Chapter 1

Introduction

1.1. Introduction

Theories of rules and discretion have become a *corner stone* in the formulation of monetary policy. Commonly, the Taylor (1993) rule model and its extensions (e.g. Clarida *et al.*, 2000) are used. The rules assume that interest rates relate linearly to the gap between actual and desired values of inflation and output. The purpose of this study is to investigate how the South African Reserve Bank (SARB, hereafter) sets interest rates in the context of both linear and nonlinear policy reaction functions. Given the recent controversial debate on whether central banks should target asset prices for economic stability (see Bernanke and Gertler, 2001; Chadha *et al.*, 2004 and Papademos, 2009), the study investigates whether the SARB pays close attention to asset prices and financial variables in their policy decisions. For instance, one of the SARB's primary goals is to protect the value of the currency and achieve and maintain financial stability. But one of the questions the thesis aims to answer is "how has the SARB reacted to financial variables?" To answer to this question, the Taylor rule is augmented with a financial conditions index that reflects the state of the housing market, the stock market, the real exchange rate and credit risk measures.

In this thesis, the issue of linearity is tested. Indeed, a number of prominent authors have proved that central banks do not (or should not) behave linearly in setting the policy instrument (see Bec *et al.*, 2002; Cukierman, 2002; Huang and Shen, 2002; Nobay and Peel, 2003; and Ruge-Murcia, 2003). Although the specification of a given model should be statistically and theoretically correct, it seems that researchers almost never give the reason they choose for most of the time linear specification. To avoid restrictions on possible nonlinear underlying economic behaviour, this study do not subjectively consider linear specification without any statistical support. As such, this research also intends to develop rival models having different specifications and so the selection of the best model will be based on empirical properties of the data.

It is well known that one of the prime benefits of robust economic models is the predictive accuracy they have. Furthermore, the Reserve Bank's target for the repo rate is one of the most anticipated and influential decisions regularly affecting financial markets and is of interest to economic analysts, economic forecasters and policymakers. As such, this thesis assesses the out-of-sample predictive ability of the alternative monetary policy rules.

1.2. Problem statement

The problem statement is oriented to four perspectives from which research questions will emerge. The first problem statement focuses on whether the flexibility of the central bank has been extended to financial stabilisation. Speaking at the Milken

Institute Forum in September 1999, Dudley the then director of US Economic Research at Goldman Sachs ascertained that they had proposed a Financial Conditions Index (FCI) as another way of assessing whether monetary policy might need to be tightened or not.

> According to Dudley (1999), the Goldman Sachs financial conditions index was made up of four variables. The first variable is the three-month LIBOR which was regarded as the primary rate in the interbank market. The second variable is the single A-rated corporate bond yield regarded as being able to capture the rate that private-sector borrowers have to pay in the market. In addition, A-rated corporate bond yield could allow the disclosure of changes in credit spreads. The third variable is the Goldman Sachs Trade-Weighted Dollar Index which was claimed to be close to the Federal Reserve Foreign Exchange Index. The last variable is the stock market variable. The first reason to include the stock market into the FCI was motivated by the recognition of the link it had with interest rate since equity market valuation was affected by changes in monetary policies. The second reason was the linkage between stock market and the real economy.

Similarly, Cecchetti *et al.* (2000) argue that in addition to future inflation and output gap, central banks should target asset prices and they emphasize that a complex rule is always more advisable than a simple Taylor rule. However, the idea to have financial variables as target does not emerge without criticism. For example, Bernanke and Gertler (1999) and Filardo (2001) show their concern about the potential costs of responding to asset price given its volatility relative to their information content[1] while Mishkin and White (2002) suggest that monetary authorities should only be concerned by asset price misalignments when they affect financial stability. By contrast, Borio and Lowe (2002)

[1] To account for economic agents' behavioural changes, due to volatile financial variables, Montagnoli and Napolitano (2005) and Castro (2008) used Kalman Filter algorithm to determine the weight of the variables; a method that allows the weight to change over time.

argued that financial instability could be a serious threat even for central banks with sound and credible economic policies. In fact, financial variables are likely to affect both future inflation and economic activity levels. Therefore, it is assumed that projecting monetary authorities ought to act before the impact of financial variables on inflation and economic activity is experienced. Luüs (2007) describes financial conditions index as a rough indicator for the conduct of monetary policy. As such, economic agents will never turn a blind eye on movements of financial variables.

Despite the above disagreements and fears, economists seem to agree on one thing; the role of financial market in determining inflation and economic performance. In his speech, Mnyande (2010) has confirmed that low inflation, stable currency value, and stable financial systems are bedrock ingredients that form the core of what the South African Reserve Bank does. Therefore, the question I to try to answer in this thesis is whether the SARB reacts to financial fluctuations. In this regard, Reid (2009) reports an interaction between the SARB and financial markets and Du Plessis (2010) suggests that Central Banks should have models that would be sensitive to financial fragility.

Second, it is also worth noting that researchers have recently questioned the linear specification and a nonlinear framework applies if, for instance, the central bank has asymmetric preferences as originally propounded by Nobay and Peel (2003) in the context of linex function. Early works that argued in favour of asymmetric policy rules include Ruge-Murcia (2002, 2004), Dolado *et al.* (2002), Bec *et al.* (2002), Nobay and Peel (2003), Cukierman and Gerlach (2003), Gerlach (2003) and Surico (2004).

Asymmetric preferences are mostly illustrated using the transition logistic function, which is in fact the most popular in the classes of regime switching models. Few works (probably none for the case of South Africa) have considered the output gap as a transition variable. For an early work, Bec *et al.* (2002) shows that depending on the state of the economy, central bankers may adopt a more (less) aggressive reaction to deviations of inflation and output gap from their targeted level.

Third, the theoretical foundations provided by Orphanides and Wilcox (2002) assume that monetary policy is set depending on a 'zone of inaction'. Corresponding literature suggests that when inflation is within the zone, the focus of the central bank is on output rather than inflation stabilisation (see Orphanides and Wilcox (2002) and a somewhat different theoretical model provided by Minford and Srinivasan (2006) for this same concept). Literature on opportunistic approach clearly explains its two features. The first feature is that monetary policy should move inflation toward an intermediate inflation target which is a function of past inflation rates and the inflation target rather than inflation target itself. The second feature is related to the concept of the zone of discretion for which policymakers are supposed to behave opportunistically by accommodating shocks that tend to move inflation towards the desired level. The interest rate will be raised when inflation is above the zone of discretion and decreased if inflation is below the zone (see Orphanides and Wilcox (2002) for more discussion). In the South African context, asymmetries that could result from the inflation target range of 3-6% framework implemented in 2000 (see Du Plessis *et al.*, 2007 and Burger and Marinkov, 2008) can be described as a necessary condition for an opportunistic monetary policy but not as a sufficient one. In fact, opportunistic approach to disinflation is a special case of asymmetric monetary policy rule which requires a range of inflation for which the central bank is supposed to behave opportunistically.

Fourth, given the recent in-sample outperformance of nonlinear monetary policy reaction functions, one can expect them to predict better the behaviour of central banks than a simple linear policy rule. However, literature review by Clements *et al.* (2004) suggests that the forecasting performance of nonlinear models is on average not particularly good relative to rival linear models. As far as monetary policy rules are concerned, the concern was evidenced by Qin and Enders (2008) who find that the univariate models forecast better than the Taylor rules, linear and nonlinear. More recently, Naraidoo and Paya (2010) find that semi-parametric model that relaxes the functional form of monetary policy rule outperforms other models especially in long horizon forecasting.

Indeed, myth or reality, the debate highlighted above gives the opportunity to ask questions and formulate some hypotheses of the research. The basic research question emerges as "what is the best specification of the monetary policy rules for South Africa"? This being the main question, our study intends to investigate the topic in various dimensions and raises the following sub questions:

(1) Has the SARB reacted to financial fluctuations?

(2) Has the SARB been reacting symmetrically or asymmetrically with respect to its objectives? In other words, how do linear and nonlinear Taylor type rule models compare in-sample?

(3) Does the SARB follow the opportunistic approach to monetary policy?

(4) Do the nonlinear Taylor rules dominate standard linear Taylor rules out-of sample?

1.3. Aim and research objectives

According to Jankowicz (2000), a good way of clarifying the purpose of a research is to examine the associated objectives in detail. In this regard, the main objective was set as *to test alternative specifications of the monetary policy rules applied to the South African monthly data*. The pursuit of this broad objective requires pursuing the following specific objectives:

(1) To investigate whether the SARB pays close attention to asset prices and financial variables in their policy decisions.

(2) To test possible nonlinear behaviour of the SARB and particularly nonlinearities controlled by changes in the state of the business cycles.

(3) To test the opportunistic approach to monetary policy with application to the South African data.

(4) To determine the best policy rule model in predictive accuracy.

(5) To propose measures that can enhance monetary policy rules for South Africa.

1.4. Importance of the research

1.4.1. Personal learning experience

This study has given me the opportunity to study interest rates and to investigate the objectives of policymakers in the quest to provide the best description of in-sample and out-of-sample SARB interest rate setting behaviour. It has also developed my ability to produce sound journal articles with advanced conceptual and technical content.

1.4.2. Conceptual interest

In addition to the personal interest, the study is also important in the field of monetary policy. In fact, the study has provided evidences for relatively newly developed concepts on monetary policy rules not covered extensively in the literature.

1.4.3. Specific context of South Africa

In this thesis several empirical approaches are adopted with the aim to identify the best empirical models describing the SARB interest rate setting behaviour and should be of interest to economic analysts, economic forecasters and policymakers, in financial institutions, research organisations and government departments. In fact, the model can guide into measuring the response of the SARB to changes in its objectives. The models can also be used to assess the possible nonlinear response of the central bank over expanding or contracting state of the economy or the nonlinear response of the key policy rate over different inflation regimes. The study is also important in that it provides significant information on how the response coefficients to inflation, output gap and financial conditions have varied across times and across regimes with the onset of the sub-prime crisis. The predictive power of the alternative models can also guide agents to the behaviour of the most anticipated rates in financial markets. Furthermore, the study has provided valuable contribution to South African monetary policy makers in that it has compiled new insights on the topic of monetary policy rules and so suggestions that can inspire them have been formulated.

1.5. Methodology

One of the definitions of research methodology is the collection of data and the processing thereof within the framework of the research process (Brynard, 1997). According to Bhattacharyya (2003), research methodology deals with research methods and techniques to be used; but its wide scope makes it differ from problem to problem. Therefore, before dealing with research methods and techniques, it is of paramount importance to know the substance of this research.

1.5.1. Type of research

Quantitative analysis has been used to describe the behaviour of the South African Reserve Bank. According to Babbie (2004), quantitative analysis is the numerical representation and manipulation of observations for the purpose of describing and explaining the phenomena that those observations reflect.

1.5.2. Research methods and techniques

In this subsection, research methods and techniques that have guided this study are overviewed in summary. Though the two terms are sometimes confused, research methods concern the *what* is being done while research techniques deal with the *how* it will be done (Jankowicz, 2000).

1.5.2.1. Research methods

By definition research method is "a systematic and orderly approach taken towards the collection and analysis of data so that information can be obtained from those data" (Jankowicz, 2000). Empirical research, which is the context of this study, includes experimental, *ex post facto* and descriptive methods. This thesis uses experimental method which can be thought of as systematic, trial and observation: 'trial' because the answer was not known before-hand, 'observation' because the results have been carefully observed and recorded, and 'systematic' because the research was planned and purposeful.

1.5.2.2. Research techniques

In simple words, Jankowicz (2000) defines research technique as "a step-by-step procedure of gathering and analyzing data". The thesis being an empirical research, time series data were subjected to statistical analysis. Initially, time series plots and descriptive statistics of the data have made a clear overview in that it is easier to compare and to summarize data. Secondly, unit root characteristics of the data have been performed to analyse their time series properties. Third, multivariate analyses are performed with the aim to determine robust linear or nonlinear empirical relationships amongst variables and so to determine the best model in predictive accuracy. As such, several steps and sub-steps have been followed:

Step 1: Data collection from the SARB's database.

Step 2: Data transformation where needed.

Step 3: Time series plots.

Step 4: Descriptive statistics of the data.

Step 5: Testing the unit root characteristics of the data.

Step 6: Perform a linear multivariate analysis of the simple Taylor rule.

Step 7: Perform a linear multivariate analysis of the Taylor rule augmented with financial conditions index.

Step 8: Testing nonlinearities controlled by output gap for a Taylor rule augmented with financial conditions index.

Step 9: Perform recursive and rolling estimation of the equations modelled in steps 7 an 8.

Step 10: Testing the opportunistic approach to monetary policy.

Step 11: Perform recursive and rolling estimation of the opportunistic approach modelled in step 10.

Step 10: Obtaining the best functional form in predictive ability amongst the models in steps 7, 8 and 10.

1.5.3. Data collection

1.5.2.1. Obtaining empirical data

According to Rosnow (1999: 81) "quantitative methods are those in which the observed data exist in a numerical form". This research uses time series data that have been collected from the South African Reserve Bank database.

1.5.2.2. Documentary secondary data

Documentary secondary data include written documents such as notices, correspondence, minutes of meetings, reports to shareholders, diaries, transcripts of speeches and administrative and public records. Written documents can also include books, journals and magazine articles (Saunders *et al.*, 2003:190).

Documentary data provides an insight to the thesis, based on the literature and studies conducted before this one. The approach outfits the study in making clear questions of the problem to be addressed in order to achieve content validity. Books, journal articles and reports on the aspects of monetary policy were consulted and so the research was able to determine the truth about the phenomenon.

1.6. Scope of study

The scope of this study identifies its boundaries in terms of area, time frame and subject. The study uses 'final' South African monthly data covering the period

2000M01-2010M12. In terms of subject, the study is limited to monetary policy rules and specifically to the Taylor (1993) rule and its extensions. Given the South African policy framework, alternative policy rules such as the McCallum (1988; 1993) rule and the Friedman's $k-$percent rule (Friedman, 1960) have not been explored. The McCallum rule can be useful in the case where money stock is the policy instrument (see Burkedin and Siklos, 2008) and the simple Friedman's $k-$percent rule cannot be formulated with an interest rate instrument (see Orphanides, 2010).

1.7. Limitations of study

The study has some limitations that can be addressed in future research. First, a longer sample period could yield more robust econometric results but the beginning of the sample is constrained by two reasons: (1) the explicit inflation targeting regime started in February 2000, and (2) data for some financial variables are only available since 1999. Another worth mentioning limitation concerns the use of final data. In fact, current literature recommends the use of real data, which are available at the time the central bank makes its decisions. Orphanides (2001) and in particular, Orphanides and van Norden (2002) have shown that empirical estimates of the output gap are subject to significant revisions and therefore the use of real time data is highly warranted for operational usefulness in monetary policy. The absence of real time data for the case of South Africa makes such analysis impossible. It is also worth mentioning that this thesis main aim is to provide an investigation on how the SARB has behaved in-sample and its likely behaviour out-of-sample. Further research is needed to answer questions such as whether the SARB should target asset prices or do nonlinear Taylor type rule models improve welfare in general. These questions are beyond the scope of this study.

1.8. Structure of the thesis

Chap. 1: Introduction

This chapter gives the broad outline of the study and includes the problem statement, the objectives of the study, the research motivation and the structure of the study is outlined in this section.

Chap. 2: Theoretical foundations and case study discussion

This chapter provides theoretical foundations and empirical evidences on monetary policy rules. Books and journal articles have been consulted to find out how different authors explain theories and/or provide evidences. In addition, this chapter gives an overview of the South African monetary policy. This will help the reader to understand the behaviour of the SARB.

Chap. 3: Research methodology

Chapter three discusses the Generalised Method of Moments (GMM) estimation used in chapters 4 to 7.

Chap. 4: Data analysis and preliminary results

Chapter 4 includes two sections. Section 1 discusses the data and Section 2 provides preliminary results of the extended linear Taylor rule. In fact, given the proliferation of candidate series, Section 2 is aimed to give an empirical evidence and indication of the data to be maintained (or excluded) for further investigations of the monetary policy rule.

Chap. 5: Financial assets, linear and nonlinear policy rules: An In-sample assessment of the reaction function of the South African Reserve Bank

Chapter 5 tests the presence of nonlinearities resulting from the state of the business cycle. Furthermore, recursive and rolling estimations for both linear and nonlinear models are reported with the aim to show how the SARB has behaved before and during the subprime crisis.

Chap. 6: The Opportunistic approach to monetary policy and financial market conditions

Chapter 6 tests the opportunistic approach to monetary policy developed by Orphanides and Wilcox (2002) for which Martin and Milas (2010a) have provided the first empirical evidence using US data.

Chap. 7: Evaluating the forecasting performance of monetary policy rules in South Africa

Chapter seven compares forecast performance of linear and nonlinear monetary policy rules estimated in chapters 4, 5 and 6. Recursive forecasts values are computed for 1- to 12-step ahead for the out-of-sample period 2006:01 to 2010:12. For the nonlinear models, bootstrapping method is used for multi-step ahead forecasts as opposed to point forecasts approach used for linear models.

Chap. 8: Summary, conclusion and recommendations

The last chapter contains summary, conclusion and policy recommendations of the study.

Chapter 2

Theoretical foundations and case study discussion

2.1. Theoretical foundations: Monetary policy and rules

According to Bordo (2010), "monetary policy is the principal way in which governments influence the macro economy". Worldwide, the implementation of monetary policy is the responsibility of a central bank which uses its policy instruments, mainly the short-term interest rate or the monetary base, to achieve and maintain low inflation and sustainable development. Existing literature suggest policy makers to set nominal interest rate that minimizes the following central bank's loss function:

$$L = (Y_t - Y_t^*)^2 + a(\pi_{t+1} - \pi^*)^2 \qquad (2.1)$$

Subject to equations (2) and (3) below

$$\pi_t = \pi_{t-1} + b(Y_{t-1} - Y_{t-1}^*) \qquad (2.2)$$

$$Y_t - Y_t^* = -c(r_{t-1} - r^*) \qquad (2.3)$$

where Y_t is the level of output,

Y_t^* is the potential output,

π_t is the inflation rate,

π^* is the inflation target,

r_t is the real interest rate,

r^* is the equilibrium real interest rate,

a is the relative weight attached to the loss from inflation,

b is a positive parameter that determines how inflation reacts to the output gap (the slope of the Phillips curve),

Equation (2.1) is the central bank's loss function which assumes an equal concern about positive and negative deviations of inflation and output from target levels. Equation (2.2) is a simple linear expression of the Phillips curve (PC) which shows the relationship between output Y_t and inflation π_t. The equation reveals that output Y_t above its potential level Y_t^* will lead to an increase in inflation above the initial level. In reverse, a negative output deviation will cause inflation to fall below the initial level. Equation (2.3) is the IS curve which shows the relationship between real interest rate and output. The IS curve has a negative slope since a low interest rate leads to a high level of investment and consumption, which in turn implies high level of output. As it can be seen in the system composed of equations (2.1) to (2.3), the assumption of timing is that output can only have effect on inflation the next period and so is the effect of the interest rate (r_{t-1}) on output Y_t. Therefore, the central bank's interest rate at time $t-1$ can only influence output at time t, and inflation at time $t+1$.

The optimal value of Y_t that minimizes L is computed by substituting equation (2.2) into equation (2.1) and by deriving the obtained equation with respect to Y_t as follows:

$$L = (Y_t - Y_t^*)^2 + a[\pi_t + b(Y_t - Y_t^*) - \pi^*]^2$$

$$\frac{\partial L}{\partial Y_t} = 2(Y_t - Y_t^*) + 2ab[\pi_t + b(Y_t - Y_t^*) - \pi^*] = 0$$

with $\pi_t = \pi_{t-1} + b(Y_{t-1} - Y_{t-1}^*)$, we have:

$$\frac{\partial L}{\partial Y_t} = (Y_t - Y_t^*) + ab(\pi_{t+1} - \pi^*) = 0 \qquad (2.4)$$

Rearranging the above equation (2.4) we find a inverse relationship between inflation and output with the slope determined by the central bank's inflation aversion, a, and the responsiveness of inflation to output gap (see Polovková, 2009). Equation (2.5) notes that if inflation shoots above its target, the policy maker raises its indirect control (output) via its policy rate to control inflationary pressures.

$$-\frac{1}{ab}(Y_t - Y_t^*) = \pi_{t+1} - \pi_t^* \qquad (2.5)$$

From the above, one can write a new system of equations, in which equations (2.2)', (2.3)' and (2.5)' respectively stand for the Phillips curve, the IS curve and monetary policy rule.

$$\pi_t = \pi_{t-1} + b(Y_{t-1} - Y_{t-1}^*) \qquad (2.2)'$$

$$Y_t - Y_t^* = -c(r_{t-1} - r^*) \qquad (2.3)'$$

$$-\frac{1}{ab}(Y_t - Y_t^*) = \pi_{t+1} - \pi_t^* \qquad (2.5)'$$

Substituting (2.2)' in (2.5)' we have

$$\pi_t + b\left(Y_t - Y_t^*\right) - \pi^* = -\frac{1}{ab}\left(Y_t - Y_t^*\right). \quad (2.6)$$

Based on the information in equation (2.3)' we solve equation (2.6) which gives

$$\pi_t + b\left(-c(r_{t-1} - r^*)\right) - \pi^* = -\frac{1}{ab}\left(-c(r_{t-1} - r^*)\right)$$

$$\pi_t - \pi^* = b\left(c(r_{t-1} - r^*)\right) + \frac{1}{ab}\left(c(r_{t-1} - r^*)\right)$$

$$= c\left(\frac{1}{ab} + b\right)\left(r_{t-1} - r^*\right) \quad (2.7)$$

Pulling the Phillips curve equation (2.2)' into (2.6) we have

$$\pi_{t-1} + b\left(Y_{t-1} - Y_{t-1}^*\right) - \pi^* = c\left(\frac{1}{ab} + b\right)\left(r_{t-1} - r^*\right)$$

Rearranging further we obtain the following

$$\left(r_{t-1} - r^*\right) = c\left(\frac{1}{ab} + b\right)\left[\left(\pi_{t-1} - \pi^*\right) + b\left(Y_{t-1} - Y_{t-1}^*\right)\right]$$

Solving for time t instead of time $t-1$ we have the following equation:

$$\left(r_t - r^*\right) = c\left(\frac{1}{ab} + b\right)\left[\left(\pi_t - \pi^*\right) + b\left(Y_t - Y_t^*\right)\right]. \quad (2.8)$$

The optimal interest rate rule in equation (2.8) takes the form of Taylor (1993) rule.

2.1.1. The original Taylor rule

A Taylor rule is by definition, a monetary policy rule that prescribes how much a central bank should adjust its interest rate policy instrument in response to changes in inflation and macroeconomic activity (see Orphanides, 2010). According to Abel and Bernanke (2010), since the Taylor rule was proposed in 1993, it has become common to assume that a central bank follows some type of rule that is similar to it. The original formulation of the Taylor (1993) rule is given by

$$\hat{i}_t = r^* + \pi_t + \alpha_\pi(\pi_t - \pi^*) + \alpha_y(Y_t - Y_t^*) \qquad (2.9)$$

where $\hat{i}_t$ is the desired level of nominal interest rate. According to the Taylor rule, both α_π and α_y should be positive. This means that the central bank should reduce the nominal interest rate in response to negative deviations of actual inflation from its target and of output from its potential level. The nominal interest rate is increased when deviations are positive.

The reduced form of the Taylor rule can be written by pulling the constants together and solving the output terms as follows

$$\hat{i}_t = \rho_0 + \rho_\pi \pi_t + \rho_y y_t \qquad (2.10)$$

where $\rho_0 = r^* - \alpha_\pi \pi^*$, $\rho_\pi = 1 + \alpha_\pi$, $\rho_y = \alpha_y$ and $y_t = Y_t - Y_t^*$. As a rough rule of thumb, Taylor (1993) set $\alpha_\pi = \alpha_y = 0.5$ and proposed $r^* = 2$ and $\pi^* = 2$ to find the following specification:

$$\hat{i}_t = 1 + 1.5\pi_t + 0.5 y_t \tag{2.11}$$

Equation (2.11) suggests that if π raises by 1%, the interest rate should be increased by 1.5%. Although Taylor admits that the coefficient ρ_π of equation (2.10) does not need to be exactly 1.5, his principle is that it has to be larger than 1. This is known as the Taylor principle.

2.1.2. Modified versions of the Taylor rule

2.1.2.1. Dynamic Taylor rule

The trial modifications of the Taylor rule include interest rate smoothing. Early versions of the Taylor rule that allowed the inclusion of lagged interest rate include Clarida *et al.* (1998, 2000), Amato and Laubach (1999), Goodhart (1999), Levin *et al.* (1999) and Woodford (1999, 2003). For a better illustration one can rewrite the reduced form of the original Taylor rule in equation (2.10).

$$\hat{i}_t = \rho_0 + \rho_\pi \pi_t + \rho_y y_t + \varepsilon_t \qquad (2.10)'$$

Allowing for interest rate smoothing (see for example Woodford, 2003) we formulate a simple partial adjustment mechanism which relates the actual and target instrument growth:

$$i_t = \rho_i(L)i_{t-1} + (1-\rho_i)\hat{i}_t \qquad (2.12)$$

where, $\rho_i(L) = \rho_{i1} + \rho_{i2}L + ... + \rho_{in}L^{n-1}$ is an indicator of the degree of smoothing of the instrument. Combining equation (2.10) and (2.12) we have

$$i_t = \rho_i(L)i_{t-1} + (1-\rho_i)\{\rho_0 + \rho_\pi \pi_t + \rho_y y_t\} \qquad (2.13)$$

Equation (2.13) has also been subjected to changes; namely backward and forward looking versions.

2.1.2.2. Backward and forward looking versions

Examples of both backward and forward looking versions of Taylor rule include Rudebusch (2002); Orphanides (2002); Osborn *et al.* (2005), and Dolado *et al.* (2005). See Rudebusch & Svensson (1999), Batini and Nelson (1999); Clarida *et al.* (2000), Orphanides (2001, 2003) and Huang *et al.* (2001) for forward looking versions. It should be noted however that existing studies of the impact of inflation and output on monetary policy use a version of the Taylor (1993) rule that is forward looking. The forward looking version of the Taylor rule can be derived from the New-Keynesian model (see Svensson, 1997, Clarida et al., 1999 and Castro, 2008) as follows:

$$\pi_{t+p} = a_1\pi_{t+p-1} + a_2\left(Y_{t-1} - Y_{t-1}^*\right) + \mu_{t+p}^s \qquad (2.14)$$

$$(Y_{t+q} - Y^*_{t+q}) = b_1(Y_{t+q-1} - Y^*_{t+q-1}) - b_2(i_t - \pi_{t+p-1}) + \mu^d_{t+q} \qquad (2.15)$$

Equation (2.14) is interpreted as an aggregate supply curve (AS curve) or a linear expression of the Phillips curve (PC) which shows the relationship between output Y_t and inflation π_t. As above, the equation shows that output Y_t above its potential level Y^*_t will lead to an increase in inflation above the initial level. In reverse, a negative output deviation will cause inflation to fall below the initial level. Equation (2.15) is the aggregate demand curve (IS curve) which shows that output gap depends on its lagged value and on the real interest rate. The IS curve has a negative slope since a low interest rate leads to a high level of investment and consumption, which in turn implies high level of output. The supply and demand shocks are respectively μ^s_{t+p} and μ^d_{t+q}.

Conditional to the information available at time t, it is assumed that the central bank uses a policy rule to control monetary policy. As such, the central bank chooses a short-term interest rate in order to minimize the following inter-temporal loss function:

$$E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \left[\lambda_1 (\pi_{t+\tau} - \pi^*)^2 + \lambda_2 (Y_{t+\tau} - Y^*_{t+\tau})^2 + \lambda_3 (i_{t+\tau} - \bar{i})^2 \right] \qquad (2.16)$$

subject to (2.14) and (2.15). The parameter δ $(0 < \delta < 1)$ is the inter-temporal discount factor and i^* $(i^* = r^* + \pi^*)$ is the long-run equilibrium nominal interest rate. The above central bank's loss function assumes that i_t affects y_t and π_t contemporaneously. However, Svensson (1997) shows that in practice i_t does not affect y_t and π_t contemporaneously. He suggests a period-by-period static minimisation given by:

$$\min_{i_t} E_t \lambda_1 \left[(\pi_{t+\tau} - \pi^*)^2 + \lambda_2 (Y_{t+\tau} - Y^*_{t+\tau})^2 + \lambda_3 \left(i_{t+\tau} - i^* \right)^2 \right] \qquad (2.17)$$

The first order necessary condition below is obtained by minimising equation (2.17) subject to equations (2.14) and (2.15)

$$\hat{i}_t = i^* + \beta E_t (\pi_{t+p} - \pi^*) + \gamma E_t (Y_{t+q} - Y^*_{t+q}) \qquad (2.18)$$

Allowing for interest rate smoothing of equation (2.12) we have equation (2.19):

$$i_t = \rho_i(L) i_{t-1} + (1 - \rho_i) \left\{ i^* + \beta E_t (\pi_{t+p} - \pi^*) + \gamma E_t (Y_{t+q} - Y^*_{t+q}) \right\} \qquad (2.19)$$

where, $\rho_i(L) = \rho_{i1} + \rho_{i2} L + ... + \rho_{in} L^{n-1}$ is an indicator of the degree of smoothing of the instrument.

2.1.2.3. Asymmetric policy rules

The above Taylor rule model and its extensions assume a linear relationship between interest rate and the gaps between actual and desired values of inflation and output. More recently, however, the focus of the monetary policy literature has been increasingly placed on nonlinear models resulting from either asymmetric central bank preferences (e.g. Nobay and Peel, 2003; Cukierman and Gerlach, 2003; Bec *et al.*, 2002; Orphanides and Wieland, 2000; and Favero *et al.*, 1999) or a nonlinear (convex) aggregate supply or Phillips curve (e.g. Dolado *et al.*, 2005 and Schaling 2004), or still when central banks follow the opportunistic approach to disinflation (Aksoy *et al.*, 2006). Dolado *et al.* (2004) discuss a model which comprises both asymmetric central bank preferences and a nonlinear Phillips curve.

Asymmetric preferences or LINEX preferences departs from the quadratic objective in that policy makers are allowed, but not required, to treat positive and negative deviations of output and inflation from target values differently. This comes from the fact that when the monetary authorities are endowed with inflation and output stabilisation, they may have an inflation bias when inflation overshoots the target and an output bias during productivity declines (Orphanides and Wilcox, 2002). Thus the monetary authorities may behave in ways that reflect asymmetries when confronted by numerous competing objectives. This implies that their responses to inflation and output may be different depending on whether these variables undershoot or overshoot their target values. The monetary authorities may also exhibit zone-like behaviours by penalising more when inflation moves out of the target range and being passive when it is within the target range. Thus an empirical framework that allows for target zones and asymmetries in monetary policy preferences is more relevant to evaluate the monetary authorities' actual practice of monetary policy setting. However, as argued by Orphanides and Wieland (2000), the quantitative evaluations of monetary policy that are based on linear models that use the Taylor (1993) rule and its extensions by Clarida *et al.* (2000) may not fully capture the actual practice of inflation targeting.

Asymmetric preferences result in nonlinear policy rules that can be illustrated using the transition logistic function, which is in fact the most popular in the classes of regime switching models. Departing from the forward looking linear equation (2.19) above, the alternative Logistic Smooth Transition Autoregression (LSTAR) model can be

$$i_t = \rho_0 + \theta M_{1t} + (1-\theta) M_{2t} + \varepsilon_t \qquad (2.20)$$

where $M_{jt} = \rho_{ji} i_{t-1} + (1-\rho_{ji})(\rho_{j\pi} E_t \pi_{t+p} + \rho_{jy} E_t y_{t+q})$ for $j = 1,2$ and the function θ is the probability that the transition variable defined by equations (2.21) to (2.23) will be less than τ percent points from the equilibrium. In model (2.20), the response to interest rate, inflation, output gap and financial conditions index is allowed to differ between regimes. M_{1t} is a linear Taylor rule that represents the behavior of policymakers when the transition variable is below the threshold value τ and M_{2t} is a linear Taylor rule that represents the behavior of policymakers above the threshold level. If $\rho_{1i} = \rho_{2i}$, $\rho_{1\pi} = \rho_{2\pi}$ and $\rho_{1y} = \rho_{2y}$ the model simplifies to the linear Taylor rule in (2.19). The definition of θ depends on the chosen transition variable as follows:

$$\theta = 1 - \frac{1}{1+\exp[-\gamma^{i}(E_t i_{t-1} - \tau_i)/\sigma_{(E_t i_{t-1})}]} \text{ if } i_{t-1} \text{ is the transition variable;} \qquad (2.21)$$

$$\theta = 1 - \frac{1}{1+\exp[-\gamma^{y}(E_t y_{t-1} - \tau_y)/\sigma_{(E_t y_{t-1})}]} \text{ if } y_{t-1} \text{ is the transition variable;} \qquad (2.22)$$

$$\theta = 1 - \frac{1}{1+\exp[-\gamma^{\pi}(E_t \pi_{t-1} - \tau_\pi)/\sigma_{(E_t \pi_{t-1})}]} \text{ if } \pi_{t-1} \text{ is the transition variable;} \qquad (2.23)$$

where $\gamma \geq 0$ is the smoothness parameter which determines the degree of smoothness of the transition from one regime to the other. τ is the threshold between the two regimes. $\theta = 0$ and $\theta = 1$ denotes that the logistic function changes monotonically from 0 to 1 as the transition variable (i_{t-1}, y_{t-1} or π_{t-1}) increases (see Franses and van Dijk, 2003). As proposed by Granger and Teräsvirta (1993) and Teräsvirta (1994) σ is the standard deviation of the transition variable which serves to make the smoothness parameter γ dimension free.

At this stage it is worth mentioning that Orphanides and Wilcox (2002) have introduced theoretical foundation of a special case of asymmetric preferences known as the opportunistic approach to monetary policy (OAMP). The so-called opportunistic approach can also emerge from equation (2.20) but with a different annotation of θ. In the case of OAMP, θ is the probability of being within the inflation target and can be approximated by the following quadratic logistic function (see, for example, van Dijk *et al.*, 2002)

$$\theta = pr\left\{-\delta \leq E_{t-1}\left(\pi_{t+p} - \pi_{t+p}^{I}\right) \leq \delta\right\} = 1 - \frac{1}{1+e^{-\gamma\left[E_{t-1}(\pi_{t+p}-\pi_{t+p}^{I}+\delta)\right]\left[E_{t-1}(\pi_{t+p}-\pi_{t+p}^{I}-\delta)\right] / \sigma^2_{E_{t-1}(\pi_{t+p}-\pi_{t+p}^{I})}}} \qquad (2.24)$$

Where π_t^I is the intermediate inflation and δ the threshold (see chapter 6 for more details on intermediate inflation). The assumption is that the policy maker responds to $E_{t-1}\left(\pi_{t+p} - \pi_{t+p}^{I} + \delta\right)$ when inflation is below the zone of discretion and to $E_{t-1}\left(\pi_{t+p} - \pi_{t+p}^{I} - \delta\right)$ when the inflation is above the zone of discretion.

2.1.2.4. Extended policy rule

In concomitance with the aforementioned Taylor rule modifications, there has also been increasing debate on whether central banks should respond to financial variables and/or asset prices. For example, Clarida *et al*, (2000) extend a forward looking Taylor rule by the inclusion of exchange rate within the model. Other examples include Knedlik (2006) who combines the estimation of the Monetary Conditions Index (MCI) with the theoretic modelling of monetary policy rules for South Africa with the assumption that monetary policy is not only interested in optimal monetary conditions but also in external stability.

Considering the probable role of asset prices and financial variables in policy setting, the central bank's loss function is augmented by a financial index (see Akram and Eitrheim, 2008). Departing from equation (2.1), the reduced form of the loss function is

$$L(\lambda) = V(\pi^{*}) + \lambda V(y^{*}) \qquad (2.1)'$$

which becomes

$$L(\lambda,\phi) = V(\pi^{*}) + \lambda V(Y^{*}) + \phi V(f) \qquad (2.25)$$

if augmented by a financial index. $V(\pi^{*})$ denotes the variance of actual inflation relative to its target level, π^{*}; $V(Y^{*})$ denotes the variance of output relative to its equilibrium path, Y^{*}; and $V(f)$ is a variance term representing financial instability. The parameters

λ and ϕ are respectively weights attached to output and financial instability. Svensson (1999) stipulates that under a strict inflation targeting regime $\lambda = 0$, while a flexible inflation targeting regime implies that $\lambda > 0$. Therefore, if the same logic is applied to equation (2.25), $\lambda = \phi = 0$ for a strict inflation targeting regime and $\lambda > 0$ and $\phi > 0$ for a flexible inflation targeting regime (see Akram and Eitrheim, 2008).

At this stage, the issue that deserves a particular attention is whether the central bank's flexibility includes financial stabilisation or not. The next section presents an overview on the South African monetary policy and so it sheds some lights on the variables that can be included in the policy rule.

2.2. The South African monetary policy: contextual overview

The aim of this section is to provide a contextual overview by discussing the South African monetary policy. This is important to understand the behaviour of the SARB and interpret empirical results. The information that has been gathered from the SARB's website (www.reservebank.co.za) has served as a baseline for the elaboration of this section. It discusses the background, the mandate, the functions and the monetary policy framework.

2.2.1. Background

The central bank of the Republic of South Africa, called the South African Reserve Bank (SARB), started its operations on the 30th June 1921 in terms of a special Act of Parliament, the Currency and Banking Act, 1920 (Act No. 31 of 1920). The current operations of the SARB are framed in the Constitution of the Republic of South Africa, sections 223 to 225 (1996) and the South African Reserve Bank Act of 1991.

Unlike the majority of central banks worldwide, the SARB has shareholders other than the government. Early 2011, the SARB had 650 shareholders. The total number of issued shares is 2,000,000 but no shareholder can be allowed to hold, or hold in aggregate with his, her or its Associates, more than 10,000 shares (see SARB, 2011a).

2.2.2. Mandate

The South Reserve Bank has the mandate "to achieve and maintain price stability in the interest of balanced and sustainable economic growth in South Africa" (SARB, 2011b). Section 224 of the Constitution (1996) stipulates that "*the Bank, in pursuit of its primary object [sic], must perform its functions independently and without fear, favour or prejudice, but there must be regular consultation between the Bank and the Cabinet member responsible for the national financial matters*." With such independence, the SARB can use any instruments of monetary policy at its disposal to achieve the entrusted policy goal of price stability. This implies that the SARB has independence to select the instrument but not the independence in the selection of monetary policy goal.

However, the achievement of price stability requires the stability of the financial system and financial markets. In this regard, a revised mandate that includes particular responsibility for financial stability was announced by the Minister of Finance during his budget policy statement held on 27 October 2010. Accordingly, the SARB has established an internal Financial Stability Committee which includes all members of the monetary policy committee expanded by other members.

For instance, one of the SARB's primary goals is to protect the value of the currency and achieve and maintain financial stability. This mandate goes in line with the current literature which provides an increasing debate on the view that a policy rule that addresses inflation and output stabilisation ignoring movements in assets prices and other financial variables may be too restrictive. Among others, De Grauwe (2007) and Papademos (2009) argue that asset prices should be monitored in the conduct of monetary policy. In fact, Papademos (2009) has acknowledged the importance of monitoring asset prices as part of monetary policy. Indeed, he reiterates that ""leaning against the wind" of booming asset prices by raising the policy interest rates would, even in the short to medium term, be compatible with the ECB's monetary policy strategy aiming at consumer price stability".

2.2.3. Functions

In addition to the primary function of price stability, the SARB takes the following responsibility:

- "*Ensuring that the South African money, banking and financial system as a whole is sound, meets the requirements of the community and keeps abreast of international development;*
- *Assisting the South African government, as well as other members of the economic community of the southern Africa, with data relevant to the formulation and implementation of macroeconomic policy; and*
- *Informing the South African community and all stakeholders abroad about monetary policy and the South African economic situation."* (SARB, 2011c).

2.2.4. Monetary policy framework

Between 1960 and January 2000, the SARB has adopted a number of frameworks; namely the exchange-rate targeting, discretionary monetary policy, monetary-aggregate targeting and "informal inflation targeting" announced in August 1999. The South African cabinet approved the proposal of a system of inflation targeting in October 1999, which was formally adopted in February 2000 (see Dykes, 2004 and SARB, 2011d). Since then, the SARB conducts monetary policy within an inflation targeting framework. Monetary policy is conducted and set by the Bank's Monetary Policy Committee (MPC) with a CPI inflation target ranging from 3 to 6 per cent on a continuous basis. The adjustment of the repo rate (interest charged on the Bank's refinancing system) is the main mechanism used by SARB for the implementation of monetary policy.

2.3. Conclusion

Chapter 2 has the aim to provide the theoretical foundations and the case study discussion. The literature has shown that the Taylor (1993) rule has gone through many modifications since the last decade of the 20th century. Modified or not, the Taylor rule (1993) can describe not only the inflation targeting regime's component, but also certain other characteristics, such as monetary policy response to business cycles. The trial modifications of the Taylor rule include interest rate smoothing, backward and forward looking versions, and nonlinear approximations. Furthermore, there has been increasing debate on whether central banks should respond to asset prices and financial variables. Despite some disagreements, economists seem to agree on the role of the financial market in determining inflation and economic performance.

As far as South Africa is concerned, a stable financial system is one of the mandates of the central bank. As such, if the Central bank has some responsibility on financial stability, this study investigates whether the SARB has adopted a more flexible inflation-targeting regime which allows a reaction to financial instability. This would be in line with the current literature which provides an increasing debate on the view that a policy rule that addresses inflation and output stabilisation ignoring movements in assets prices and other financial variables may be restrictive.