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Zone targeting monetary policy preferences and financial market conditions: a flexible nonlinear policy reaction function of the SARB monetary policy

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Abstract

Based on a representation of policymaker's preferences that capture inflation zone targeting behaviors, we estimate a flexible model of the monetary policy reaction function of the South African Reserve Bank (SARB). To address the current debate on the importance of financial asset prices in monetary policy decision making, we augment the analysis to allow for responses to financial market conditions over and above prices and output stabilisation. The main findings are that the monetary authorities' response towards inflation is zone symmetric. Secondly, the monetary authorities' response towards output is asymmetric with increased reaction during business cycle downturns versus upturns. Thirdly, the monetary authorities' pay close attention to financial conditions index. They place the same weight on financial market booms and recessions so that their response is symmetric.

JEL classification: C51, E12, E58

Keywords: Zones, asymmetries, financial conditions index

1. Introduction

Since 2000, South Africa has adopted inflation targeting as a preferred framework for monetary policy whereby an inflation target range of 3 to 6 percent was set. Contrary to the most widely used model of monetary policy to study the objectives of policy makers, viz., the Taylor rule model and its extensions (e.g., Taylor, 1993; Clarida et al., 2000), where interest rates relate linearly to the gap between actual and desired values of inflation and output, the inflation target band practice instead suggests that policymakers may exhibit 'zone-like' behaviour by responding more to inflation when inflation is some way from the target band but by responding more passively when inflation is inside the target band. The literature has also suggested 'asymmetries' in which case the response of interest rates to inflation and/or output is different for positive and negative inflation and/or output deviations from their desired level. All these issues are relevant and are currently debated in the case of both South Africa and a number of other economies such as the UK. This is because they have undergone important changes in their monetary policy settings over the last two decades. In this paper, we estimate an optimal monetary policy rule that addresses these issues.

The theoretical basis of the linear Taylor rule comes from the assumption that policymakers have a quadratic loss function and that the aggregate supply or Phillips curve is linear. Recently, researchers have 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 a linear function for the preferences of the Central Banks. A number of other studies have made use of these types of preferences; Cukierman (2002), Ruge-Murcia (2003), a nonlinear Phillips curve (Schaling 2004) or, if it follows the opportunistic approach to disinflation (OAD) (Aksoy et al. 2006). Dolado et al. (2004) discuss a model which comprises both asymmetric central bank preferences and a nonlinear Phillips curve.

Empirical analysis of asymmetric monetary policy reaction functions have received some attention in the field, for instance, Davradakis and Taylor (2006), Assenmacher-Wesche (2006) and Surico (2007a,b) among others. In addition, it has been suggested that policymakers may exhibit 'zone-like' behaviours with the toleration of small deviations of inflation from the target. Orphanides and Weiland (2000) have analysed such behaviours in the context of zone quadratic preferences.

Boinet and Martin (2008) have extended this model to allow for both zone-like and asymmetric behaviour in investigating monetary policy in the UK.

Recent economic events have turned the attention on the behaviour of certain asset prices (stock prices, house prices, and the exchange rate) and the concern by central banks over the maintenance of financial stability. If that is the case, it is most likely that the monetary policy reaction function responds to them once they reach certain "unsustainable" levels as opposed to when they follow their "fundamental" path.

There has been some controversial debate in academic and policy circles on whether or not monetary authorities should react to movements in financial asset markets. The proponents against targeting asset prices are most notably the former Federal Reserve chairman, Alan Greenspan (2004, 2005, 2008), the current chairman of the Federal Reserve, Bernanke (2002) and the former member of the Board of Governor of the Federal Reserve, Mishkin (2008). However, a number of key policy-makers have moved a step closer in acknowledging the importance to react to booming financial markets in an attempt to prevent deflationary risk in the events of asset price bubbles bursts. Among them are the president of the San Francisco Federal Reserve, Yellen (2009), the former president of the Minneapolis Federal Reserve, Stern (2008), the president of the Boston Federal Reserve Rosengren (2009), the president of the European Central Bank (ECB), Trichet (2005, 2009) and in particular, the vice president of the European Central Bank, Papademos (2009).

In the South African context, it is worth noting that the SARB's other primary goals, as defined in the Constitution, is to protect the value of the currency and achieve and maintain financial stability though the South African financial institutions experienced no direct exposure to the sub prime crisis in terms of interbank or liquidity problems of the type experienced in developed countries (see Mboweni, 2008a, 2008b and Mminele, 2009).

This paper therefore contributes to a set of other studies by deriving and estimating a nonlinear flexible optimal monetary policy rule that allows for both zone-like and asymmetric behaviours. To the best of our knowledge, this is the first attempt to model the South African monetary policy using a nonlinear optimal model of the interest rate rule of this nature. Also to contribute to the discussion on financial asset prices, we see whether the optimal policy rule could instead be augmented with an

alternative variable that collects and synthesises the information from the asset and financial markets much in vein with Castro (2008).

The next section gives the description of the augmented theoretical model with asset prices. The methodology and data are discussed in section 3 with emphasis on the construction of a financial conditions index. In section 4, the optimal monetary policy rule is empirically estimated and analysed to determine the usefulness of the index of financial conditions in monetary policy conduct, while section 5 concludes with a discussion on the major findings and policy recommendations.

2. Theoretical model

The monetary authorities' policy preferences are modelled as an intertemporal optimisation problem following Svensson (1999), Surico (2007a,b) and Boinet and Martin (2008). The monetary authorities' policy design problem is to minimise a loss function with the structure of the economy forming a set of constraints, which is the adaptation of the New Keynesian model derived in Yun (1996) and Woodford (2003).

2.1 Central bank's preferences

The monetary authorities use all information which is available at the end of period $t-1$ to set the nominal interest rates at the beginning of period t . This is captured by the following intertemporal criterion where δ and L are the discount factor and the period loss function, respectively:

$$\text{Min}_{\{i_t\}} E_{t-1} \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau} \quad [1]$$

Following Boinet and Martin (2008), the period loss function is specified such that it captures asymmetries by allowing monetary authorities to treat target variables differently when they overshoot or undershoot their reference values. It is also exhibits target zones by allowing monetary authorities to treat target variables differently depending on whether they fluctuate within or outside the given target

bands, a feature which was introduced by Orphanides and Wieland (2000). Therefore the period loss function is specified as follows:

$$L_t = \frac{e^{\alpha_\pi(\pi_t - \pi^*)^{\beta_\pi}} - \alpha_\pi(\pi_t - \pi^*)^{\beta_\pi} - 1}{\beta_\pi \alpha_\pi^2} + \lambda \left(\frac{e^{\alpha_y(y_t)^{\beta_y}} - \alpha_y(y_t)^{\beta_y} - 1}{\beta_y \alpha_y^2} \right) + \phi \left(\frac{e^{\alpha_z(z_t)^{\beta_z}} - \alpha_z(z_t)^{\beta_z} - 1}{\beta_z \alpha_z^2} \right) + \frac{\mu}{2} (i_t - i^*)^2 \quad [2]$$

Where π_t is the inflation rate, y_t is the output gap, z_t is the index of financial conditions and i_t is the nominal interest rate. i^* and π^* are the desired level of interest rate and the inflation target, respectively. α_π , α_y and α_z capture the asymmetries, while β_π , β_y and β_z capture the zone-like properties in the monetary authorities' preferences. λ , ϕ and μ are coefficients which measure the monetary authorities' aversion to fluctuations in the level of output, financial conditions and interest rates. These coefficients are assumed to be greater than zero and are expressed in relative terms so that the policy preference towards inflation stability is normalised to 1. The period loss functions nest the linear, the linex, the quadratic, and the zone-like functional forms. When $\beta_\pi; \beta_y; \beta_z = 1$, the period loss function generalises to a linex loss function. Using L'Hopital's rule when $\alpha_\pi; \alpha_y; \alpha_z \rightarrow 0$, the period loss function generalises to a quadratic loss function.

The period loss function also nests numerous configurations of linearities, asymmetries and zone-like features and can take different forms depending on the combinations of the values $\beta_\pi; \beta_y; \beta_z$ as well as $\alpha_\pi; \alpha_y; \alpha_z$. When $\alpha_\pi; \alpha_y; \alpha_z > 0$, the monetary authorities are more aggressive if output, Inflation and financial conditions overshoot than when they undershoot their desired values by the same magnitude. On the flipside, the monetary authorities are more aggressive if output, Inflation and financial conditions undershoot than when they overshoot their desired values by the same magnitude when $\alpha_\pi; \alpha_y; \alpha_z < 0$. When $\beta_\pi; \beta_y; \beta_z = 1$, the period loss function exhibits asymmetries and it exhibits zone-like properties when $\beta_\pi; \beta_y; \beta_z > 1$, where it becomes zone symmetric when $\beta_\pi; \beta_y; \beta_z = 3, 5, 7, \dots$, while the values of

$\beta_\pi; \beta_y; \beta_z = 2, 4, 6, \dots$ imply a zone asymmetric period loss function. Thus the monetary authorities behave differently when the target variables are inside and when they are outside this zone. This is because the marginal loss from deviations of target variables is negligible within the target zone, while it increases when these variables move outside their target zones. It is important to note that the monetary authorities' response to the fluctuations of target variables may be different so that α_π , α_y and α_z and β_π , β_y and β_z need not assume equal values in any particular instance.

As illustrated in Figure 1, when values $\beta_\pi; \beta_y; \beta_z$ equal one and those of $\alpha_\pi; \alpha_y; \alpha_x$ approach zero, the period loss function is symmetric. Thus the monetary authorities give equal weight to positive and negative deviations of target variables from their desired values. The period loss function becomes asymmetric when values $\beta_\pi; \beta_y; \beta_z$ equal one and those of $\alpha_\pi; \alpha_y; \alpha_x$ are greater than zero. In this instance, the monetary authorities are more aggressive when the target variables overshoot their desired values, while they become relatively passive in the event that $\alpha_\pi; \alpha_y; \alpha_x$ are less than zero. The monetary authorities can also be passive when the target variables fluctuate within a target zone but become more aggressive when they fluctuate outside this zone. Thus the monetary authorities are equally aggressive regardless of whether the target variables overshoot or undershoot the target zone so that their preferences can be described as being symmetric and zone-like. In this particular case, the values of $\beta_\pi; \beta_y; \beta_z$ are even and the higher these values, the wider the width of the zone. The values of $\alpha_\pi; \alpha_y; \alpha_x$ can either be less, greater or equal to zero and they govern the slope of the loss function.

In the event that the values of $\beta_\pi; \beta_y; \beta_z$ are odd, the period loss function is asymmetric. As above, the monetary authorities' reaction inside the target zone is relatively passive but increasingly aggressive when they fluctuate outside this zone. The difference here is that the monetary authorities' aggressiveness is not the same when the target variables overshoot and when they undershoot the target zone by the same magnitudes so that their preferences are described as being asymmetric and zone-like. The values of $\alpha_\pi; \alpha_y; \alpha_x$ can still be less, greater or equal to zero but in this case they govern both the slope and sign of asymmetry of the loss function.

2.2 Structure of the economy

The structure of the economy is represented by a system comprising the aggregate demand and the aggregate supply following Clarida et al. (1999) as well as McCallum and Nelson (1999). The aggregate demand is the forward looking demand relationship derived from the Euler equation for consumption which is augmented with the index of financial conditions to capture the effect of financial variables on output. It is worth noting that such modified specification of the aggregate demand function has been proposed in the field, for e.g., Goodhart and Hofmann (2001) and Castro (2008).

$$y_t = E_t y_{t+1} - \rho(i_{t-1} - E_t \pi_{t+1}) + \psi z_t + \varepsilon_t^d \quad [3]$$

where $\rho > 0$ and $\psi > 0$ are the coefficients and ε_t^d is the i.i.d demand shock. The aggregate supply captures, in a log-linearised manner, the staggered feature derived from the Calvo (1983) model of staggered price adjustment:

$$\pi_t = \theta E_t \pi_{t+1} + k y_t + \varepsilon_t^s \quad [4]$$

where $\theta > 0$ and $k > 0$ are the coefficients, while ε_t^s is the i.i.d supply shock.

2.3 Optimal Monetary Policy

The monetary authorities choose the per period instrument i_t under discretion to minimise the following objective function:

$$E_{t-1} \left(\frac{e^{\alpha_\pi (\pi - \pi^*)^{\beta_\pi}} - \alpha_\pi (\pi_t - \pi^*)^{\beta_\pi} - 1}{\beta_\pi \alpha^2} \right) + \lambda E_{t-1} \left(\frac{e^{\alpha_y (y)^{\beta_y}} - \alpha_y (y)^{\beta_y} - 1}{\beta_y \alpha^2} \right) \quad [5]$$

$$+ \xi E_{t-1} \left(\frac{e^{\alpha_z (z_t)^{\beta_z}} - \alpha_z (z_t)^{\beta_z} - 1}{\beta_z \alpha^2} \right) + \frac{\mu}{2} (i_t - i^*) + F_t$$

Subject to $y_t = -\rho i_t + \psi z_t + g_t$ and $\pi_t = k y_t + f_t$, where $F_t \equiv E_{t-1} \sum_{\tau=0}^{\infty} \delta^\tau L_{t+\tau}$,

$g_t \equiv E_t y_{t+1} - \varphi E_t \pi_{t+1} + \varepsilon_t^d$ and $f_t \equiv \theta E_t \pi_{t+1} + \varepsilon_t^s$. It is assumed that the monetary

authorities cannot directly manipulate expectations so that F_t , g_t and f_t are taken as given.

2.4 Central bank's reaction function

The reaction function according to which the monetary authorities chooses policy rates in response to developments in the economy is given by the following first order condition describing the monetary authorities' optimal monetary policy rule:

$$\begin{aligned} \delta E_{t-1} f'(\pi_{t+1}) \frac{\partial \pi_{t+1} \partial y_{t+1}}{\partial y_{t+1} \partial i_t} + \delta E_{t-1} f'(y_{t+1}) \frac{\partial y_{t+1}}{\partial i_t} \\ + \delta E_{t-1} f'(z_{t+1}) \frac{\partial z_{t+1}}{\partial i_t} + \mu(i_t - i^*) = 0 \end{aligned} \quad [6]$$

where $f(x_t; \alpha, \beta) = \left(\frac{e^{\alpha x_t^\beta} - \alpha x_t^\beta - 1}{\beta \alpha^2} \right)$ and $f'(\cdot)$ is the first derivative. Solving the first

order condition achieves the reduced form central bank's reaction function:

$$\begin{aligned} \hat{i}_t = i^* + \omega_\pi E_{t-1} g(\pi_{t+1} - \pi_t)(\pi_{t+1} - \pi_t) \\ + \omega_y E_{t-1} g(y_{t+1})(y_{t+1}) + \omega_z E_{t-1} g(z_{t+1})(z_{t+1}) \end{aligned} \quad [7]$$

where $\omega_\pi = \left(\frac{k\rho\delta}{\mu} \right)$, $\omega_y = \left(\frac{\lambda\rho\delta}{\mu} \right)$, $\omega_z = \left(\frac{\xi\rho\delta}{\mu} \right)$ are convolutions of parameters

representing the monetary authorities' preferences and the structure of the economy

and $g(x_t; \alpha, \beta) = x_t^{\beta-1} \left(\frac{e^{\alpha x_t^\beta} - 1}{\alpha} \right)$ and \hat{i} is the optimal interest rate. Using L'Hopital's

rule on equation [7] as $\beta_\pi; \beta_y; \beta_z = 1$ and $\alpha_\pi; \alpha_y; \alpha_x \rightarrow 0$, $g(\cdot)$ tends to unity and the central bank's monetary policy rule generalises to a linear Taylor (1993) rule.

As shown in Figure 2, the optimal monetary policy rule can take different forms depending on the values $\beta_\pi; \beta_y; \beta_z$ and $\alpha_\pi; \alpha_y; \alpha_x$. When $\alpha_\pi; \alpha_y; \alpha_x = 0$, monetary authorities react linearly to deviations of inflation, output and financial conditions from their target values. Thus they place equal weight to negative and positive deviations

of inflation, output and financial conditions from their target values. When $\alpha_\pi; \alpha_y; \alpha_x > 0$, monetary authorities weight inflation, output and financial conditions more severely when they overshoot their target values and become less aggressive interest rates. The opposite is true for $\alpha_\pi; \alpha_y; \alpha_x < 0$ where the monetary authorities move interest rates more aggressively when the target variables undershoot their reference values than when they overshoot them. In a more realistic world, the monetary authorities are expected to be more sensitive to inflation and financial conditions when they overshoot their desired values than when they are low, while they are expected to be more aggressive to output contractions than to output expansions of the same magnitude. Surico (2007a) made similar findings of preferences for output expansion in the context of the Fed's monetary policy rule.

When $\beta_\pi; \beta_y; \beta_z = 1$, the monetary authorities have quadratic preferences so that the optimal monetary policy rule follows the linex function as proposed by Nobay and Peel (2003) as well as Surico (2007a,b). The response of monetary authorities to inflation, output and financial conditions fluctuations from their desired values is asymmetric and their aggressiveness to deviations of the target variables from their desired values depends on the values of $\alpha_\pi; \alpha_y; \alpha_x$. When $\beta_\pi; \beta_y; \beta_z = 2, 4, 6, \dots$, the monetary authorities have zone-like preferences as proposed by Orphanides and Wieland (2000). In this case, monetary authorities are passive when inflation, output and financial conditions fluctuate within a particular zone and become increasingly aggressive when the target variables fluctuate outside these zones. The response of monetary authorities to inflation, output and financial conditions fluctuations is symmetric and their aggressiveness outside this zone increases with the larger values of $\alpha_\pi; \alpha_y; \alpha_x$. For values of $\beta_\pi; \beta_y; \beta_z = 3, 5, 7, \dots$, the monetary authorities response to fluctuations of target variables is both zone-like and asymmetric. Thus the specified monetary policy response functions nest two very important features where monetary authorities' policy preferences can be asymmetric and zone-like in their responses, simultaneously.

2.5 Empirical model

Estimating the central bank's reaction function in equation [7] to test the statistical significance of the parameters amounts to testing linearity against a non-linear

model. To overcome this problem, the central bank's reaction function is linearised to eliminate the expectation terms by approximating equation [7] using a first order Taylor series expansion when α_π , α_y and α_z tend to zero. Thus by using a first order Taylor series expansion and replacing the expectations terms with realised values, the reduced form central bank's reaction function now becomes:

$$\begin{aligned} \hat{i}_t = & i^* + \omega_\pi (\pi_{t+1} - \pi_t)^{2\beta-1} \left(1 + \frac{\alpha_\pi}{2} (\pi_{t+1} - \pi_t)^{\beta_\pi} \right) \\ & + \omega_y (y_{t+1})^{2\beta-1} \left(1 + \frac{\alpha_y}{2} (y_{t+1})^{\beta_y} \right) + \omega_z (z_{t+1})^{2\beta-1} \left(1 + \frac{\alpha_z}{2} (z_{t+1})^{\beta_z} \right) \end{aligned} \quad [8]$$

When $\beta_\pi; \beta_y; \beta_z = 1$ the monetary authorities has linex preferences and the monetary policy reaction function generalises to a linear Taylor rule when $\alpha_\pi; \alpha_y; \alpha_z \rightarrow 0$.

Adding a partial adjustment mechanism $i_t = \rho(L)i_{t-1} + (1 - \rho(L))\hat{i}_t$ to allow for interest rate persistence following Clarida et al. (1999), Boinet and Martin (2008) as well as Surico (2007a,b) achieves the following reduced form central bank's reaction function:

$$i_t = \rho(L)i_{t-1} + (1 - \rho(L)) \left(\begin{aligned} & \omega_0 + \omega_\pi (\pi_{t+1} - \pi_t)^{2\beta-1} \left(1 + \frac{\alpha_\pi}{2} (\pi_{t+1} - \pi_t)^{\beta_\pi} \right) \\ & + \omega_y (y_{t+1})^{2\beta-1} \left(1 + \frac{\alpha_y}{2} (y_{t+1})^{\beta_y} \right) + \omega_z (z_{t+1})^{2\beta-1} \left(1 + \frac{\alpha_z}{2} (z_{t+1})^{\beta_z} \right) \end{aligned} \right) + \varepsilon_t \quad [9]$$

Where ε_t is the residual of the Taylor's series expansion defined as:

$$\begin{aligned} \varepsilon_t = & -\omega_\pi (1 - \rho(L)) \left(\left((\pi_{t+1} - \pi^*)^{2\beta-1} - E_{t-1}(\pi_{t+1} - \pi^*)^{2\beta-1} \right) + \frac{\alpha_\pi}{2} \left((\pi_{t+1} - \pi^*)^{3\beta-1} - E_{t-1}(\pi_{t+1} - \pi^*)^{3\beta-1} \right) \right) \\ & - \omega_y (1 - \rho(L)) \left(\left((y_{t+1})^{2\beta-1} - E_{t-1}(y_{t+1})^{2\beta-1} \right) + \frac{\alpha_y}{2} \left((y_{t+1})^{3\beta-1} - E_{t-1}(y_{t+1})^{3\beta-1} \right) \right) \\ & - \omega_z (1 - \rho(L)) \left(\left((z_{t+1})^{2\beta-1} - E_{t-1}(z_{t+1})^{2\beta-1} \right) + \frac{\alpha_z}{2} \left((z_{t+1})^{3\beta-1} - E_{t-1}(z_{t+1})^{3\beta-1} \right) \right) \end{aligned}$$

3. Data discussion

The data used in this analysis is sourced from the South African reserve Bank database. It is denominated in monthly frequency and the sample ranges from 2000:01 to 2008:12, which covers the inflation targeting regime in South Africa. The 91-day Treasury bill rate measures the nominal interest rate as it contains more variation compared to other closely related money market rates such as the key repo rate or the prime overdraft rate, the rates set by commercial banks. Inflation is approximated by the annual change in the consumer price index. In this paper, output is measured using the Coincident business cycle indicator computed by the SARB and we measure the output gap as the deviation of this from a Hodrick-Prescott (1997) trend.

Financial variables and asset prices represent another group of variables that have been recently considered in the specification of the monetary policy rule for the analysis of the behaviour of central banks following Castro (2008) and the others discussed above. The financial index variable pools together relevant information provided by a number of financial variables¹. The index is constructed as a weighted average of (i) the real effective exchange rate with the foreign exchange rate in the denominator, (ii) the real house price index where the house price index is an average price of all houses compiled by the ABSA bank, deflated by the consumer price index (iii) the real stock price which is measured by the Johannesburg Stock Exchange All Share index, deflated by the consumer price index (iv) the credit spread which is the spread between the yield on the 10-year government bond and the yield on A rated corporate bonds, and (v) the future spread which is the change of spread between the 3-month interest rate futures contracts in the previous quarter and the current short-term interest rate.

The real effective exchange rate, stock price and house price variables are detrended by a HP filter. To tackle the end-point problem in calculating the HP trend (see Mise et al, 2005a,b), we applied an Autoregressive (AR(n)) model (with n set at

¹ According to Castro (2008), these variables contain valuable information from the monetary authorities point of view in that they provide an indication of financial markets stability and expectations about the monetary policy stance. In particular, the credit spread is a good proxy for the business cycle and financial stress, while future interest rates spread is a good indicator of expected interest rates by the economic agents. The index of financial conditions recognises the importance of the transmission of monetary policy through the asset prices and the credit channels over and above the interest rate channel (Mishkin, 1996 and Bernanke and Gertler, 2000). The asset price channel comprises the exchange rate, the equity price and the real estate channels whereas the credit channel comprises the bank lending as well as the balance sheet channels

4 to eliminate serial correlation) to the output measure and the components of the financial index. The AR model was used to forecast twelve additional months that were then added to each of the series before applying the HP filter. The constructed financial index is expressed in standardised form, relative to the mean value of 2000 and where the vertical scale measures deviations in terms of standard deviations; therefore, a value of 1 represents a 1-standard deviation difference from the mean. Additionally, all data are seasonally adjusted. The index is also in the spirit of the UK financial conditions index provided by the Bank of England's Financial Stability Report (Bank of England, 2007).

The evolution of the main variables is shown in Appendix 1. Inflation has had a sustained fall over the sample period. The inflation rate is showing a persistent increase towards the end of the sample together with an accompanying increase in interest rate. The output gap is showing a severe downturn by the end of 2008. Movements in the financial index have a similar pattern to the interest rate which indicates a close link between the two variables, particularly towards the end of the sample.

4. Empirical results

The specifications for the preferred optimal policy rule allow for one lag of the interest rate, with the lead structure of 6 months on inflation gap, one month on the output gap and one month on the financial conditions index. Assuming perfect foresight for inflation, we replace forecasts of inflation gap, output gap and financial conditions index by their respective future realizations. The orthogonality conditions in the central bank's reaction function allow the use of Generalised Method of Moments (GMM) in estimation. As discussed above, the instrument set includes the lags of independent variables, long term government bond yield, and annual growth in M3. For the purpose of the selection of the best model, equation [9] is estimated for various assumptions concerning β_π , β_y and β_z . This results in 64 estimated models for the cases where inflation, output gap and financial conditions are linear, asymmetric, zone symmetric and zone asymmetric. The estimated standard errors of the regression equations are presented in table 1. The lowest standard error is obtained for the model with zone symmetric inflation, asymmetric output gap and linear financial conditions.

The model with zone symmetric inflation, asymmetric output gap and linear financial conditions implies that the monetary authorities' response towards inflation is zone-like. This is in line with the inflation target framework in South Africa where inflation is allowed to fluctuate within a specified band of 3 to 6 percent. This model also implies that the monetary authorities' response towards output is asymmetric. This means that the monetary authorities weigh differently negative and positive output deviations from its potential. Finally, the model implies that the monetary authorities' response to financial conditions is linear so that the monetary authorities do not weigh the deviations of financial conditions differently regardless of whether they overshoot or undershoot their desired values. The estimates of the preferred model based on the lowest standard error are presented in table 2. The results are compared with those from the model with linear inflation, output gap and financial conditions, which is the benchmark for estimated monetary policy rules. The Hansen's J-test is carried out to determine the validity of instruments under the null hypothesis of that the over identifying restrictions are satisfied. The validity of the instruments used is confirmed by the reported p-values for the Hansen's J-statistics for the benchmark monetary policy rule and the preferred model.

It is worth noting that the augmented linear monetary policy rule performs poorly in terms of robustness compared to the preferred model with zone symmetric inflation, asymmetric output gap and linear financial conditions. However, the results of the linear monetary policy rule show that all the coefficients are statistically significant except the coefficient on the output gap. The coefficients show a positive response to the interest rate changes implying that interest rate hikes are associated with rising inflation, output gap and the financial conditions. The results show that the monetary authorities increase interest rates by 1.19 percent when inflation overshoots its long term trend by one percent. Irrespective of the deviation of inflation from the target, there is a constant proportional response of interest rates to inflation and the response implied by the linear model for inflation is stronger than that of the preferred model when inflation is between 7.56 and 1.44 percent. In particular, the linear model records a statistically significant response to the index of financial conditions. A one standard deviation increase in the index relative to its mean triggers an interest rate increase of 1.94 per cent which is in excess of one percentage point required by the Taylor principle.

The preferred model with zone symmetric inflation, asymmetric output gap and linear financial conditions performs better than all the alternatives in terms of robustness and all the coefficients are statistically significant. Figure 4 shows the plots of the monetary authorities' responses to inflation, the output gap and financial conditions. It is obtained by substituting the estimated coefficients into equation [9]. The preferred model shows negligible response to inflation when it is between 4 and 5 percent. This implies that the monetary authorities are almost entirely passive when inflation is within 0.5 percentage points of the inflation zone target mid-point of 4.5 percent. The Taylor principle requires that monetary authorities raise the nominal interest rate by more than one-to-one when inflation exceeds its target rate. According to the results, the monetary authorities satisfy the Taylor principle by raising the nominal interest rates by 1 percent when inflation is outside the range 2.56 to 6.44 percent so that the inflation gap is about 1.94 percent deviation from an assumed target of 4.5 percent. When inflation reaches the upper threshold of the inflation target of 6 percent, the monetary authorities increase desired interest rate by 0.47 percent above the equilibrium interest rate of 8.34 percent.

The monetary policy responses to the output gap and financial conditions are depicted in Figure 3. The empirical results show that the monetary authorities cut interest rates by one percent when the output undershoots its long term trend by 0.72 percent. The results further show a statistically significant response to the financial conditions index where a one standard deviation increase in the index relative to its mean triggers an interest rate increase of 1.84 percentage point. The statistically significant coefficient on the index of financial conditions in the estimated optimal monetary policy rule implies that monetary authorities do take financial conditions into consideration when determining monetary policy outcomes. The results further show monetary authorities react more to downward output deviations relative to their desired values. Thus by implication, monetary authorities tend to place a greater weight on output contractions, a result which is not at odds with the developing economy like South Africa.

This is the first attempt to estimate the type of monetary policy rules which feature zone-like and asymmetric preferences on the part of monetary authorities for South Africa. As a result, there are no readily available studies to make direct comparison of the results, however, attempts have been made to compare the estimated results to those of Ortiz and Sturznegger (2008). Using a dynamic stochastic general equilibrium for the period 1983 to 2002, they found almost similar results to the

results in this study for a linear monetary policy rule. According to their results, the monetary authorities in South Africa increase the nominal interest rates by 1.11, 0.27 and 0.11 when inflation, output and the exchange rate increase by one percent, respectively. They further compare their results with the GMM estimates by Lubik and Schorfheide (2007) for the UK and its former colonies and conclude the South African monetary authorities' reaction to inflation, output and exchange rate fluctuations are almost similar to in these countries.

5. Conclusion

In this paper, an optimal monetary policy rule whose foundation relies on a representation of policymaker's preferences that allow for zone targeting and asymmetric behaviours with respect to its objectives was derived and estimated. This model was augmented with a comprehensive index of financial conditions such as the stock prices, property prices, real exchange rates and measures of credit risk to address the current debate of the instance of Central Banks on targeting financial asset prices. The estimation was carried out using monthly data for South Africa spanning the period since the adoption of the inflation targeting framework. This theory both fits the data in its own terms and the model with zone symmetric inflation, asymmetric output and linear financial conditions is superior in-sample to alternative monetary policy rules including the traditional linear Taylor rule representation.

According to the empirical results, the preferred model shows negligible response to inflation when inflation lies in a zone of 4 to 5 percent. The Taylor principle is satisfied when inflation is outside the range 2.56 to 6.44 percent so that the inflation gap is about 1.94 percent. The monetary authorities increase desired interest rate by 0.47 percent above the equilibrium interest rate when inflation reaches the upper threshold of the inflation target. The empirical results further show that the monetary authorities cut interest rates by one percent when the output undershoots its long term trend by 0.72 percent. The results also reveal that that the monetary authorities pay close attention to the financial conditions index when setting interest rates by allowing a more symmetric response to financial conditions irrespective of financial market upturn or downturn.

The response of the SARB policy-makers to financial conditions arguably has important policy implications as it might shed some light on why the current downturn

in South Africa where the financial market occupies 25 percent of its total output is less severe than in the US where financial conditions do not feature in the Federal Reserve Bank's reaction function. Similar results have been found in the context of the European Central Bank that targets financial conditions, contrary to the UK and the US central banks. This lack of attention to the financial conditions might have made the UK and the US more vulnerable to the recent credit crunch than the Euro zone and economies such as South Africa. For future research, it would also be interesting to investigate the robustness of our results with respect to the evaluation of the alternative models within an out-of-sample forecasting experiment to see which model best predict the interest rate setting behaviour of the Reserve Bank.

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Table 1 Standard errors for values of β_π , β_y and β_z

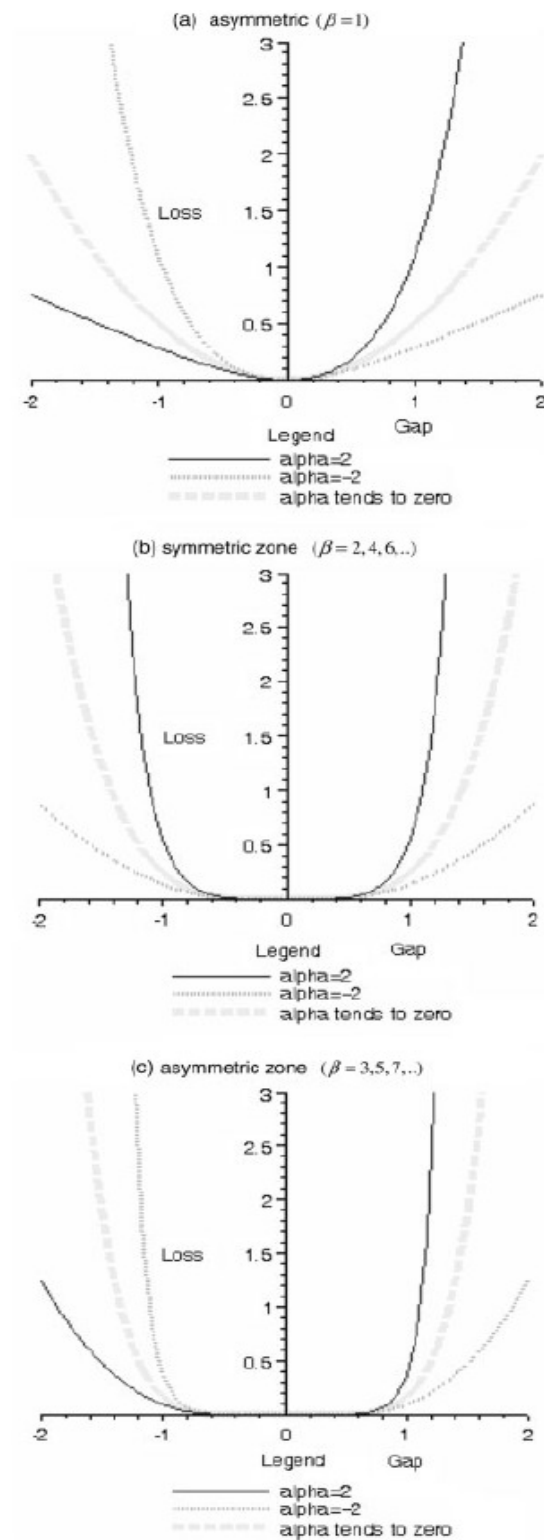
Linear financial conditions: $\alpha_z \rightarrow 0; \beta_z = 1$				
	Linear $\alpha_\pi \rightarrow 0; \beta_\pi = 1$	Asymmetric $\alpha_\pi \neq 0; \beta_\pi = 1$	Zone Symmetric $\alpha_\pi \neq 0; \beta_\pi = 2$	Zone Asymmetric $\alpha_\pi \neq 0; \beta_\pi = 3$
Linear $\alpha_y \rightarrow 0; \beta_y = 1$	0.314689	0.308391	0.314172	0.315627
Asymmetric $\alpha_y \neq 0; \beta_y = 1$	0.302862	0.303284	0.297457	0.310285
Zone symmetric $\alpha_y \neq 0; \beta_y = 2$	0.320607	0.312832	0.316278	0.317292
Zone Asymmetric $\alpha_y \neq 0; \beta_y = 3$	0.314185	0.307910	0.309356	0.308664
Asymmetric financial conditions: $\alpha_z \neq 0; \beta_z = 1$				
	Linear $\alpha_\pi \rightarrow 0; \beta_\pi = 1$	Asymmetric $\alpha_\pi \neq 0; \beta_\pi = 1$	Zone Symmetric $\alpha_\pi \neq 0; \beta_\pi = 2$	Zone Asymmetric $\alpha_\pi \neq 0; \beta_\pi = 3$
Linear $\alpha_y \rightarrow 0; \beta_y = 1$	0.318243	0.308653	0.316046	0.319528
Asymmetric $\alpha_y \neq 0; \beta_y = 1$	0.302139	0.301873	0.297827	0.304986
Zone symmetric $\alpha_y \neq 0; \beta_y = 2$	0.323654	0.313151	0.318329	0.320061
Zone Asymmetric $\alpha_y \neq 0; \beta_y = 3$	0.323654	0.313151	0.318329	0.320091
Zone symmetric financial conditions: $\alpha_z \neq 0; \beta_z = 2$				
	Linear $\alpha_\pi \rightarrow 0; \beta_\pi = 1$	Asymmetric $\alpha_\pi \neq 0; \beta_\pi = 1$	Zone Symmetric $\alpha_\pi \neq 0; \beta_\pi = 2$	Zone Asymmetric $\alpha_\pi \neq 0; \beta_\pi = 3$
Linear $\alpha_y \rightarrow 0; \beta_y = 1$	0.318233	0.308653	0.316046	0.321598
Asymmetric $\alpha_y \neq 0; \beta_y = 1$	0.306474	0.306951	0.300983	0.300396
Zone symmetric $\alpha_y \neq 0; \beta_y = 2$	0.325196	0.316229	0.319986	0.323798
Zone Asymmetric $\alpha_y \neq 0; \beta_y = 3$	0.319746	0.313013	0.313846	0.316622
Zone asymmetric financial conditions: $\alpha_z \neq 0; \beta_z = 3$				
	Linear $\alpha_\pi \rightarrow 0; \beta_\pi = 1$	Asymmetric $\alpha_\pi \neq 0; \beta_\pi = 1$	Zone Symmetric $\alpha_\pi \neq 0; \beta_\pi = 2$	Zone Asymmetric $\alpha_\pi \neq 0; \beta_\pi = 3$
Linear $\alpha_y \rightarrow 0; \beta_y = 1$	0.319457	0.312405	0.318609	0.318672
Asymmetric $\alpha_y \neq 0; \beta_y = 1$	0.317553	0.307958	0.300282	0.300258
Zone symmetric $\alpha_y \neq 0; \beta_y = 2$	0.327429	0.318748	0.320263	0.325099
Zone Asymmetric $\alpha_y \neq 0; \beta_y = 3$	0.322155	0.314588	0.315419	0.319071

Table 2 GMM Estimates for the Augmented Taylor rules

	Linear inflation, linear output gap and linear financial conditions $\alpha_\pi \rightarrow 0; \alpha_y \rightarrow 0; \alpha_z \rightarrow 0;$ $\beta_\pi = 1; \beta_y = 1; \beta_z = 1$		Zone symmetric inflation, asymmetric output gap and linear financial conditions $\alpha_\pi \neq 0; \alpha_y \neq 0; \alpha_z \rightarrow 0;$ $\beta_\pi = 2; \beta_y = 1; \beta_z = 1;$	
	Coefficient	Std error	Coefficient	Std error
ρ_1	0.959768*	0.009797	0.968038*	0.007557
ω_0	7.145260*	0.381297	8.377442*	0.413661
ω_π	1.192263*	0.273845	0.144554*	0.035553
α_π			-0.025840*	0.000686
ω_y	0.223371	0.221525	1.036774*	0.315709
α_y			-0.957549*	0.260831
ω_z	1.938763*	0.823699	1.840314*	0.789281
\bar{R}^2	0.971140		0.974214	
<i>Std.Error</i>	0.314689		0.297457	
<i>J – statistic</i>	0.978468		0.988056	

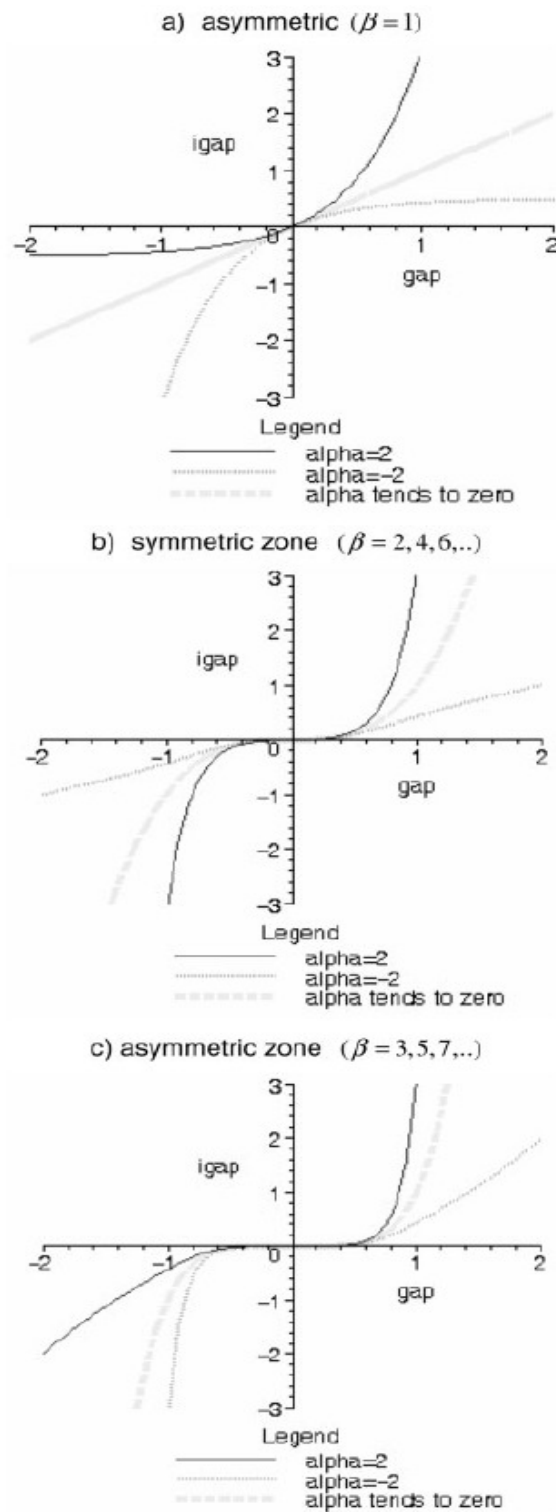
- * reports statistical significance at 5 percent level
- J-statistic reports the p-value of the Hansen's J test

Figure 1 **The loss function**



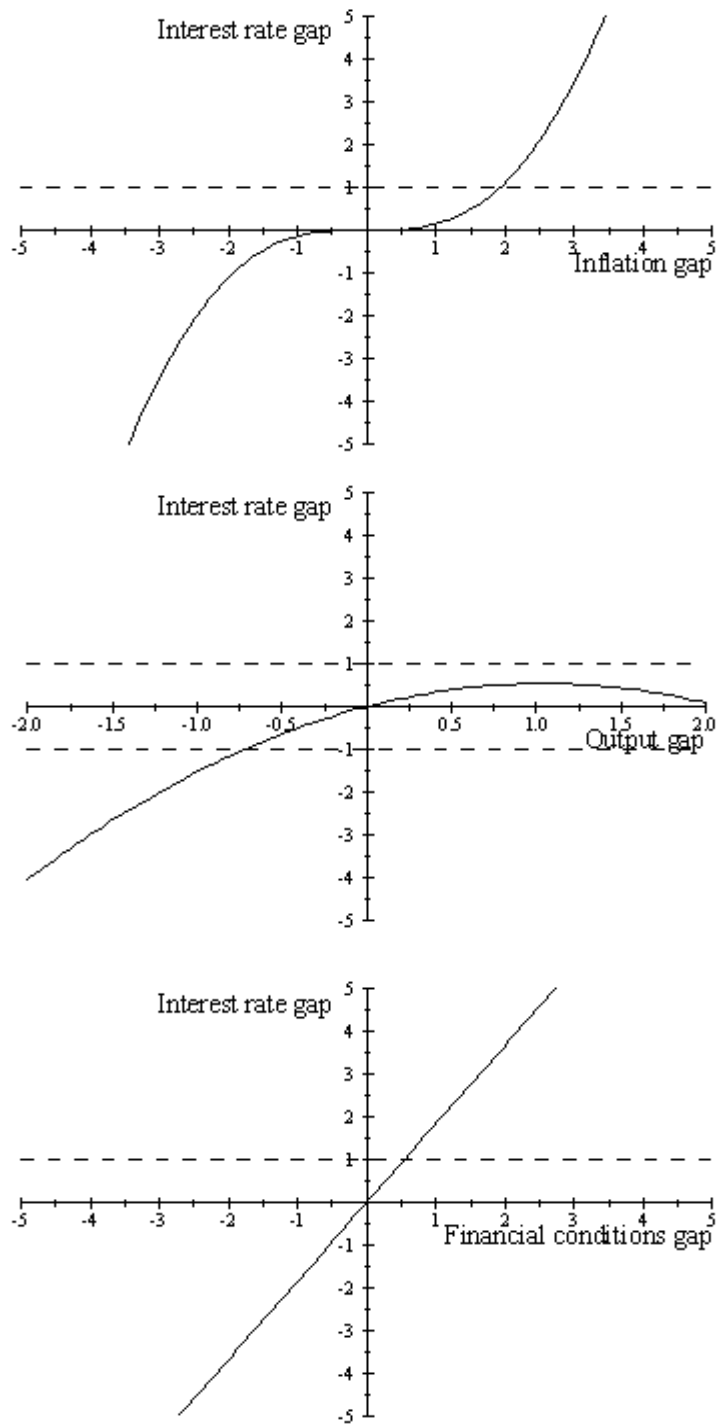
Note: The figure illustrates the preferences over inflation, output and financial conditions under different assumptions on α and β . The figure is adopted from Boinet and Martin (2008).

Figure 2 **Optimal monetary policy rules**



Note: The figure illustrates the gap between the steady-state and equilibrium interest rates, denoted by *igap*, calculated using equation [7]. The figure is adopted from Boinet and Martin (2008).

Figure 3 **Estimated optimal monetary policy responses**

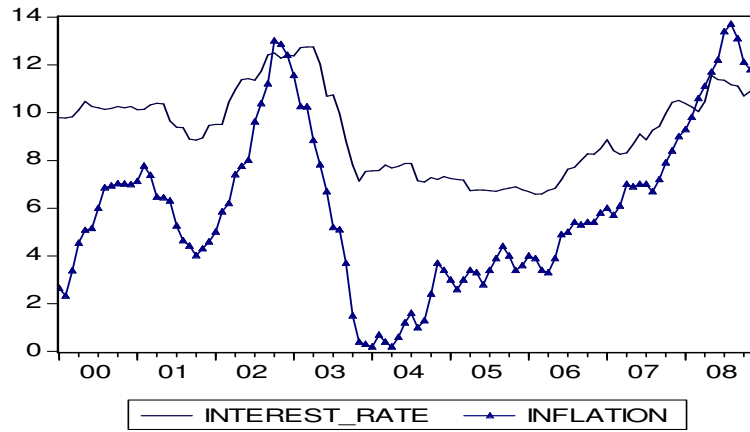


Note: The figure illustrates the gap between desired and equilibrium interest rate obtained by substituting the estimated coefficients into equation [9]

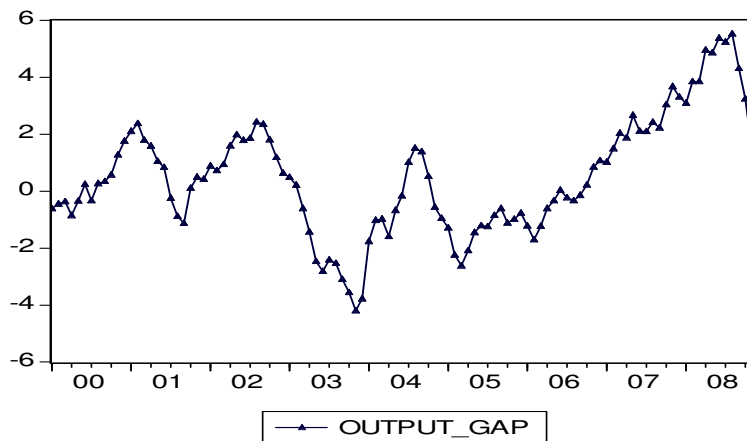
Appendix 1

Evolution of the main variables

a) Interest rate and inflation measures



b) Output gap measures



c) Financial conditions index

