What is the SARB's inflation targeting policy, and is it appropriate?

Ellyne, Mark and Veller, Carl

University of Cape Town

30 August 2011

(PRELIMINARY DRAFT)

WHAT IS THE SARB'S INFLATION TARGETING POLICY, AND IS IT APPROPRIATE?

Carl Veller[†] and Mark Ellyne[††]

August 2011

Abstract

Since its adoption of inflation targeting in 2000, the South African Reserve Bank has been accused of placing too great an emphasis on meeting its inflation target, and too small an emphasis on the high rate of unemployment in the country. On the other hand, the SARB has regularly missed its inflation target. We attempt to characterise the SARB's inflation targeting policy by analysing the Bank's interest rate setting behaviour before and after the adoption of inflation targeting, making use of Taylor-like rules to determine whether the SARB has emphasised inflation, the output gap, the real exchange rate, and asset price deviations in its monetary policy. We find that the SARB has significantly changed its behaviour with the adoption of inflation targeting, and show that the SARB runs a very flexible inflation targeting regime, with strong emphasis on the output gap. Indeed, we find evidence that the emphasis on inflation is too low, and potentially conducive to instability in the inflation process.

JEL classification: E52, E58
Keywords: South Africa, monetary policy, inflation targeting

Authors' e-mail: carl.veller@gmail.com, mark.ellyne@uct.ac.za

For presentation at the Biennial Conference of the Economic Society of South Africa, University of Stellenbosch, 5-7 September 2011.

[†]Graduate student, Department of Mathematics and Applied Mathematics, University of Cape Town
[††]Adjunct Associate Professor, Department of Economics, University of Cape Town

1 Introduction

Following a growing host of countries, South Africa adopted inflation targeting in 2000, explicitly making the goal of low and stable inflation the primary objective of monetary policy. Since then, the regime has received a substantial amount of criticism, with the most persistent critic, the Congress of South African Trade Unions (COSATU), complaining that too strict a focus on price stability has come with the cost of higher unemployment, lower growth and an unstable exchange rate. Supporting their call for a review of the mandate of the South African Reserve Bank (SARB) is Nobel laureate Joseph Stiglitz, who, in an article entitled 'The Failure of Inflation Targeting', dismisses inflation targeting in general as a 'crude recipe . . . based on little economic theory or empirical evidence' (Stiglitz, 2008).

Such criticisms prompt a number of questions. Has inflation targeting been successful in other countries? What exactly is the SARB's inflation targeting policy, and has it been successful? Does the SARB place an overriding emphasis on meeting its inflation targets, as COSATU claims, or does it have other objectives as well? Has inflation in fact been successfully stabilised in South Africa? This paper seeks to address these questions by analysing the conduct and results of South African monetary policy before and after the adoption of inflation targeting. Specifically, we compare a 'pre-inflation targeting' (pre-IT) period of 1990Q1-1999Q4 with the inflation targeting (IT) period of 2000Q1-2011Q1.

Broadly, our results suggest that the above criticisms are unfounded. Under inflation targeting, the SARB has exercised a large degree of flexibility in conducting monetary policy, with strong consideration shown to real economic variables such as the level of output. In fact, we argue that the emphasis placed on inflation in this period has been *too low*, and has been conducive to the substantial volatility in the inflation rate experienced over the period.[1] There are theoretical reasons for believing this to be the case, and our estimates of the weight the SARB has accorded inflation in its instrument setting behaviour in the IT period are significantly lower than corresponding estimates obtained for other countries in separate studies.

We give evidence that, unlike in the pre-IT regime, under inflation targeting the SARB has paid little attention to the real exchange rate and other asset prices in their own right. This suggests a significant simplification of monetary policy over the pre-IT regime, which is known to have focussed on more eclectic targets (Aron and Muellbauer, 2007). We argue that the decreased focus on the exchange rate and other asset prices has not necessarily led to their becoming more volatile, and that inflation targeting, if properly implemented, can provide a unified framework with which to achieve stability both in these variables and in inflation.

The paper proceeds as follows: Section 2 briefly outlines the theory and workings of inflation targeting. Section 3 discusses the international evidence for the success of inflation targeting as a monetary regime. Section 4 describes and compares the monetary regimes in South Africa since the mid-1980s. Section 5 is a discussion and estimation of the SARB's instrument reaction behaviour using Taylor-like rules. Section 6 concludes.

[1] It is noteworthy, for example, that a regime that emphasises keeping inflation within a relatively wide target band has only managed to do so in 19 of the 37 quarters since the year for which the targets were first aimed to be achieved (2002).

2 The theory of inflation targeting

2.1 Why worry about inflation?

A low and stable rate of inflation is accepted as a central goal of monetary policy for a number of reasons:

- High inflation tends to depress savings and investment. High inflation is associated with substantial inflation volatility, which causes uncertainty in price-level expectations, making long-term economic decision-making more difficult (Freedman and Laxton, 2009). This uncertainty can also complicate labour negotiations, a problem with particular relevance to South Africa with its highly unionised labour market.

- High inflation distorts relative prices. Whenever firms' price changes are not synchronised, relative prices will not reflect relative costs of production, distorting consumer choices and leading to welfare losses (Sørensen and Whitta-Jacobsen, 2005, chap. 20).

- High inflation disproportionately affects the poor. While individuals can in principle hedge against inflation through the use of inflation-linked financial instruments, these instruments tend not to be available to the poor, who hold a large portion of their wealth in the form of inflation-exposed cash (Romer and Romer, 1998; Easterly and Fischer, 2001).

- High inflation has a distortionary effect on unindexed accounting measures and taxes. Inflation causes returns to nominal assets to be overtaxed relative to real assets, and therefore distorts investment decisions (Sørensen and Whitta-Jacobsen, 2005, chap. 20). In addition, if income tax brackets do not move while inflation increases nominal incomes, individuals could move into higher tax brackets despite their real incomes not having changed.

2.2 The need for a nominal anchor

Accepting low inflation as a primary goal of monetary policy, central banks typically rely on a nominal anchor to steer policy decisions. The central bank's pledge to keep a chosen nominal variable constant or within specified boundaries helps to clarify the objective of the central bank's policy, both within the central bank and to the public, to provide a publicly visible goal according to which the central bank can communicate any changes in policy and their rationales, and to guide public expectations with respect to the policy goal, and subsequently other variables as well.

2.3 What is inflation targeting?

Broadly speaking, inflation targeting involves taking the inflation rate as the nominal anchor and creating a policy response 'function' to manage it. However, inflation targeting is more than an instrument response rule for managing monetary policy - it has evolved into a framework with several key elements (Bernanke and Mishkin, 1997; Miao, 2009):

- *Inflation target identification.* The authorities publicly announce a medium-term inflation target as a point or band. They acknowledge that low, stable inflation is the primary goal of monetary policy.
- *A clear transparency framework.* High levels of transparency through communication with the public regarding goals, plans and decisions of the monetary authority. The authorities typically publish regular reports stating the inflation targets and steps being taken to attain them.
- *An accountability framework.* The monetary authorities are held responsible for achieving their stated objectives and generally must answer to the government for any failure to achieve them.
- *Appropriate institutional arrangements.* The central bank needs to be independent and credible to achieve its goals. To implement an inflation targeting regime also requires a sufficiently developed financial market and stable relationships among financial variables and economic behaviour.
- *A policy rule* that guides the choice of targets and instruments to manage monetary policy.

The targeting and instrument rules are not mutually exclusive. A targeting rule specifies the target variables and their desired levels, usually with reference to minimising an economic loss function of the general form

$$L = \sum_{t=0}^{\tau} \left[V(\pi_t) + \beta_1 V(z_{1t}) + \beta_2 V(z_{2t}) + \ldots \right],$$

where π_t is some measure of inflation, the z_{it} are other variables (such as output, the exchange rate, etc.), $V(\cdot)$ is a function that captures deviations from target levels, and the β_i are subjective weights.

Instrument rules, on the other hand, express the setting of the policy instrument, usually a short term interest rate, as a function of predetermined or forward-looking variables. Such rules are typified by the Taylor Rule (Taylor, 1993), under which the monetary authority changes the interest rate linearly in response to changes in inflation and the output gap:

$$i_t = i^* + \phi_\pi(\pi_t - \pi^*) + \phi_y y_t,$$

where i_t is the nominal interest rate, i^* is its (constant) equilibrium level (consistent with inflation at its target and a zero output gap), π^* is the inflation target, y_t is the output gap, and ϕ_π and ϕ_y are subjective weights. Since current policy decisions affect inflation with a lag, the inflation variable often becomes forecasted/expected future inflation: the central bank forecasts a path for inflation to be used as an intermediate target, and selects an instrument path to coincide with that target at some horizon (Svensson, 2000). In more general forms, additional variables enter on the right hand side, so that monetary policy reacts to changes in these variables as well.

The instrument rule should not be interpreted as a mechanical prescription for monetary policy, but rather as guide, as well as a tool for ex-post description (Taylor, 1993).

2.4 Strict vs flexible inflation targeting

An important distinction exists between strict and flexible inflation targeting. Strict inflation targeting allows only inflation to enter the monetary authority's objective function, so that the sole objective of monetary policy is the stability of inflation. Flexible inflation targeting, on the other hand, permits other variables such as output to have a nonzero weight in the objective function; their stability is a goal of monetary policy as well.

Allowing other variables to enter a central bank's objective function can be reconciled with the bank's primary goal of meeting an inflation target if there is a stated horizon over which the inflation target must be achieved. This gives the central bank time to address issues other than inflation, while still being able to meet its medium-term inflation target. Further flexibility may be allowed if the target is a band rather than a point (as in the case of South Africa), or if there is a 'tolerance band' around the point target (as there is for most inflation targeters).

The SARB has been accused of running an inflexible inflation targeting regime, focussing too much on inflation stability at the cost of lower growth and an unstable exchange rate. In the later empirical analysis, we shall interrogate this claim. As Svensson (2010) notes though, all inflation targeters exercise some degree of flexibility.

2.5 How inflation targeting works

The success of inflation targeting's ability to smooth the business cycle in response to a shock in the economy depends fundamentally on whether the shock comes from the demand or supply side of the economy. A negative demand shock depresses output while simultaneously causing a decrease in inflation. The correct interest rate response under an inflation targeting framework is to decrease rates, the effect of which is to increase inflation *and* output back towards desired levels, a result referred to by Blanchard and Galí (2007) as a 'divine coincidence'.

Supply shocks present a greater challenge to inflation targeters. A negative supply shock, such as a sharp increase in the oil price, increases prices while simultaneously decreasing output. A policy that responds simply to immediate changes in the inflation rate would raise interest rates, but this would put further strain on flagging output. This is the type of situation Stiglitz (2008) has in mind when he brands inflation targeting as a rule decreeing that 'whenever price growth exceeds a target level, interest rates should be raised ... regardless of the source of inflation.' Of course, this and many other criticisms of inflation targeting attack a straw man, since all inflation targeters exercise a degree of flexibility and tend to focus on target horizons. If the monetary authority believes the supply shock is temporary, they might be inclined to keep interest rates constant (or even to decrease them) if their forecast of *medium-term* inflation is still around the inflation target. Furthermore, flexible inflation targeters do place weight on fluctuations in output and employment in addition to inflation; the medium-term nature of the inflation target gives the monetary authority time to concentrate on the stability of these variables as well.

The temporary 'first-round' effect of a supply shock can flow through into inflation expectations and wage- and price-setting, the so-called 'second-round' effects of the supply shock. Since these second-round effects do influence medium-term inflation projections, an inflation targeting regime must respond to them. Thus, the decision of whether or not to respond to supply-side shocks, such as oil price shocks, can be a complex one, and may trigger an immediate or delayed response (Cuevas and Topak, 2009). Vigorous communication with the public by a credible central bank, emphasising the temporary nature of the supply shock and the bank's unchanged outlook for core inflation, can help to contain inflationary expectations and therefore second-round effects as well.

3 International experiences of inflation targeting

Inflation targeting was initially adopted in the early 1990s by industrialised countries such as New Zealand, Canada and the United Kingdom. Later, a number of emerging economies also adopted this regime. It is not an insignificant observation that no country that has adopted inflation targeting has subsequently discarded it; as Rose (2007) points out, such endurance is a rarity in the world of monetary policy, where regimes have historically not been durable. Figure 1 highlights the increasing prominence of inflation targeting amongst worldwide monetary regimes.

Preliminary analyses have suggested that inflation targeting has been successful for both industrialised and emerging economies. However, because inflation targeting is a relative newcomer to monetary policy, empirical analyses of its success are necessarily tentative, especially for emerging economies.

While the post-1990 period was generally a successful one for most industrialised countries, with strong growth and a trend towards lower and more stable inflation rates, evidence suggests that inflation targeters enjoyed relatively more success than non-inflation-targeters (Hyvonen, 2004; Vega and Winkelried, 2005; Mishkin and Schmidt-Hebbel, 2007).

Evidence from emerging economies also suggests a positive link between inflation targeting and better macroeconomic performance. An IMF (2006) study involving 13 emerging market inflation targeters and 29 comparable emerging market non-targeters over the period 1990-2004 shows that, while countries in general improved macroeconomically over the sample period, inflation targeters saw even greater improvements than non-targeters in the level and volatility of inflation, inflation expectations and output growth. On average, the inflation targeters enjoyed a 4.8% reduction in inflation relative to other regimes, as

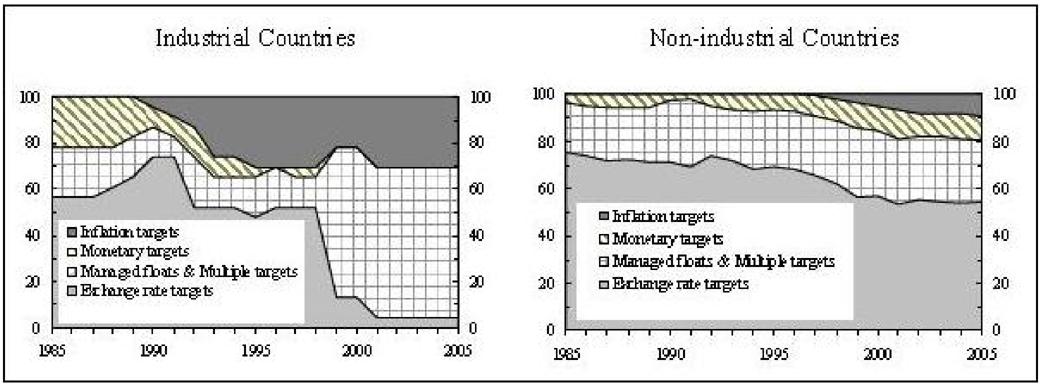

Figure 1: Evolution of the world composition of monetary policy regimes, 1985-2005. Source: IMF (2006)

well as an average 3.6% reduction in the standard deviation of inflation. These results are shown to be robust to a number of sensitivity tests, including removing countries that adopted inflation targeting with very high (> 40%) inflation rates. This addresses Ball and Sheridan's (2005) objection that empirical analyses such as those cited above often simply reflect 'regression to the mean'.[2]

4 South African monetary policy

4.1 Monetary regimes since the mid-1980s

South Africa has, since the mid-1980s, experienced two broad monetary policy regimes. The first, spanning the period 1986-1999, was essentially a system of money supply targeting; the second, spanning the period 2000-present, is a system of inflation targeting.

Under the money supply targeting regime, target ranges for a broad definition of money (M3) were announced each year. These targets, the ultimate aim of which was to protect the internal and external value of the rand, were intended as guidelines, rather than rules, and the SARB was allowed to breach the targets without penalty or the requirement of an explanation (Aron and Muellbauer, 2007). The main policy emphasis was on the SARB's repurchase (repo) interest rate, the rate at which the Reserve Bank repurchases government securities from commercial banks. Through the repo rate, the SARB could influence overnight collateralised lending and thus the short term market interest rate as well.

The extensive financial liberalisation that began in the late 1980s rendered the monetary targets ineffective, and, from 1990, the guidelines were supplemented by a wide range of indicators, including the exchange rate, asset prices, the output gap, the balance of payments, wage settlements, total credit extension, and the fiscal stance, which were explicitly expected to play a role in monetary decision making (see the SARB's *Quarterly Bulletin*, October 1997), although they likely had played a non-explicit role before then (Aron and Muellbauer, 2001). In March 1998, the repo rate became market-determined through 'repurchase transactions', daily tenders of liquidity. The SARB was able to signal its policy intentions on short term rates by the amount of liquidity it offered at these daily tenders (see the *Quarterly Bulletin*, June 1999). Aron and Muellbauer (2001) have pointed out that this system did not represent a significant departure from previous (1986-1998) policy, since commercial banks in practice remained heavily influenced by SARB-directed preferences for the interest rate. Monetary growth guidelines continued to be announced (although on a three year, rather than current, basis).

The system of inflation targeting was introduced in February 2000, with the explicit and overriding aim of keeping inflation low and stable. The measure of inflation chosen to target was the rate of change of the overall consumer price index excluding the mortgage interest cost (known as the CPIX).[3] The target range was set by the Ministry of Finance (later, this became the role of the National Treasury, a department within the Ministry of Finance); in the early years it was altered several times. The initial target, announced in

[2]Ball and Sheridan (2005) point out that emerging countries that adopted inflation targeting often did so because they had problems with high and volatile inflation. They therefore had more room for improvement than other countries in the typical sample.

[3]The mortgage interest cost was excluded because it is directly affected by interest rate changes.

February 2000, was an average level of CPIX inflation of 3-6% for the calendar year 2002. It was revised in October 2001 to 3-6% for 2003 and 3-5% for the years 2004 and 2005, again in October 2002 to 3-6% for 2004 and 3-5% for 2005, and again in February 2003 to 3-6% for 2005. After November 2003, the target range became constant and continuous (rather than for distinct calendar years) at 3-6%, though the measure of inflation to be targeted was changed in the beginning of 2009 to headline (overall consumer price index - CPI) inflation, with the method of calculating housing costs in the consumer price index altered from a mortgage interest cost to a rental equivalence cost.

The main policy instrument has remained the repo rate, which the Reserve Bank resets after meetings of the Monetary Policy Committee (MPC). In the initial stages of the inflation targeting regime, the MPC met every six to eight weeks, but in 2002 it was decided that the MPC should meet quarterly, with meetings coinciding with the release of the SARB's *Quarterly Bulletin*. (Provision was made for unscheduled meetings if deemed necessary.) In June 2003, it was decided that the frequency of MPC meetings should increase to around 6 per year, so that meetings would occur roughly every two months.

The inflation targeting regime focusses on a medium term horizon for three main reasons: (i) the effects of monetary policy decisions are expected to follow those decisions with a lag; (ii) a medium term horizon prevents short term shocks over which monetary policy has no control from having a large influence on monetary policy decisions, allowing the Bank to avoid unnecessary instability in output and interest rates (Gordhan, 2010); and (iii) while the overriding objective of the monetary regime is price stability, the medium term horizon allows the bank to focus on other issues as well, such as the output gap, in the short term.

Under inflation targeting, monetary policy in South Africa has become far more transparent, with extensive channels of communication having been set up between the SARB and the public, including the Monetary Policy Forums, the *Monetary Policy Review*, and statements after each MPC meeting explaining any policy changes and their rationales. This represents a significant improvement over the opaque 1986-1999 regime (Aron and Muellbauer, 2007). This communication is carried out with the aim of building strong credibility, and ultimately conditioning public expectations of inflation towards the target.

4.2 The data, and initial quantitative observations

The data for the various empirical analyses that follow are quarterly rather than monthly for two main reasons: (i) the highest frequency data available for real GDP, a central variable in this paper's analysis, are quarterly, and (ii) the frequency of the SARB's MPC meetings, where the main instrument rate is set, has been roughly two-monthly since June 2003, so that using monthly data to analyse the SARB's behaviour would result in 'inactive' observations.

The data set spans the period 1990Q1 - 2011Q1, so the 'pre-IT' period considered is 1990Q1 - 1999Q4, while the IT period is 2000Q1 - 2011Q1. A description of the data may be found in Table 1 in the appendix.

As a first step of analysis, it is instructive to examine whether the level and stability of major economic variables have improved in South Africa under inflation targeting, keeping n mind that South Africa's experience under inflation targeting, apart from being relatively brief, has also coincided with a number of external shocks, making conclusions more difficult to distill. Much of the literature on monetary policy has argued that its most important goals are stability of inflation and the output gap, defined as the difference between actual real output and some measure of the trend level of real output.

To construct a measure of the output gap, we apply a Hodrick-Prescott (HP) filter ($\lambda = 1600$, as is conventional for quarterly data) to our seasonally-adjusted quarterly data for real GDP to determine the trend level of real GDP over time. The real output gap is then defined as the difference between the actual and trend level, measured as a percentage of the trend level. As du Plessis et al. (2008) report, univariate statistical techniques such as the HP filter have yielded very similar estimates of potential GDP to those yielded by structural production function methods in the case of South Africa. Thus, we may have some confidence in the robustness of this measure. We take headline inflation, as reported by the SARB, as our measure of inflation (for now).

Figure 2 plots headline inflation and the real output gap over the period 1990Q1-2011Q1.

As illustrated in Figure 2, and summarised in Table 2, the average level of headline inflation in the IT period (5.92%) has been significantly lower than in the pre-IT period (9.91%); the standard deviation of inflation has decreased slightly (from 3.62% to 3.12%). However, using the standard deviation of inflation to compare the two regimes (as many studies do; for example, Kahn, 2008) might be misleading, given the obvious trend of

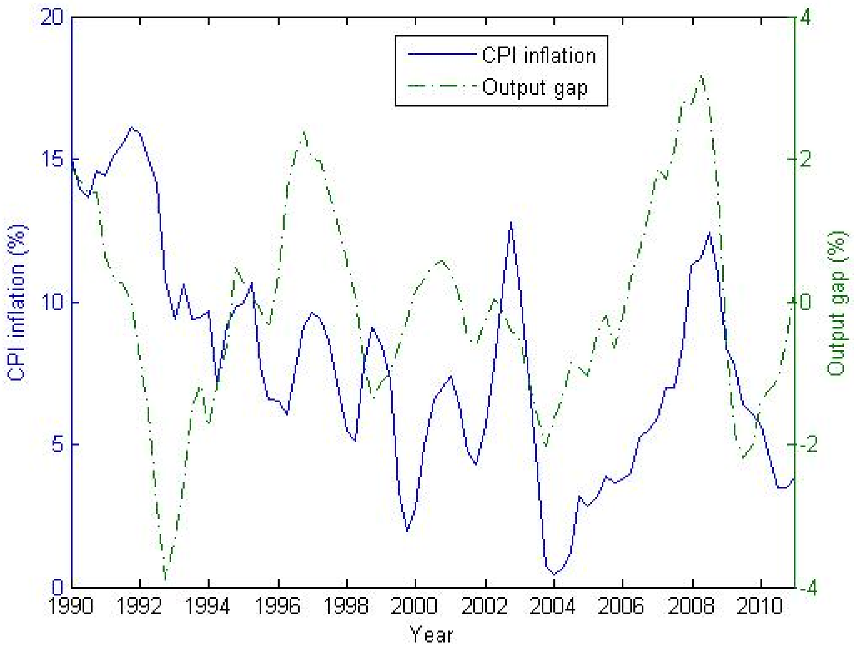

Figure 2: Evolution of headline inflation and the real output gap over the period 1990Q1-2011Q1. Source: Authors' calculations using data from SARB (2011).

disinflation in the pre-IT period, from around 15% in 1990Q1 to around 2% in 1999Q4.[4] To address this, we apply a straight-line trend to each period's inflation evolution, and measure the standard error of detrended inflation. This procedure yields a substantially lower standard deviation (1.86%) for the pre-IT period than for the IT period (3.11%).

The average growth rate of output increased from the pre-IT period (1.40%) to the IT period (3.57%), while the standard deviation of the output gap decreased slightly from pre-IT (1.54%) to IT (1.37%). However, the sample period is too short for these results to be considered telling. In addition, the periods in question saw significant external shocks.

Clearly, if low and stable inflation were the sole factor by which the SARB is judged, the Bank could not hope for a favourable review. Despite the decrease in the average headline inflation rate under IT, CPIX inflation exceeded the upper bound of the target zone (6%) in 14 of the 28 quarters between 2002Q1 (the first year for which the inflation target was intended to be achieved) and 2008Q4 (the date at which the CPIX target was discarded). Headline inflation exceeded 6% in 16 of the 37 quarters between 2002Q1 and 2011Q1. The regular achievement of inflation targets is key both in promoting credibility of an inflation targeting central bank and in stabilising expectations of inflation at or near the target. That the SARB regularly misses the inflation target casts doubt on how successful it could have been in achieving these two goals.

5 The instrument reaction model

In this section, we compare the behaviour of the SARB pre- and post-adoption of inflation targeting by attempting to fit to the instrument-setting of the SARB generalised Taylor-like rules of the form

$$i_t = i^* + \phi_\pi(E_t\pi_{t+T|t} - \pi^*) + \phi_y(E_t y_{t+\tau|t}) + \boldsymbol{\theta} \cdot \mathbf{z}_t, \tag{1}$$

where i_t is the period-t nominal interest rate, i^* is the equilibrium nominal interest rate, $E_t\pi_{t+T|t}$ is the Reserve Bank's period-t expectation[5] of the average inflation rate between periods t and $t+T$, π^* is the target rate of inflation, $E_t y_{t+\tau|t}$ is the Reserve Bank's period-t expectation of the average output gap over the period t to $t+\tau$, and $\mathbf{z}_t$ is a vector of other variables to which the Reserve Bank might respond. ϕ_π, ϕ_y and $\boldsymbol{\theta}$ are subjective weights, to be estimated. We use the expectations of future inflation and output since it is to these variables that monetary policy usually responds, cognisant of the fact that its influence is not immediate. However, not having knowledge of these expectations, we shall have to proxy for them using variables we do have at our disposal.

We take as the nominal interest rate the end-of-quarter repo rate. Other studies have used the treasury bill rate as the measure for the nominal interest rate; since the treasury

[4]Indeed, if inflation had decreased in a perfectly straight line from its beginning to end levels in the pre-IT period, the standard deviation of inflation would have been 3.94%.

[5]It is important that the forecast considered is the central bank's internal forecast, rather than an external forecast or market expectation. If the central bank lets its instrument react systematically to market expectations, there may be inherent instability, nonuniqueness or nonexistence of equilibria (Bernanke and Woodford, 1997; Svensson, 2000). Using an estimation of a specification like (1) to analyse market expectations (as Naraidoo and Gupta (2009) do for the case of South Africa) would also be misleading, since the central bank's reactions depend on its own expectations.

bill rate and the repo rate are almost perfectly correlated (correlation coefficient of 0.975 in our sample), this should have no meaningful effect on our results.

For now we proxy the SARB's expectations of future inflation and the output gap by their contemporaneous levels. For now, then, the specification of (1) that we shall consider is

$$i_t = i^* + \phi_\pi(\pi_t - \pi^*) + \phi_y y_t + \boldsymbol{\theta} \cdot \mathbf{z}_t. \tag{2}$$

This study seeks to estimate such Taylor-like rules in order to analyse the relative weights the SARB accorded to monetary policy targets when setting interest rates in the periods under study. Our discussion of the pre-IT period in Section 4.1 suggests that emphasis was placed on an eclectic set of indicators, so that the Reserve Bank's behaviour could not be well approximated by the the basic Taylor Rule. Rather, we might expect the fit to improve as addional indicators are introduced into the specification.

For the IT period, we expect estimations of the above specification to return a significant coefficient on the inflation gap, since it is the stability of this variable that is the overriding objective of monetary policy under inflation targeting. However, there is also a provision in the SARB's mandate that allows for consideration of variables other than inflation; through our estimation of Taylor-like rules we hope to gain insight into what variables the SARB considers in exercising this flexibility. For example, a significantly positive coefficient on the output gap would be evidence that the SARB adjusts countercylically with demand shocks but accommodates supply shocks (which are reflected in the trend level of output).

One difficulty, to be discussed in greater detail below, is that our proxy for expected inflation, namely current inflation, may be too simple; Svensson (2000) points out that the inflation forecast of a central bank is likely to depend on a large number of variables. If we discover these variables to be significant in estimations of Taylor-like rules, their significance may simply reflect their weighting in the SARB's inflation forecast, rather than the SARB's exercising flexibility by targeting these variables directly. Section 5.8 provides a detailed analysis of this potential problem.

We shall use our data to estimate the coefficients in (2), beginning with the simplest form ($\mathbf{z} = \mathbf{0}$) and gradually use more complicated specifications. Naturally, the most robust observations will be those of later models, since omitted variable bias may play a large role in the estimations of simpler specifications. This is a caveat we shall keep in mind when discussing the results of earlier specifications.

The econometric estimations will be carried out by OLS, and thus we first consider whether the time series in question are stationary or not, a subject with which the following subsection concerns itself. It is also important to note that the explanatory variables in (2) can not be *strictly* exogenous, since the nominal interest rate affects future values of the explanatory variables. However, since we use the end-of-quarter repo rate, the explanatory variables are *contemporaneously* exogenous, so that our estimates will be consistent in the absence of any other econometric problems.

5.1 Stationarity of the variables

Using OLS to estimate an equation in which two or more non-stationary variables lurk may result in the conventional t and F tests suggesting relationships where none exist. It also may result in an artificially high R-squared. This is the problem of spurious regression, first identified by Yule (1926).

To test for stationarity, we employ a range of Dickey-Fuller tests; the results are reported in Table 3 in the Appendix. The tests unanimously fail to reject the hypothesis of a unit root in the repo rate for both the pre-IT and IT periods, as well as the rate of inflation for the pre-IT period. There is also a strong suspicion of a unit root in the output gap for the IT period. The results for the other variables are mixed, with some periods showing evidence of stationarity and others not. These results necessitate a careful consideration of how we might alter our functional form to deal with the threat of spuriosity.

In response to the strong suspicions of nonstationary variables, we take the first difference of the equation to be estimated (2), which yields the general specification:

$$\Delta i_t = \phi_\pi \Delta \pi_t + \phi_y \Delta y_t + \boldsymbol{\theta} \cdot \Delta \mathbf{z}_t. \tag{3}$$

It is important to keep in mind that the coefficients in (3) are identical to those in (2), and thus their interpretation (and that of our estimates of them) is unchanged.

It is interesting to note that the use of first differencing (or indeed, any other method) to guard against spuriosity in the estimation of Taylor-like rules seems to be the exception rather than the rule. For example, Clarida et al. (2000), in estimating a general Taylor-like rule for the United States, assume that both the inflation rate and the nominal interest rate are stationary, despite finding evidence (via conventional unit root tests) to the contrary. In defending this assumption, they point to theoretical reasons for believing the time series to be stationary, as well as the low power of the unit root tests employed.

Among South African studies, Naraidoo and Gupta (2009) claim that unit root tests confirm that the nominal interest rate, inflation and the output gap are stationary variables over the period we are considering, though the results are not reported. It is not clear whether the authors carried out the tests for different periods, a potentially significant consideration given the fact that our results show evidence of the stationarity of some variables to alter between the pre-IT and IT periods.[6] Rangasamy (2009) also argues that, in considering the inertia of inflation, one must account for potential structural breaks. He shows that, in the case of South Africa, conventional Chow tests reject the hypothesis of no structural change in the inflation process (in an econometric specification similar to the unit root tests we have employed) at the point 1999Q4. It is thus vital that unit root tests be carried out for each period when analysing the stationarity of the variables.

An alternative technique, facing potential nonstationarity in variables, is to test for cointegration. Engle-Granger tests (Engle and Granger, 1987) were carried out for both periods, using the critical values provided by MacKinnon (2010); the results are presented in Table 4. First, we tested for cointegration between i_t, i_{t-1}, π_t, y_t and e_t: our results provide evidence for cointegration in the pre-IT period (significant at the 5% level) but not in the IT period (not significant at the 10% level). Omitting the output gap measure (which displays evidence of stationarity, and indeed is constructed as such) and testing for cointegration between the remaining variables, we again find evidence of cointegration in

[6]Indeed, changes in the level of inertia of variables are significant not just on econometric grounds, but on analytical grounds as well. For example, one of the commonly-used tests of the success of inflation targeting is whether inflation has come to exhibit less inertia or not (Ball and Sheridan, 2005).

the pre-IT period (5% level) but not in the IT period. That we cannot reject the hypothesis of non-cointegration for the IT period suggests that we should not rely on cointegration in our regressions for this period; for the sake of comparability, we do the same for the pre-IT period as well, and so we shall use OLS on the first-differenced specification for both periods.

To illustrate the potential pitfalls of directly estimating equations of the form (2) for our data despite the strong evidence of nonstationary processes presented in Table 3, we carry out an OLS estimation of the following equation:

$$i_t = \beta_0 + \beta_1 i_{t-1} + \beta_2 \pi_t + \beta_3 y_t \tag{4}$$

for the IT period. This is similar to forms estimated in the papers mentioned above, where first differences were not taken. The OLS regression returns an R-squared of 0.912 and a Durbin-Watson d-statistic of 0.965. This comes very close to contravening the Granger and Newbold (1974) rule of thumb to suspect that the estimated regression is spurious, to wit $R^2 > d$. On the other hand, an OLS estimation of the first differenced form of (4), and thus of the same coefficients as those in (4), returns an R-squared of 0.642 and a Durbin-Watson d-statistic of 2.061. The concern that our results are spurious is no longer present. A similar observation is made by Österholm (2005) citing studies that use US data; the author also expresses concerns about the possible spuriosity of estimates of Taylor rules that ignore the potential nonstationarity of the data.

Moreover, as Mehra and Sawhney (2010) show, serial correlation in the error term might lead to a spuriously significant coefficient on the i_{t-1} term, mistakenly leading to the belief that the central bank is smoothing interest rates (see Section 5.3) when it might in fact not be.

5.2 The basic Taylor Rule

We begin with the basic Taylor Rule, which Taylor (1993) and numerous subsequent studies have shown to provide a good approximation of the behaviour of many central banks:

$$i_t = i^* + \phi_\pi(\pi_t - \pi^*) + \phi_y y_t, \tag{5}$$

We may gain greater theoretical insight into the workings of (5) if we rewrite it as an implicit rule for the real interest rate, approximating the real interest rate r_t by $i_t - \pi_t$:

$$r_t = i^* - \pi^* + (\phi_\pi - 1)(\pi_t - \pi^*) + \phi_y y_t. \tag{6}$$

Standard macroeconomic wisdom holds that it is changes in the *real* interest rate that matter for the evolution of variables such as inflation and the output gap; generally speaking, lower real rates stimulate the economy and inflation, while higher real rates have the opposite effect.

The important insight that (6) offers is this: if a central bank follows a rule of the form (5), or if such a rule is a good approximation of the behaviour of a central bank, then $\phi_\pi > 1$ will tend to be stabilising in the sense that the real interest rate will move in directions that stabilise changes in inflation. On the other hand, if $\phi_\pi \leq 1$, monetary policy will tend to be destabilising by accommodating changes in inflation. A similar distinction can be made between stabilising and destabilising policy if ϕ_y is greater than or less than zero respectively (Clarida et al., 2000). This stability benchmark ($\phi_\pi > 1, \phi_y > 0$), known as the 'Taylor principle', is generalisable to any of the linear Taylor-like rules of the general form (1).

We now estimate the coefficients in (5), first differencing and including a zero-mean white noise term to yield:

$$\Delta i_t = \phi_\pi \Delta \pi_t + \phi_y \Delta y_t + \nu_t. \tag{7}$$

The pre-IT regression, regression (i) in Table 5, yields an estimate for the coefficient on the inflation gap of $\hat{\phi}_\pi = 0.322$, statistically significant at the 5% level. The coefficient on the output gap is statistically indistinguishable from zero at conventional levels. As expected, the current specification provides a poor fit for the pre-IT period, with an R-squared of just 0.127.

The regression for the IT period, regression (ii) in Table 5, returns estimates of $\hat{\phi}_\pi = 0.302$ and $\hat{\phi}_y = 0.574$, both statistically significant at the 1% level. The estimated equation provides a far better fit than for the pre-IT period, with an R-squared of 0.599.

A number of tentative observations may be drawn from these results. First, as expected, the simple Taylor-rule provides a poor approximation of the instrument reaction behaviour of the SARB pre-IT (and a good fit for the IT period). Still, as we consider more eclectic forms of (2), the fit of the pre-IT regressions will not match the fit of the simple Taylor Rule in the IT period, suggesting that monetary policy has become both more rules-based with the adoption of IT (or more precisely, that instrument reactions have more closely approximated a rule under IT), as well as simpler.

Second, that the SARB's IT regime is flexible is evidenced by the significantly positive coefficient on the output gap for the IT period - the SARB responds significantly to short term movements in the output gap. This counters claims by COSATU and others that the Reserve Bank focusses too strictly on inflation, and gives little or no consideration to the output gap.

Third, in both periods the coefficient on the inflation gap is significantly smaller than unity, a disturbing result given our discussion of the Taylor principle above. This charge, that monetary policy in both periods was conducive to an unstable inflation process, is a serious one, and will be discussed further below (drawing on the results of more predictor-laden models, with which the problem of omitted variable bias is lessof a concern).

Fourth, it would be reasonable to expect ϕ_π to have increased under IT; the results tentatively suggest that this might not be the case. Of course, this may be an artifact of omitted variable bias, although the finding will persist in later regressions as well. This counterintuitive observation is one that casts some doubt on the SARB's commitment to a greater focus on price stability under inflation targeting.

5.3 Accounting for interest rate smoothing

Our specification may be modified slightly to account for the oft-noted tendency of central banks to smooth changes in interest rates; i.e. to change interest rates to the desired level gradually, rather than immediately. To account for this, we employ the following specification for the current nominal interest rate in terms of the target rate and the previous period's rate:

$$i_t = \alpha i_{t-1} + (1-\alpha)\tilde{i}_t, \tag{8}$$

where $\tilde{i}_t$ is the target nominal interest rate given by (2). The central bank, cognisant of its target level for the interest rate, adjusts the actual interest rate a positive fraction $1-\alpha \in (0,1]$ of the gap between the previous period's actual rate and the target rate. The parameter α is thus a measure of the degree of interest rate smoothing exercised by the central bank. To illustrate, if the target rate were to change to $\tilde{i}$ in period t, and remain constant thereafter, we have the following expression for the period $t+n$ difference between the actual and target interest rates:

$$i_{t+n} - \tilde{i} = \alpha^n \left[i_t - \tilde{i} \right].$$

The larger is α, the slower the interest rate adjusts towards the target level.

Incorporating (8) into our general specification yields

$$i_t = \alpha i_{t-1} + (1-\alpha)\left[i^* + \phi_\pi(\pi_t - \pi^*) + \phi_y y_t + \boldsymbol{\theta} \cdot \mathbf{z}_t \right]. \tag{9}$$

This specification permits an interpretation of the coefficients in terms of the 'short run' and the 'long run': The immediate response to a unit change in, say, the inflation gap is to change the interest rate by $(1-\alpha)\phi_\pi$. This may be seen as the short run reaction. If the target interest rate remains unchanged thereafter, the eventual (asymptotic) effect is that the interest rate changes by ϕ_π. This is the long run effect; it is necessarily greater in magnitude than the short run effect. The same holds for the coefficients on the output gap and other predictors.

Our first estimates of (9) will be of the simple case where $\mathbf{z}_t = \mathbf{0}$, i.e. of the basic Taylor Rule augmented to account for interest rate smoothing. First differencing and including a zero-mean white noise term results in the following specification

$$\Delta i_t = \alpha \Delta i_{t-1} + (1-\alpha)\phi_\pi \Delta \pi_t + (1-\alpha)\phi_y \Delta y_t + \nu_t, \tag{10}$$

which we estimate using OLS; the results are displayed in columns (iii) and (iv) of Table 5. We report the coefficients on the predictors (estimates of $(1-\alpha)\phi_\pi$ etc., the short run reaction parameters), as well as the implied values of the long run parameters ϕ_π and ϕ_y, calculated in each case using the respective point estimate of α, with the standard errors calculated using the delta method.

For the pre-IT period, the estimate for α, the interest rate smoothing parameter, is statistically indistinguishable from zero; there is no evidence at this stage that the Reserve Bank smoothed interest rates in a systematic way in the pre-IT period. The coefficients on the inflation and output gaps are also statistically insignificant, and the model provides a poor fit, with an R-squared of just 0.150. Our estimates of the long run inflation reaction parameter ϕ_π is positive (0.299) and statistically significant at the 10% level, while that of ϕ_y is statistically indistinguishable from zero.

The estimated interest smoothing parameter for the IT period is 0.252; it is significant at the 5% level. Thus, we find initial evidence of systematic interest rate smoothing under IT. The coefficients on the inflation and output gaps are both significant at the 1% level, and our accounting for interest rate smoothing has slightly improved the fit of the model, with the R-squared having increased to 0.642.

Using our point estimate of α, we obtain the following estimates for the IT period: $\hat{\phi}_\pi = 0.292$ and $\hat{\phi}_y = 0.762$, both significant at the 1% level. The estimates of the Reserve Bank's weights on the inflation gap for the two periods have not changed substantially after accounting for interest rate smoothing, and are still substantially (and statistically significantly) below unity, in contravention of the Taylor principle. Our estimate of the coefficient on the output gap has increased for the IT period, and is still statistically significantly positive, providing further evidence that the SARB's IT regime is flexible.

5.4 The real exchange rate

5.4.1 Should the real exchange rate be targeted?

One of the major criticisms levelled at South Africa's inflation targeting regime, most prominently by COSATU, is that it exerts little control over the exchange rate; South Africa's real exchange rate is extremely volatile compared to most other countries. A volatile exchange rate, or one that is persistently overvalued, can have negative repercussions for international trade and investment, and so, some say, the SARB should focus more on the exchange rate.

It should be made clear from the outset is that an inflation targeting regime does not ignore the exchange rate. Since a depreciation in the exchange rate tends to place upward pressure on inflation, while an appreciation has the opposite effect, a regime that is concerned (even solely) with inflation would respond to movements in the exchange rate, and tend to do so in the direction that stabilises the exchange rate as well (by increasing the interest rate in response to a depreciation, and vice versa).

If exchange rate stability is an objective of monetary policy, there are a number of strategies to achieve this end.

The most extreme form of exvhange rate targeting would be some form of fixing the exchange rate, the major attractions of which are a simple nominal anchor and a simultaneous reduction in the currency risk component in domestic interest rates. The major detraction is that domestic interest rates must be aligned to those in the anchor country/countries - monetary policy forfeits the ability to respond directly to domestic shocks. Since South Africa's economy is not highly integrated with any of the more stable economies of the world, pegging the rand to any of their currencies would result in our suffering their economic shocks, while being unable to adequately address our own. Moreover, the mobility and size of modern capital markets have made defending fixed exchange rates against speculation enormously expensive; this is the practical consideration Obstfeld and Rogoff (1995) have in mind when they emphatically proclaim that 'it is folly to try to recapture the lost innocence of fixed exchange rates'. The case for target bands is not much stronger - when the band's boundary is reached, the problems of fixed exchange rates become relevant.

A less severe strategy is for the monetary authority to respond to movements in the real exchange rate using the instruments available to it, (at least partly) independent of any effect the change in the exchange rate might have on other variables such as inflation; i.e. to directly stabilise the real exchange rate via its instrument reaction. Beyond responding to exchange rate movements only insofar as they signal changes in inflation (though this would be, as noted, exchange rate-stabilising to some extent), trade-offs between the goals of monetary policy would necessarily emerge - required interest rate movements to stabilise inflation, the exchange rate, and the output gap are not always harmonious. In this sense, the interest rate is a 'sledgehammer', not a 'surgical scalpel': it cannot be employed to affect one variable (the exchange rate, say) without affecting a number of other variables as well (inflation, output, etc.).

A good example of this 'sledgehammer' effect is found in the savage interest rate spike with which the SARB reacted to the 1997/8 currency depreciation. While the rand did strengthen slightly, the country also suffered a plunge in the real output gap. Aron and Muellbauer (2007) compare this reaction to the more moderate one with which the SARB responded to the 2001 rand depreciation; the latter saw a lower cost to output and a greater degree of stability overall.

5.4.2 Has the real exchange rate been targeted?

To test whether the real exchange rate formed part of the decision making of the SARB pre- and post-adoption of IT, we add a measure of the real exchange rate to our specification by incorporating it as an element of $\mathbf{z}_t$. Because we would like to make some fairly robust observations at this stage, we include measures of asset prices (see next section) to mitigate the possibility of omitted variable bias. We keep the specification that accounts for interest rate smoothing, so that the equation to be estimated is

$$i_t = \alpha i_{t-1} + (1-\alpha)\left[i^* + \phi_\pi(\pi_t - \pi^*) + \phi_y y_t + \phi_e(e_t - e^*) + \boldsymbol{\theta}\cdot\mathbf{z}_t\right], \tag{11}$$

where e_t is the real exchange rate[7] and e^* is the target real rate. $\mathbf{z}_t$ includes the asset price gaps that will be defined properly in the next section. In keeping with the nature of the other variables in the specification, we interpret $e_t - e^*$ as a 'gap' or deviation from equilibrium, in percentage form.[8] We first-difference (11) and estimate the coefficients using OLS, as before. The results for the two periods form columns (v) and (vi) in Table 5 in the appendix.

Adding the real exchange rate gap (and the asset price gaps) to the pre-IT regression substantially improves the fit of the model, with the R-squared increasing to 0.388 (from just 0.150).[9] This confirms the 'eclectic' nature of monetary policy pre-IT: variables other than those specified in the basic Taylor Rule explain more of the instrument variability than the 'classic' variables (inflation and the output gap). The coefficient on the real exchange rate is negative (-0.135), and significant at the 1% level, suggesting that the SARB tended to raise rates in response to depreciations and to lower rates in response to appreciations, behaviour consistent with attempting to stabilise the exchange rate. The coefficient on the inflation gap is significant at the 10% level, while the coefficient on the output gap is insignificant. The coefficient on the inflation gap, when augmented by the

[7] We use the real effective exchange rate calculated by the IMF, which is defined as an index with base of 100. The rate is defined in local currency per unit of foreign currency, so that an increase corresponds to an appreciation.

[8] We take the target or equilibrium value of e as 100, so that deviations from the target are percentages of the target as well. If the equilibrium exchange rate is not 100, but some other constant, the only effect on our estimation will be a scaling of $\hat{\phi}_e$ - its sign and significance will be unchanged.

[9] Adding the real exchange rate to the specification, but not the asset price gaps, results in a still much improved R-squared of 0.256.

factor $1/(1-\hat{\alpha})$, is still significantly below unity. There is still no evidence of systematic interest rate smoothing in the pre-IT period, with the coefficient on the lagged repo rate insignificant, even at the 10% level.

The inclusion of the exchange rate and asset price gaps for the IT period only marginally improves the fit of the model, with the R-squared increasing to 0.680. The coefficient on the real exchange rate for the IT period is negative, and statistically significant at the 10% level, though it is small in magnitude (-0.030, compared to the pre-IT estimate -0.135), suggesting that, in terms of instrument decisions, the SARB has not responded substantially to changes in the real exchange rate. Again, there is evidence of interest rate smoothing, with the coefficient on the lagged repo rate significant at the 5% level, and similar in magnitude to that in the previous IT regression. The coefficients on the inflation and output gaps have not changed noticeably with the inclusion of the real exchange rate and asset price gaps, with the estimates of both the short-run and long-run inflation reaction parameters still significantly below unity for the IT period.

5.5 Asset prices

5.5.1 Should asset prices be targeted?

The recent financial crisis has raised questions around the extent to which monetary policy should react to movements in asset prices;[10] inflation targeting in particular has been accused of ignoring asset price bubbles.

Again, we note that inflation targeting does already respond to asset price movements insofar as they signal changes in expected inflation. Since asset prices, aggregate demand and inflation expectations tend to move in the same direction, interest rate responses under an inflation targeting framework will tend to induce the correct (directionally) stabilisation response with respect to each in the face of asset price instability. Moreover, because asset price shocks fall primarily on the demand side of the economy, standard business cycle theory suggests that inflation targeting is a particularly good policy to play this countercyclical role (Sørensen and Whitta-Jacobsen, 2005, chap. 20). Price stability and financial stability can be complementary objectives, and inflation targeting provides a unified framework to address both. Furthermore, public knowledge that a credible central bank systematically addresses asset price movements countercyclically under an inflation targeting framework can help to reduce the 'irrational exuberance' that leads to bubbles in the first place.

Critics of inflation targeting contend that the monetary authorities should provide responses to asset price movements *over and above* those dealing with inflationary expectations. In other words, central banks should target asset prices to some degree. The difficulty with such a strategy is that it is nearly impossible to tell whether movements in asset prices are the result of fundamental factors or nonfundamental factors.[11] As Mishkin (2007) notes, to assume that monetary authorities can distinguish between fundamental

[10] We do not consider exchange rates here, although they are asset prices, since they have been separately considered in a previous section.

[11] Or indeed, both. If it were not already difficult enough to distinguish between fundamental and nonfundamental movements, it would be even more difficult to accurately quantify the two if asset price movements were the result of both. A correctly tailored response under an asset price targeting framework would then be practically impossible.

and non-fundamental movements is to assume that they have better information and predictive ability than the private sector. This is not to deny the existence or damaging effects of asset price bubbles - the point is that, without an informational advantage over private markets, monetary authorities would be as likely to mispredict the presence or absence of a bubble as private markets, and as a result would frequently be mistaken, damaging their credibility. A unified strategy of inflation targeting, on the other hand, allows the central bank to respond to asset booms and busts without getting into the murky business of deciding what is fundamental and what is not (Bernanke and Gertler, 2000).

Moreover, the 'sledgehammer' effect of interest rates is even more problematic with asset prices; their sensitivity to interest rate changes is generally much lower than that of output, inflation or the exchange rate. For example, the interest rate increase needed to deflate a supposed bubble is likely to wreak havoc on the rest of the economy.

Our contention is that monetary policy responses to asset price movements should be limited to addressing the inflationary repercussions of those movements - asset price regulation may fall more appropriately under financial market regulation and supervision than monetary policy control.For example, if rapidly rising prices in the housing market are deemed to be unsustainable, there are more effective instruments to deflate the supposed bubble than monetary policy, including regulation of loan-to-value ratios and minimum mortgages (Svensson, 2010).

5.5.2 Have asset prices been targeted?

Some studies that seek to estimate an instrument reaction function for the SARB have incorporated asset prices by adding a composite asset price index to Taylor-like specifications (see, for example, Naraidoo and Paya, 2010). We find the use of a composite asset price index inadvisable, since it imposes a given weighting for each asset price within the index and thus within the rule as a whole. A less restrictive method for testing would be to include asset prices individually, and to test the hypothesis of their joint significance; this is the method we employ.

In testing whether the instrument reaction decisions of the Reserve Bank have depended on asset prices in the two periods under study, we consider two asset prices distinct from the exchange rate: share prices (we use the All Share Index) and house prices (ABSA's Average House Price Index). We add to our specification two measures: a share price gap and a house price gap, both calculated using a Hodrick-Prescott filter ($\lambda = 1600$) and taken as percentages of the trend. We use this measure rather than, say, year-on-year percentage increases, to account for the fact that these variables often have distinct trends that cannot be captured adequately and systematically by taking percentage increases and the like.[12] Our specification is then:

$$i_t = \alpha i_{t-1} + (1-\alpha)\left[i^* + \phi_\pi(\pi_t - \pi^*) + \phi_y y_t + \phi_e e_t + \mathbf{\Phi} \cdot \mathbf{A}_t\right], \tag{12}$$

where $\mathbf{A}_t$ is the vector of asset price gaps $(sharegap_t, housegap_t)$, and $\mathbf{\Phi} = (\Phi_{sh}, \Phi_h)$ is

[12] In particular, taking percentage increases and incorporating them into our linear specification implicitly assumes that the target level for the percentage increases is constant, and that for the prices themselves is exponential. One can readily see from diagrams of the evolution of these asset prices that this would be a poor approximation of any acceptable trend.

the vector of the weights placed on the asset price gaps.

(12) is the fully defined version of (11), whose coefficients we have already estimated, with the results presented in columns (v) and (vi) of Table 5.

For the pre-IT period, of the asset price gaps, only the coefficient on the share price gap is statistically significant at conventional levels, being significant at the 5% level. The sign of the coefficient on the share gap is positive, in line with what we would expect. Adding the asset price gaps to a specification that already includes the exchange rate increases the R-squared from 0.256 to 0.388, suggesting that asset prices explain a large part of the SARB's instrument decision variation pre-IT. This is confirmed by an F-test of the hypothesis that the asset price gaps are jointly insignificant pre-IT: the null hypothesis of no significance is rejected at the 5% level ($F_{2,33} = 3.55$; $p = 4.00\%$).

None of the coefficients on the asset gaps is significant at conventional levels for the IT period. The R-squared increases only marginally when we add the asset price gaps to a regression that already includes the real exchange rate, from 0.677 to 0.688; an F-test fails to reject the hypothesis that the asset prices are jointly insignificant at conventional levels ($F_{3,38} = 0.63$; $p = 53.65\%$). The evidence suggests that, under inflation targeting, the SARB has not targeted asset prices.

5.6 What measure of inflation?

The question of what measure of inflation should be targeted is equivalent to the question of what prices the monetary authority considers important to stabilise the growth of in the medium term. Since the central bank does not know, but can only forecast, what the medium-term level of that inflation rate will be, another question is raised: What current measure of inflation, in conjunction with other variables, is most useful in indicating what the medium term level of the targeted inflation rate will be? It may seem obvious that the current level of the variable whose medium term level is targeted would best perform this role, but we shall argue below that this is not necessarily the case.

With regard to the first question, viz. what variable should form the medium term target, we consider four measures of inflation relevant to South Africa: headline (CPI) inflation, CPIX inflation, domestic inflation, and core inflation. Roughly speaking, CPI inflation is the rate of change of the price of a bundle of goods that is representative of the typical consumption patterns of a South African citizen. This bundle includes imported goods, so that CPI inflation depends on the domestic price of goods produced elsewhere. As noted previously, CPIX inflation is the rate of change of the price of the same bundle used in calculating CPI inflation, but excluding the mortgage interest cost. Domestic price inflation is the rate of change of the price of a bundle of goods produced domestically. Finally, core inflation is calculated in the same way as CPI inflation, but excludes the prices of certain food products, the cost of mortgage bonds and certain indirect taxes.

The SARB initially chose CPIX inflation over CPI inflation as the variable to target, since the mortgage interest payments that form part of the CPI measure (but not CPIX) are directly affected by changes in the repo rate, resulting in an unwanted feedback from inflation to changes in the repo rate back to inflation. However, this disadvantage of CPI inflation targeting can be, and has been in most countries that target CPI inflation, eliminated by altering the method with which housing costs are calculated. At the beginning of

2009, the Reserve Bank changed its target variable to CPI inflation, altering the measurement of housing costs from mortgage interest costs to a rental equivalence measure (Kahn, 2008). Thus, in practice, CPI inflation targeting and CPIX inflation targeting collapse to a single case, which we shall call CPI inflation targeting. This allows us to simplify our discussion to CPI inflation targeting, domestic price inflation targeting and core inflation targeting.

CPI inflation targeting has the benefit that it targets a measure of inflation that applies to the typical consumption patterns of a South African citizen; i.e. it targets the most meaningful measure of inflation for most members of society. In addition, it is easily understood by the public. The problem with targeting CPI inflation is that the measure is influenced by goods whose prices are very volatile (such as food). This leads to a larger degree of uncertainty in forecasts of future inflation (and thus greater uncertainty in instrument setting), and adds an unavoidable element of volatility to a variable whose stability is the expressed aim of monetary policy. Moreover, by using such a broad measure of inflation, the Bank's target may be affected by exogenous shocks over which it has no control (van der Merwe, 2004).

Domestic price inflation targeting excludes the price of imported goods from the target. To the extent that imported goods form a significant part of the consumption preferences of a typical South African, this measure does not capture a meaningful (from society's perspective) measure of inflation. Domestic price inflation is also influenced by goods whose prices are volatile, leading to the same problems as with CPI inflation targeting noted above. These represent significant weaknesses, which have led all inflation-targeting countries to eschew domestic price inflation targeting.

Core inflation targeting removes the effects of food prices and other volatile prices from the target. Again, to the extent that these goods form a significant part of the typical South African's consumption bundle, the target will not be meaningful from society's perspective. It is also more difficult for the public to understand than CPI inflation targeting, potentially damaging credibility (van der Merwe, 2004). However, using core inflation as the target would provide the advantage that the volatile prices that are problematic for CPI inflation targeting would not be part of the target, allowing the central bank to avoid the problems that these volatile prices cause for CPI inflation targeting.

It is notable that the core index in South Africa, unlike most countries' core indexes, includes a nontrivial weighting for an index of the petrol price (currently 3.99%, higher than its weighting in the CPI). Thus, using the official measure of core inflation as the target would remove some, but not all of the volatile prices over which monetary policy has no control from the targeted measure.[13]

The problems inherent in domestic price inflation targeting warrant its exclusion from further consideration as a viable target. In choosing between CPI inflation and core inflation, a tradeoff has been identified between the meaningfulness and understandability

[13] Of course, this difficulty could easily be overcome by removing the petrol price from the core index. It truly is odd that it is included in the core measure, since the definition of 'core inflation' essentially prohibits its inclusion. It is even more bizarre that petrol's weighting in the core index is even higher than petrol's weighting in the CPI. Core inflation certainly should account for some of the second round effects of changes in the oil price, but directly including the oil price in the measure results in even very temporary changes in the oil price (which should have only limited pass through under a credible regime) causing fluctuations in the official measure of core inflation.

of the target on one hand (a benefit of CPI inflation targeting, and a weakness of core inflation targeting), and the potentially misleading effects of volatile prices and those over which the monetary authority have no influence on the other hand (a problem with CPI inflation targeting, but not for core inflation targeting). In reality, a flexible regime with a medium-term horizon for its target can have, to a certain extent, the best of both worlds. It can use CPI inflation as its target, and thus enjoy the benefits of a meaningful and publicly understandable target, but can choose to ignore temporary changes in prices that are inherently volatile or over which the monetary authority has no control, since its target is neither immediate nor strict. Of course, policy decisions that are based on a large degree of discretion must be communicated extensively to the public to maintain credibility.

Whatever the measure of inflation used, though, the target is a future one, often as far as two years in the future. This raises the question of which current measure provides the most use in foreasting the level of the target inflation rate in the future. The problem with using current CPI inflation to forecast future inflation, even if the target is future CPI inflation, is immediately obvious: because CPI inflation is influenced by goods whose price is inherently volatile, the current level of CPI inflation comprises a trend component of prices that are not volatile, and a more variable component of prices that are volatile and whose current level is thus very much temporary. The latter component is useless in forecasting what inflation will be in the future, and if current CPI inflation is blindly used to this end, it could be very misleading.

Core inflation, on the other hand, does not (or at least, should not) include these volatile prices. Thus, it provides a better indicator of the underlying trend of inflation, and in this regard is more useful in forecasting future inflation than CPI inflation is (Blinder and Reis, 2005). Also, because most of the prices that make up the core index are not reset very often, they are necessarily set with future inflation in mind (Krugman, 2010).

We might therefore expect core inflation to be more significant in the Reserve Bank's forecast model for future headline inflation, and to the extent that the Bank's instrument reaction decisions are well approximated by a forward-looking rule of the general form specified in (1), we would expect core inflation to be more significant (and possibly to have a higher coefficient as well) in estimations of rules of the form (1).

To test these hypotheses, we include each of CPI inflation, CPIX inflation and the official measure of core inflation in a separate regression of the form specified in (11). Since the official measurement of CPI was altered at the end of 2008, we estimate the specifications for the period 2000Q1-2008Q4, so that our results are comparable. Again, in each case we first-difference and estimate the coefficients using OLS. The results form columns (vii), (viii) and (ix) of Table 5.

The CPI inflation and CPIX inflation specifications provide similarly good fits: the CPI specification has an R-squared of 0.659, while the R-squared for the CPIX specification is 0.658. Both measures of inflation are significant at the 5% level in their respective regressions, with the coefficient on CPIX inflation higher than that on CPI inflation. The coefficient on the lagged repo rate is insignificant in the CPI inflation regression, but is significant in the CPIX inflation regression. Using the point estimates of α in each regression, the implied estimates of ϕ_π are 0.265 and 0.417 in the CPI and CPIX regressions respectively, both substantially and statistically significantly below unity.

The core inflation specification provides the worst fit of the three inflation measures, with an R-squared of 0.614; indeed, the coefficient on core inflation is not statistically distinguishable from zero at conventional levels. Removing the petrol price component from the official core index (the petrol index's weight in the core index was 5.44% over the period 2000-2008) yields a purer core index, which we enter into our specification and estimate (results not reported in Table 5). The fit improves marginally from the official core specification, with the R-squared increasing to 0.632, and the core inflation variable becomes significant at the 10% level ($p = 6.1\%$).

The discussion above, advocating a greater weight on current core inflation since it should be a better predictor of future inflation, suggests that these should be considered worrying results. There is no evidence to suggest that the SARB implicitly responded to changes in core inflation, despite core inflation having a large degree of inertia and thus providing a better measure of the trend of inflation.

5.7 Discussion of results and their limitations

Our specification now provides a reasonable enough fit for both periods for us to make some more confident observations. First, as expected, the simpler specifications provide a poor fit for the pre-IT period, when monetary policy was known to be eclectic. Only whenwe control for the real exchange rate and some other asset prices does the fit of the model improve significantly, with both the real exchange rate and the other asset prices significant at conventional levels. The output gap is insignificant in all of the pre-IT regressions, suggesting that monetary policy paid little or no attention to output, focussing rather on other target variables.

For the IT period, the basic Taylor Rule provides a good fit, and even more so when we augment it to account for interest rate smoothing. The coefficient on the output gap is significantly positive, suggesting that the inflation targeting regime followed by the SARB has indeed been flexible. As previously noted, a positive coefficient on the output gap is also evidence that the Reserve Bank has tended to react countercyclically to demand shocks but has tended to accommodate supply shocks. In the IT regressions, the coefficient on the real exchange rate is weakly statistically significant but small in magnitude, while those on asset prices are not significant, suggesting that monetary policy has paid little attention to these variables under inflation targeting. CPI and CPIX inflation provide similarly good fits, while the fit of the specification using core inflation is relatively worse, despite core inflation's tendency to be a better predictor of future headline inflation.

The differences between the regimes are thus fairly clear. Broadly, the pre-IT regime focussed on exchange rates and possibly asset prices, and not on output. The IT regime has focussed strongly on output, but not on exchange rates and asset prices. The SARB focussed on inflation in both periods, and its instrument setting behaviour seems to have been influenced by a tendency to systematically smooth interest rates in both periods.

The major concern raised throughout our analysis has been that the weight on the inflation gap is low in both periods. (It is also noteworthy that the weight on the inflation gap seems paradoxically to have decreased under inflation targeting.) A weight on the inflation gap lower than unity has been shown to result in an unstable inflation process in a wide range of macroeconomic models; in all of our regressions (both pre-IT and IT), the short run and (inplied) long run weights on the inflation gap are substantially and statistically significantly lower than unity. This would appear to contravene the Taylor principle that these weights should be greater than unity, and suggests that the monetary policy of the SARB has been conducive to inflation instability in both periods, perversely allowing the real interest rate to rise in response to decreases in inflation, and vice versa. This result warrants more investigation; in particular, it necessitates a discussion of whether our low estimates of the inflation weights might be driven by specification or other econometric issues, rather than a truly low inflation emphasis.

A plausible explanation lies in the relation between the original forward-looking specification (1) and its contemporaneous counterpart (2), which was the specification we used in our estimations. The Taylor principle, applied to (1), advises that the coefficient on the expected future inflation gap be larger than unity. We noted that our proxy for expected future inflation, viz. current inflation, was likely an oversimplification, since the Reserve Bank considers many more variables than current inflation in forming its expectation of future inflation. The small coefficient on current inflation in our regressions might therefore reflect the small weight placed on this variable in the SARB's formation of its expectation of future inflation, rather than a low weight placed on expected future inflation in the first place. To illustrate, suppose the SARB's forecast model for future inflation is of the simple linear form

$$E_t\pi_{t+T|t} = \gamma_0 + \gamma_1\pi_t + \gamma_2 y_t + \gamma_3 e_t + \boldsymbol{\psi}\cdot\mathbf{x}_t, \tag{13}$$

where the γ_i and the elements of $\boldsymbol{\psi}$ are constants, and $\mathbf{x}_t$ is a vector of other variables the SARB might consider in forecasting future inflation. Keeping the proxy for the SARB's forecast of the future output gap as the output gap's contemporaneous level, and substituting (13) into (1), yields a reaction function of the same general form as (2):

$$i_t = k + \gamma_1\phi_\pi\pi_t + (\gamma_2\phi_\pi + \phi_y)y_t + (\gamma_3\phi_\pi + \phi_e)e_t + \ldots \tag{14}$$

where k is a constant. Note that the coefficient on the inflation gap is the product of two coefficients: the coefficient on expected future inflation in the Taylor-like rule, and the weight on current inflation in the forecast model for future inflation. If ϕ_π is greater than unity, in line with the Taylor principle, but smaller than $1/\gamma_1$, then the overall coefficient on the inflation gap will be less than unity, and would be expected to be estimated as such in an unbiased regression. For example, our point estimate of ϕ_π in the IT regression (vi) is 0.237. If the true $\phi_\pi > 1$, and any attenuation of our estimate of ϕ_π stems solely from the above problem, it would be required that $\gamma_1 < 0.237$.

In fact, (14) highlights a general difficulty in interpreting the results of our regression: Is the significance of a coefficient on a variable the result of the SARB's targeting that variable separately, or is it a result of that variable forming part of the SARB's forecast of future inflation? On this question, our regressions are necessarily ambiguous. One point that can be made is that the two terms in each coefficient on the non-inflation variables are unlikely to cancel each other out; they should be of the same sign.

Our low estimates of the SARB's inflation weights could also be the result of attenuation bias stemming from our inflation variable being mismeasured. Since we are attempting to characterise the behaviour of the Reserve Bank, it would be most advisable to use real-time data rather than revised ex-post data, since it is obviously real-time data that the Reserve Bank uses in its decision-making (Orphanides, 2001). To the extent that revised data is a mismeasured form of real-time data, there is a possibility of attenuation bias in our estimate of the weights on inflation. If the real-time inflation rate and its revised ex-post form are related by

$$\pi_{rt} = \pi_{ep} + \nu,$$

and the classical measurement error acondition, $E(\nu|\pi_{ep}) = 0$, holds, then we would expect our estimate of the weight on inflation to be biased towards zero if we use π_{ep} in our regression, rather than π_{rt}.

These caveats notwithstanding, there remain strong reasons to believe that our results represent evidence that the SARB has been 'soft on inflation'. First, the estimated coefficient on the inflation gap is lower for the IT period than for the pre-IT period. It is unlikely that structural changes (for example, in the formation of inflation forecasts) can account for this paradoxical change in apparent emphasis. Second, similar studies (using current inflation and OLS, and as such, subject to the same general objections as those raised above) carried out for other countries have yielded estimates of inflation weights that are significantly above unity.

6 Conclusions

Under inflation targeting, the SARB has missed its official inflation target in 19 of the 37 quarters since the year for which the target was first set. While this gives the lie to the accusations of COSATU and others that the Reserve Bank focusses too much on meeting its inflation targets, it also raises serious doubts around how successful the regime has been with respect to its primary goal, price stability. Indeed, the volatility of inflation seems to have *increased* under inflation targeting, relative to the previous monetary targeting regime. This contrasts with most international experiences of inflation targeting; the regime has in general been associated with a greater degree of macroeconomic stability.

In this paper, we have sought to explain these anomalies by empirically analysing the behaviour of the SARB before and after the adoption of inflation targeting, making use of Taylor-like rules to gain insight into what variables the SARB focussed on (and with what weightings) when setting its interest rates in the two periods.

Our approximation of an instrument rule for the pre-IT period suggested that the SARB reacted primarily to changes in inflation, the real exchange rate and other asset prices in this period; we found no evidence of a tendency to smooth interest rates. The emphasis on the real exchange rate and other asset prices is consistent with the eclectic focus this regime is known to have had.

In contrast, our approximation of a rule for the IT period revealed that the SARB has reacted to changes in inflation and the output gap under inflation targeting, and has exhibited little or no targeting of the exchange rate or other asset prices. The significance of the output gap in our IT regressions, along with its relatively large weight, points to a large degree of flexibility exercised by the SARB (in contrast to COSATU's claims). Evidence of a tendency to smooth interest rates in this period was found.

Of major concern is the very low coefficient on inflation in our regressions for both periods. Theory suggests that a weighting lower than unity for inflation in an instrument rule could lead to an unstable inflation process, and in every regression our estimate of this weight was both substantially and statistically significantly smaller than this threshold. This is a particularly disturbing result for the IT period (for which the estimated weighting was actually lower than that for the pre-IT period), and casts further doubt on the SARB's insistence that price stability is its overriding objective.

This low coefficient could be explained away if the SARB places a low weight on current inflation in its forecast for future inflation, since it is actually the forecast for which it has a target. The low coefficient on current inflation in our regressions might reflect this, rather than a weak focus on keeping inflation within the target band. Also, because instrument decisions in the period under study would have been made making use of real-time data, while we use ex-post data in our estimations, our results could suffer from the problems associated with mismeasured variables, and in particular, attenuation bias.

Still, that the coefficient on inflation in our regressions was smaller for the IT period than for the pre-IT period, and that in similar estimations for other countries, inflation coefficients significantly greater than unity have been found, support the suspicion that the SARB has tended to respond more timidly to changes in inflation than theory suggests it should have.

Thus, we have found evidence that the SARB places too low a weight on its inflation target when setting the interest rate, which may explain the high volatility of inflation observed in the IT period.

References

J. Aron and J. Muellbauer. Estimating Monetary Policy Rules for South Africa. *The Centre for the Study of African Economies Working Paper Series*, 2001.

J. Aron and J. Muellbauer. Review of monetary policy in South Africa since 1994. *Journal of African Economies*, 16(5):705, 2007.

L. Ball and N. Sheridan. Does inflation-targeting matter? In B. Bernanke and M. Woodford, editors, *The inflation-targeting debate*, pages 249–276. University of Chicago Press, 2005.

B.S. Bernanke and M. Gertler. Monetary policy and asset price volatility. 2000.

B.S. Bernanke and F.S. Mishkin. Inflation targeting: A new framework for monetary policy? *The Journal of Economic Perspectives*, 11(2):97–116, 1997.

B.S. Bernanke and M. Woodford. Inflation forecasts and monetary policy. *Journal of Money, Credit & Banking*, 29(4), 1997.

O. Blanchard and J. Galí. Real wages, rigidities and the New Keynesian Model. *Journal of Money, Credit and Banking*, 39(1):35–65, 2007.

A.S. Blinder and R. Reis. Understanding the Greenspan Standard. 2005.

R. Clarida, J. Galí, and M. Gertler. Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory. *The Quarterly Journal of Economics*, 115(1):147–180, 2000.

A. Cuevas and S. Topak. Monetary Policy and Relative Price Shocks in South Africa and Other Inflation Targeters. *IMF Working Papers*, 2009.

D.A. Dickey and W.A. Fuller. Distribution of the Estimators for Autoregressive Time Series With a Unit Root. *Journal of the American Statistical Association*, 74(366): 427–431, 1979.

S. du Plessis, B. Smit, and F. Sturzenegger. Identifying aggregate supply and demand shocks in South Africa. *Journal of African Economies*, 17(5):765, 2008.

W. Easterly and S. Fischer. Inflation and the poor. *Journal of Money, Credit and Banking*, 33(2):160–178, 2001.

R.F. Engle and C.W.J. Granger. Co-integration and error correction: representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, pages 251–276, 1987.

C. Freedman and D. Laxton. Why inflation targeting? *IMF Working Paper*, 2009.

P. Gordhan. Letter to Gill Marcus, Re: Clarification of Reserve Bank's mandate. 2010.

C.W.J. Granger and P. Newbold. Spurious Regressions in Econometrics. *Journal of Econometrics*, 2:111–120, 1974.

M. Hyvonen. Inflation convergence across countries. *Reserve Bank of Australia Research Discussion Paper*, 2004.

IMF. Inflation targeting and the IMF. *IMF Working Paper*, 2006.

B. Kahn. Challenges of inflation targeting for emerging-market economies: the South African case. 2008.

P.R. Krugman. *The Conscience of a Liberal - Core Logic.* [Online]: `http://krugman.blogs.nytimes.com/2010/02/26/core-logic/`, 2010.

J. MacKinnon. Critical values for cointegration tests. *Queen's Economics Department Working Papers*, 2010.

Y.P. Mehra and B. Sawhney. Inflation measure, Taylor rules, and the Greenspan-Bernanke years. *Economic Quarterly*, pages 123–151, 2010.

Y. Miao. In search of successful inflation targeting: evidence from an inflation targeting index. *IMF Working Papers*, 2009.

F.S. Mishkin. The transmission mechanism and the role of asset prices in monetary policy. In F.S. Mishkin, editor, *Monetary policy strategy*. MIT Press, 2007.

F.S. Mishkin and K. Schmidt-Hebbel. Does inflation targeting make a difference? *NBER working paper*, 2007.

R. Naraidoo and R. Gupta. Modelling Monetary Policy in South Africa: Focus on Inflation Targeting Era Using a Simple Learning Rule. *University of Pretoria Department of Economics Working Paper Series*, 2009.

R. Naraidoo and I. Paya. Forecasting Monetary Rules in South Africa. *University of Pretoria Department of Economics Working Paper Series*, 2010.

M. Obstfeld and K. Rogoff. The mirage of fixed exchange rates. *The Journal of Economic Perspectives*, 9(4):73–96, 1995.

A. Orphanides. Monetary policy rules based on real-time data. *American Economic Review*, pages 964–985, 2001.

P. Österholm. The taylor rule: A spurious regression? *Bulletin of Economic Research*, 57 (3):217–247, 2005.

L. Rangasamy. How persistent is South Africa's inflation? *ERSA Working Papers*, 2009.

C.D. Romer and D.H. Romer. Monetary policy and the well-being of the poor, 1998.

A.K. Rose. A stable international monetary system emerges: Inflation targeting is Bretton Woods, reversed. *Journal of International Money and Finance*, 26(5):663–681, 2007.

P.B. Sørensen and H.J. Whitta-Jacobsen. *Introducing Advanced Macroeconomics: Growth and Business Cycles*. McGraw-Hill, 2005.

J.E. Stiglitz. *The Failure of Inflation Targeting*. [Online]: `http://www.project-syndicate.org/commentary/stiglitz99/English`, 2008.

L.E.O. Svensson. Open-economy inflation targeting. *Journal of International Economics*, 50(1):155–183, 2000.

L.E.O. Svensson. Inflation targeting after the financial crisis, Speech delivered at International Research Conference Challenges to Central Banking in the Context of Financial Crises, Mumbai, 2010.

J.B. Taylor. Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39:195–214, 1993.

E.J. van der Merwe. Inflation targeting in South Africa. *SARB Occasional paper*, 19, 2004.

M. Vega and D. Winkelried. Inflation targeting and inflation behavior: a successful story? *International Journal of Central Banking*, 1(3):153–75, 2005.

G.U. Yule. Why Do We Sometimes Get Nonsense Correlations Between Time Series? A Study in Sampling and the Nature of Time Series. *Journal of the Royal Statistical Society*, 89:1–64, 1926.

Appendix

Table 1: List of variables used

Variable	Symbol used	Source	Description
repo rate	i_t	SARB	The rate at which the SARB repurchases government securities.
CPI inflation	π_t^{CPI}	SARB	The year-on-year rate of change of the consumer price index.
CPIX inflation	π_t^{CPIX}	SARB	The year-on-year rate of change of the consumer price index, excluding the mortgage interest rate cost.
core inflation	π_t^{core}	SARB	The year-on-year rate of change of the consumer price index, excluding certain food products, the mortgage interest rate cost, overdrafts and personal loans, value-added tax and property taxes.
output gap	y_t	SARB/own calc.	The percentage difference between actual and trend real (seasonally adjusted) GDP, with the trend level determined using a Hodrick-Prescott filter ($\lambda = 1600$).
REER	e_t	IMF IFS	The real effective exchange rate, CPI-based, with PPP when $e_t = 100$.
share price gap	$sharegap_t$	IMF IFS/own calc.	The percentage difference between the actual and trend level of the All Share Index, with the trend level determined using a Hodrick-Prescott filter ($\lambda = 1600$).
house price gap	$housegap_t$	ABSA/own calc.	The percentage difference between the actual and trend level of the ABSA Average House Price Index, with the trend level determined using a Hodrick-Prescott filter ($\lambda = 1600$).

Table 2: Summary of inflation statistics for pre-IT and IT periods

	Pre-IT	IT
	1990Q1-1999Q4	2000Q1 -2011Q1
Mean (%)	9.91	5.92
Minimum (%)	1.96	0.44
Maximum (%)	16.11	12.75
Standard deviation (%)	3.62	3.12
Standard deviation around linear trend (%)	1.86	3.11

Source: Authors' calculations, using data as described in Table 1.

Table 3: Results of tests for unit root processes in the variables

	H_0: variable has a unit root					
	Standard DF test		Aug. DF test - 1 lag		Aug. DF test - 2 lags	
	θ	$\|t\|$	θ	$\|t\|$	θ	$\|t\|$
$repo_t$	−0.032	1.07	−0.053	1.89	−0.041	1.46
$repo_t$ (pre-IT)	−0.136	1.56	−0.211	2.45	−0.179	1.93
$repo_t$ (IT)	−0.049	0.88	−0.104	2.28	−0.093	1.97
π_t^{CPI}	−0.082	2.07	-0.109^{**}	3.10	-0.103^{*}	2.79
π_t^{CPI} (pre-IT)	−0.038	0.58	−0.069	1.04	−0.061	0.90
π_t^{CPI} (IT)	−0.128	1.81	-0.205^{***}	3.84	-0.199^{**}	3.14
π_t^{CPIX} (IT)	−0.037	0.50	−0.156	2.09	−0.190	2.32
π_t^{core} (IT)	−0.040	0.51	−0.140	1.63	−0.174	1.87
y_t	−0.090	2.13	-0.126^{***}	3.75	-0.122^{**}	3.40
y_t (pre-IT)	−0.095	1.58	−0.114	2.29	−0.112	2.11
y_t (IT)	−0.085	1.38	-0.143^{**}	3.06	-0.138^{*}	2.65
e_t	−0.054	1.61	−0.062	1.86	−0.057	1.69
e_t (pre-IT)	−0.054	0.77	−0.066	0.88	−0.039	0.50
e_t (IT)	−0.119	1.58	−0.164	2.15	−0.167	2.02
$sharegap_t$	-0.215^{**}	3.15	-0.270^{***}	3.85	-0.271^{**}	3.54
$sharegap_t$ (pre-IT)	-0.332^{*}	2.78	-0.422^{**}	3.33	-0.397^{*}	2.72
$sharegap_t$ (IT)	−0.171	1.98	−0.218	2.47	−0.235	2.47
$housegap_t$	−0.065	1.60	-0.117^{***}	3.87	-0.082^{*}	2.61
$housegap_t$ (pre-IT)	−0.140	1.53	-0.294^{***}	4.44	-0.291^{***}	3.55
$housegap_t$ (IT)	−0.054	1.07	−0.095	2.57	−0.059	1.59

The standard Dickey-Fuller (DF) test is applied by estimating the regression: $\Delta x_t = \alpha + \theta x_{t-1} + e_t$, so that θ is the first order autocorrelation of x. The augmented DF tests add lags of Δx to the above regression. A value for θ that is statistically significantly different from zero is evidence against x being a unit root process. The values for θ, as well as their corresponding t-values, are reported. *,** ,*** represent statistically significant difference from zero at the 10%, 5% and 1% levels respectively, according to the Dickey-Fuller distribution (Dickey and Fuller, 1979).

Table 4: Results of Engle-Granger tests for cointegration

Variable set		Pre-IT 1990Q1-1999Q4	IT 2000Q1 -2011Q1
$\{i_t, i_{t-1}, \pi_t, y_t, e_t\}$	t-statistic	4.56	3.81
	Critical value 10%	4.02	4.00
	5%	4.38	4.35
	1%	5.12	5.06
$\{i_t, i_{t-1}, \pi_t, e_t\}$	t-statistic	4.17	3.37
	Critical value 10%	3.61	3.59
	5%	3.96	3.94
	1%	4.67	4.63

The Engle-Granger test is carried out by obtaining the residuals from a regression of one of the variables in the set of variables being tested for cointegration on the others, and using the residuals to test for a unit root in the error process. (The null hypothesis is that there is a unit root in the error process, and therefore that the variables are not cointegrated.) The unit root test is identical in procedure to the simple Dickey-Fuller test carried out above, but the critical values are different; we use the estimates provided by MacKinnon (2010).

Table 5: Regression results

	Dependent variable: $\Delta repo_t$								
Regression:	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Start:	1990Q1	2000Q1	1990Q1	2000Q1	1990Q1	2000Q1	2000Q1	2000Q1	2000Q1
End:	1999Q4	2011Q1	1999Q4	2011Q1	1999Q4	2011Q1	2008Q4	2008Q4	2008Q4
Obs:	40	45	40	45	40	45	36	36	36
$\Delta repo_{t-1}$	-	-	0.175	0.252^{**}	0.235	0.306^{**}	0.225	0.349^{**}	0.405^{**}
			(0.173)	(0.113)	(0.197)	(0.132)	(0.177)	(0.155)	(0.163)
$\Delta\pi_t^{CPI}$	0.322^{**}	0.302^{***}	0.247	0.218^{***}	0.272^{*}	0.199^{***}	0.205^{**}	-	-
	(0.137)	(0.063)	(0.156)	(0.071)	(0.141)	(0.070)	(0.083)		
$\Delta\pi_t^{CPIX}$	-	-	-	-	-	-	-	0.271^{**}	-
								(0.108)	
$\Delta\pi_t^{core}$	-	-	-	-	-	-	-	-	0.150
									(0.102)
Δy_t	-0.014	0.574^{***}	0.055	0.570^{***}	-0.394	0.476^{**}	0.636^{*}	0.548	0.693^{*}
	(0.327)	(0.167)	(0.334)	(0.160)	(0.324)	(0.207)	(0.324)	(0.334)	(0.347)
Δe_t	-	-	-	-	-0.135^{***}	-0.030^{*}	-0.018	-0.028	-0.034
					(0.047)	(0.016)	(0.020)	(0.020)	(0.021)
$\Delta sharegap_t$	-	-	-	-	0.066^{**}	0.012	0.012	0.013	0.013
					(0.031)	(0.011)	(0.012)	(0.012)	(0.013)
$\Delta housegap_t$	-	-	-	-	0.123	-0.019	-0.117	-0.057	-0.068
					(0.118)	(0.060)	(0.086)	(0.080)	(0.092)
$\hat{\phi}_\pi$	0.322^{**}	0.302^{***}	0.299^{*}	0.292^{***}	0.356^{**}	0.286^{***}	0.265^{***}	0.417^{**}	0.253
$\hat{\phi}_\pi - 1$	-0.678^{***}	-0.698^{***}	-0.701^{***}	-0.708^{***}	-0.644^{***}	-0.714^{***}	-0.735^{***}	-0.583^{***}	-0.747^{***}
	(0.137)	(0.063)	(0.169)	(0.080)	(0.162)	(0.087)	(0.086)	(0.163)	(0.165)
$\hat{\phi}_y$	-0.014	0.574^{***}	0.066	0.762^{***}	-0.514	0.685^{**}	0.820^{**}	0.842^{*}	1.165^{**}
	(0.327)	(0.167)	(0.408)	(0.242)	(0.439)	(0.280)	(0.393)	(0.465)	(0.516)
R^2	0.127	0.599	0.150	0.642	0.388	0.680	0.659	0.658	0.614
adj. R^2	0.081	0.581	0.081	0.616	0.280	0.630	0.591	0.590	0.536
$\hat{\rho}$	0.224	0.058	0.122	-0.114	0.088	-0.146	-0.117	-0.185	-0.078
$P > \|t\|$	0.161	0.705	0.447	0.452	0.581	0.333	0.502	0.289	0.651
DW d-stat.	1.542	1.691	1.738	2.061	1.733	2.121	2.100	2.216	2.066

Standard errors are reported in parentheses. Statistical significance at the 10%, 5% and 1% significance levels represented by *,** and *** respectively. Output, share price, oil price and house price gaps calculated using a Hodrick-Prescott filter, $\lambda = 1600$, and are represented as percentages of the trend. $\hat{\rho}$ is the estimated coefficient in a regression of the residual on its lagged value; a value for $\hat{\rho}$ that is statistically significantly different from zero is evidence of serial correlation in the error terms. (None exists here.)