-1.02877]

DCC	-0.004228	0.596412	0.067422	0.034713	-0.002136
	(0.01096)	(0.20892)	(0.13991)	(0.01012)	(0.00522)
	[-0.38591]	[2.85468]	[0.48190]	[3.43136]	[-0.40934]
R-squared	0.303034	0.282849	0.335791	0.213089	0.143825
Adj. R-squared	0.250485	0.228778	0.285712	0.153758	0.079272
Sum sq. resids	0.281647	102.4109	45.92690	0.240114	0.063898
S.E. equation	0.033431	0.637489	0.426907	0.030868	0.015924
F-statistic	5.766684	5.231064	6.705192	3.591546	2.228018
Log likelihood	548.7636	-253.1053	-144.0411	570.4608	750.5021
Akaike AIC	-3.887968	2.008127	1.206185	-4.047506	-5.371339
Schwarz SC	-3.622835	2.273260	1.471317	-3.782373	-5.106207
Mean dependent	0.001479	-0.038235	-0.005607	0.004828	0.012144
S.D. dependent	0.038616	0.725910	0.505122	0.033555	0.016595

Determinant resid covariance (dof adj.)	1.77E-11
Determinant resid covariance	1.21E-11
Log likelihood	1488.842
Akaike information criterion	-10.17531
Schwarz criterion	-8.783364

Appendix 3- Technical Appendix: Unrestricted VAR and the Johansen cointegration Procedure and the issue of Robustness.

Section 3A gives a succinct account of the procedure of Unrestricted VAR method that was employed in the first part of this work as well as the Johansen cointegration method procedure which was employed in the second part to establish the long- run relationship among variables. Thereafter, the issue of stability of VAR was taken into consideration in the second part.

Section 3Ai- Unrestricted VAR Procedure

Following Sim (1980), the interpretation of recursive VAR is based on the Arnostova and Hurnik (2005), Cheng (2006) and Tsangarides (2010). An unrestricted VAR methodology may be explained by using equation (4.32) in section 4.3.1 of chapter 4 of this study which is re-written as equation A1 below:

$$Y_t = A(L)Y_t + B(X_t) + \varepsilon_t \qquad \text{(A1)}$$

Where $A(L)Y_t = [\ DY \quad DINFL \quad DI \quad DX \quad DM2\ ]$

And $B(X_t) = [DOP \quad DPR \quad D94 \quad D2000 \quad DCC]$

The reduced form of equation in (A1) was calculated by e-view software by imposing matrix on the structural form equations. The reason for matrix algebra is because the structural equation cannot be estimated directly via OLS, thus by imposing matrix, the equation can be estimated using the standard OLS.

Section 3Aii - Johansen method of reduced rank regression and the results from the VECM for all the different models.

The cointegrating VAR and VECM in this work is the type which was adapted from Johansen (1991). The Johansen method of reduced rank regression may be explained by using equation (4.46) in section 4.40 of chapter 4 of these studies which can be written below as equation A2 and excludes the intercept and the trend (ψD_t) to simplify the equation:

$$\Delta z_t = \Pi z_{t-1} + \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2.} ... + \Gamma_{p-1} \Delta z_{t-(p-1)} + \varepsilon_t \qquad \text{(A2)}$$

Where $\Pi = \Pi_1 + \Pi_2 + ... + \Pi_{p-1}$ and $\Gamma_i = -(\Pi_{i+1} + \Pi_{i+2} + ... + \Pi_p)$ for i=1, …, p-1

The eigenvalues of Π indicates stability of the VAR model and the number of cointegrating vector. The rank of $\Pi = \alpha\beta$ which is equal to the number of cointegrating vectors. The rank is usually denoted as r and is equal to the column dimension of α and the column dimension of β, ie., the row dimension of β. The number of cointegrating vectors reduces the rank of Π by k-r. Furthermore α represents the speed of adjustment to disequilibrium, while β is a matrix of long run coeeficients.