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The Opportunistic approach to monetary policy and financial markets

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Abstract

We test the concept of the Opportunistic Approach to monetary policy in South Africa post 2000 inflation targeting regime. Our findings support the two features of the opportunistic approach. First, we find that the models that include an intermediate target that reflects the recent history of inflation rather than simple inflation target improve the fit of the models. Second, the data supports the view that the South African Reserve Bank (SARB) behaves with some degree of non-responsiveness when inflation is within the zone of discretion but react aggressively otherwise. Recursive estimates from our preferred model reveal that overall there has been a subdued reaction to inflation, output and financial conditions amidst the increased economic uncertainty of the 2007-2009 financial crisis.

Keywords: monetary policy, opportunistic approach, intermediate inflation, financial conditions

JEL: C51; C52; C53; E52; E58

1. Introduction

It is now almost two decades that economists approximate central banker's reaction function using mostly the Taylor rule (Taylor, 1993) and its modification by Clarida *et al.* (2000) and Woodford (2003). These models assume a constant proportional reaction of the interest rate to inflation and/or output deviations from desired levels. However, a number of academics (e.g. Nobay and Peel, 2003; Cukierman and Gerlach, 2004; Bec *et al.*, 2002; Orphanides and Wieland, 2000, and Favero *et al.*, 1999) have put into question the linear restriction. The view is that monetary policymakers have good spirit of discernment and so they are not rigid in their decision making. In fact, economic recession and economic expansion have different impact on future economic performance. Likewise, low inflation (below the target), desired inflation (hitting the target) and high inflation (above the target) have different impact on the monetary policy stance and to economy. As such, the inflation target band practice suggests that policymakers may exhibit 'zone-like' behaviour by responding more to inflation when inflation is some way from the target band and passively when inflation is inside the target.

In this paper we test the opportunistic approach to monetary policy developed by Orphanides and Wilcox (2002) and Martin and Milas (2010a) have provided the first empirical evidence of this model using US data. The theoretical foundations provided by Orphanides and Wilcox (2002) assume that monetary policy is set depending on a 'zone of inaction'.[1] Accordingly, the literature suggests that when inflation is within the zone, the focus of the central bank is on output rather than inflation stabilization (see Orphanides and Wilcox (2002) and a somewhat different theoretical model provided by Minford and Srinivasan (2006) for this same concept). In their contribution to the topic, Bomfim and Rudebusch (2000) judge that though opportunistic strategy may be able to achieve disinflation at a lower cost, it can probably take longer to achieve price stability than a deliberate approach. Bomfim and Rudebusch (2000) consider that "*the opportunistic policymaker takes no deliberate action to reduce inflation further, but waits to exploit recessions and favorable supply shocks to lower inflation. When inflation gets pushed down by a shock, the interim inflation target is reset to equal the new prevailing lower rate, and, in this fashion, price stability is eventually achieved*". From this statement, the two features of the opportunistic approach emerge clearly.

The first feature is related to the concept of the zone of discretion for which policymakers

[1]In fact, asymmetries resulting from a framework of target range of inflation can be described as a necessary condition for an opportunistic monetary policy but not as a sufficient one.

are supposed to behave opportunistically by accommodating shocks that tend to move inflation towards the desired level. By contrast, it is argued that policymakers should react when inflation tends to move away from 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. The second feature is that monetary policy should move inflation toward an intermediate inflation resulting from inflation target and previous actual inflation rates. This feature of intermediate inflation is based on the idea that the central bank should not pursue a target for inflation that is too ambitious in the short run but, it should instead pursue a practical target for inflation that is within the grasp of the short term. This is particularly relevant for developing countries which might be more concerned about the inflation-output trade-off in the short-run.

The recent financial crisis has provided an additional challenge to simple Taylor rule models adding to the debate on whether Central Banks can improve macroeconomic stability by targeting financial asset prices (such as exchange rates, house prices and stock prices). For instance, amongst others, De Grauwe (2007) argues that asset prices should figure out as an objective for the central bank whereas Federal Reserve governor Mishkin (2008) and Federal Reserve Chairman Bernanke and Gertler (2001) argue for the converse. We follow previous works by Naraidoo and Raputsoane (2010) and Naraidoo and Kasai (2010) who find that the SARB has been reacting to financial conditions and that the inclusion of a financial conditions index in the reaction function improves the fit of the model. This motivation follows from works by Rudebusch (2002) who raises the issue of an omitted variables problem by pointing out that the significance of interest rate persistence in the policy rule could be due to omitting a financial spread variable from the estimated regression. Gerlach-Kirsten (2004) and English *et al.* (2003) find that inclusion of a financial spread reduces the empirical importance of interest rate smoothing (amongst others, Estrella and Mishkin (1997) analyze the influence of a term structure variable in policy rules).

Our contribution in this paper on top of investigating whether the monetary policy reaction function for the (SARB) could express the consistency of the opportunistic approach is to augment such framework with a more comprehensive financial index variable that pools together relevant information provided by a number of financial variables. Furthermore, the main model is estimated over expanding windows of data. Recursive estimation provides significant information on how the response coefficients to inflation, output gap and financial conditions have varied across times and across regimes (within and outside the zone of discretion) with the oncoming of the sub-prime crisis.

There are a number of findings worth mentioning. The models that include intermediate rather than simple inflation target improve the fit of the models. Among linear and nonlinear models, a quadratic logistic function outperforms all other models and provides support that monetary policymakers of the SARB have behaved opportunistically by accommodating shocks when inflation is within the zone of discretion but reacting aggressively otherwise. The outperforming model reveals that the zone of discretion is symmetrically extending from 1.81 percent below and above the intermediate inflation rate. Estimated inflation target range of 3.62 percent is reasonable for the SARB as the difference between the pre announced lower bound and upper bound is 3 percent. Taking the official target range of 3 to 6 percent as a benchmark to our estimate, we can suggest that estimated target zone spans from 2.69 to 6.31 percent. We further use the preferred model to evaluate parameter evolution since January 2006. Recursive estimation reveals that in general, the 2007-2009 financial crisis witnesses an overall decreased reaction to inflation, output and financial conditions amidst uncertainty of the oncoming recession, having gone through an extended boom recently.

The remainder of the paper proceeds as follows. Section 2 outlines the model of Orphanides and Wilcox (2002) and Aksoy *et al.* (2006) and motivates the inclusion of financial conditions in the framework and we suggest how it might be estimated. Section 3 talks about the data. Section 4 discusses findings. Section 5 provides some concluding remarks.

2. Model specification

We use the model of Orphanides and Wilcox (2002) with the inclusion of financial conditions a la Martin and Milas (2010b).[2] As such, unlike the conventional loss function, the loss function in this paper reflects a concern with financial stability by including a measure of domestic financial stability (f). As in Martin and Milas (2010b), equation (4) assumes that financial stability can be increased by reducing nominal interest rates; allowing financial institutions to re-capitalize at a lower cost.

$$\mathrm{L} = \left(\pi - \pi^I\right)^2 + \gamma y^2 + \kappa f^2 + \psi \mathrm{abs}(y) \tag{1}$$

$$\pi_t = \pi^e + \alpha y_t + \varepsilon_{st} \tag{2}$$

[2] Martin and Milas (2010b) develop a flexible theoretical model to allow for changes in the preferences of policymakers when there is a financial crisis.

$$y_t = \alpha_0 - \alpha_r\left(r_t - r^*\right) + \varepsilon_{dt} \tag{3}$$

$$f_t = \bar{f} - \alpha_f(i_t - i^*) + \varepsilon_{ft} \tag{4}$$

where π is the inflation rate, π^I is the intermediate inflation target, y is the output gap, f is the financial conditions index, r is the real interest rate, $r*$ is the equilibrium real interest rate, i is the nominal interest rate, $i*$ is the equilibrium nominal interest rate, α s are positive parameters, ε_s is supply shock, ε_d is a demand shock and ε_{ft} is a financial shock. Equation (1) specifies the policymakers' loss function in terms of expected discounted sums of quadratic deviations of inflation from the inflation intermediate target, the loss from output comprises a conventional quadratic term and also a linear function of the absolute value of the output and the policymakers have preferences for f, the financial conditions index being close to equilibrium reflecting their desire to stabilise the financial system[3]. Equation (2) is a static expectations-augmented Phillips curve while equation (3) is a simple, static aggregate demand relationship.

Assuming that policy-makers choose the optimal interest rate for period *t* at the end of period *t* - 1 using information available up to the end of period *t* - 1, Orphanides and Wilcox (2002) proposed the optimal monetary policy rule similar to equation (5) below:

$$\begin{aligned}
i_t &= i^* + \rho_{ZD}E_{t-1}(\pi_t - \pi_t^I) + \rho_y E_{t-1}y_t + \rho_f E_{t-1}f_t && \text{if } -\delta \le E_{t-1}(\pi_t - \pi_t^I) \le \delta \\
i_t &= i^* + \rho_{OZD}E_{t-1}(\pi_t - \pi_t^I + \delta) + \rho_y E_{t-1}y_t + \rho_f E_{t-1}f_t && \text{if } -\delta > E_{t-1}(\pi_t - \pi_t^I) \\
i_t &= i^* + \rho_{OZD}E_{t-1}(\pi_t - \pi_t^I - \delta) + \rho_y E_{t-1}y_t + \rho_f E_{t-1}f_t && \text{if } \delta < E_{t-1}(\pi_t - \pi_t^I)
\end{aligned} \tag{5}$$

The above nonlinear monetary policy rule comprises of three Taylor-like policy rules describing the reaction function of the policy-makers and it depends on whether expected inflation is below, within or above the zone of discretion. The zone ranges from δ percentage points below the intermediate inflation target to δ percentage points above. ρ_y and ρ_f are respectively the coefficient of output gap and financial conditions index. ρ_{ZD} and ρ_{OZD} are respectively the coefficient of inflation within the zone of discretion and the coefficient of inflation outside the zone. If

[3] We provide a detailed explanation of how the financial conditions index is constructed in the data section.

$\rho_{ZD} \neq \rho_{OZD}$, it is an indication that the response by monetary policy makers depends on whether inflation is within the zone of discretion or not. By contrast, if $\rho_{ZD} = \rho_{OZD}$, it is an indication that the monetary policy reaction function is linear and so equation (5) simplifies to the following equation:

$$i_t = i^* + \rho_\pi E_{t-1}(\pi_t - \pi_t^I) + \rho_y E_{t-1} y_t + \rho_f E_{t-1} f_t \tag{6}$$

Replacing the intermediate inflation target in equation (1) with the conventional point inflation target π^T, equation (6) becomes

$$i_t = i^* + \rho_\pi E_{t-1}(\pi_t - \pi_t^T) + \rho_y E_{t-1} y_t + \rho_f E_{t-1} f_t \tag{7}$$

Allowing for interest rate smoothing as in for e.g. Woodford (2003) we assume:

$$i_t = \rho_i(L) i_{t-1} + (1-\rho_i)\hat{i}_t \tag{8}$$

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 and $\hat{i}$ is the desired interest rate given by equation (7) above:

$$\hat{i}_t = i^* + \rho_\pi E_{t-1}(\pi_t - \pi_t^T) + \rho_y E_{t-1} y_t + \rho_f E_{t-1} f_t \tag{9}$$

Combining equation (8) and (9), solving for the expectation operator, *E,* and allowing for a forward looking version we have

$$i_t = \rho_i(L) i_{t-1} + (1-\rho_i)\left\{i^* + \rho_\pi\left(\pi_{t+p} - \pi^T\right) + \rho_y y_{t+q} + \rho_f f_{t+r}\right\} + \varepsilon_t \tag{10}$$

where ε_t is an error term composed of expectational errors. As seen above, one of the opportunistic approach features is the use of intermediate inflation rather than simple inflation target. To allow for this feature, we rewrite equation (10) by replacing the inflation target by the intermediate inflation target to have

$$i_t = \rho_i(L) i_{t-1} + (1-\rho_i)\left\{i^* + \rho_\pi\left(\pi_{t+p} - \pi^I\right) + \rho_y y_{t+q} + \rho_f f_{t+r}\right\} + \varepsilon_t \tag{11}$$

where the intermediate inflation target is defined as

$$\pi_t^I = \mu\left(\frac{1}{n}\sum_{j=1}^{n} \pi_{t-j}\right) + (1-\mu)\pi^T \tag{12}$$

It is worth noting that King (1996) has identified equation (12) as a simple inflation learning rule. After experiencing high inflation for a long period of time, there may be good reasons for the private sector not to believe the disinflation policy fully (see also Bomfim and Rudebusch, 2000). In his discussion of endogenous learning, King (1996) says that it might be rational for the private sector to suppose that in trying to learn about the future inflation rate many of the relevant factors are exogenous to the path of inflation itself. In light of this, King assumes that private sector inflation expectations follow a simple rule, that is a linear function of the inflation target and the lagged inflation rate. Therefore, the intermediate inflation target is particularly applicable for countries which have experienced relatively high inflation rate. Equation (11) allows us to approximate the intermediate inflation target included in the standard Taylor rule. Note that the inflation target will not be identified as it is part of the constant[4].

To test for the presence of opportunistic behavior, and so the presence of asymmetries, we define different regimes and allow for the possibility that the dynamic behavior of the monetary authority depends on whether inflation is lying within the target zone or not. As far as opportunistic approach is concerned, the model assumes two different regimes; namely the zone of discretion and the outside zone. Therefore, at this stage we consider the use of two-regime switching models. That is, the lower and upper boundaries of the target zone are regarded as the regime-determining processes. It is important to notice that the change from one regime to another can be abrupt or smooth. If the change is abrupt, then the non linear model will be of the following form

$$
\begin{aligned}
i_t &= \rho_i(L)i_{t-1} + (1-\rho_i)\left\{i^* + \rho_{ZD}E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right) + \rho_y E_{t-1}y_{t+q} + \rho_f E_{t-1}f_{t+r}\right\} \\
&\qquad \text{if } -\delta \le E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right) \le \delta \\
i_t &= \rho_i(L)i_{t-1} + (1-\rho_i)\left\{i^* + \rho_{OZD}E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p} + \delta\right) + \rho_y E_{t-1}y_{t+q} + \rho_f E_{t-1}f_{t+r}\right\} \\
&\qquad \textit{if } -\delta > E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right) \\
i_t &= \rho_i(L)i_{t-1} + (1-\rho_i)\left\{i^* + \rho_{OZD}E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p} - \delta\right) + \rho_y E_{t-1}y_{t+q} + \rho_f E_{t-1}f_{t+r}\right\} \\
&\qquad \textit{if } \delta < \left(\pi_{t+p} - \pi^I_{t+p}\right)
\end{aligned}
\tag{13}
$$

[4] Martin and Milas (2010a) have noted this feature previously.

However, it is more likely to experience a smooth change from one regime to another. In that case, a so called Smooth Transition Autoregressive (STAR) model is appropriate:

$$\begin{aligned}
i_t &= \rho_i(L)i_{t-1} + (1-\rho_i)\left\{i^* + \rho_{ZD}E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right) + \rho_y E_{t-1}y_{t+q} + \rho_f E_{t-1}f_{t+r}\right\} \\
&\qquad pr\left\{-\delta \le E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right) \le \delta\right\} \\
i_t &= \rho_i(L)i_{t-1} + (1-\rho_i)\left\{i^* + \rho_{OZD}E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p} + \delta\right) + \rho_y E_{t-1}y_{t+q} + \rho_f E_{t-1}f_{t+r}\right\} \\
&\qquad pr\left\{-\delta > E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right)\right\} \\
i_t &= \rho_i(L)i_{t-1} + (1-\rho_i)\left\{i^* + \rho_{OZD}E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p} - \delta\right) + \rho_y E_{t-1}y_{t+q} + \rho_f E_{t-1}f_{t+r}\right\} \\
&\qquad pr\left\{\delta < E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right)\right\}
\end{aligned} \tag{14}$$

We model the probabilities in (14) using the logistic functions (see e.g. van Dijk *et al.*, 2002)

$$pr\left\{-\delta > E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right)\right\} = 1 - \frac{1}{1+e^{-\gamma E_{t-1}\left(\pi_{t+p}-\pi^I_{t+p}+\delta\right)/\sigma_{E_{t-1}\left(\pi_{t+p}-\pi^I_{t+p}\right)}}} \tag{15a}$$

and

$$pr\left\{\delta < E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right)\right\} = \frac{1}{1+e^{-\gamma E_{t-1}\left(\pi_{t+p}-\pi^I_{t+p}-\delta\right)/\sigma_{E_{t-1}\left(\pi_{t+p}-\pi^I_{t+p}\right)}}} \tag{15b}$$

In (15 a, b) we follow Granger and Teräsvirta (1993) and Teräsvirta (1994) in making the smoothness parameter $\gamma > 0$ dimension-free by dividing it by the standard deviation of $E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right)$. In equation (14) it is assumed that the policy maker responds to $E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p} + \delta\right)$ when inflation is below the zone of discretion and to $E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p} - \delta\right)$ when the inflation is above the zone of discretion. As an alternative to (14), equation (16) assumes that the policymaker responds to $E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right)$.

$$i_t = \rho_i(L)i_{t-1} + (1-\rho_i)\left\{\begin{array}{l} i^* + \rho_y E_{t-1}y_{t+q} + \rho_f E_{t-1}f_{t+r} + \theta_t \rho_{ZD}E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right) \\ +\left(1-\theta_t\right)\rho_{OZD}E_{t-1}\left(\pi_{t+p} - \pi^I_{t+p}\right)\end{array}\right\} + \varepsilon_t \tag{16}$$

where $\theta = pr\{-\delta \leq E_{t-1}(\pi_{t+p} - \pi^I_{t+p}) \leq \delta\}$ is the probability that the economy is within the zone of discretion. In equation (16) the response to inflation is contingent on whether inflation is within the zone of discretion. We model the probability of being within the zone using the quadratic logistic function (see, for example, van Dijk *et al.*, 2002)

$$\theta = pr\{-\delta \leq E_{t-1}(\pi_{t+p} - \pi^I_{t+p}) \leq \delta\} = 1 - \frac{1}{1+e^{-\gamma\left[E_{t-1}(\pi_{t+p}-\pi^I_{t+p}+\delta)\right]\left[E_{t-1}(\pi_{t+p}-\pi^I_{t+p}-\delta)\right]/\sigma^2_{E_{t-1}(\pi_{t+p}-\pi^I_{t+p})}}} \tag{17}$$

Note that in equation (16), we have entered output and financial conditions linearly in the model. However, we have investigated whether there is a different response of interest rates to output and financial conditions inside and outside the zone of discretion. There was no evidence of these effects[5].

3. Data description

We use South African seasonally adjusted data for the period spanning from January 2000 to December 2008. The beginning of the sample corresponds to the implementation of the official inflation targeting regime. The nominal interest rate is the repurchase rate (repo rate), inflation is the annual change in the consumer price index and output gap is measured as the log difference between industrial production[6] and its Hodrick-Prescott (HP, 1997) trend. The financial index is constructed as an average of (i) the real effective exchange rate $(REER_t)$ where the rand appreciation increases the index; (ii) the house price index (RH_t) compiled by the ABSA bank, deflated by the consumer price index; (iii) the stock price (RS_t) which is measured by the Johannesburg Stock Exchange All Share index, deflated by the consumer price index; (iv) the credit spread (CS_t) which is the spread between the yield on the 10-year government bond and the yield on A rated corporate bonds; and

[5] These results are available from the authors upon request. Similar conclusions have been found by Naraidoo and Kasai (2010) and Naraidoo and Raputsoane (2010) in the context of financial market conditions whereby the monetary authorities place an equal weight on financial market booms and recessions.

[6] We also note that output can be measured using the coincident business cycle indicator computed by the SARB and we have provided robustness checks in Table 3, investigating the effect of this alternative measures of the output gap (measured as the deviation of this from a Hodrick-Prescott (1997) trend. In this paper, industrial production seems to give a better explanation of the behavior of the SARB.

(v) the future interest rate spread which is the change of spread between the 3-month interest rate futures contracts (F_t) in the previous quarter and the current short-term interest rate.

The real effective exchange rate, stock price and house price variables are de-trended 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 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 Figure 1[7]. 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. Descriptive statistics are reported in Table 1.

4. Empirical results

4.1 Tests and parameter estimates

The specification which fits the data best allows for one lag of the interest rate, $p = 1$ for inflation, $q = 0$ for the output gap, and $r = 0$ for the financial index. The set of instruments includes a constant, lagged values of inflation, the output gap, the financial index, the 10-year government bond and M3 growth. Our empirical models that exclude the financial index variable performed very poorly compared to the models reported here in terms of the AIC criterion and the lagged interest rate effect turned out to be slightly higher than the one reported here, therefore providing some

[7] We have done some analysis of stationarity and this suggests that the inflation series follows a non-stationary process. ADF and PP unit root tests do not reject the null with p-values of around 0.13. However, in line with common practice, inflation is treated as stationary in our study. (See Fuhrer and Moore 1995, for discussion of similar issues).

support for an omitted variables problem as outlined in the introduction. Each case reveals strong evidence that the SARB has been reacting to financial conditions index since the null hypothesis $H_0 : \rho_f = 0$ is rejected at 1% level of significance. Column (i) of Table 2 represents estimates of equation (10), the linear Taylor rule model. We find that $\rho_i = 0.89, \rho_\pi = 0.84, \rho_y = 1.06$ and that $\rho_f = 1.10$. This particular model does not comply with the Taylor principle which stipulates that the response to inflation is expected to be in greater proportion than the variation of inflation.[8]

The second step is estimation of equation (11) which uses intermediate inflation rather than simple inflation target. Intermediate inflation target at period t, is computed as a weighted average of inflation target and historical inflation measured as an average of inflation of three previous months. We have also tried historical inflation measured as averages of 1-6, 9 and 12 months but none of these alternatives could outperform the average of three months. Findings in column (ii) of Table 2 show that the substitution of inflation target by intermediate inflation target is supported by the data. In terms of AIC the model in column (ii) does better than the model in column (i). Furthermore, it is worth noting that μ, the weight on past inflation is estimated at $\mu = 0.33$ and is statistically significant . This is evidence that intermediate inflation reveals the behavior of the policy makers of the SARB better than simple inflation target. Therefore, one of the features of opportunistic approach to monetary policy is met.

The third step is to test the consistency of the feature regarding zone of discretion. In doing so, both linear models, equation (10) in column (i) and equation (11) in column (ii), are subjected to powerful tests of linearity. The λ test by Hamilton (2001) and λ_A and g tests by Dahl and González-Riviera (2003) reject the null hypothesis of linearity.[9] We then provide estimates of the TAR model (equation (13)) in column (iii) of Table 2. We find that $\delta = 1.81$ and that the model performs better than the linear models presented in column (i) and (ii).

The fourth step is aimed at comparing the non linear models, namely equation (13), (14) and (16). With the aim to reduce the number of parameters to be estimated in equations (14) and (16) we

[8] Similar results of inflation effect being lower than one for the case of South Africa has been noted by Woglom (2003) and Naraidoo and Gupta (2010).

[9] We run the tests using Gauss codes obtained from Hamilton's web page at: http://weber.ucsd.edu/~jhamilto/software.htm#other. To account for the small sample, we report bootstrapped *p*-values of the three tests based on 1000 re-samples.

set $\mu = 0.33$ as suggested by model (11) above and $\delta = 1.81$ as estimated in column (iii). Results of model (16) in column (v) exhibits lower standard error and better AIC than any other model we have estimated[10]. Therefore, we prefer this model for further investigations regarding parameter evolution in the next section. Estimation reveals that the null hypothesis of $\rho_{ZD} = 0$ is not rejected while the null of $\rho_{OZD} = 0$ is rejected. Therefore, the preferred model supports the view that monetary policymakers of the SARB have behaved opportunistically by accommodating shocks when inflation is within the zone of discretion but reacting aggressively otherwise. From the outperforming model (16) in column (v) we report that $\rho_y > \rho_{ZD} = 0$ and that $\rho_f > \rho_{ZD} = 0$. These results indicate that the SARB turns its attention to output gap and financial conditions when inflation is reported to be within the zone of discretion. This outperforming model reveals that the zone of discretion is symmetrically extending from 1.81 percent below and above the intermediate inflation rate. Estimated zone of discretion of 3.62 percent is reasonable for the SARB as the difference between the announced lower bound and upper bound is 3 percent. Taking the official target range of 3 to 6 percent as a benchmark to our estimate, we can suggest that estimated target zone spans from 2.69 to 6.31 percent.

4.2 Recursive estimates

To obtain an idea of how the response parameters ρ_{OZD}, ρ_y, and ρ_f evolve over time, Figure 2 plots the recursive estimates (plus/minus 2*standard errors) over expanding data windows for our preferred model; equation (16). The response to inflation is relatively stable up until August 2007. From February 2008 onward, the Taylor principle did not hold as the coefficient was slightly less than unity. A plausible explanation is that the authority was faced with high uncertainty over evolving economic conditions with the oncoming recession, having been in a boom recently. The response to the output gap was relatively unstable early 2006 but has started declining consistently only toward the third quarter of 2007. However, it should be kept in mind that Orphanides (2001)

[10] We have conducted a series of robustness checks, investigating the effect of alternative measures of the output gap. Our results were robust to these alternative specifications as shown in Table 3. We have estimated models based on three alternative measures of output gap for equation (16); namely output gap using industrial production (the one in the main text), output gap using the coincident business cycle indicator (measured as the deviation of this from a Hodrick-Prescott (1997) trend) and output growth. The SARB provides measures of the coincident business cycle indicator and it is made publicly available. In this paper, the model with industrial production provides better AIC.

and in particular Orphanides and van Norden (2002) have suggested the use of real time data in monetary policy since data used to compute output gap are subject to significant revisions. A possible explanation of our findings is that the magnitude of the response using final data for the output gap could suffer from downward bias owing to the errors-in-variables problem. Panel (c) in figure 2 reveals a more volatile response to financial index increasing from 0.56 early in 2006 to 1.00 late in 2007. Since then, the response to financial conditions decreased significantly until it reaches 0.36 in the third quarter of 2008. This relatively more frequent volatility advocates in favor of the concern raised by Bernanke and Gertler (1999) and Filardo (2000) about the potential costs of responding to asset price given its volatility relative to their information content. Overall, the 2007-2009 financial crisis witnesses an overall decreased reaction to inflation, output and financial conditions amidst uncertainty of the oncoming recession, given that the economy has gone through a period of prolonged boom recently.

5. Conclusion

With the aim to test whether the SARB's monetary policy makers have behaved opportunistically, we have estimated monetary policy reaction function for the period spanning from 2000M1 to 2008M12. We first test whether monetary policy makers of the SARB have been using intermediate inflation target rather than simple inflation target. The equations that include intermediate rather than simple inflation target improve the fit of the models. For linear models we use powerful tests for linearity and find that the null of linear model is rejected by the data. In addition, we test whether policy makers have been responding aggressively to inflation when it is outside the zone of discretion but accommodating the shock when inflation is within the target zone. We compare different linear and non linear models and find that a smooth transition model, supporting the view of opportunistic approach, fits the data better. In our preferred model, we find that the zone of discretion is symmetric, extending from 1.64 percent below and above the intermediate inflation rate. Estimated inflation target range of 3.62 percent is reasonable for the SARB as the difference between the announced lower bound and upper bound is 3 percent. Taking the official target range of 3 to 6 percent as a benchmark to our estimate, we can suggest that the estimated target zone spans from 2.69 to 6.31 percent.

With the aim to appraise how monetary policy makers have behaved during the sub-prime crisis, we have also assessed parameter evolution of the preferred model by recursive estimation of the data window adding one data point at each time. We find that in general the 2007-2009 financial crisis witnesses an overall decreased reaction to inflation, output and financial conditions amidst uncertainty of the oncoming recession, having gone through a boom recently.

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Table 1: Descriptive statistics of the main variables

	i_t	π_t	y_t	fin_index_t	$(REER_t)$	(RH_t)	(RS_t)	(CS_t)	(F_t)
Mean	9.98	5.87	0.32	0.10	0.14	0.09	0.13	1.23	-0.04
Median	10.00	5.40	0.26	0.11	0.49	0.47	-0.11	1.21	0.02
Maximum	13.50	13.70	4.85	2.82	2.92	2.09	8.88	2.30	30.97
Minimum	7.00	0.20	-4.24	-3.26	-4.20	-3.28	-13.31	-1.33	-29.50
Std. Dev.	2.14	3.32	1.91	0.90	1.43	1.40	4.65	0.43	8.26
Skewness	0.01	0.46	0.20	-0.17	-0.96	-0.69	-0.19	-1.62	0.12
Kurtosis	1.61	2.69	3.00	4.45	3.77	2.57	2.90	13.28	5.19
Jarque-Bera	8.33	4.12	0.76	9.84	19.33	9.55	0.73	523.58	21.89
Probability	0.01	0.12	0.68	0.01	0.00	0.01	0.69	0.00	0.00

Table 2: GMM estimates of the Opportunistic Approach on SA data, (2000:M1-2005:M12)

	(i)	(ii)	(iii)	(iv)	(v)
ρ_i	0.89 (0.01)	0.89 (0.01)	0.87 (0.01)	0.87 (0.01)	0.86 (0.01)
ρ_π	0.84 (0.02)	1.31 (0.22)			
ρ_{ZD}			0.71 (0.28)	-10.89 (3.03)	-0.58 (0.43)
ρ_{OZD}			1.18 (0.19)	0.67 (0.20)	1.08 (0.06)
ρ_y	1.06 (0.15)	0.85 (0.08)	0.68 (0.12)	0.69 (0.13)	0.58 (0.12)
ρ_f	1.10 (0.11)	1.01 (0.09)	0.81 (0.14)	0.74 (0.09)	0.56 (0.12)
μ		0.33 (0.08)	0.18 (0.11)	0.33 (0.08)	0.33 (0.08)
δ			1.81 (0.41)	1.81 (0.41)	1.81 (0.41)
S.E	0.373	0.369	0.367	0.372	0.365
AIC	0.944	0.920	0.936	0.938	0.897
H_0: $\rho_{ZD} = \rho_{OZD}$ (*p* value)			0.026	0.000	0.000
J-statistic (*p* value)	0.998	0.998	0.997	0.998	0.999
λ test (*p* value)	0.001	0.01			
λ_A test (*p* value)	0.000	0.00			
g test (*p* value)	0.001	0.01			

Notes: Numbers in parentheses are standard errors. S.E is the regression standard error. AIC is Akaike Information criterion. J-statistic is the *p*-value of a chi-square test of the model's over-identifying restrictions (Hansen, 1982). The set of instruments includes a constant and 12 lagged values of the regressors included in the model. The table also reports bootstrapped *p*-values of the λ, λ_A, and g tests based on 1000 re-samples.

Table 3: GMM estimates using alternative measures of output gap

Coefficients	**Nonlinear (quadratic logistic)**		
	(a)	**(b)**	**(c)**
ρ_i	0.88 (0.01)	0.86 (0.01)	0.87 (0.01)
ρ_π			
ρ_{ZD}	0.34 (0.38)	-0.58 (0.43)	-0.44 (0.68)
ρ_{OZD}	1.23 (0.10)	1.08 (0.06)	1.21 (016)
ρ_y	0.36 (0.08)	0.58 (0.12)	0.24 (0.06)
ρ_{index}	0.37 (0.10)	0.56 (0.12)	0.52 (0.17)
μ	0.40 (0.09)	0.33 (0.08)	0.33 (0.05)
δ	2.36 (0.37)	1.81 (0.41)	1.77 (0.37)
AIC	0.902	**0.897**	0.930
S.E	0.366	**0.365**	0.365
J-Stat (P-value)	0.998	0.999	0.998

Where:

(a) Output gap is measured as the log difference between the business indicator and its Hodrick-Prescott (HP, 1997) trend;

(b) Output gap is measured as the log difference between the industrial production and its Hodrick-Prescott (HP, 1997) trend;

(c) Model using output growth rather than output gap. The output growth is measured as the annual growth of industrial production.

Figure 1: Interest rate, inflation, output measures and financial index

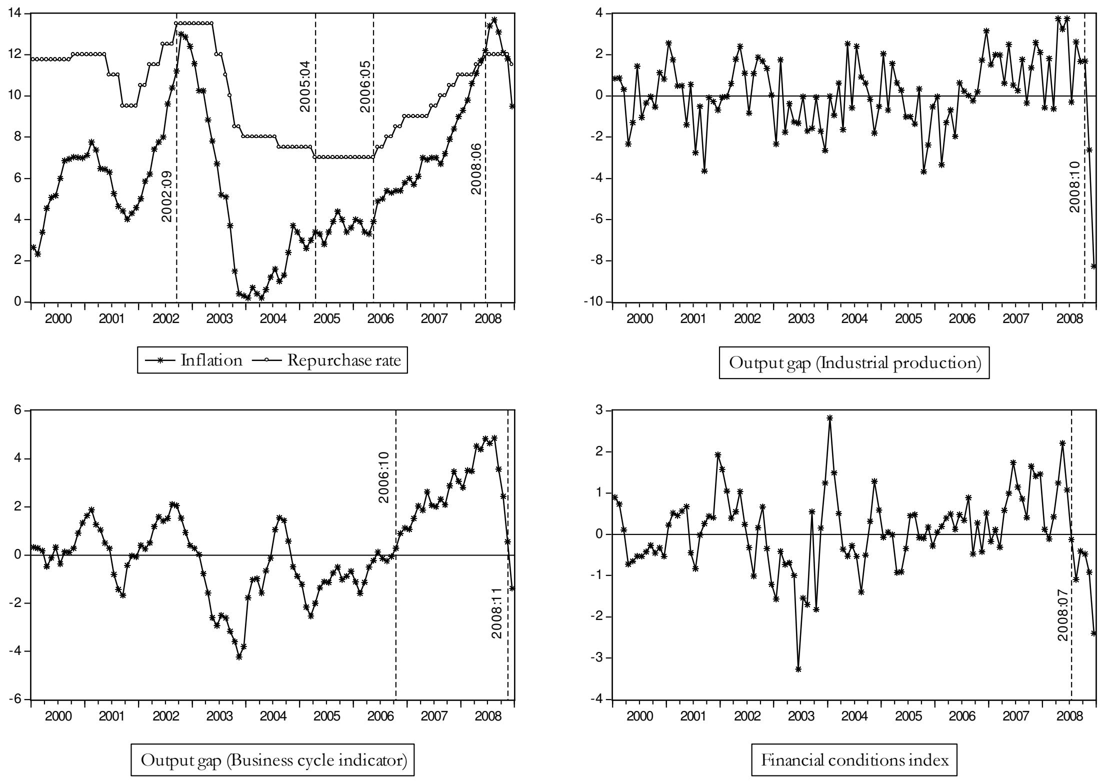

Figure 2: Recursive estimates