

Chapter 5

Financial assets, linear and nonlinear policy rules: an in-sample assessment of the reaction function of the South African Reserve Bank³

5.1. Introduction

This chapter investigates the objectives of the South African Reserve Bank (the SARB, hereafter) in the light of instrument rules. More precisely, we use 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. Recently however, 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 banks⁴, a nonlinear Phillips curve (Schaling, 2004) or, if it follows the opportunistic approach to disinflation (OAD) (Aksoy *et al.*, 2007).

³ Forthcoming in the Journal of Economic Studies. We thank an anonymous referee of the Journal of Economic Studies and a referee of the ERSA for their helpful comments, seminar participants at the University of Pretoria, participants at the African Econometric Society conference and the Economic Society of South Africa conference for valuable feedback on this chapter.

⁴A number of other studies have made use of these types of preferences; Bec *et al.*, 2002; Cukierman, 2002; Huang and Shen, 2002 and Ruge-Murcia, 2003.

These abovementioned nonlinear specifications have been the subject of intense debate in the last few years and recent economic events have turned the attention on the behaviour of certain asset prices (stock prices, house prices, the exchange rate) and the concern by central banks over the maintenance of financial stability (see Bernanke and Gertler, 2001; Chadha *et al.*, 2004). The view that a central bank's objective function (which addresses inflation and output stabilisation ignoring movements in assets prices and other financial variables) may be too restrictive is gaining momentum. For instance, De Grauwe (2007) argues that asset prices should be targeted as central banks cannot avoid taking more responsibilities beyond inflation targeting. In particular the vice president of the European Central Bank, Papademos (2009), in a similar remark said that "... close monitoring and deeper analysis of asset price movements, monetary and credit developments, ...can provide valuable information for the conduct of monetary policy." He further argues that "The ECB's monetary policy strategy provides a framework for such analysis." However, it should be kept in mind that Mishkin (2008) points out that asset price bubbles are hard to identify and even if they are identified, their response to interest rates is far from certain.

In the South African context, it is worth noting that one of the SARB's primary goals is to protect the value of the currency and achieve and maintain financial stability. This implicit goal might be the reason why the South African financial institutions experienced no direct exposure to the subprime crisis in terms of interbank or liquidity problems of the type experienced in developed countries (see Mboweni, 2008a, 2008b and Mminele, 2009). The current governor of the SARB, Gill Marcus (2010) has

emphasised that the central bank has an implicit financial stability mandate. But the question is how does the SARB fulfil this implicit financial stability mandate? Does the SARB respond to financial fluctuations?

Few works in the monetary policy literature have concentrated on nonlinear models and fewer have considered the financial index as a variable targeted by central bankers. For a recent work using such an index, Castro (2010) shows that, in contrast to the Federal Reserve and the Bank of England, ECB policymakers pay close attention to financial conditions when setting the Euro zone interest rate. This marks a significant point of departure of the chapter: using inflation, output and a proxy for financial conditions as the main underlying variables, the thesis examines whether monetary policy in the form of nonlinear Taylor type rule models can provide additional information over a linear model. This is motivated by a widespread dissatisfaction with the assumption that the interest rate's response to inflation and output is constant whatever the state of the economy. Asymmetric and zone models have econometrically dominated linear policy rules. For instance, Boinet and Martin (2008) and Martin and Milas (2010a), have recently reported the outperformance of nonlinear policy rules over the linear ones in explaining central banks' monetary policy setting of the interest rate in-sample at least. In this chapter, we employ an extension of the linear Taylor rule to a regime-switching framework, where the transition from one regime to the other occurs in a smooth way. The switching between regimes is controlled by output. This feature of the smooth transition model allows to test the ability of the state of the business cycles in describing the nonlinear dynamics of the interest rate in South Africa. Given the results reported in

chapter 4, this chapter chooses the financial conditions index constructed as an equal weight average of the real effective exchange rate, real house prices, real stock prices, credit spread and futures interest rate spread.

To assess the ability of the alternative policy rules to predict the SARB's interest rates in-sample, we use final data. All models are estimated over sequences of both recursive expanding windows of data and fixed-length rolling windows of data. Recursive and rolling estimations of the policy rules provide significant information on how the response coefficients to inflation, output and financial conditions have varied across times and across regimes (the state of business cycles).

The chapter reports five main findings. First, we find that the nonlinear Taylor rule improves its performance with the advent of the financial crisis, providing the best description of in-sample SARB interest rate setting behaviour with fixed-length rolling window estimation. The latter estimation technique is better able to capture parameter shifts as the crisis unfolds. However, one should also keep in mind that the number of crisis observations as a proportion of the total number of observations is greater in the case of fixed-length rolling estimation and thus the parameters can be more sensitive to changes over time and would therefore provide more accurate information as to how the SARB has reacted with the advent of the crisis. Secondly, the SARB policy-makers pay close attention to the financial conditions index when setting interest rates; the effect of the index remains significant even when nonlinearities are accounted for. Thirdly, given that inflation has been relatively high during most of the sample period

(see Tawadros, 2009, who evaluated inflation targeting effect on inflation for 27 countries that have adopted an inflation-targeting regime), the SARB's response of monetary policy to inflation is greater during business cycle expansions and lower during economic downturns. By contrast, high importance is placed on output during downturns. Fourthly, the 2007-2009 financial crisis witnesses an overall decreased reaction to inflation and financial conditions amidst uncertainty on the onset of recession. Fifthly, rolling estimation reveals that inflation, the output gap and financial index coefficients are remarkably unstable since mid 2007 with the onset of the crisis.

The chapter proceeds as follows. Section 5.2 summarises the linear and nonlinear models. Section 5.3 reports the in-sample analysis. Section 5.4 provides some concluding remarks.

5.2. Linear and nonlinear Taylor rule models

The model specification of this chapter departs from equation (2.10) which allows a forward looking version and the inclusion of the financial conditions index f as follows

$$\hat{i}_t = \rho_0 + \rho_\pi \pi_{t+p} + \rho_y y_{t+q} + \rho_f f_{t+r} \quad (5.1)$$

As in chapter 2, $\rho_0 = r^* - \alpha_\pi \pi^*$, $\rho_\pi = 1 + \alpha_\pi$, $\rho_y = \alpha_y$, $y_t = Y_t - Y_t^*$ and \hat{i}_t is the desired nominal interest rate. π_{t+p} is the inflation rate expected at time $(t + p)$, y_{t+q} is the

output gap expected at time $(t+q)$, f_{t+r} is a measure of financial conditions index expected at time $(t+r)$ used to augment the original rule,⁵ ρ_π is the weight on inflation, ρ_y is the weight on output gap and ρ_f is the weight on the financial conditions index. The inclusion of the financial index is based on the assumption that policymakers have preferences for this index being close to equilibrium, reflecting their desire to stabilise the financial system. Walsh (2009) points out that when financial factors cause distortions, these distortions will in general introduce corresponding terms in a loss function for monetary policy (see for example the theoretical model of Martin and Milas, 2010b; Papademos, 2009, re-iterates that the ECB aims at safeguarding financial stability in addition to achieving price stability). An alternative theoretical justification for the inclusion of the financial index in the policy rule is that the index determines movements in the differential between policy rates and 3-month interbank rates, the latter being the benchmark for private sector interest rates (see for example Martin and Milas, 2009).

Given the above, the financial conditions index is included in the Taylor rule that allows for interest rate smoothing (see e.g. Woodford, 2003). Interest rate smoothing is also in line with gradualism in the conduct of monetary policy as suggested by Helder and Manoel (2010). Hence, it is assumed that the actual nominal interest rate, i_t , adjusts towards the desired rate as follows

⁵The theoretical justification for including the financial conditions measure might either be that it enters the aggregate demand curve, similar to Castro (2008) or Goodhart and Hoffman (2002) or still the policymaker might have preferences for this index being close to equilibrium as in Naraidoo and Raputsoane (2010).

$$i_t = \rho_i(L)i_{t-1} + (1 - \rho_i)i_t^* \quad (5.2)$$

We write the empirical Taylor rule as

Model 1:

$$i_t = \rho_i(L)i_{t-1} + (1 - \rho_i)\{\rho_0 + \rho_\pi\pi_{t+p} + \rho_y y_{t+q} + \rho_f f_{t+r}\} + \varepsilon_t \quad (5.3)$$

where, $\rho_i(L) = \rho_{i1} + \rho_{i2}L + \dots + \rho_{in}L^{n-1}$ (we can use $\rho_i \equiv \rho_i(1)$ as a measure of interest rate persistence) and ε_t is an error term.

The theoretical basis of the linear Taylor rule (5.3) comes from the assumption that policymakers have a quadratic loss function and that the aggregate supply or Phillips curve is linear. Asymmetric preferences, instead, lead to a Taylor rule model in which 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. This chapter considers the case where monetary policy response differs over output regimes, viz., business cycle booms versus recessions. The theoretical reason for such variation follows the work of Cukierman (2002) whereby monetary policymakers are more sensitive to negative than to positive output gaps. Furthermore, as posited by Bec *et al.* (2002), there is the widespread belief that central bankers' interventions through changes in a short-term interest rate are influenced by the state of the current and/or expected state of the business cycle.

We consider the following nonlinear policy rule

Model 2:

$$i_t = \rho_i(L)i_t + (1 - \rho_i) \left\{ \rho_0 + \theta_t^y(E_t y_{t+q}; \gamma^y; \tau) M_{1t} + (1 - \theta_t^y)(E_t y_{t+q}; \gamma^y; \tau) M_{2t} \right\} + \varepsilon_t \quad (5.4)$$

where $M_{jt} = \rho_{j\pi} E_t \pi_{t+p} + \rho_{jy} E_t y_{t+q} + \rho_{jf} f_{t+r}$ for $j=1,2$ and the function $\theta_t^y(E_t y_{t+q}; \gamma^y; \tau)$ is the weight (defined below in (5.5)), at the beginning of period t , that output in period $(t+q)$ will be less than τ percent points from equilibrium. In model (5.4), the response to inflation, the output gap and the financial index is allowed to differ between output regimes. M_{1t} is a linear Taylor rule that represents the behaviour of policymakers during business cycle recessions (when output is expected to be less than τ percentage points from equilibrium), and M_{2t} is a linear Taylor rule that represents the behaviour of policymakers during business cycle expansions. If $\rho_{1\pi} = \rho_{2\pi}$, $\rho_{1y} = \rho_{2y}$ and $\rho_{1f} = \rho_{2f}$ the model simplifies to the linear Taylor rule in (5.3). It is worth noting that if $\rho_{1\pi} < \rho_{2\pi}$ the response of monetary policy to inflation is greater during business cycle expansions and lower during business cycle recessions. The weight $\theta_t^y(E_t y_{t+q}; \gamma^y; \tau)$ is modelled using the following logistic function (see e.g. van Dijk *et al.*, 2002):

$$\theta_t^y(E_t y_{t+q}; \gamma^y; \tau) = 1 - \frac{1}{1 + e^{-\gamma^y (E_t y_{t+q} - \tau) / \sigma(E_t y_{t+q})}} \quad (5.5)$$

In (5.5) the smoothness parameter $\gamma^y > 0$ determines the smoothness of the transition regimes. We follow Granger and Teräsvirta (1993) and Teräsvirta (1994) in making γ^y

dimension-free by dividing it by the standard deviation of $E_t y_{t+q}$. The switch between regimes is endogenously determined as both γ^y and the threshold τ are estimated jointly with the remaining parameters.

5.3. In-sample analysis

Findings for the models set out in section 2 are reported in Table 6. The specification which fits the data best allows for $p = q = 3$ for inflation ($E_t \pi_{t+q}$) and output gap ($E_t y_{t+q}$) and, a current rather than a forward-looking version for the financial index ($E_t f_{t+r}$) and one lag of the interest rate. Assuming perfect foresight for inflation and output gap, we replace forecasts of inflation and output gap by final realizations of inflation and output gap and then estimate models 1 and 2 by the Generalized Method of Moments (GMM). The set of instruments includes a constant, lagged values of inflation, the output gap, the 10-year government bond, M3 growth, and the financial index.

We estimate over recursive expanding windows of data, where the first data window runs from 2000:M1 to 2005:M12, and each successive data window is extended by one observation, hence, the last data window runs from 2000:M1 to 2010:M9 (this setup delivers 57 expanding windows). From a policy point of view, this allows us to identify the evolution of the estimated model parameters over time and across regimes. For robustness reasons, however, our exercise also reports results based on a sequence of fixed-length rolling windows where each successive window is constructed by shifting

the preceding window ahead by one observation. It should be noted that in the forecasting arena, Stock and Watson (2005) have argued that recursive forecasts are more accurate than the rolling forecasts for macroeconomic datasets whereas Giacomini and White (2006) have found that rolling window can lead to substantial forecast accuracy gains over the recursive schemes. The rolling scheme can also be used to guard against moment or parameter drift which might be particularly relevant amidst the financial crisis.

5.3.1 Empirical results for the first window of estimation

Table 6 reports estimates of the Taylor rule Models 1 and 2 (linear and nonlinear models respectively) over the first data window, which runs from 2000:M1 to 2005:M12. In all cases, the inflation (ρ_π), output gap (ρ_y) and financial index (ρ_f) effects are statistically significant. For the linear model, and in line with previous literature (see e.g. Castro, 2008; Gerdesmeier and Roffia, 2005; and references therein), the inflation effect ρ_π is higher than one, satisfying the “Taylor principle” that inflation increases trigger an increase in the real interest rate. The linear model records a statistically significant effect from the financial indicator variable; a one standard deviation increase in the index relative to its mean triggers an increase in the interest rate at 0.1 percentage point. An estimate of the inflation target is derived as

$\pi^* = \frac{i^* - \rho_0}{\rho_\pi}$, where (see e.g. Clarida *et al.*, 2000) we rely on the sample mean of the interest rate (which is equal to 9.53%) as a proxy for the equilibrium nominal interest rate i^* . From Table 6, the linear model delivers an implied target of approximately

$\pi^* = 6.03\%$, which is on the upper bound of the SARB's inflation target zone of 3-6%. One can also note that implied inflation target of the nonlinear model is 6.58. The two implied inflation targets indicate the so-called hardening of the upper bound of the inflation target since the values seem close to the 6% official upper bound.

For the linear model (Model 1), the last three rows of Table 6 report Hamilton's (2001) λ -test, and the λ_A and g -tests proposed by Dahl and González-Rivera (2003). Under the null hypothesis of linearity, these are Lagrange Multiplier test statistics following the χ^2 distribution.⁶ These tests are powerful in detecting non-linear regime-switching behaviour like the one considered by Model 2. All three tests reject linearity.

From Table 6, Model 2 reports the response of interest rates to inflation, output gap and financial index effects depending on whether output gap is positive or negative with an estimated output gap threshold of zero. The smoothness parameter γ^y has an estimated value of 5, indicating a rather quick switch from one regime to another. From the nonlinear model (column 2 of Table 6) we report that $\rho_{1\pi} < \rho_{2\pi}$; hence, the response of monetary policy to inflation is greater during business cycle upturns and lower during business cycle downswing with the Taylor principle requirement not being met over business cycle downturns.

⁶ 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.

Table 6: Model estimates, 2000:M01 - 2005:M12

Coefficients	Model 1 (Linear)	Model 2 (Nonlinear)
ρ_0	2.228*** (0.48)	1.634*** (0.20)
ρ_1	0.918*** (0.01)	0.918*** (0.00)
ρ_π	1.211*** (0.06)	
ρ_y	0.240*** (0.08)	
ρ_f	0.098*** (0.01)	
$\rho_{1\pi}$		0.625*** (0.04)
ρ_{1y}		3.720*** (0.24)
ρ_{1f}		0.036* (0.02)
$\rho_{2\pi}$		1.778*** (0.04)
ρ_{2y}		0.555*** (0.09)
ρ_{2f}		0.140*** (0.01)
τ		0.00 0.00
γ^y		5.00
Implied π^*	6.034	6.580
AIC	0.983	0.975
S.E	0.380	0.370
\bar{R}^2	0.974	0.975
J-stat	0.253	0.243
λ -test	0.001	
λ_A -test	0.000	
g -test	0.001	

Notes:

- (i) Where Model 1 is $i_t = \rho_1 i_{t-1} + (1 - \rho_1) \{ \rho_0 + \rho_\pi E_t \pi_{t+3} + \rho_y E_t y_{t+3} + \rho_f E_t f_t \} + \varepsilon_t$ and Model 2 is $i_t = \rho_1 i_{t-1} + (1 - \rho_1) \{ \rho_0 + \theta_i^y (y_t; \gamma^y; \tau) M_{1t} + (1 - \theta_i^y) (y_t; \gamma^y; \tau) M_{2t} \} + \varepsilon_t$ with $M_{jt} = \rho_{j\pi} E_t \pi_{t+3} + \rho_{jy} E_t y_{t+3} + \rho_{jf} E_t f_t$ for $j=1, 2$ and y_t is the transition variable.

- (ii) Numbers in parentheses are standard errors. *(**)[***] indicate that the parameter is significant at a 10(5)[1] % level respectively. The implied target π^* is derived as $\pi^* = \frac{i^* - \rho_0}{\rho_\pi}$, where $i^* = 9.53\%$. AIC is the Akaike

Information Criterion. J stat 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, 1-6, 9, 12 lagged values of repo rate, the inflation, the output gap, the 10-year government bond, money (M3) growth, and the financial index. The table also reports bootstrapped p -values of the λ , λ_A , and g tests based on 1000 re-samples.

Also, $\rho_{1y} > \rho_{2y}$, suggesting that the SARB reacts very aggressively to output gap in recessionary states of the economy. The results also reveal that $\rho_{1f} < \rho_{2f}$, that is, a stronger response to the financial conditions index during business cycle upturns than during business cycle downturns. In fact, Rudebusch (2002) 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-Kristen (2003) 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) analyse the influence of a term structure variable in policy rules). Keeping this in mind, the empirical models that exclude the financial index variable performed very poorly compared to the models reported here in terms of the AIC criterion. Therefore, the conclusion is that the SARB pays close attention to financial conditions when setting interest rate; moreover, the response to the financial index depends on the state of the economy, viz., the business cycles.

5.3.2 Parameter evolution with recursive expanding windows of estimation

To get an idea of how the response parameters ρ_{π} , ρ_y , and ρ_f evolve over time, Figures 4 and 5 plot respectively the recursive estimates (plus/minus 2*standard errors) over expanding data windows and the implied inflation target rate, π^* for Model 1. Figures 6 and 7 plot respectively recursive estimates (plus/minus 2*standard errors) of

the response parameters $\rho_{j\pi}$, ρ_{jy} , ρ_{jf} ($j=1,2$) and the implied inflation target rate, π^* for Model 2.

For the linear model (Figure 4), the response to inflation is relatively stable up until late 2007 after which it drops. The response to the output gap increases initially till end of 2007, then surprisingly falls significantly in the second semester of 2008. A possible explanation of our findings is that during that period the SARB has tended to focus exclusively on the double digit inflation. Indeed, the level of inflation was on average 11.5% which is almost the double of the upper bound of inflation target zone. The response to the financial index remains relatively stable until early 2009 but after which it drops slightly. Overall, the reaction to the objectives of the central bank has dropped. A plausible explanation is that the authority was faced with high uncertainty over evolving economic conditions with the onset of recession, having been in a boom recently. The evolution of the implied target inflation rate depicted in Figure 5 has been relatively stable with a slight upward tendency to deviate from the target zone of 3-6%, conformed to the fall in the response to inflation over the recent business cycle downturn.

Figure 4: Recursive coefficients for the linear model

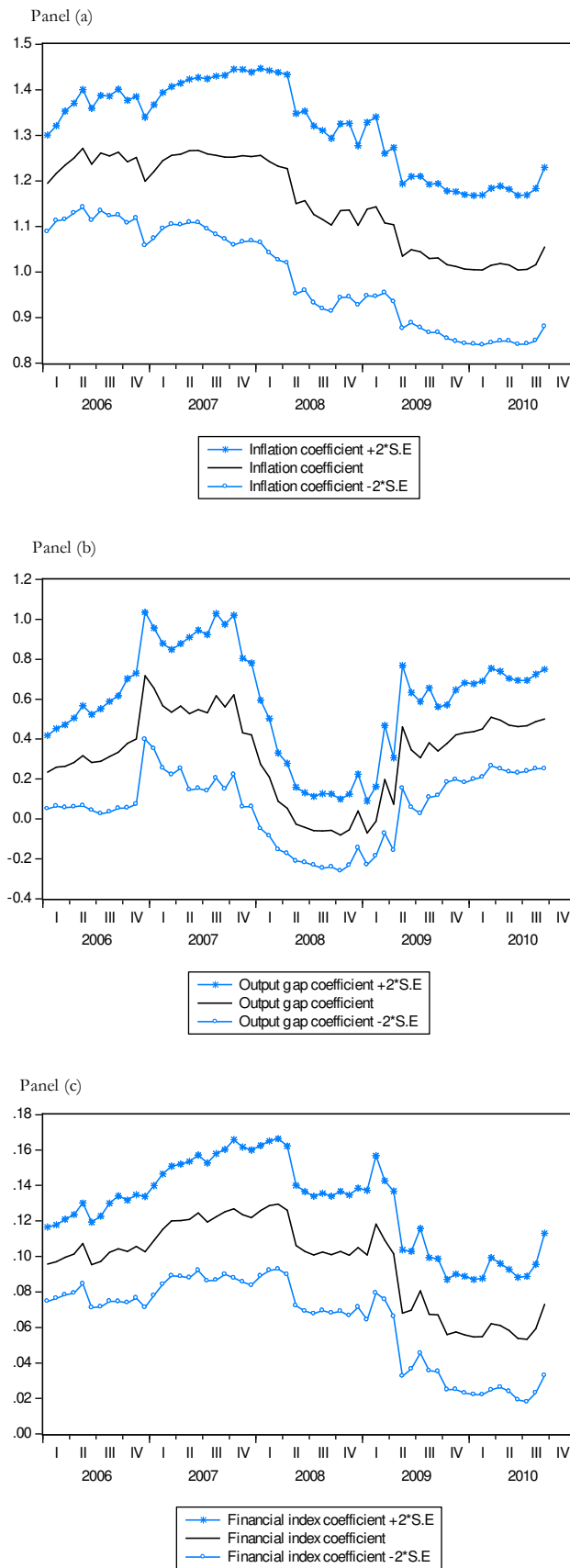


Figure 5: Implied inflation target for the linear recursive model

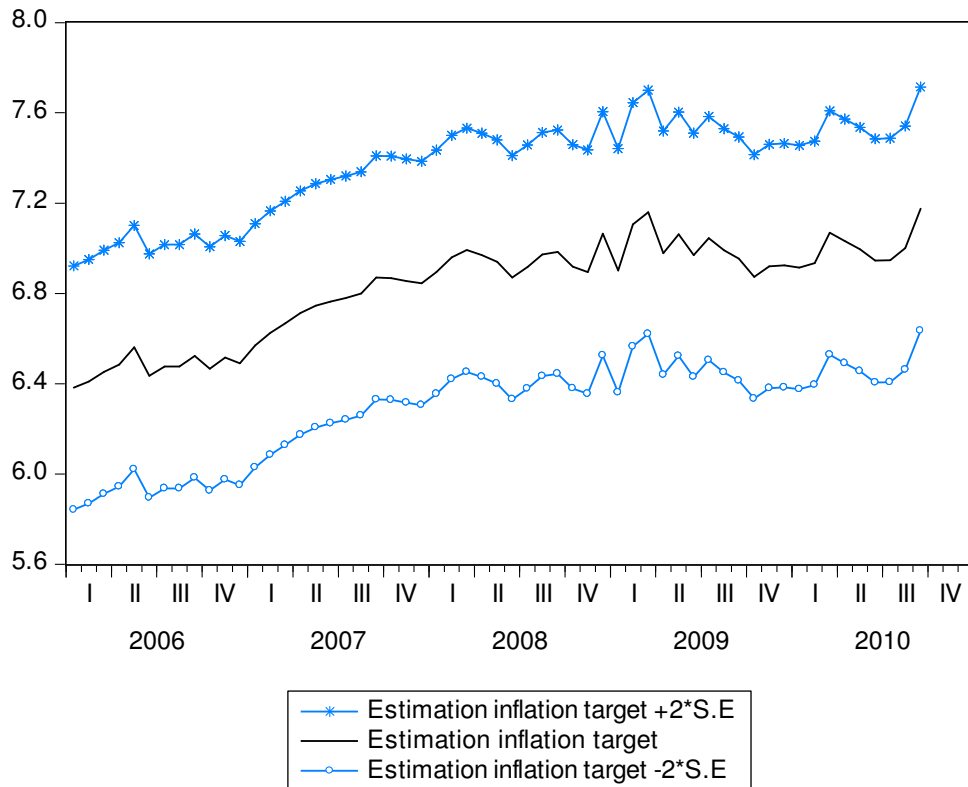


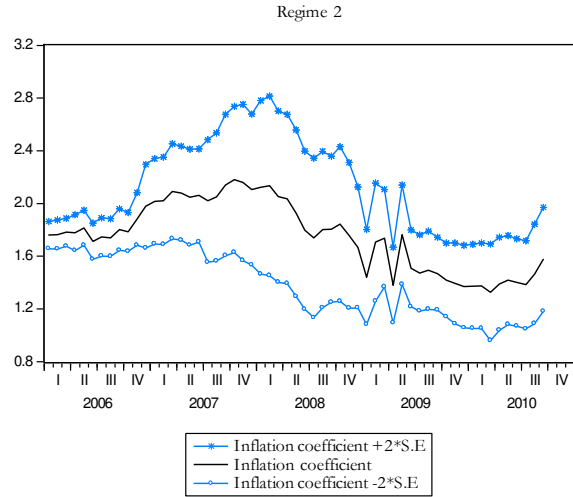
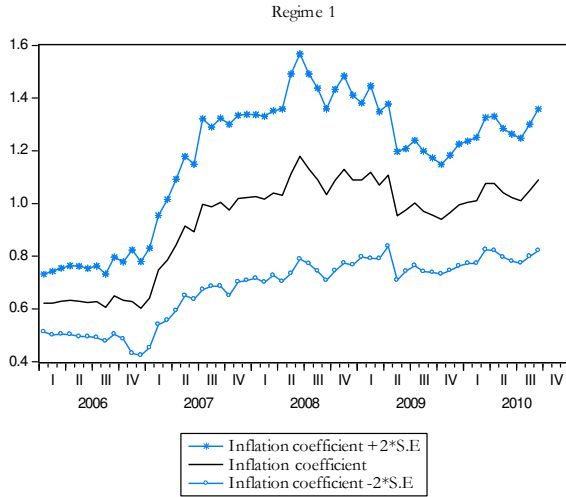
Figure 6 plots the recursively estimated response coefficients $\rho_{1\pi}$, ρ_{1y} , ρ_{1f} , $\rho_{2\pi}$, ρ_{2y} , and ρ_{2f} for the nonlinear Model 2. In this model, the policy response switches from $\rho_{1\pi}$, ρ_{1y} and ρ_{1f} to $\rho_{2\pi}$, ρ_{2y} and ρ_{2f} , respectively depending on whether expected output gap is below or above the threshold level. The recursively estimated inflation coefficients $\rho_{1\pi} < \rho_{2\pi}$ support our earlier findings over the first window of estimation. From 2007 onward, the response to inflation over business cycle upturns has declined slightly while that over recessionary states suggests an upward movement. From early 2007 onwards and as we move into the financial crisis period, the policy

response to the output gap over business cycle booms has increased while the response has dropped dramatically over business cycle recessions and has become largely insignificant. The financial index response is marginally higher over business cycle upturns versus downturns beginning of 2006. However as the financial crisis unfolds, the response to the financial conditions becomes more important in downturns than in upturns.

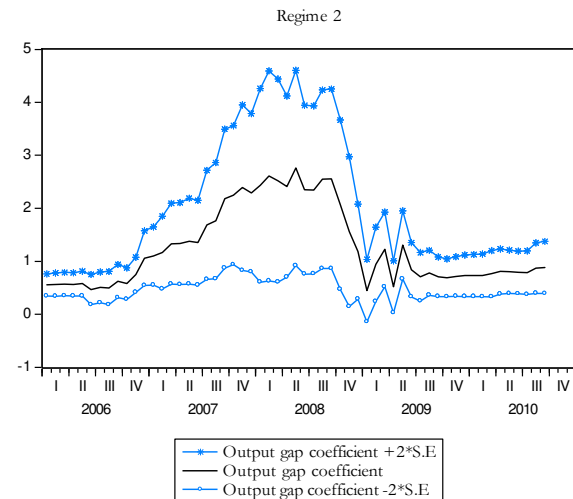
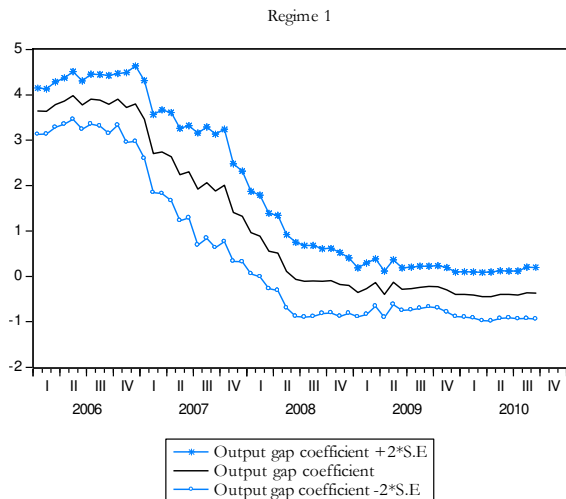
The results also reveal that the monetary authorities pay close attention to the financial conditions index when setting interest rates by allowing an asymmetric response to financial conditions depending on whether the business cycle is in upturn or in downturn. The nonlinear estimates indicate that the SARB has kept its firm instance on targeting inflation given South Africa's past history of high inflation and the concern for output stabilisation seems to drop as the crisis unfolds. This result should however be taken with caution as the uncertainties associated with measuring the output gap have largely been documented in the field and the lack of real time data leaves us with no strong conclusion to draw. The crisis also saw a shift from a symmetric policy response to financial conditions, to a more asymmetric response depending on the state of the economy. According to Mminele (2010), "inflation targeting in effect tries to strike a balance between the application of inflexible policy rules and potentially undisciplined monetary policy discretion, and has been aptly referred to by Bernanke (2003) as a framework of constrained discretion." He also reiterates that the SARB is undoubtedly a flexible inflation targeter rather than a strict inflation targeter. As such, the SARB has discretion as to the time horizon for bringing inflation back into the target range.

Figure 6: Recursive coefficients for the nonlinear model

(a) Inflation



(b) Output gap



(c) Financial conditions index (FCI_{EW})

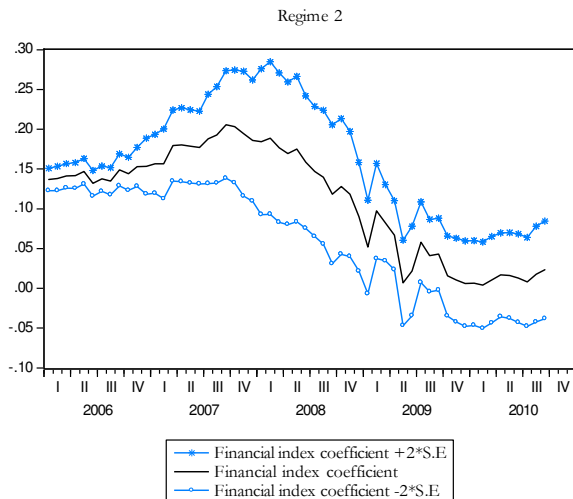
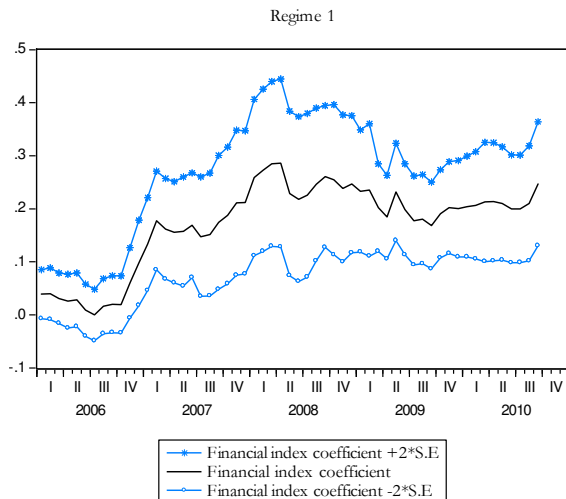


Figure 7: Implied inflation target for the nonlinear model

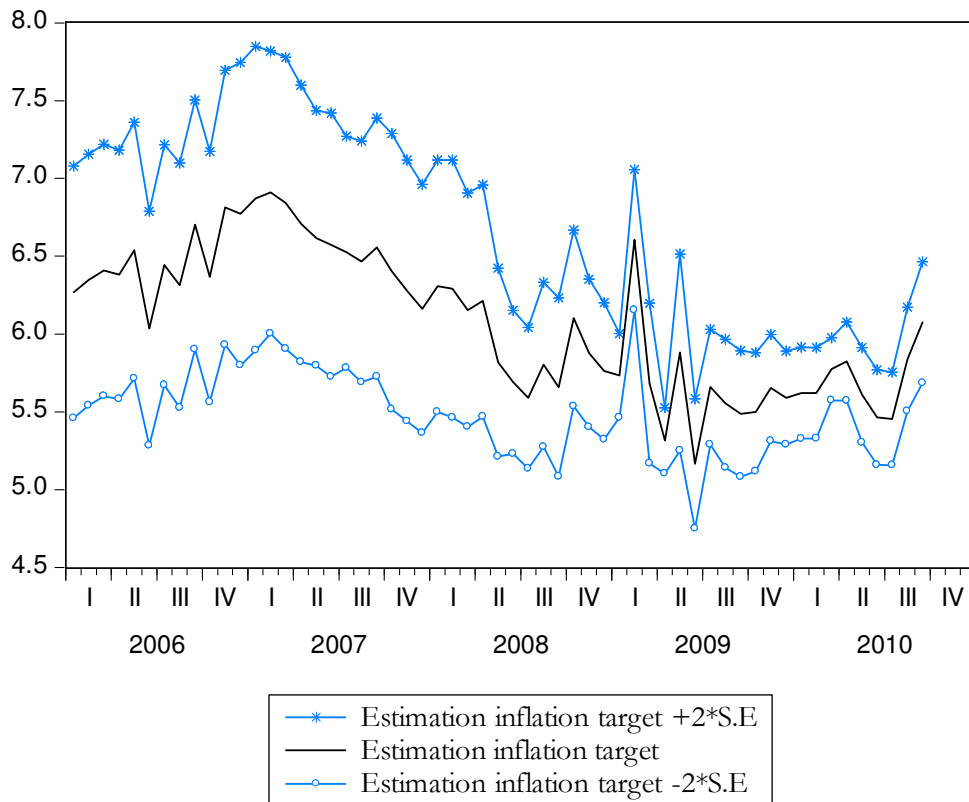
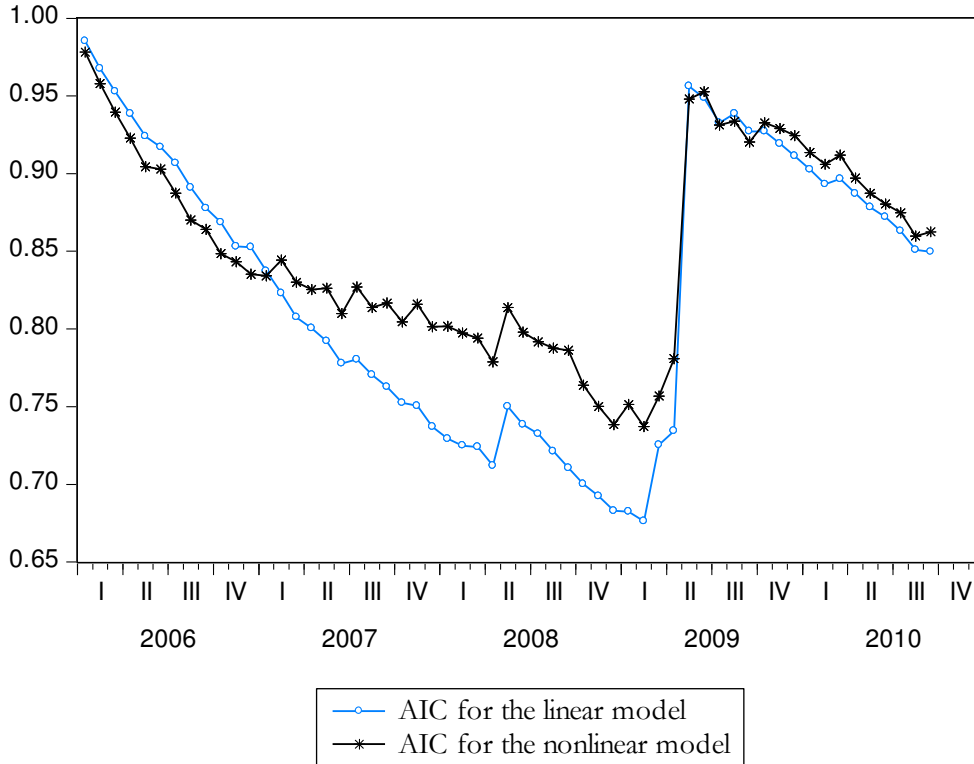


Figure 7 depicts the estimated implied inflation target rate for the recursive nonlinear model is relatively stable around the upper bound and the confidence intervals get relatively narrower with the change of the CPI's definition.

An inspection of recursive models shows that there is very little to discriminate amongst the estimated Taylor rule models in terms of the adjusted R^2 and the regression standard error. Figure 8 plots the recursive AIC values for both linear and nonlinear recursive

models. On average, Model 1 (the linear model) records lower Akaike Information Criterion (AIC).

Figure 8: AIC for linear and nonlinear recursive models



5.3.3. Parameter evolution with fixed-length rolling windows of estimation

Figure 9 plots the rolling fixed-length window estimated response coefficients (plus/minus 2*standard errors) ρ_π , ρ_y , ρ_f for the linear Model 1 and figure 11 plots the rolling estimates (plus/minus 2*standard errors) $\rho_{j\pi}$, ρ_{jy} , ρ_{jf} ($j=1,2$) for Model 2.

Figure 9: Rolling coefficients for the linear model

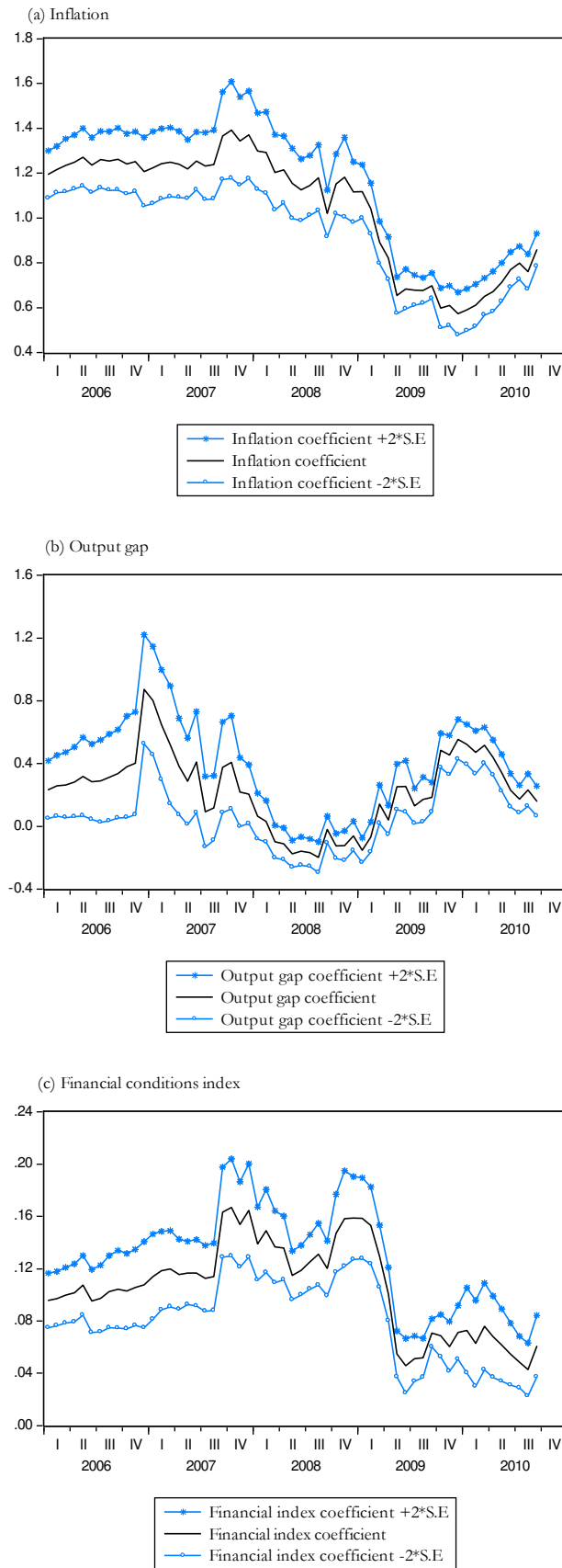


Figure 9 displays similar patterns for the responses to inflation, output gap and financial conditions as obtained under the recursive estimation, with a somewhat stronger and more volatile response since the onset of the financial crisis onward. The implied inflation target reported in Figure 10 has constantly increased above the upper bound of 6%.

Figure 10: Implied inflation target for the linear rolling model

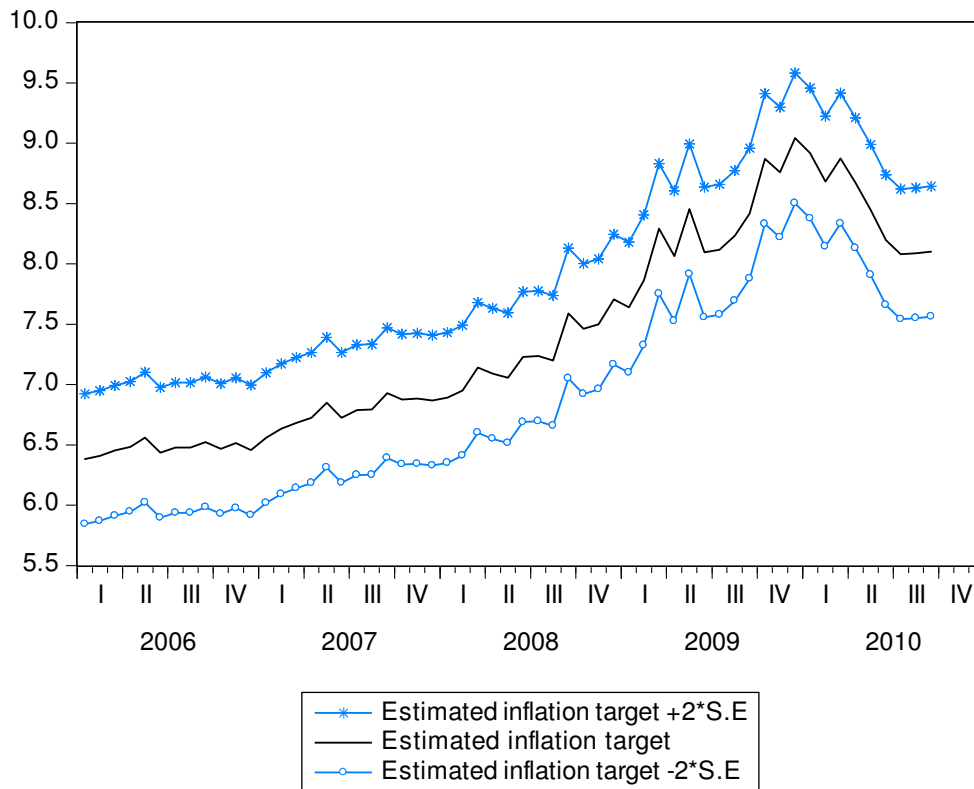
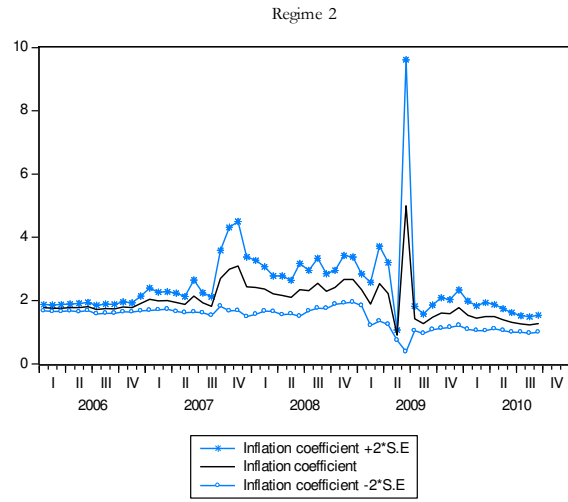
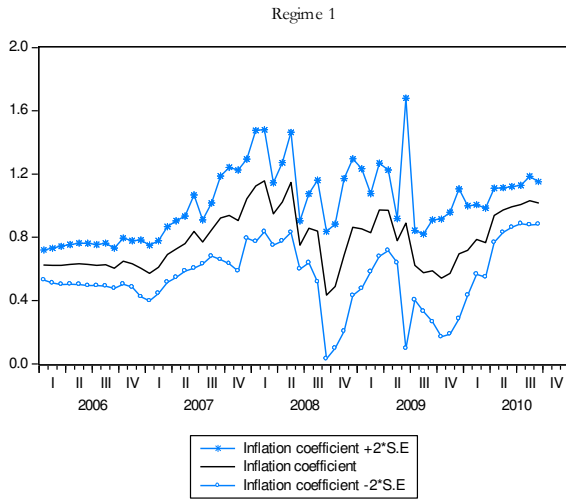
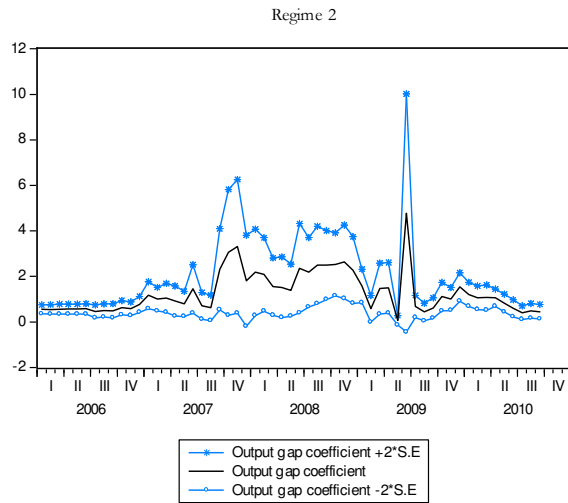
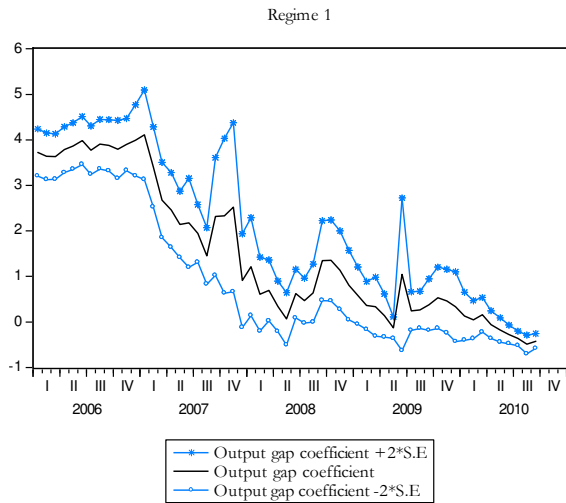


Figure 11: Rolling coefficients for the nonlinear model

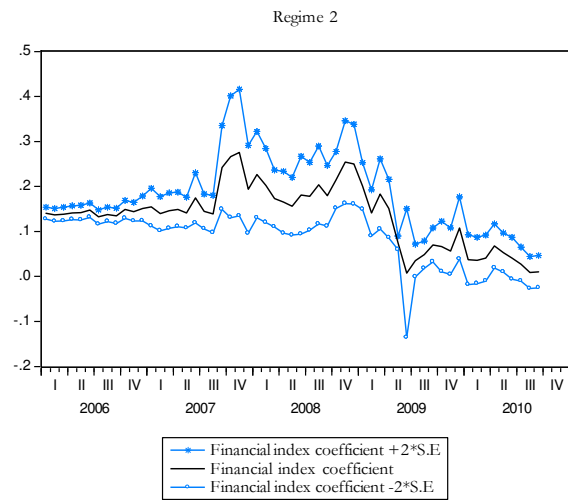
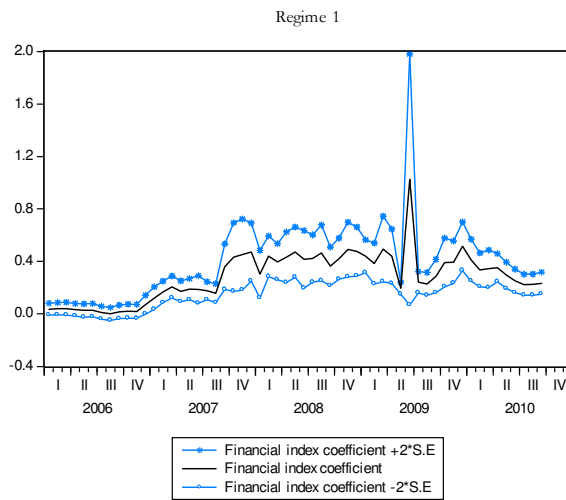
(a) Inflation



(b) Output gap



(c) Financial conditions index



A stark finding comes with an inspection of Figure 11 with volatile responses toward the end of 2007. Findings make clear that the rolling estimated inflation coefficients $\rho_{1\pi} < \rho_{2\pi}$ support our earlier results with the recursive estimation, with a more volatile response during business cycle downturns post 2007. From early 2007 onwards and as we move into the financial crisis period, the policy response to the output gap has dropped dramatically over business cycle recessions and has become largely insignificant while the response over business cycle booms has been relatively stable. The recursively estimated financial index coefficients ρ_{1f} and ρ_{2f} are fairly stable suggesting a sustained response to financial markets in the SARB monetary policy. There is also a volatile implied inflation target rate around the official upper bound of 6% which confirms the so-called hardening of the upper bound.

Figure 12: Implied inflation target for the nonlinear rolling model

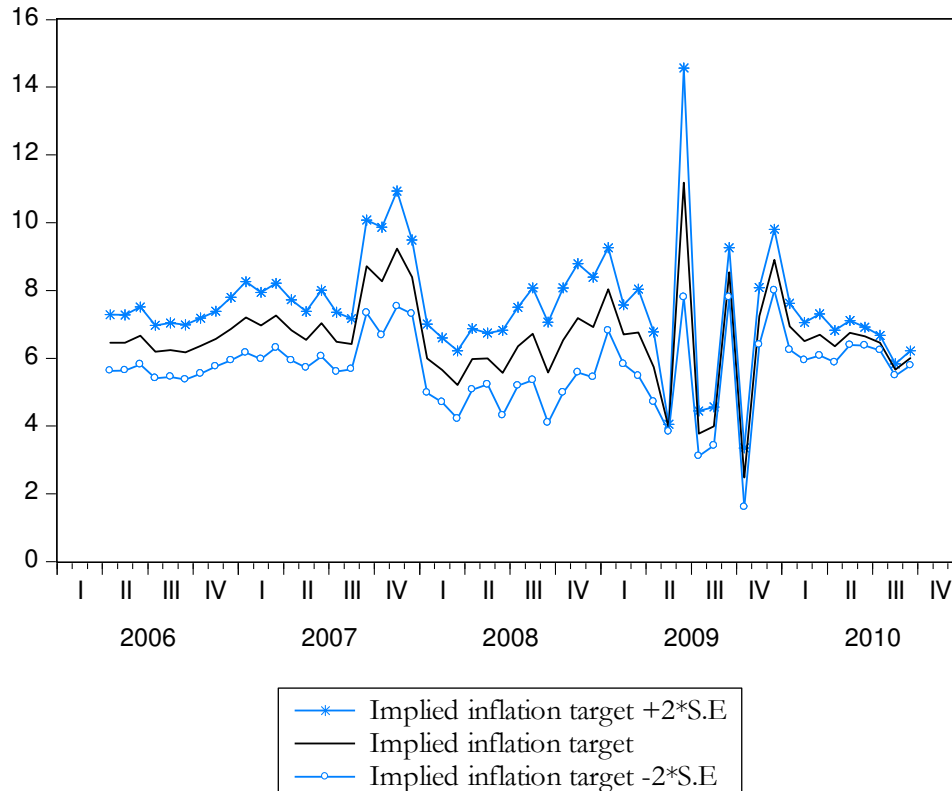


Figure 13: AIC for linear and nonlinear rolling models

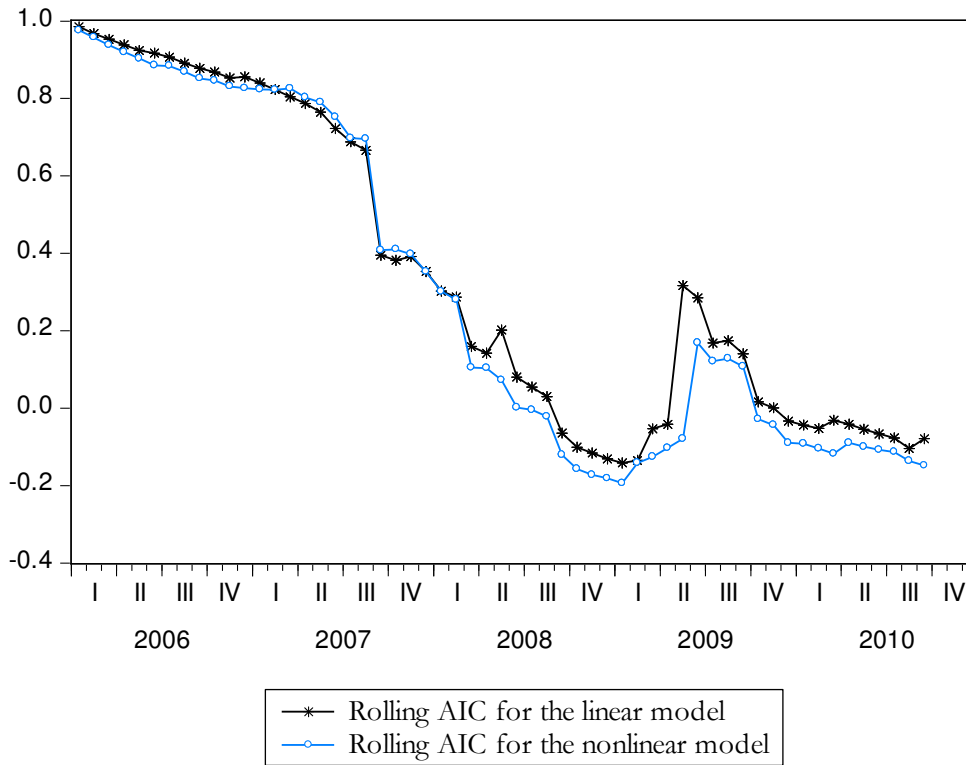


Figure 13 plots the rolling AIC values for both linear and nonlinear models. Unlike the recursive models, the nonlinear model under fixed-length rolling estimation records the lower AIC criterion and consistently dominates the linear estimates with the oncoming of the financial crisis.

5.4. Conclusions

In this Chapter we investigate both linear and nonlinear Taylor type monetary policy reaction functions for the SARB. Using inflation, output and a proxy for financial conditions as the main underlying variables, the study assesses policy in-sample. In addition, recursive and rolling estimations of the policy rules are performed with the aim to provide significant information on how the response coefficients to inflation, output and financial conditions have varied across times and across regimes (with respect to the state of the economy, viz., the business cycles).

We find that the nonlinear model under fixed-length rolling estimation records the best description of the interest rate setting behaviour of the SARB. The estimation unanimously shows that the SARB pays close attention to the financial conditions index when setting interest rates. Furthermore, we also found that owing to the relatively high inflation rate over the sample period, the SARB's response of monetary policy to inflation is greater during business cycle expansions with low response to output and a higher weight placed on output during recession periods. On the other hand, the 2007-2009 financial crisis witnesses a more asymmetric response to financial conditions depending on whether the business cycle is in upturn or in downturn. Rolling estimation reveals that inflation, output gap and financial index coefficients are highly unstable since mid 2007.

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.

Chapter 6

The opportunistic approach to monetary policy and financial market conditions⁷

6.1. 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 behave rationally and so 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 the economy. As such, the inflation

⁷ Revised and resubmitted to Applied Economics. We thank an anonymous referee of the Applied Economics and seminar participants at the University of Pretoria for their helpful comments.

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 chapter 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’. 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. The sufficient condition is met for central banks which do not respond to inflation when it lies within the target range and when the feature of an intermediate inflation rather than inflation target should be met. Accordingly, the 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). 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. The latter is an approach which takes a deliberate path to an ultimate goal of low inflation. Although the deliberate and the opportunistic approaches have the same ultimate goal of low inflation, the latter assumes that the policy maker takes action only when inflation is too high. Bomfim and Rudebusch (2000) consider that “*the opportunistic*

policymaker takes no deliberate action to reduce inflation further, but waits to exploit recessions and favourable 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 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 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. For instance, Gerlach-Kirsten (2004) and English *et al.* (2003) find that the inclusion of a financial spread reduces the empirical importance of interest rate smoothing (amongst others, Estrella and Mishkin (1997) analyse the influence of a term structure variable in policy rules).

The contribution in this chapter 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 a 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 2.05 percent below and above the intermediate inflation rate. Estimated inflation target range of 4.10 percent is reasonable for the SARB as the difference between the pre-announced lower and upper bound is 3 percent. Taking the official target range of 3 to 6 percent as a benchmark to our estimate, one can suggest that estimated target zone spans from 2.45 to 6.55 percent. We further use the preferred model to evaluate parameter evolution since January 2006. Recursive and rolling estimations reveal that in general, the 2007-2009 financial crisis witnesses an overall increased reaction to inflation and financial conditions. These results also indicate that until the end of 2008, the SARB increases the importance that it attaches to inflation and financial conditions relative to the output gap. A plausible explanation is that for that period inflation was on average approaching 12 percent, which is indeed the double of the upper bound of the announced target range. However, since early 2009, there has been a renewed attempt to stabilise output as a result of the new CPI inflation target which is lower than the previous measure.

The remainder of the chapter 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 explains the data. Section 4 discusses findings. Section 5 provides some concluding remarks.

6.2. Model specification

We use the model of Orphanides and Wilcox (2002) with the inclusion of financial conditions *a la* Martin and Milas (2010b). Martin and Milas (2010b) develop a flexible theoretical model to allow for changes in the preferences of policymakers when there is a financial crisis. Unlike the conventional loss function, the loss function in this chapter reflects a concern with financial stability by including a measure of domestic financial stability (f). For instance, Walsh (2009) points out that when financial factors cause distortions, these distortions will in general introduce corresponding terms in a loss function for monetary policy. As in Martin and Milas (2010b), equation (6.4) assumes that financial stability can be increased by reducing nominal interest rates; allowing financial institutions to re-capitalize at a lower cost.

$$L = (\pi - \pi^I)^2 + \gamma y^2 + \kappa f^2 + \psi \text{abs}(y) \quad (6.1)$$

$$\pi_t = \pi^e + \alpha y_t + \varepsilon_{st} \quad (6.2)$$

$$y_t = \alpha_0 - \alpha_r (r_t - r^*) + \varepsilon_{dt} \quad (6.3)$$

$$f_t = \bar{f} - \alpha_f (i_t - i^*) + \varepsilon_{ft} \quad (6.4)$$

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 a supply shock, ε_d is a demand shock and ε_f is a financial shock. Equation (6.1) specifies the policymaker's loss function in terms of expected discounted sums of quadratic deviations of inflation from the intermediate inflation target, the loss from output comprising a conventional quadratic term, a linear function of the absolute value of the output and the preferences of the policy maker for the financial conditions index to be close to equilibrium, reflecting their desire to stabilize the financial system.⁸ Equation (6.2) is a static expectations-augmented Phillips curve while Equation (6.3) 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 (6.5) below:

$$\begin{aligned} \hat{i}_t &= i^* + \rho_{ZD} E_{t-1}(\pi_t - \pi_t^l) + \rho_y E_{t-1} y_t + \rho_f E_{t-1} f_t & \text{if } -\delta \leq E_{t-1}(\pi_t - \pi_t^l) \leq \delta \\ \hat{i}_t &= i^* + \rho_{OZD} E_{t-1}(\pi_t - \pi_t^l + \delta) + \rho_y E_{t-1} y_t + \rho_f E_{t-1} f_t & \text{if } -\delta > E_{t-1}(\pi_t - \pi_t^l) \\ \hat{i}_t &= i^* + \rho_{OZD} E_{t-1}(\pi_t - \pi_t^l - \delta) + \rho_y E_{t-1} y_t + \rho_f E_{t-1} f_t & \text{if } \delta < E_{t-1}(\pi_t - \pi_t^l) \end{aligned} \quad (6.5)$$

⁸ A detailed explanation of how the financial conditions index is constructed is provided in the data section.

The above nonlinear monetary policy rule comprises of two 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 $\rho_{ZD} \neq \rho_{OZD}$, 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 (6.5) simplifies to the following equation:

$$\hat{i}_t = i^* + \rho_\pi E_{t-1}(\pi_t - \pi_t^l) + \rho_y E_{t-1} y_t + \rho_f E_{t-1} f_t \quad (6.6)$$

Replacing the intermediate inflation target in equation (6.1) with the conventional point inflation target π^* , equation (6.6) becomes

$$\hat{i}_t = i^* + \rho_\pi E_{t-1}(\pi_t - \pi_t^*) + \rho_y E_{t-1} y_t + \rho_f E_{t-1} f_t \quad (6.7)$$

Allowing for interest rate smoothing as in for e.g. Woodford (2003) it is assumed that:

$$i_t = \rho_i(L)i_{t-1} + (1 - \rho_i)\hat{i}_t \quad (6.8)$$

Where $\rho_i(L) = \rho_{i1} + \rho_{i2}L + \dots + \rho_{in}L^{n-1}$ is an indicator of the degree of smoothing of the instrument and \hat{i} is the desired interest rate given by equation (6.7) above:

$$\hat{i}_t = i^* + \rho_\pi E_{t-1}(\pi_t - \pi_t^*) + \rho_y E_{t-1}y_t + \rho_f E_{t-1}f_t \quad (6.9)$$

Combining equations (6.8) and (6.9), solving for the expectation operator, E , and allowing for a forward looking version we have

$$i_t = \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ i^* + \rho_\pi (\pi_{t+p} - \pi^T) + \rho_y y_{t+q} + \rho_f f_{t+r} \right\} + \varepsilon_t \quad (6.10)$$

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 (6.10) by replacing the inflation target by the intermediate inflation target to have

$$i_t = \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ i^* + \rho_\pi (\pi_{t+p}^I - \pi^T) + \rho_y y_{t+q} + \rho_f f_{t+r} \right\} + \varepsilon_t \quad (6.11)$$

where the intermediate inflation target is defined as

$$\pi_t^I = \mu \left(\frac{1}{n} \sum_{j=1}^n \pi_{t-j} \right) + (1 - \mu) \pi^T \quad (6.12)$$

It is worth noting that King (1996) has identified Equation (6.12) 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 a relatively high inflation rate. Equation (6.11) 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 term i^* .⁹

To test for the presence of opportunistic behaviour, and so the presence of asymmetries, one can define different regimes and allow for the possibility that the dynamic behaviour 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

⁹ Martin and Milas (2010a) have noted this feature previously.

another can be abrupt or smooth. If the change is abrupt, then the non linear model will be of the following form

$$\begin{aligned}
 i_t &= \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ \tilde{i}^* + \rho_{ZD} E_{t-1} (\pi_{t+p} - \pi_{t+p}^l) + \rho_y E_{t-1} y_{t+q} + \rho_f E_{t-1} f_{t+r} \right\} \\
 &\quad \text{if } -\delta \leq E_{t-1} (\pi_{t+p} - \pi_{t+p}^l) \leq \delta \\
 \\
 i_t &= \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ \tilde{i}^* + \rho_{OZD} E_{t-1} (\pi_{t+p} - \pi_{t+p}^l + \delta) + \rho_y E_{t-1} y_{t+q} + \rho_f E_{t-1} f_{t+r} \right\} \\
 &\quad \text{if } -\delta > E_{t-1} (\pi_{t+p} - \pi_{t+p}^l) \\
 \\
 i_t &= \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ \tilde{i}^* + \rho_{OZD} E_{t-1} (\pi_{t+p} - \pi_{t+p}^l - \delta) + \rho_y E_{t-1} y_{t+q} + \rho_f E_{t-1} f_{t+r} \right\} \\
 &\quad \text{if } \delta < E_{t-1} (\pi_{t+p} - \pi_{t+p}^l)
 \end{aligned} \tag{6.13}$$

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:

$$\begin{aligned}
 i_t &= \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ \tilde{i}^* + \rho_{ZD} E_{t-1} (\pi_{t+p} - \pi_{t+p}^l) + \rho_y E_{t-1} y_{t+q} + \rho_f E_{t-1} f_{t+r} \right\} \\
 &\quad pr \left\{ -\delta \leq E_{t-1} (\pi_{t+p} - \pi_{t+p}^l) \leq \delta \right\} \\
 \\
 i_t &= \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ \tilde{i}^* + \rho_{OZD} E_{t-1} (\pi_{t+p} - \pi_{t+p}^l + \delta) + \rho_y E_{t-1} y_{t+q} + \rho_f E_{t-1} f_{t+r} \right\} \\
 &\quad pr \left\{ -\delta > E_{t-1} (\pi_{t+p} - \pi_{t+p}^l) \right\} \\
 \\
 i_t &= \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ \tilde{i}^* + \rho_{OZD} E_{t-1} (\pi_{t+p} - \pi_{t+p}^l - \delta) + \rho_y E_{t-1} y_{t+q} + \rho_f E_{t-1} f_{t+r} \right\} \\
 &\quad pr \left\{ \delta < E_{t-1} (\pi_{t+p} - \pi_{t+p}^l) \right\}
 \end{aligned} \tag{6.14}$$

We model the probabilities in (6.14) using the logistic functions (see e.g. van Dijk *et al.*, 2002)

$$pr\{\delta > E_{t-1}(\pi_{t+p} - \pi_{t+p}^I)\} = 1 - \frac{1}{1 + e^{-\gamma E_{t-1}(\pi_{t+p} - \pi_{t+p}^I + \delta) / \sigma_{E_{t-1}(\pi_{t+p} - \pi_{t+p}^I)}}} \quad (6.15a)$$

and

$$pr\{\delta < E_{t-1}(\pi_{t+p} - \pi_{t+p}^I)\} = \frac{1}{1 + e^{-\gamma E_{t-1}(\pi_{t+p} - \pi_{t+p}^I - \delta) / \sigma_{E_{t-1}(\pi_{t+p} - \pi_{t+p}^I)}}} \quad (6.15b)$$

In (6.15 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 $E_{t-1}(\pi_{t+p} - \pi_{t+p}^I)$. In equation (6.14) it is assumed that the policy maker responds to $E_{t-1}(\pi_{t+p} - \pi_{t+p}^I + \delta)$ when inflation is below the zone of discretion and to $E_{t-1}(\pi_{t+p} - \pi_{t+p}^I - \delta)$ when the inflation is above the zone of discretion. As an alternative to (6.14), equation (6.16) assumes that the policymaker responds to $E_{t-1}(\pi_{t+p} - \pi_{t+p}^I)$.

$$i_t = \rho_i(L)i_{t-1} + (1 - \rho_i) \left\{ \begin{array}{l} i^* + \theta_i \rho_{ZD} E_{t-1}(\pi_{t+p} - \pi_{t+p}^I) + (1 - \theta_i) \rho_{OZD} E_{t-1}(\pi_{t+p} - \pi_{t+p}^I) \\ + \rho_y E_{t-1} y_{t+q} + \rho_f E_{t-1} f_{t+r} \end{array} \right\} + \varepsilon_t \quad (6.16)$$

where $\theta = pr\{\delta \leq E_{t-1}(\pi_{t+p} - \pi_{t+p}^I) \leq \delta\}$ is the probability that the economy is within the zone of discretion. In equation (6.16) 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)

$$\theta = pr\{-\delta \leq E_{t-1}(\pi_{t+p} - \pi_{t+p}^I) \leq \delta\} = 1 - \frac{1}{1 + e^{\frac{-\gamma [E_{t-1}(\pi_{t+p} - \pi_{t+p}^I + \delta)] [E_{t-1}(\pi_{t+p} - \pi_{t+p}^I - \delta)]}{\sigma_{E_{t-1}(\pi_{t+p} - \pi_{t+p}^I)}^2}}} \quad (6.17)$$

Note that in equation (6.16), we have entered output and financial conditions linearly in the model. However, the study has 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.¹⁰

6.3. Empirical results

6.3.1. 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 conditions index, the 10-year government bond and M3 growth. The 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 support for an omitted variables problem as outlined in the introduction. Each case reveals evidence

¹⁰ Similar conclusions have been found in chapter 2 and by 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.

that the SARB has been reacting to the financial conditions index since the null hypothesis $H_0: \rho_f = 0$ is rejected at 1% level of significance. Column (i) of Table 7 represents estimates of equation (6.10), the linear Taylor rule model. We find that $\rho_i = 0.91, \rho_\pi = 1.21, \rho_y = 0.24$ and that $\rho_f = 0.10$. This model is in line with the Taylor principle which stipulates that the response to inflation is expected to be in greater proportion than the variation of inflation.¹¹

The second step is the estimation of the equation (6.11) that uses intermediate inflation rather than a simple inflation target. The intermediate inflation target at period t , is computed as a weighted average of the inflation target and historical inflation measured as an average of inflation of three previous months. The study has 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.

¹¹ In contrast to previous results by Woglom (2003) and Naraidoo and Gupta (2010) who have reported inflation effect lower than one.

Table 7: GMM estimates of the opportunistic approach on SA data, (2000:M1-2005:M12)

Coefficient	(i)	(ii)	(iii)	(iv)	(v)
ρ_i	0.91*** (0.01)	0.908*** (0.01)	0.875*** 0.01	0.915** (0.01)	0.890*** (0.01)
ρ_π	1.211*** (0.06)	1.752*** (0.16)			
ρ_{ZD}			0.840*** 0.28	4.344 (4.17)	0.396 (0.30)
ρ_{OZD}			1.217*** 0.22	2.478*** (0.44)	1.509*** (0.09)
ρ_y	0.240*** (0.08)	0.431*** (0.05)	0.564*** 0.08	0.753*** (0.07)	0.330*** (0.05)
ρ_f	0.098*** (0.01)	0.073*** (0.01)	0.038*** 0.01	0.071*** (0.01)	0.041*** (0.01)
μ		0.465*** (0.03)	0.212* 0.12	0.465*** (0.03)	0.465*** (0.03)
δ			1.869*** 0.37	2.05	2.05
S.E	0.380	0.360	0.373	0.367	0.359
AIC	0.983	0.890	0.936	0.931	0.884
\bar{R}^2	0.974	0.977	0.975	0.976	0.977
$H_0: \rho_{ZD} = \rho_{OZD}$ (p value)	-	-	0.09	0.026	0.000
J-statistic (p value)	0.253	0.245	0.241	0.255	0.254
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, 1-6, 9, 12 lagged values of repo rate, the inflation, the output gap, the 10-year government bond, money (M3) growth, and the financial index. The table also reports bootstrapped p -values of the λ , λ_A , and g tests based on 1000 re-samples.

Findings in column (ii) of Table 7 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 $\mu=0.46$ and is statistically significant. This is evidence that intermediate inflation reveals the behaviour of the policy makers of the SARB better than a 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 the zone of discretion. In doing so, both linear models, equation (6.10) in column (i) and equation (6.11) in column (ii), are subject 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.¹² We then provide estimates of equation (6.13) in column (iii) of Table 7. We find that $\delta=2.05$ and that in terms of the AIC, equation (6.13) performs better than the linear model presented in column (i) but does not outperform the model in column (ii).

The fourth step is aimed at comparing the nonlinear models, namely equations (6.13), (6.14) and (6.16). With the aim to reduce the number of parameters to be estimated in equations (6.14) and (6.16) we set $\mu=0.46$ as suggested by model (6.11) above and $\delta=2.05$ as estimated in column (iii). In terms of AIC, equation (6.14) is not different from the results of equation (6.13). However, results of equation (6.16) in column (v)

¹² 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.

exhibits lower standard error and better AIC than any other model we have estimated. 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 (Model 3, hereafter) 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 equation (6.16) in column (v) we report that ρ_{ZD} is not statistically different from zero. The same column reveals that $\rho_y > \rho_{ZD}$, $\rho_f > \rho_{ZD}$ and that $\rho_{OZD} > \rho_{ZD}$. These results indicate that the SARB increases the importance that it attaches to inflation relative to the output gap and financial conditions once inflation moves outside the zone. This outperforming model reveals that the zone of discretion is symmetrically extending from 2.05 percent below and above the intermediate inflation target rate. The estimated zone of discretion of 4.10 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 2.45 to 6.55 percent.

Figure 14: Transition function and inflation

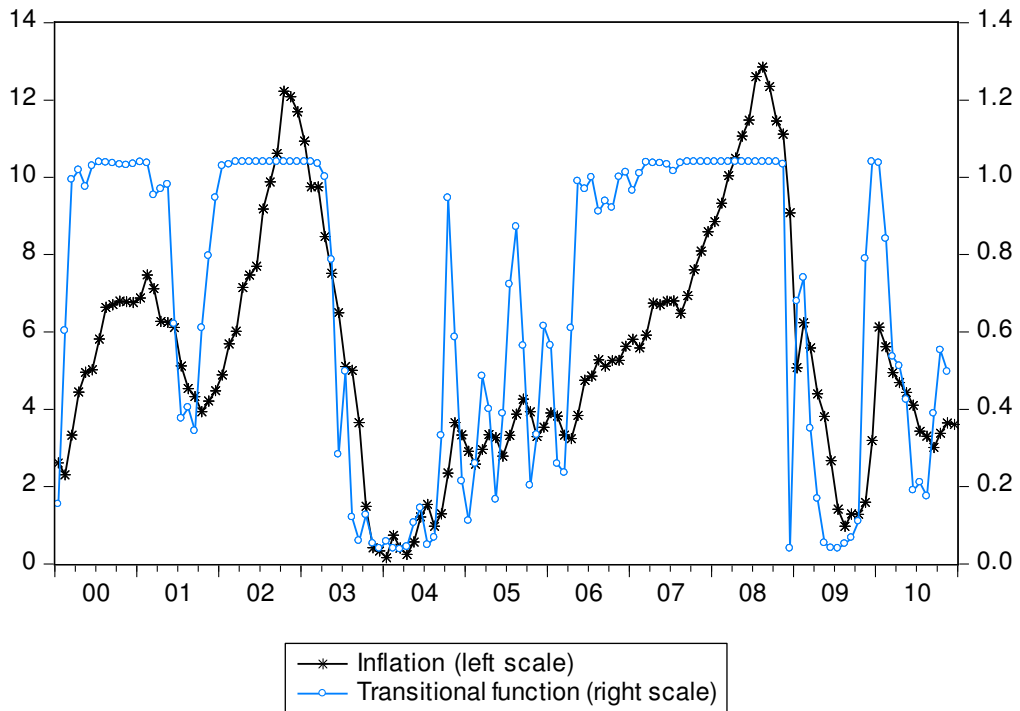


Figure 14 plots the transition function θ_t in equation (6.17) compared to the level of inflation. It can be seen that θ_t fluctuates between 0 and 1 depending on the level of inflation. Precisely, the transition function θ_t tends to 1 when inflation is high and as inflation tends to be low, θ_t tends to zero.

6.3.2. Recursive estimates

To obtain an idea of how the response parameters ρ_{OZD} , ρ_y , and ρ_f evolve over time, Figure 15 plots the recursive estimates (plus/minus 2*standard errors) over expanding data windows for the preferred model equation (6.16). The response to inflation is relatively stable up until late 2008. From early 2009 onward, the response has decreased but the Taylor principle still holds as the coefficient was higher than unity. The response to the output gap was decreasing until late 2008 but started increasing consistently only toward 2009. A plausible explanation is that in the second semester of 2008 inflation was on average approaching 12 percent, which is indeed the double of the upper bound of the announced target range. However, since early 2009, the relative importance turns to the output gap as a result of the new CPI inflation which is lower than the previous measure. Panel (c) in Figure 15 reveals an increasing response to the financial index until late in 2008. Since then, the response to financial conditions decreased and reached its level of 2006. Overall, the 2007-2009 financial crisis witnesses an overall increased reaction to inflation and financial conditions. The observed decrease of the reaction to output gap prior to 2009 might show the SARB's preference of price stability over economic stabilisation.

Figure 15: Recursive estimates for the OAD model

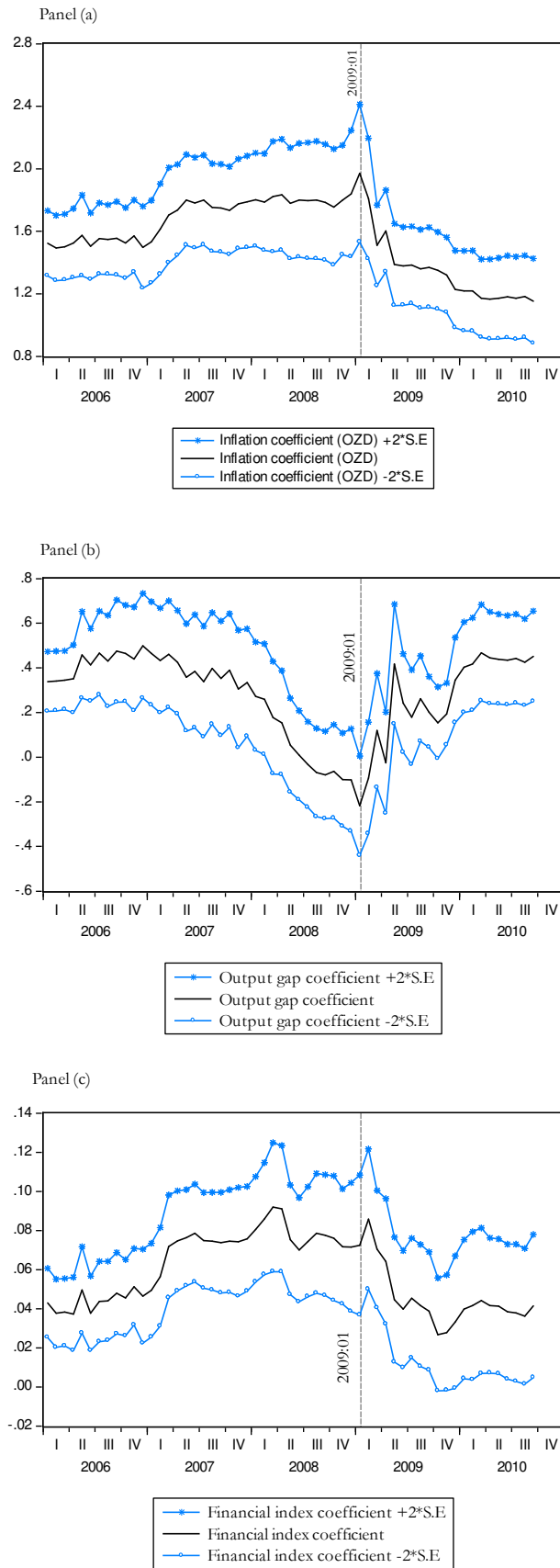
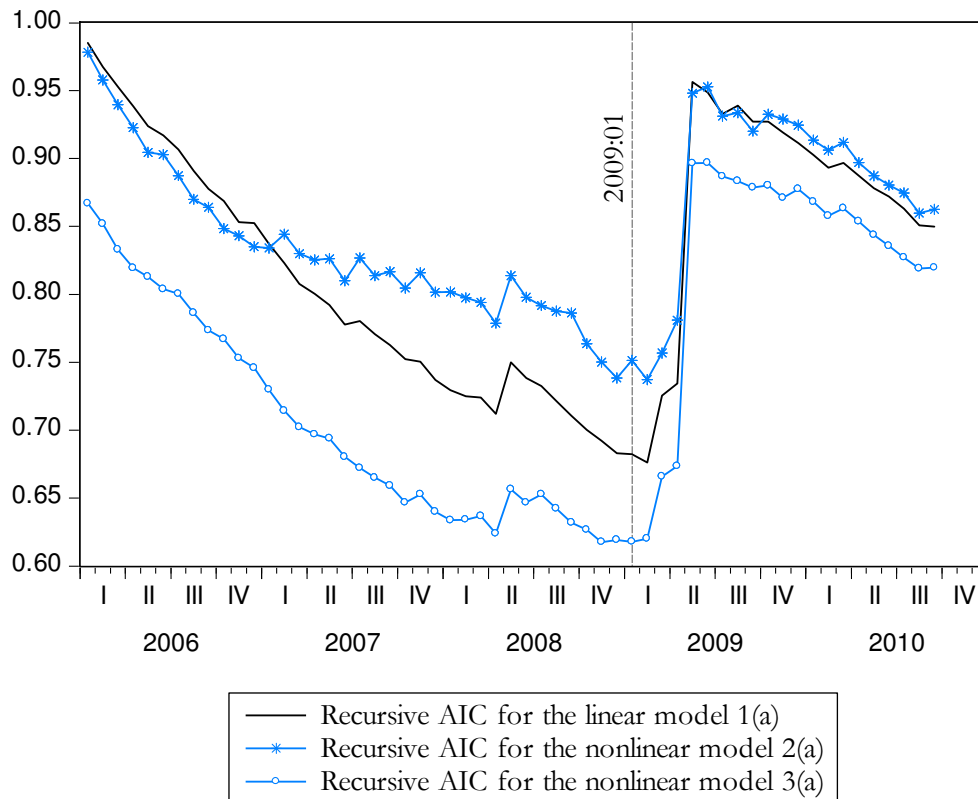


Figure 16: AIC for recursive Models 1, 2 and 3



In this section, we also compare the results for model 3 to the ones for models 1 and 2 reported in chapter 5. As reported by Figures 16, the quadratic logistic function (Model 3) exhibits the lowest AIC in terms of recursive estimates.

6.3.3. Rolling estimates

Figure 17 plots the rolling fixed-length window estimated response coefficients (plus/minus 2*standard errors) ρ_{OZD} , ρ_y , ρ_f for the model reported in column (v).

Figure 17 displays similar patterns for the responses to inflation, the output gap and

financial conditions as obtained under the recursive estimation in Figure 15, but with a somewhat stronger and more volatile response since the onset of the financial crisis. As for chapter 5, a plausible explanation is that the number of crisis observations as proportion of all observations is greater in the case of fixed-length rolling estimation and thus the parameter can be more sensitive to changes over time.

Figure 17: Rolling estimates for the OAD model

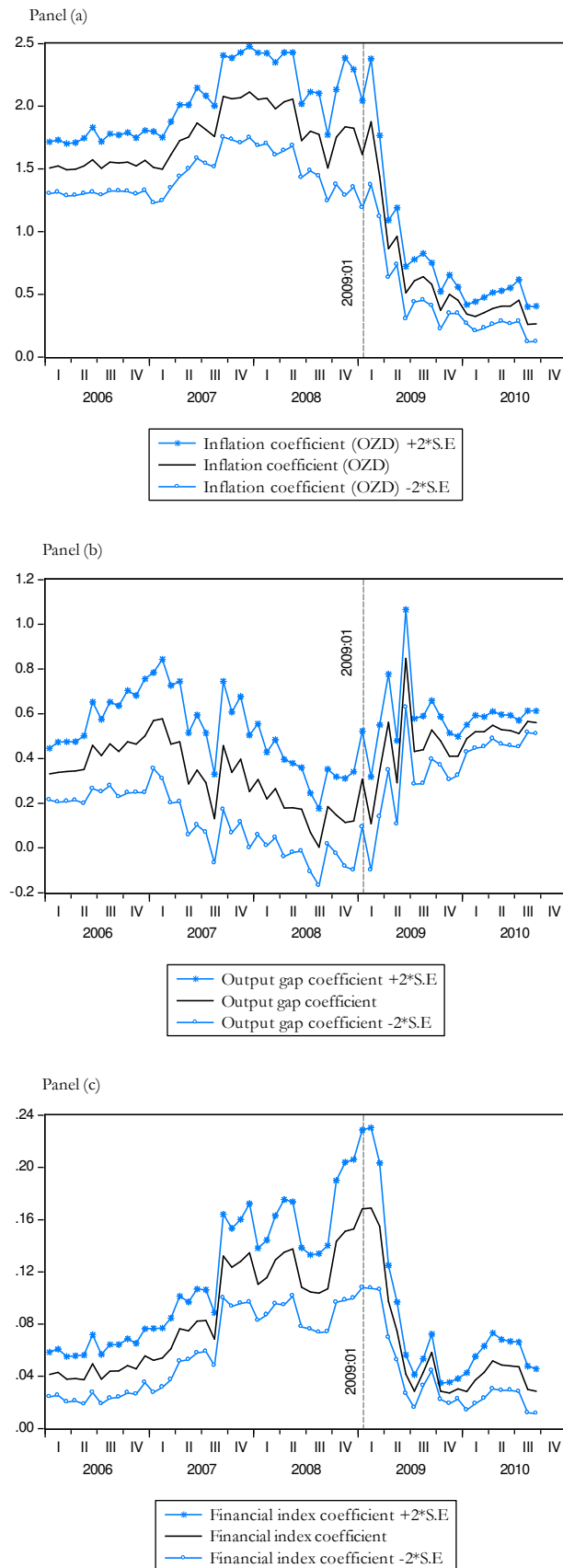
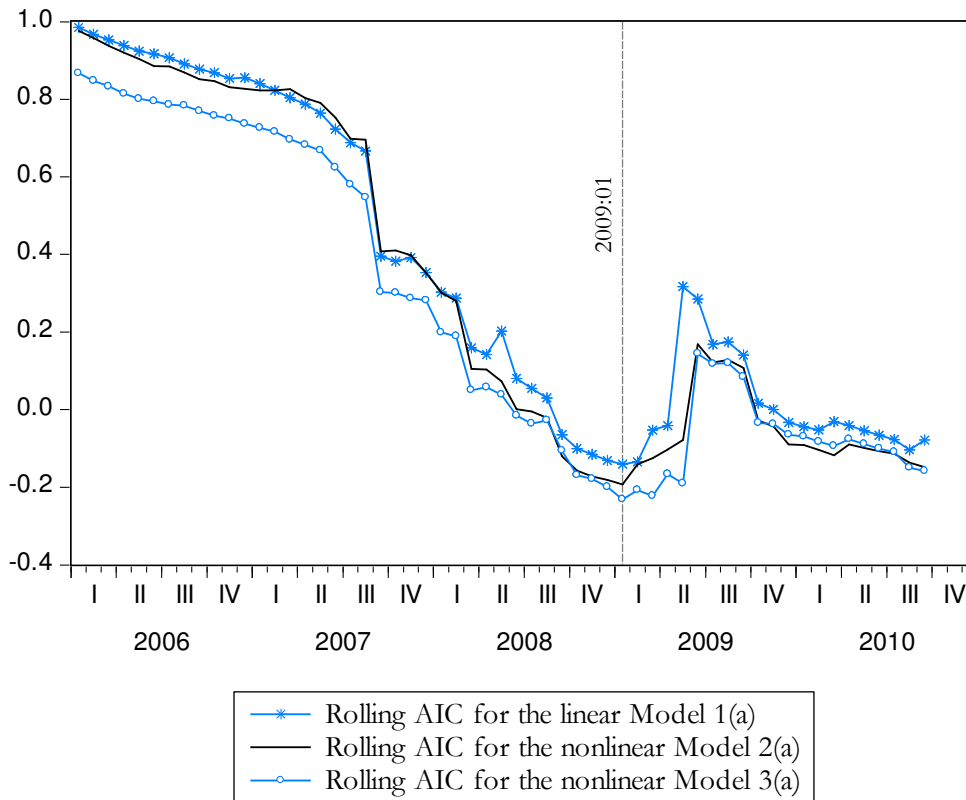


Figure 18: AIC for rolling Models 1, 2 and 3



Results for rolling estimations of chapter 6 are also compared to the ones for models 1 and 2 reported in chapter 5. As for the recursive estimates, Figures 18 shows that the quadratic logistic function (Model 3) exhibits the lowest AIC in terms of rolling estimates. All in all, it can be concluded that a quadratic logistic function which accommodates a band of inaction provides a better in-sample representation of the SARB's policy rule.

6.4. Conclusion

With the aim to test whether the SARB's monetary policy makers have behaved opportunistically, we have estimated a monetary policy reaction function for the period spanning from 2000M1 to 2010M12. We first test whether monetary policy-makers of the SARB have been using an intermediate inflation target rather than a simple inflation target. The equations that include intermediate rather than a 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, it has been tested 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 nonlinear models and find that a smooth transition model, supporting the view of opportunistic approach, fits the data better. In the preferred model, we find that the zone of discretion is symmetric, extending from 2.05 percent below and above the intermediate inflation rate. The estimated inflation target range of 4.10 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, one can suggest that the estimated target zone spans from 2.45 to 6.55 percent.

With the aim to appraise how monetary policy makers have behaved during the sub-prime crisis, the study has also assessed parameter evolution of the preferred model by

recursive estimation of the data window adding one data point at each time. It is reported that in general the 2007-2009 financial crisis witnesses an overall increased reaction to inflation and financial conditions. However, the relative importance turns to the output gap since early 2009. This is quite comprehensible as the South African economy took the toll of the financial crisis only lately. It is also worth noting that there has been lower concern to inflation beginning 2009 as a result of the new CPI inflation target which is lower than the previous measure.