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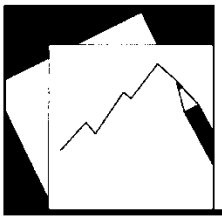

IMF Working Paper

Estimating the Implicit Inflation Target of the South African Reserve Bank

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African

Estimating the Implicit Inflation Target of the South African Reserve Bank[1]

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Abstract

This paper applies a state-space approach to estimate the implicit inflation target of the South African Reserve Bank (SARB) since the adoption of the Inflation Targeting (IT) framework. The paper's findings are two. First, although the official inflation target range is 3–6 percent, in practice, the SARB seems to have aimed for the upper segment of the band (4½–6 percent) for most of the period, despite the substantial variation of the output gap. Second, the estimation results show that the implicit inflation target varied over time, and in recent years it has shifted toward the upper limit of the inflation target range. This perhaps suggests that since the outbreak of the financial crisis in 2008, the SARB's tolerance for higher inflation has somewhat increased to better support economic activity.

JEL Classification Numbers: E3; E52; E58

Keywords: Monetary policy; Taylor rule; state space models; Kalman filter

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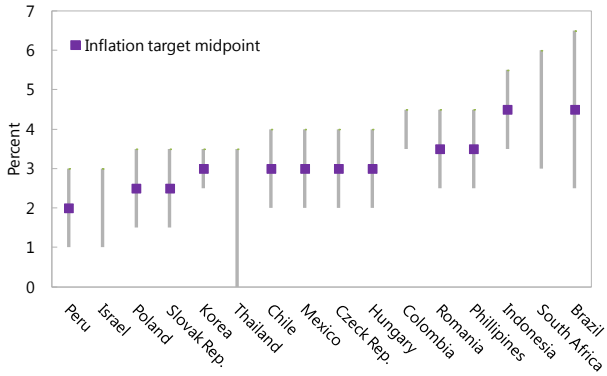
Contents Page

I. INTRODUCTION

South Africa adopted inflation targeting (IT) as a formal framework for monetary policy in February 2000.[2] This framework was implemented after the South African Reserve Bank (SARB) pursued "informal" inflation targeting during the 1990s, when monetary policy placed considerable emphasis on price stability to bring inflation rates down. The first year for which an inflation target was specified on the basis of an annual rate of between 3 and 6 percent was 2002; since then, this range was largely maintained, although the target measure was re-defined several times.[3]

The adoption of the IT framework has clearly strengthened the SARB's mandate to focus on price stability, and increased the SARB's accountability toward its main objective. The SARB, however, has refrained from announcing a mid-point, bringing on some degree of uncertainty regarding it's "true" inflation target objective. And indeed, international comparison shows that South Africa stands out in this regard. Only South Africa, Israel and Thailand have not announced a point inflation target while using an inflation target range that exceeds a 1 percentage point (Figure 1).

Figure 1. Inflation Targets in Selected Emerging Markets



Sources: Habermeier and others (2009) and central bank websites.

The lack of transparency regarding an inflation target point has provided the SARB with greater flexibility in implementing monetary policy in an environment of volatile inflation. However, the high flexibility may have undermined the monetary policy's efforts to anchor medium and long-term inflation expectations at a lower level and may have complicated the market participants' projections regarding the future path of the SARB's policy rate and monetary policy stance more generally. Market participants, therefore, may find it difficult to determine where the policy rate is heading based on a simple Taylor rule as the lack of an inflation target point adds another dimension of uncertainty to the estimated equation, particularly because it could move over time and change with the state of the economy and with the degree of the Monetary Policy Committee's (MPC) conservatism.

[2] An extensive review of the implementation of South Africa's inflation target framework appears in van der Merwe (2004).

[3] Until end-2008, the target measure was the CPIX, which was defined as the consumer price index for metropolitan and other urban areas, excluding the interest cost on mortgage bonds. From 2009, StatSA stopped to calculating the CPIX, and the SARB started to target headline inflation. Additionally, since 2004, the SARB has aimed at achieving the target on a continuous basis instead of an annual average basis.

Against this background, this paper aims at 'revealing" the SARB's ex-post inflation target point and assess to what extent it varied since the IT introduction. In particular, the analysis builds on Leigh's (2008) work, which explored the implicit inflation target of the Federal Reserve during the Volker-Greenspan period, by estimating a simple Taylor rule in a state space approach where the coefficients of the Taylor rule components are estimated alongside the inflation target. This approach has several advantages, including that it relaxes the assumption that the inflation target is constant over time by allowing it to vary based on a pre-determined "random walk" process.

The paper's main findings are two. First, the estimation results suggest that, although the official inflation target range is 3–6 percent, in practice, the SARB aimed for the upper segment of the band (4½–6 percent) for most of the period, despite the substantial variation of the output gap. Second, the estimation results show that the implicit inflation target varied over time; since 2008 it gradually increased toward the upper limit of the inflation target range, perhaps suggesting that the SARB's tolerance to higher inflation has somewhat increased to better support economic activity (compared to the pre-crisis period).

The rest of the paper is structured as follows. Section II presents the methodology and the data used in the analysis; Section III discusses the results under the assumption that the natural real rate is constant over time; Section IV looks at the sensitivity of the results to the assumed parameters; Section V examines how the results would change if a time-varying natural real rate is assumed; and Section VI complements the robustness test by comparing the dynamic simulations for the policy rate under different specifications. Section VII concludes.

II. THE EMPIRICAL MODEL

The monetary policy reaction function is usually estimated by a Taylor rule.[4] This approach stipulates to what extent the central bank changes its policy rate in response to a divergence of output from its potential level (output gap) and the projected inflation (or inflation expectations) from its desired rate. In particular, the central bank's reaction function can be presented as follows:

$$i^* = r^n + \pi_t^e + (\beta - 1)(\pi_t^e - \pi_t^*) + \gamma \tilde{y}_t \quad (1)$$

Where i^* is the target level of the SARB's repo rate, π_t^e is the expected inflation, $\tilde{y}_t$ is the output gap, r^n is the natural real rate, and π^* is the desired inflation rate or the inflation target. Note that β should be above one to allow inflation stabilization. This implies that, other things being equal, a positive deviation of one percent in the expected inflation from its target will lead to an increase of the real rate above the natural real rate. Additionally, the negative impact of the

[4] Taylor (1993).

real interest rate on the aggregate demand implies that γ should be positive to facilitate the stabilization of the output gap.

Although the specification in Eq. (1) has been widely used to estimate the monetary policy reaction functions, it disregards the tendency of the central bank to smooth the interest rate to preserve financial stability (Clarida, Gali and Gertler, 1999). Such a smoothing mechanism requires the relative weights of the targeted interest rate and the interest rate level in the previous period to sum up to one as follows:

$$i_t = \delta i_{t-1} + (1-\delta) i_t^* + \varepsilon_t \ , \qquad 0 < \delta < 1 \tag{2}$$

Combining Eq. (1) and Eq. (2), the model to be estimated is:

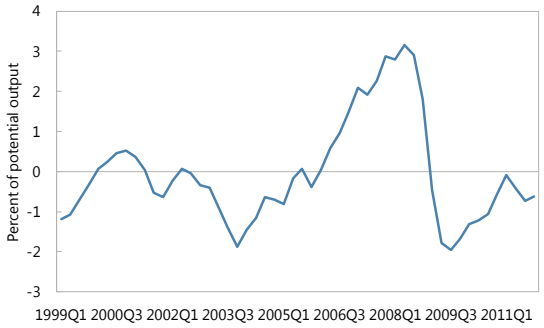
$$\begin{aligned} i_t &= (1-\delta)[r^n + \pi_t^e + (\beta - 1)(\pi_t^e - \pi_t^*) + \gamma \tilde{y}_t] + \delta i_{t-1} + \varepsilon_t \\ \pi_t^* &= \pi_{t-1}^* + v_t \ \ , \ Var(v_t) = \lambda Var(\varepsilon_t) \end{aligned} \tag{3}$$

This equation can be estimated in a state-space form. The implicit target is assumed to follow a random walk process, where its variability is linked to the variability of the policy rate. The terms ε_t and v_t are mean zero, serially uncorrelated Gaussian disturbances. The parameter λ is the "signal-to-noise" ratio, which determines the link between the policy rate's variance and the implicit inflation target's variance ($\lambda = \sigma_v^2 / \sigma_\varepsilon^2$). In this context, $\lambda = 0$ means that the implicit target is constant over-time, and therefore there is no link between the movements of the policy rate and the inflation target.

Data and the sample period

The analysis uses quarterly data for 2001Q1–2011Q4.[5] The data for the policy/repo rate and real GDP were taken from the SARB's website.[6] The output gap, which is not observable, is computed by using the natural logarithm of the real GDP de-trended from the Hodrick-Prescott filter. This approach implicitly assumes that potential output growth varies over time.[7] The computed output gap shows that it fluctuated 3.2 percent (2008Q2) and -2 percent (2009Q3); and

Figure 2. South Africa: Output Gap by Hodrick-Presscot Filter



Sources: Author's calculations

[5] The starting point was determined by the availability of Reuters Econometer Consensus of inflation expectations.

[6] http://www.resbank.co.za

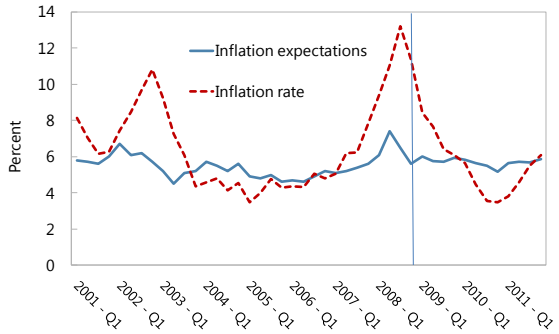
[7] To avoid end-point bias, we extended the real GDP series by the medium-term projection of the April 2012 World Economic Outlook.

while at the current juncture it is still negative, it is projected to close by end-2014 (Figure 2).

The natural real rate is an additional unobservable variable. One approach is to assume that the rate is constant over time at the historical average rate, which is about 3.25 percent. Another approach that has become increasingly popular in recent years is to assume the natural real rate varies over time. In this paper we apply both approaches to examine to what extent the SARB's reaction function (and its implicit inflation target) is sensitive to the assumed behavior of the natural real rate.

Last, we use Reuters Econometer Consensus of inflation expectations for four quarters ahead.[8] Since the inflation target measure was re-defined, the inflation expectations series includes the Reuters Econometer Consensus expectations for CPIX until 2008q4 and from this date onward – the expectations for headline inflation. The advantage of using inflation expectations (instead of actual inflation) is that it injects a forward looking element to the Taylor rule estimation. Moreover, inflation expectations are more stable over time because of their relative limited sensitivity to the volatility in commodity prices and exchange rate movements (Figure 3).

Figure 3. Inflation and Inflation Expectations[1]



[1]Until end-2008, the chart indicates expectations and actual change of the CPIX. From 2009 onward, the chart reflects expectations and actual change of the CPI.
Sources: Haver, BER, and staff calculations.

III. Estimation Results Under a Constant Natural Real Rate

In this section we estimate the specification in Eq. (3) assuming that the natural real rate is constant over time at 3.25 percent. This level reflects the real rate's average during the sample period,[9] and is broadly in line with the average of the estimated potential output growth during the post-apartheid period.

The estimated equation is consistent with the Taylor rule principles (Table 1). First, the parameter β is positive and significantly greater than one (3.9), emphasizing the rather aggressive response of the SARB to the deviation of inflation expectations from its target rate over the sample period; γ is also positive and significantly different from zero (1. 9), thus

[8] This measure seems more adequate for monetary policymaking than the surveys conducted by the Bureau of Economic Research (BER), which focus on inflation expectations for calendar years.

[9] The SARB's policy rate, deflated by Reuters' inflation expectations for four quarters ahead.

suggesting the SARB also looks at output gap stabilization as a secondary objective; and δ is equal to 0.8, pointing to a high degree of interest rate smoothing.[10]

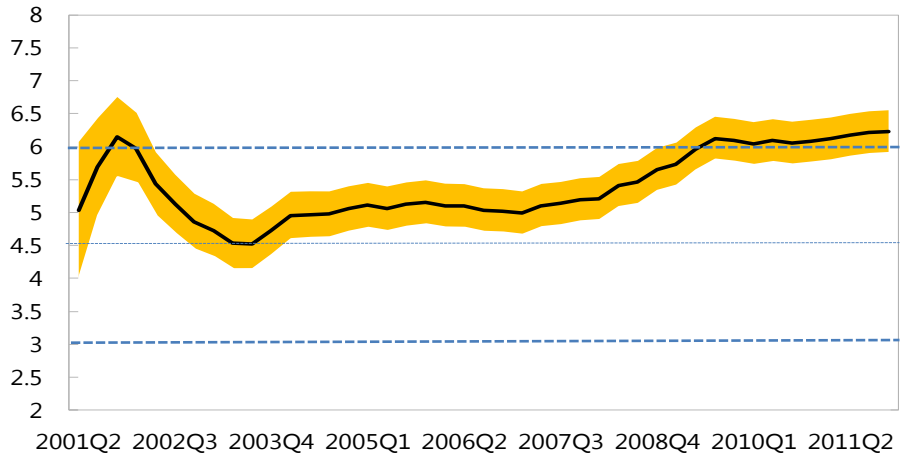
Table 1. Estimated Response Function of the SARB, 2001Q4–2011Q4[1]

δ	0.795 (0.071)
γ	1.913 (0.627)
β	3.940 (1.559)
$Var(\varepsilon_t)$	0.386 (0.093)
$Var(v_t)$	0.00965
λ	0.025

[1]Figures in parenthesis indicate standard errors.

The estimation results should be treated with caution given the uncertainties regarding the "true" values of output gap and the natural interest rate. However, they show that while the SARB's "official" inflation target range is defined as 3 to 6 percent, in practice, the SARB aimed for the upper segment of the target since the introduction of the inflation targeting framework, despite the substantial variation of the output gap during this period (Figure 4).

Figure 4. The Estimated Implicit Inflation Target[1]



[1] Band indicate +/-1 standard error.
Source: Author's estimation.

The estimated implicit target shows a substantial variation over time, and a Wald test rejects the null hypothesis that the target is constant over time (for $H_0: Var(v_t) = 0$) with a confidence of 99 percent. Moreover, the results indicate that the implicit inflation target was elevated at around 6 percent in 2001-02, when the rand crisis hit; nevertheless it moderated substantially in the course of 2003 to 4½ percent. In 2004-07, the implicit inflation target was broadly stable at around 5 percent, but from 2007q4 it recorded a steady increase to around 5½ percent in

[10] Similar degree of interest rate smoothing was also found in Leigh (2008).

2008q3. And with the outbreak of the global financial crisis and the substantial monetary easing in late-2008 and early-2009, the estimated target recorded a further increase toward the upper limit of the inflation target range (6 percent), and remained in this neighborhood throughout 2010 and 2011.

A close look at the factors that led to the sharp increase in the implicit inflation target during 2008 reveals that both inflation expectations and output gap were significantly elevated in this period. In particular, inflation expectations increased to a record-high 7.4 percent in 2008q2 while output is estimated to have increased to 3.2 percent above its potential level. Given that the policy rate hike in 2008 was lower than the one implied by the SARB's reaction function for a given inflation target, the estimated inflation target increased to some 6 percent in 2009q3. As the implicit inflation target is assumed to follow a random walk process, this increase was "permanent" in the sense that the target remained at the upper limit of the official inflation target range throughout the financial crisis and the post-crisis periods.

The following sections will relax the assumption of the random walk process and evaluate how this and other factors affect the trajectory of the implicit inflation target.

IV. The Sensitivity of the Results to the Pre-determined Parameters

Three elements are pre-determined in the baseline estimation: the intercept of the Taylor rule equation, which is the assumed natural real rate, the signal-to-noise ratio, which determines the variability of the implicit inflation target relative to the variability of the policy rate, and the statistical process of the implicit inflation target, which is assumed to follow a random walk process. In this section, we evaluate how the trajectory of the estimated implicit inflation target would change with different assumptions on these three elements.

A. A Random Walk or a Stationary Process?

The statistical process of the inflation target is assumed to follow a random walk process.[11] However, this assumption can be relaxed by adding the coefficient φ without a-priori assumptions on its size in the following manner:

$$\pi_t^* = \varphi \pi_{t-1}^* + v_t \qquad (4)$$

We can now inject Eq. (4) to Eq. (3) and re-estimate it to (i) assess whether the implicit inflation target follows a random walk or a stationary process; and (ii) evaluate whether the change of this specification affects the trajectory of the implicit inflation target.

[11] While the assumption of a random walk process is used for the baseline estimation, which rely on a relatively short sample period, it not plausible for long sample periods as it suggest that the inflation target can move upwards and downwards without a limit.

The estimation results show that the implicit target follows a random walk process as a Wald coefficient test cannot reject the hypothesis that φ is equal to one (Table 2). Moreover, the rest of the estimated parameters do not change much compared to the baseline estimation, and consequently, the trajectory of the estimated implicit target is very close to the baseline's trajectory, though the average target for 2010–11 is marginally lower than the baseline's (Table 2 and Figure 1A in Appendix 1).

Table 2. Estimated Response Function with a Relaxation of the Random Walk Assumption, 2001Q1-2011Q4[1]

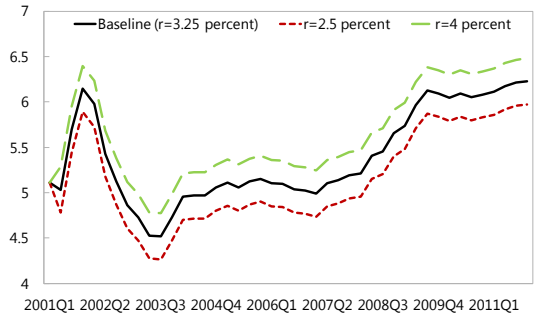
	Baseline	Alternative
Parameter	$\pi_t^* = \pi_{t-1}^* + v_t$	$\pi_t^* = \varphi\pi_{t-1}^* + v_t$
δ	0.795 (0.071)	0.805 (0.072)
γ	1.913 (0.627)	1.971 (0.705)
β	3.940 (1.559)	4.00 (1.6867)
$Var(\varepsilon_t)$	0.386 (0.093)	0.383 (0.093)
$Var(v_t)$	0.00965	0.00957
λ	0.025	0.025
φ	-----	0.999 (0.001)

[1]Figures in parenthesis indicate standard errors.

B. A Different (Constant) Natural Real Rate

To evaluate the impact of the natural real rate on the inflation target's trajectory we estimate two alternative scenarios. The first scenario assumes that the level of the natural real rate is 75 basis points above the historical average (4 percent) while the second scenario assumes that the natural real rate is 75 basis points below the historical average (2.5 percent).

Figure 5. The Estimated Implicit Inflation Target with Different Levels of Natural Real Rate



Sources: Author's estimates.

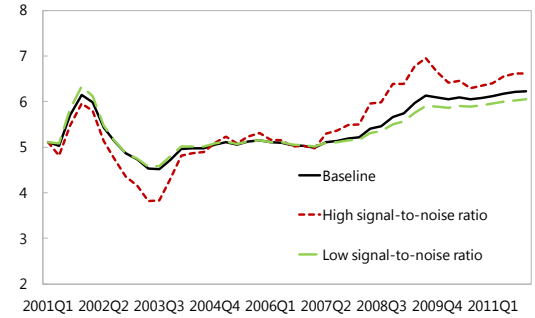
The estimations show that a change in the constant natural real rate would lead to a vertical shift in the implicit target (by approximately $\Delta r \cdot (1 - \delta)$) throughout the estimation period without a change in the coefficients' size and significance level (Figure 5). This also implies that the upward drift in the implicit inflation target in 2008-9 is unchanged, though the level of the implicit target is determined by the assumed natural rate.

C. Alternative Signal-to-Noise Ratios

This exercise explores how the estimated implicit target path would change if a different signal-to-noise ratio (λ) is assumed. Clearly, higher (lower) λ implies that the implicit target could change more (less) rapidly over the sample period.

The estimations reveal that a change in the signal-to-noise ratio has a non-linear impact on the estimated trajectory of the implicit inflation target (Figure 6). The results indeed show that higher λ is associated with greater variability of the estimated target because it brings the estimated target below the baseline at the beginning of the period, while it increases faster toward the end. Under the high signal-to-noise ratio, therefore, the implicit target climbs to a peak of 7 percent in 2009q3 before it moderates to around 6.6 percent. Under the low signal-to-noise ratio, the implicit target is significantly more stable over time, though it also shows an upward drift in 2007–09. Overall, the average inflation target for 2010–11 under the low signal-to-noise ratio is 6 percent, which is significantly lower than under the high signal-to-noise scenario (6.5 percent). The relative weights in the SARB's response function change as well (Table 3): While both alternative estimations lead to lower relative weight of inflation stabilization (measured by the β/γ ratio) compared to the baseline, higher λ is associated with lower interest rate smoothing.

Figure 6. The Estimated Implicit Inflation Target with Alternative Signal-to-Noise Ratios



Source: Author's estimates.

Table 3. Estimated Response Function with Constant Natural Real Rate and Different Signal-to-Noise Ratios, 2001Q1–2011Q4[1]

Parameter	Baseline ($\lambda = 0.025$))	$\lambda = 0.0125$	$\lambda = 0.2$
δ	0.795 (0.071)	0.823 (0.077)	0.742 (0.061)
γ	1.913 (0.627)	2.106 (0.822)	1.718 (0.405)
β	3.940 (1.559)	4.028 (1.842)	3.351 (0.991)
$Var(\varepsilon_t)$	0.386 (0.093)	0.421 (0.1015)	0.277 (0.101)
$Var(v_t)$	0.00965	0.00526	0.0554
β/γ	2.1	1.9	2.0

[1]Figures in parenthesis indicate standard errors.

V. TIME-VARYING NATURAL REAL RATE

Previous sections estimated the SARB's response function by assuming that the natural real rate is fixed throughout the sample period. This assumption might be overly restrictive, particularly given the possibility that the natural real rate has declined substantially since the outbreak of the financial crisis. Recent evidence indeed suggests that the potential growth, which is closely linked to the natural real rate, has decelerated in some advanced and emerging economies as a result of the global financial crisis.

The previous section showed that a lower natural rate is reflected in a lower trajectory of the estimated inflation target. And indeed, if the SARB views the natural real rate to have declined since the outbreak of the financial crisis and acted accordingly in determining the policy rate, then the upward drift in the implicit target since 2008 may be overestimated.

To evaluate the impact of the natural real rate's fluctuations on the estimated implicit inflation target we adopt two approaches. In particular, we assume:

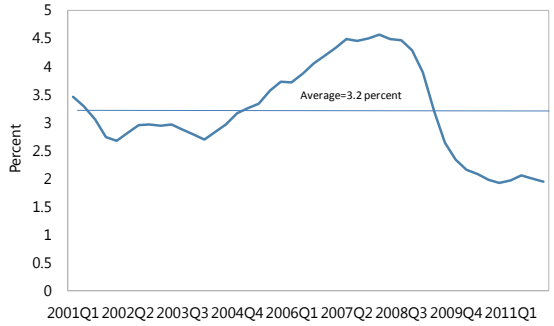
- **Full variation over time.** The natural real rate varies throughout the sample period. Here, we adopt the approach put forward by Laubach and Williams (2003) and estimate a state-space system that links the natural real rate to the estimated potential GDP growth. Under this approach the natural real rate depends on the trend growth of output, and is subjected to random disturbances.

- **Partial variation over time.** The natural real rate is constant at 3.25 percent up to the outbreak of the financial crisis (2008q4). From this point onwards, we assume that it has declined to 2 percent.

Estimation results

The estimated natural rate according to the "full variation" estimation is presented in Figure 7. The results show that the natural rate increased quite sharply during the upturn in economic activity (2006–2008) to some 4.5 percent in mid-2008 from around 3 percent earlier, and declined significantly with the outbreak of the global financial crisis to 2 percent, in line with the deceleration of potential output growth (Klein, 2011).

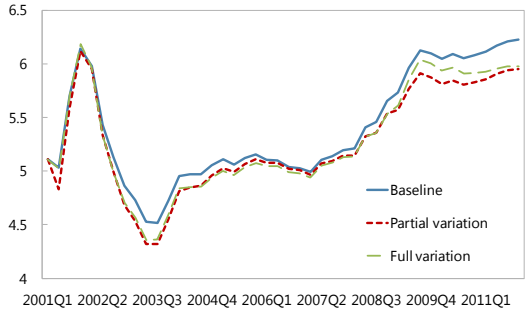
Figure 7. Estimated Time-Varying Natural Real Rate, 2001-11



Source: Author's estimates.

The implicit inflation target estimates for both alternative estimations are presented in Table 4 and Figure 8. The results show that inclusion of a time-varying natural real rate shifts the trajectory of the inflation target slightly downward, yet the finding that the SARB targeted the upper segment of the inflation target range since the introduction of the IT regime still holds. Also, both alternative scenarios envisage an upward drift in the inflation target in 2007–09 as was observed in the baseline estimation. The estimated coefficients remain significantly different from zero, though their sizes change somewhat compared to the baseline (Table 4). Worth mentioning is the observation that under the full variation scenario, the β/γ

Figure 8. The Estimated Implicit Inflation Target with Time-Varying Natural Real Rate



Source: Author's estimations.

ratio increases to 2.5 compared to its level in the partial variation and the baseline estimations (2.1), thus suggesting that the relative importance of inflation stabilization versus output gap stabilization is higher in this specification.

Table 4. Estimated Response Function with Time-Varying Natural Real Rate, 2001Q1–2011Q4[1]

Parameter	Baseline r=3.25 percent	Partial variation	Full variation
δ	0.795 (0.071)	0.779 (0.059)	0.799 (0.072)
γ	1.913 (0.627)	1.640 (0.519)	1.525 (0.637)
β	3.940 (1.559)	3.429 (1.133	3.813 (1.547)
$Var(\varepsilon_t)$	0.386 (0.093)	0.356 (0.085)	0.395 (0.090)
$Var(v_t)$	0.00965	0.0089	0.0098
β/γ	2.1	2.1	2.5

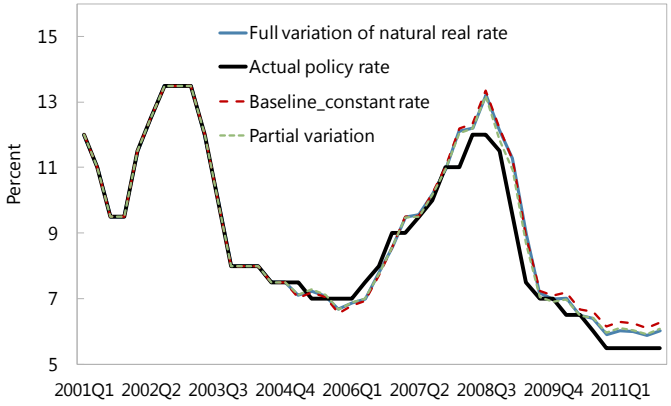
[1]Figures in parenthesis indicate standard errors.

VI. THE ACTUAL VERSUS THE PREDICTED POLICY RATE

To complement the robustness tests, we perform a dynamic forecast for the policy rate to explore to what extent these specifications adequately describe the SARB's reaction function. We use the specifications of fixed and time-varying natural real rates, and start the exercise at 2005Q1 to allow sufficient cycles in the policy rate.

The estimations show that the fitted rates follow the actual rate quite well, and nicely predict the monetary tightening in 2006–08; and, more recently, the monetary relaxation in 2009 onwards (Figure 9). Although this exercise is not intended for forecast use, the estimations reveal that the specification with a partial time-varying natural rate is superior to the "full variation" and the baseline specifications as the sum of squared errors (SSE) is significantly lower.[12]

Figure 9. Actual and Predicted Policy Rate



Source: Author's estimates

[12] The sum of squared errors (SSE) in the partial time-varying specification is 9.0, and is significantly lower than the SSE with a full variation (11.3) and the SSE for the baseline (13.7).

VII. CONCLUSIONS

The analysis in this paper aims at exploring the implicit inflation target of the South African Reserve Bank since the introduction of the inflation targeting regime. The implicit inflation target is estimated by a Taylor rule equation in a state-space approach, where the implicit target is allowed to vary over time, based on a random walk process.

Although the estimations' results should be treated with caution given the uncertainties regarding the "true" values of the output gap and natural real rate, they suggest that SARB aimed for the upper segment of the official inflation target (4½–6 percent) since the introduction of the inflation target framework. In addition, the results show that the implicit inflation target varied over time, and in recent years it drifted upward toward the upper limit of the inflation target range (6 percent). This perhaps implies that since the outbreak of the financial crisis in 2008 the SARB has become more tolerant toward higher levels of inflation to better support economic activity in the face of an extremely challenging global environment.

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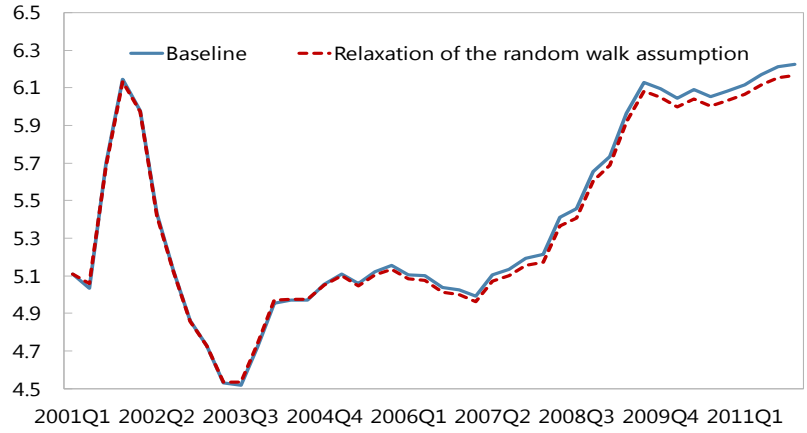
Appendix

Table 1A. Descriptive Statistics, 2001q1–2011q4

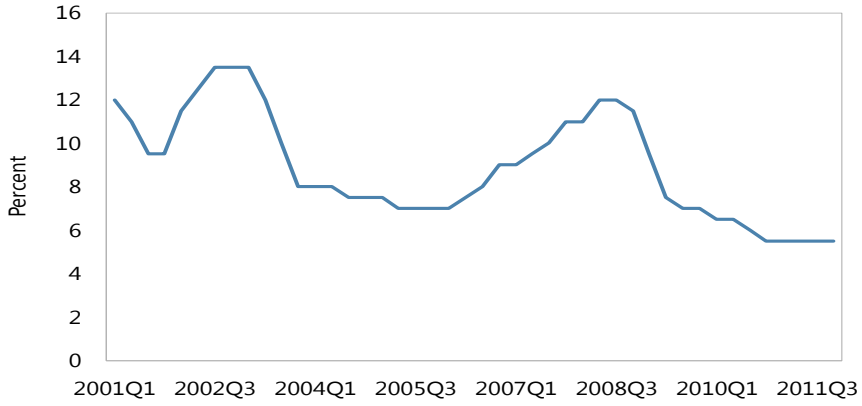
	Inflation	Inflation Expectations	Output Gap	Policy Rate
Mean	5.217	5.532	-0.004	8.886
Median	5.315	5.600	-0.389	8.000
Maximum	12.830	7.400	3.164	13.500
Minimum	-2.060	4.500	-1.951	5.500
Std. Dev.	3.486	0.562	1.389	2.449
Skewness	-0.056	0.613	0.881	0.366
Kurtosis	2.777	4.455	2.831	1.952
Observations	44	44	44	44

Figure 1.A. The Estimated Implicit Inflation Target



Source: Author's estimates.

Figure 2A. The SARB's Policy Rate, 2001q1-2011q4



Source: SARB.