Policy regime changes and central bank preferences

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Abstract

This paper establishes whether central bank preferences are related to governors' preferences when there is a change in policy regime. We use a time-varying parameter approach that allows the policy preferences to vary over the sample period. The results show that the policy parameters exhibit significant changes and that the South African Reserve Bank places more weight on output relative to inflation over the period 2000 and 2007. The dynamic responses of output and inflation under different central bank governors show different outcomes. This is as a result of changes in central bank preferences and not necessarily because of different governors at the central bank. We find that policy changes have an important effect on the weight a central bank attaches to inflation and output stability and governors preferences are linked to policy regime. (JEL: C22, E43, E52, E58)

Keywords: policy preferences, regimes, time-varying parameter, South African Reserve Bank

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1 Introduction

Central bank preferences are subject to change as a result of changes in monetary policy regimes and any uncertainty about the future state of the economy. Thus the importance that central banks attach to inflation and output and their views on the economic structure may change over time. This results in uncertainty for private agents about future monetary policy conduct, and this uncertainty also affects monetary policy conduct by changing central banks' preferences on inflation and output parameters. For example, Clarida et al. (2000), Cogley and Sargent (2005), Kim and Nelson (2006), Taylor and Williams (2010) and Orphanides and Williams (2011), find that the Federal Reserve Board responded less to inflation volatility in the 1980s compared to the 1970s.

In spite of this, no consensus has emerged on central banks' optimal preferences on inflation and output stability. This has made recent studies such as Taylor (2014) and Aruoba and Schorfheide (2015) suggest that further investigation into the following is necessary: first, the effects of monetary policy on inflation trends to identify the key policy risk and performance of inflation targeting regime after the global financial crisis; secondly, determine the factors that influence policy preference changes to understand the drivers of inflation and output volatility, and finally, incorporate the interaction of financial and macroeconomic variables in modern models due to near zero rates and unconventional monetary policy pursued during the financial crisis.

This paper focuses on the second debate, that is, factors that influence changes in policy preferences, to understand the dynamics of inflation and output volatility. We propose in this paper that central bank preferences to target variables such as inflation and output vary over time and different preferences of policy authorities may coincide with the tenure of a particular central bank governor. The central bank of interest in this analysis is the South African Reserve Bank. This debate is relevant and current to the SARB's monetary policy regimes decisions, because the South African economy has experienced significant changes in its monetary policy framework over the past three decades. This includes competition in the financial markets in the early 1980s, the monetary aggregates targeting rule first set in 1986, and inflation targeting in 2000. Moreover, the SARB has had four governors, of which three have had consistent terms of approximately ten years each between 1981 and 2009, but each have had varying beliefs about monetary policy conduct.[1] Further, the governors also served under different political regimes, that is, the apartheid era and constitutional democracy. These may influence the weights the governors attach to the policy preferences for inflation and output stability. In particular, the paper analyses whether changes in central bank preferences are related to governors' preferences, that is, do individual governors exert policy influence in an event of policy regime changes in the context of a time-varying parameter approach?

This study relates to other literature that examines changing central banks policy, for example Primiceri (2005), Kim and Nelson (2006), Baxa et al. (2014), Lakdawala (2016), Belongia and Ireland (2016) and Keating and Valcarcel (2017). Further, most of these studies only examine the effect of monetary policy innovations on the economy, for example Primiceri (2005), Baxa et al. (2014) and Lakdawala (2016). This paper is different, however, for its main contribution to the literature is that it focuses on the role played by changes in central banks' policy preferences and its associated shock volatility on the economy due to monetary policy conduct. Two algorithms are used to determine whether there are time–varying monetary policy parameters which capture changing policy authorities' preferences and, thus, regime changes. The algorithms are the Kalman filter and the independence Metropolis-Hastings. The Kalman filter is used to obtain the estimates of the time-varying parameter Taylor type rule. The independence Metropolis-Hastings computes the dynamic responses and stochastic volatility within a setup of a time-varying parameter of a Taylor-type rule. This implies that the variances of the stochastic processes vary over the sample period.

The importance of this undertaking is twofold. First, changes in policy authorities' preferences are characterised by the possibility of time-varying monetary policy regime changes that may be influenced by the changing structure of the economy and different governors at the central bank. Secondly, this paper adds to the existing research about South Africa, where changes in policy regime investigations are carried out under the assumption of time-invariant policy preferences.[2] Therefore, the relevance of this

[1] The governors' tenures are De Kock from January 1, 1981 to August 7, 1989; Stals from August 8, 1989 to August 7, 1999; Mboweni from August 8, 1999 to November 8, 2009 and Marcus from November 9, 2009 to November 8, 2014.

[2] This includes sub-sample, instrumental variables and a generalised method of moments (GMM)

paper is that it shows that at different points in time and over different monetary policy regimes, the economy responds differently to policy shocks. Also, a counterfactual analysis is provided to estimate time-varying parameters that capture changing policy preferences. More specifically, alternative issues, such as how monetary policy would have been with no change in governors, no monetary policy regime changes and the impact of the financial crisis in 2008 on the South African economy, is evaluated.

The findings suggest that the SARB changed its policy responses to inflation and output from the beginning of the 1980s. In an inflation targeting regime the dynamic responses to output are higher than the responses in a monetary aggregates regime.[3] Throughout the sample period, variations in the policy preference parameters are found. Furthermore, the baseline results are robust to the output gap characterisation of monetary policy conduct. That is, volatility of the policy innovations show upward persistence in the output gap but remain low in the policy rate and in inflation which is similar to the baseline results.

This study also found that the SARB's policy preference for output stability increased significantly between 2000 and 2007, then shifted to inflation stability in 2008.[4] These findings relate to those of Lakdawala (2016) and Belongia and Ireland (2016), who find that the Federal Reserve Board attached larger weight to output than inflation from 2000 to 2007. All the counterfactual experiments carried out herein suggest that regime changes exert substantial effects on central banks' preferences for output and inflation compared to potential outcomes, had there not been a regime change.

The remainder of this paper is as follows: section two surveys the literature; sections three and four lay out the theoretical model and estimation strategies, while section five

that are weak to capture the changing dynamics of the economy (see Aron and Muellbauer (2002), Ortiz and Sturzenegger (2007), Gupta et al. (2010) and Naraidoo and Raputsoane (2015)). Further, other literature that evaluates monetary policy conduct focuses on a nonlinear econometric framework and asymmetric preferences that include Naraidoo and Paya (2012) and Baaziz (2015).

[3]That is, inflation targeting began February 2000 and is the existing monetary policy framework and a monetary aggregates regime started between 1986 and 1999.

[4]During this period, the South African consumer price index inflation exhibited a rising trajectory over the years 2006 and 2008 and inflation peaks in August 2008 at about a 12 per cent. This is also consistent with oil price peaking over the June and July 2008 period. This could have led to a change in policy preferences towards inflation stability.

presents the empirical results. Section six provides some remarks and a conclusion.

2 Related Literature

This section surveys the literature to ascertain the effects of changes in monetary policy regimes and the behaviour of central banks. Changing central bank preferences as well as the changing structure of an economy raise significant issues about monetary policy conduct. Thus important issues surround whether central banks behaviour changes over time and whether changes in monetary policy regimes explain low volatility in macroeconomic variables, such as inflation and output.

To address these questions, Taylor (1993) proposes a monetary policy rule that characterises monetary policy conduct and thus exhibits the conduct of the Federal Reserve Board.[5] This means that the Taylor rule contains information on central banks' preferences and policy authorities' views about the structure of the economy.

With regards to the central bank preferences, a puzzle that has emerged about the Taylor rule is: what is the optimal trade-off between inflation and output preference parameters of central banks? In the Taylor rule, a preference parameter of inflation larger than one suggests that changes in the interest rate are strong enough to stabilise inflation. Taylor (1999) shows that when the inflation parameter is smaller than one, a positive inflation shock leads to an increase in a nominal interest rate, which is not sufficient to help reduce the real interest rate and may destabilise the economy. To examine policy authorities' views about the state of the economy, the formal approach is to minimise the central bank loss function together with private agents' optimisation problems. When the weight on output is zero in the loss function, the central bank does not care about the output gap. If, however, the output parameter is not zero, then there is a possibility of a dual objective of inflation and output stability. On the contrary, Woodford (2003a) suggests that incorporating the output gap in the loss function does not imply that central banks have dual objectives. Instead, the output gap may have

[5] The initial policy rule suggests that the nominal interest rate should be set to a long run interest rate plus a weighted average of a real GDP gap and a four-quarter moving average of actual GDP deflator less target inflation. But the Taylor rule did not specify the target inflation of the central bank. The focus was on how central banks should set the policy rule with weights of 1.5 and 0.5 for GDP deflator and GDP gap, respectively.

predictive content about inflation and output stability.

Over the past two decades, the Taylor rule has attracted attention from policy authorities. Though the literature has proven that the Taylor rule fits central banks' preferences well in a number of advanced and emerging economies, no consensus has emerged on the appropriate specification of the Taylor rule for all economies (see Woodford (2015), Taylor (2014) and McCallum (2015)).

Alternative monetary policy rules, however, have been proposed due to some weaknesses of the Taylor rule. This includes a lack of forward-looking in the Taylor rule, parameter instability and data uncertainty that may lead to multiple equilibria. These researchers include Taylor (1999), Sack and Wieland (2000), Svensson (2003) and others. An important point in the discussion of alternative monetary policy rules is whether the policy preference parameters change over time in relation to personalities at the helm of the central bank. Among others, Boivin (2005) and Kim and Nelson (2006) estimate Taylor-type rules and find that the behaviour of the Federal Reserve Board changes over time. Further, the Federal Reserve Board reacted less to real economic activity in the 1980s compared to the 1970s. Similarly, Kuzin (2006) and Assenmacher-Wesche (2006) use a backward-looking Taylor rule with money target as the instrument, and find that the Bundesbank sensitivity to inflation varies over time. They indicate that the Bundesbank places more weight on inflation relative to the Federal Reserve Board.

Furthermore, Taylor (1999) and Ball and Mazumder (2011) posit that monetary policy shifts anchored inflation in the 1980s and 1990s. These studies used historical, split sample and instrumental variable techniques to investigate the effects of monetary policy on inflation and output. Unfortunately, these techniques are unable to capture heterogeneity across the entire sample period as well as nonlinear dynamic patterns, such as amplitude dependence and asymmetries. This paper, therefore, seeks to address this issue by employing a time-varying coefficients with multivariate stochastic volatility. Because the inflation targeting performance of different monetary policy regimes did not affect developed economies, but inflation targeting emerging economies benefited (Ball, 2010; Mishkin and Schmidt-Hebbel, 2007; Abo-Zaid and Tuzemen, 2012). These studies also ascertain that the conduct of monetary policy by the European Central Bank has less effect on national central banks.

According to Lucas (1976), orthodox macroeconometric techniques are weak in accounting for the link between macroeconomic fundamentals and policy regime shifts. The Lucas critique has revolutionised macroeconometrics, resulting in a new class of estimation strategies. One of the estimation strategies is the reduced-form Markov-switching model of Hamilton (1989). Markov-switching studies show that central banks respond to policy regime shifts and there are improvements in the fit with persistent heterogeneity in the policy rule (see Sims and Zha (2006), Lange (2010) and Canova and Ferroni (2012)). A difficulty with reduced-form Markov-switching analyses is that it may not be easy to interpret the unobservable state variables and is not suitable for nonstationary data.

To overcome these problems associated with the Markov-switching model, this paper employs a time-varying parameter technique. A time-varying parameter technique allows one to capture the changes across the entire sample period and considers the patterns of models with nonlinear dynamics (see Primiceri (2005), Trecroci and Vassalli (2010), Korobilis (2013), Baxa et al. (2014), Lakdawala (2016) and Belongia and Ireland (2016)). Further, the central message of these authors is that exogenous and endogenous shocks explain high volatility in inflation over the 1970s compared to the 1980s. That is, inflation volatility declined and unexpected changes in monetary policy shocks affected output, exchange rate and money growth. Consequently, traditional techniques of splitting samples may provide misleading empirical results of monetary policy outcomes.

In emerging economies, Mohanty and Klau (2005), Perrelli and Roache (2014) and others estimate monetary policy regime changes, and suggest that central banks allocate more weight to output than inflation and also allocate some weight to the exchange rate. Further, some policy authorities react to financial and banking stress indicators and also to the exchange rate in small open economies, see Batini et al. (2003) and Baxa et al. (2013).

In South Africa, there are quite a number of recent studies (Ortiz and Sturzenegger (2007), Steinbach et al. (2009), Alpanda et al. (2010) and Peters (2016)). However, these authors' analyses are confined to constant parameter estimations. Ortiz and Sturzenegger (2007) use a rolling regression in a dynamic general equilibrium model to examine the SARB policy strategies. They find that the SARB exhibits an anti-inflation bias, has increased its weight on the output gap, and attaches a low weight to the exchange rate.[6]

Some of the findings of a constant parameter analyses in South Africa are summarised in Table 1. From Table 1, most of the findings of the SARB's policy preferences are

Table 1: Summary of literature results in South Africa

Author(s)	Sample	Method	Inflation	Output
Aron and Muellbauer (2002)	1986:Q2 -1997:Q4	IV	-0.19 (5.80)	0.37 (3.70)
Mohanty and Klau (2005)	1990:Q1-2002:Q4	GMM	0.04 (7.09)	0.07 (7.53)
Ortiz and Sturzenegger (2007)	1983:Q1 - 2002:Q4	RR	1.11	0.27
Alpanda et al. (2010)	1994:Q1 - 2008:Q4	BM	1.42	0.29
Naraidoo and Raputsoane (2015)	2000:M1 - 2012:M4	GMM	1.43 (29.08)	0.60 (17.06)
Peters (2016)	1979:Q3 - 2007:Q3	ML	0.84 (6.10)	0.07 (1.40)

Source: Author's compilation August 31, 2016. Note: BM is Bayesian method, IV is instrumental variables, GMM is generalised method of moments, ML is maximum likelihood estimates and RR is rolling regression. t-statistics in parentheses.

not different from advanced and other emerging economies. However, the question that arises is: does the weight allocated to output and inflation preferences change over time? To answer this question, it is necessary to model monetary policy regime changes in a time-varying setting. This paper, therefore, analyses the preferences of the SARB while using a time-varying parameter approach that may allow one to understand how monetary policy regime changes have evolved over time.

3 The Model

This section presents a baseline open economy model that could be modified to be consistent with a closed economy model. A structural small open economy model of Gali and Monacelli (2005) is used. Rotemberg and Woodford (1997) discuss a similar New Keynesian monetary policy structural model. This model is used to characterise

[6] However, they admitted that the method used is weak to—account for interventions used by the SARB to control inflation, output and the exchange rate.

the South African economy. The small open economy model blocks are as follows:[7]

$$\pi_t = \beta_\pi \pi_{t+1|t} + \kappa_\alpha y_t + \mu_{\pi,t}, \tag{1}$$

$$\pi_t^{cpi} = \pi_t + \alpha(s_t - s_{t-1}) = \pi_t + \alpha(\Delta s_t), \tag{2}$$

$$q_t = q_{t+1|t} - (1-\alpha)(i_t - \pi_{t+1|t}) + (1-\alpha)(i_t^f - \pi_{t+1|t}^f) + (1-\alpha)\mu_{q,t}, \tag{3}$$

$$y_t = y_{t+1|t} - \beta_{\rho,t}(i_t - \pi_{t+1}) + \mu_{y,t}. \tag{4}$$

Eqn. (1) is the aggregate supply function, π_t denotes domestic inflation, β_π is the rate of time preference and y_t is the output gap and $\mu_{\pi,t}$ is the supply shock at time $t-k$ that is not accounted for at time t and has zero mean independently identically distribution (i.i.d.).

Eqn. (2) characterises the consumer price index inflation, where s_t is the terms of trade and shows the effect of imported goods on consurmer price inflation. Eqn. (3) links the uncovered interest rate parity condition to the real exchange rate. i_t is the policy rate, i_t^f and π_{t+1}^f are the foreign interest and inflation rates with zero mean i.i.d and $\mu_{q,t}$ is the exchange rate risk premia.

Eqn. (4) is the aggregate demand function and all the parameters are nonnegative, where $\rho_t = i_t - \pi_{t+1}$ is the real interest rate and $\mu_{y,t}$ is the demand shock with zero mean i.i.d. q_t is the real exchange rate and is measured as follows

$$q_t \equiv s_t + p_t^h - p_t = (1-\alpha)s_t, \tag{5}$$

Eqns. (1)- (3) of these model blocks collapse to a closed economy model similar to Clarida et al. (2002) and Woodford (2003a), that is, if either $\alpha = 0$ or $\omega_\alpha = \sigma\eta = 1$, then $\kappa_\alpha = \dfrac{(1-\theta)(1-\beta\theta)}{\theta}(\vartheta + \theta)$ and $\beta_\rho = \dfrac{1}{\sigma}$.

The optimising central bank intertemporal loss function in an open economy as an unconditional expectation of the form is written thus

$$E_t \sum_{k=0}^{\infty} \beta^k L_{t+k}, \tag{6}$$

as $\beta \to 1$, the central bank single-period loss function takes the form

$$L_{t+k} = \lambda_{\pi^{cpi},t+k}(\pi_{t+k|t}^{cpi})^2 + \lambda_{y,t+k}(y_{t+k|t})^2 + \lambda_i(i_{t+k} - i_{t+k-1})^2. \tag{7}$$

[7]Where $\kappa_\alpha = \dfrac{(1-\theta)(1-\beta\theta)}{\theta}(\vartheta + \dfrac{\theta}{\omega_\alpha})$, α is the degree of openness which is the share of domestic expenditure on foreign goods. A larger parameter means that the domestic economy is more open and $\beta_p = \dfrac{\omega_\alpha}{\sigma}$.

The parameters $\lambda_{\pi^{cpi},t+k}$, $\lambda_{y,t+k}$ and $\lambda_{i,k-1}$ are the weights central banks place on inflation, output stability and interest rate smoothing.

The interest rate smoothing term is added to account for the possibility of policy authorities' desire to gradually adjust their policy rates and thus captures inertia in policy rate adjustments, see Clarida et al. (1999) and Woodford (2003a). Similarly, see also Sack and Wieland (2000), who are critical of the interest rate smoothing argument. In this case, the dual mandate of the central bank is consumer price inflation and output stability.

All the weights are nonnegative and also time-varying, except for the weight for the interest rate smoothing. The time-varying concept allows for a departure from the basic central bank loss function, in that the weight attached to inflation relative to output stability varies over time.[8] There are a number of reasons to model the parameters as time-varying. First, these weights change with a particular central bank governor or the composition of the monetary policy committee. For example, a new governor may exhibit an anti-inflation bias, whereas another governor may accommodate inflation. Secondly, the degree of political pressure on monetary policy authorities may change central bank preferences. This changing political pressure can be accounted for by a time variation in the weights the committee attaches to inflation relative to output stability. Thirdly, periods of economic uncertainty—such as the Asian currency crisis in 1998 and the global financial crisis over the period 2007 and 2008—may account for changes in the weights that a central bank attaches to inflation relative to output stability.

To close the present model, a monetary policy rule that follows a Taylor-type rule is derived and used to show how a central bank responds to macroeconomic variables. Eqn. (3) is respecified in the form

$$i_t - \pi_{t+1|t} = \frac{1}{(1-\alpha)}[q_{t+1|t} - q_t] + (i_t^f - \pi_{t+1|t}^f) + \mu_{q,t}, \tag{8}$$

substituting eqn. (8) into eqn. (4) yield

$$y_t = y_{t+1|t} - \beta_{p,t}[\frac{1}{(1-\alpha)}(q_{t+1|t} - q_t) + i_t^f - \pi_{t+1|t}^f + \mu_{q,t}] + \mu_{y,t}. \tag{9}$$

[8] However, here it is assumed that the weight a central bank attaches to interest rate smoothing does not change over the sample period.

Further, following Dennis (2007), the foreign interest rate, inflation and exchange rate risk premium are normalised to zero. Then re-arranged to yield

$$y_{t+1|t} = y_t + \beta_{p,t}[\frac{1}{(1-\alpha)}(q_{t+1|t} - q_t)] - \mu_{y,t}. \tag{10}$$

From eqn. (5), if the extent of openness is non-zero, that is, $\alpha \neq 0$, then $s_t = \dfrac{q_t}{1-\alpha}$ and $s_{t-1} = \dfrac{q_{t-1}}{1-\alpha}$. Therefore, s_t and s_{t-1} are replaced with q_t and q_{t-1}, respectively in eqn. (2) to yield.

$$\pi_t^{cpi} = \pi_t + \frac{\alpha}{1-\alpha}(q_t - q_{t-1}) = \pi_t + \frac{\alpha}{1-\alpha}(\Delta q_t). \tag{11}$$

Similarly, eqn. (11) is iterated one period ahead and conditional expectations are taken at time t to yield the following:

$$\pi_{t+1|t}^{cpi} = \pi_{t+1|t} + \frac{\alpha}{1-\alpha}(q_{t+1|t} - q_t). \tag{12}$$

Eqns. (12) and (10) are substituted into eqn. (7) and using $q_{t+1|t}$ as a control variable similar to Ball (1999), and the central bank loss function is solved to yield

$$\begin{aligned}[q_{t+1|t} - q_t] = &-\frac{\lambda_{y,t}\beta_{p,t}}{(1-\alpha_t)[\lambda_{\pi^{cpi},t}(\frac{\alpha_t}{1-\alpha_t})^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]}y_t - \frac{\lambda_{\pi^{cpi},t}\alpha_t}{(1-\alpha_t)[\lambda_{\pi^{cpi},t}(\frac{\alpha_t}{1-\alpha_t})^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]}\pi_{t+1|t} \\ &+ \frac{\lambda_{y,t}\beta_{p,t}}{(1-\alpha_t)[\lambda_{\pi^{cpi},t}(\frac{\alpha_t}{1-\alpha_t})^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]}\mu_{y,t},\end{aligned} \tag{13}$$

Eqn. (8) thus becomes $i_t - \pi_{t+1|t} = \dfrac{1}{(1-\alpha)}[q_{t+1|t} - q_t]$, because $i_t^f = \pi_{t+1|t}^f = \mu_{q,t} = 0$ are normalised to zero and substitute eqn. (13) into it to yield

$$\begin{aligned} i_t = &\left(1 - \frac{\lambda_{\pi^{cpi},t}\alpha_t}{(1-\alpha_t)^2[\lambda_{\pi^{cpi},t}(\frac{\alpha_t}{1-\alpha_t})^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]}\right)\pi_{t+1|t} \\ &- \frac{\lambda_{y,t}\beta_{p,t}}{(1-\alpha_t)^2[\lambda_{\pi^{cpi},t}(\frac{\alpha_t}{1-\alpha_t})^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]}y_t + \frac{\lambda_{y,t}\beta_{p,t}}{(1-\alpha_t)^2[\lambda_{\pi^{cpi},t}(\frac{\alpha_t}{1-\alpha_t})^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]}\mu_{y,t}.\end{aligned} \tag{14}$$

The parameters in eqn. (14) are summarised to yield

$$i_t = f_{\pi,t}\pi_{t+1|t} + f_{y,t}y_t + \xi_{k,t}. \tag{15}$$

where $f_{\pi,t} = \left(1 - \dfrac{\lambda_{\pi^{cpi},t}\alpha_t}{(1-\alpha_t)^2[\lambda_{\pi^{cpi},t}(\frac{\alpha_t}{1-\alpha_t})^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]}\right)$,

$$f_{y,t} = \left(-\frac{\lambda_{y,t}\beta_{p,t}}{(1-\alpha_t)^2[\lambda_{\pi^{cpi},t}\frac{\alpha_t}{1-\alpha_t}^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]}\right),$$

and $\quad \xi_{k,t} = \left(\frac{\lambda_{y,t}\beta_{p,t}}{(1-\alpha_t)^2[\lambda_{\pi^{cpi},t}(\frac{\alpha_t}{1-\alpha_t})^2 + \lambda_{y,t}(\frac{\beta_{p,t}}{1-\alpha_t})^2]} \right) \mu_{y,t}.$

Eqn. (15) is the open economy optimal monetary policy rule. This implies that a central bank adjusts its policy rate on the basis of expected domestic price inflation, output gap, and innovations hitting the economy. Thus, changes in policy rate is determined by changes in a structural small open economy model. Clarida et al. (2002) demonstrate that eqn. (15) is an optimal monetary policy rule and takes the form of a Taylor-type rule.

For lack of quarterly forecast data on inflation and output over the sample period 1970:Q1 and 2014:Q4, as well as computational convenience, a backward-looking Taylor-type rule is used. According to McCallum (1999), a policy rule with backward features characterise the data well, because informational assumption are more realistic. It is acknowledged that policy authority responds to an expected inflation and output gap by using a wide array of variables, which have predictive content about the expected inflation and output gap. Thus two lags of the policy rate in eqn. (15) are taken to account for the interest rate smoothing in line with Woodford (2003b), who argues that an optimal Taylor-type rule takes into account an interest rate of recent past levels with approximate lags of two. In this paper, however, our primary interest is on the weights central banks put on inflation relative to output stability. It is further assumed that monetary policy shocks on inflation and output are subdued after three and two lags. This is in line with Svensson (1999), who argues that the real policy rate has a longer effect on inflation than does output. This gives a modified optimal Taylor-type rule of the form

$$\begin{aligned} i_t = {} & f_{i1,t} i_{t-1} + f_{i2,t} i_{t-2} + f_{y,t} y_t + f_{y1,t} y_{t-1} + f_{y2,t} y_{t-2} \\ & + f_{\pi,t} \pi_t + f_{\pi 1,t} \pi_{t-1} + f_{\pi 2,t} \pi_{t-2} + \xi_{k,t}. \end{aligned} \tag{16}$$

4 Econometric and Estimation Strategies

4.1 Econometric Layout

A time-varying parameter model allows for modeling the possibility of changes in monetary policy preferences that may be influenced by changes in macroeconomic variables, changes in central bank governors and in lower and upper bounds of target variables. Here a time-varying parameter approach is used to estimate the Taylor-type rule in eqn. (16). The time-varying monetary policy rule measurement and transition equations are as follows

$$X_t = Z_t\beta_t + \varepsilon_t \quad \varepsilon_t \ is \ i.i.d. \sim N(0, I_t), \tag{17}$$

$$\beta_t = \beta_{t-1} + \eta_t \quad \eta_t \ is \ i.i.d. \sim N(0, Q_t). \tag{18}$$

Eqn. (17) is the measurement equation. Where $X_t = [i_t, \pi_t^{cpi}, y_t]$ are vectors containing system observed variables with $M \times 1$ dimension, $Z_t = I_t \otimes [i_{t-1}, i_{t-2}, y_t, y_{t-1}, y_{t-2}, \pi_t, \pi_{t-1}, \pi_{t-2}]$ is $M \times k$ matrix that defines each time-varying parameter vector autoregressive equation, and contains two lags of each observed variable.

Eqn. (18) is the transition equation, where $\beta_t = [f_{i,t}, f_{y,t}, f_{\pi^{cpi},t}]$ are the structural parameters of the model. This is similar to an econometric model used by Primiceri (2005) and Cogley et al. (2010) to account for gradual changes in monetary policy conduct.[9] Thus the estimators β_t attach more weights to current observations than past observations whereas OLS assigns equal weights to all observations. Therefore, a time-varying parameter generates smooth estimates of discrete changes, resulting in parameters starting to gradually change before the actual break date. Thus, it is possible to determine whether the identified changes are consistent with a discrete break model.

$\varepsilon_t = (\xi_{k,t})$ is a vector of structural innovations with zero mean and a time-varying covariance matrix I_t decomposed as $I_t = A_t^{-1} H_t (A_t^{-1})^1$, where H_t is a vector containing the diagonal elements of $h_{kj,t}$ of the form

$$H_t = \begin{pmatrix} h_{11,t} & 0 & 0 \\ 0 & h_{22,t} & 0 \\ 0 & 0 & h_{33,t} \end{pmatrix}. \tag{19}$$

A lower triangular matrix A_t is specified to simulate the relation of the structural shocks by recursive identification. A_t assumes a diagonal element equal to one of the

[9] If, however, the changes are discrete jumps for all parameters simultaneously, the time-varying parameter estimates will not be reliable. Even though this occurs in special cases, the time-varying parameter can provide a useful approximation when there are discrete jumps.

form

$$A_t = \begin{pmatrix} 1 & 0 & 0 \\ a_{21,t} & 1 & 0 \\ a_{31,t} & a_{32,t} & 1 \end{pmatrix}, \tag{20}$$

$a_{kj,t}$ and $h_{kj,t}$ are assumed to follow a random walk similar to Nakajima et al. (2011) of the form

$$a_{kj,t} = a_{kj,t-1} + \zeta_t \qquad \zeta_t \sim N(0, S), \tag{21}$$

$$lnh_{kj,t} = lnh_{kj,t-1} + \sigma_k \mu_t \quad \mu_t \sim N(0, W) \;\; and \;\; j \in [y_t, \pi_t, i_t], \tag{22}$$

where $a_{kj,t}$ is modeled as a driftless random walk and $h_{kj,t} = [h_{i,t}, h_{y,t}, h_{\pi,t}]$ are vectors of volatilities assumed to evolve as a geometric random walk independent of each other. η_t, ζ_t and μ_t in eqns. (18), (21) and (22) are i.i.d. The variance-covariance W in eqn. (22) depends on the free parameter of σ_k. A block-diagonal structure is imposed to make the blocks of E independent to enable the covariance state to be estimated equation by equation. E is of the form

$$E \begin{pmatrix} \varepsilon_t \\ \eta_t \\ \zeta_t \\ \mu_t \end{pmatrix} \equiv var(\xi) = \begin{pmatrix} I_3 & \theta_{3\times21} & \theta_{3\times3}, & \theta_{3\times3} \\ \theta_{21\times3} & Q & \theta_{21\times3} & \theta_{21\times3} \\ \theta_{3\times3} & \theta_{3\times3} & S & \theta_{3\times3} \\ \theta_{3\times3} & \theta_{3\times3} & \theta_{3\times3} & W \end{pmatrix}. \tag{23}$$

Once I_t in eqn. (17) and Q_t in eqn. (18) are specified, prior condition for the initial values ($\beta_0, I_0 \, and \, Q_0$) and priors for any remaining parameters of the model are specified, then Bayesian inference can follow using Markov Chain Monte Carlo (MCMC).

4.2 Choice of Priors

The MCMC method involves numerical sampling from the posterior distribution which is carried out through the Kalman filter and the independence Metropolis-Hastings (MH) algorithms. The Kalman filter is applied to eqns. (17) and (18) to obtain the estimates of the time-varying parameter Taylor-type rule in eqn. (16), see Appendix A for how the algorithm is initiated. What is new is that the weight attached to each explanatory variable is assumed to vary over time. As the central bank's preferences change, the weight attached to each explanatory variable also changes.

The independence MH algorithm is implemented to obtain the estimated time-varying parameter dynamic responses and stochastic volatility. Here, in line with Jacquier et al. (2002), a brief explanation of the estimation steps is provided and the generic steps are provided in Appendix B. For the training sample, a standard time invariant vector autoregression using OLS is estimated. The first ten years of the observations are used as the training period to obtain the priors. The priors for the time-invariant parameters are assumed to be normal with the prior means equal to the OLS estimates for the training sample. The prior variances are set high enough to make them non-informative.

The prior for Q in eqn. (18) captures the variances of the prior preference parameters and is set to the inverse Wishart distribution. The posterior distribution of Q comes from the same distribution of the prior distribution of Q. A large value of Q implies more stochastic volatility in the central bank's preference parameters. For this reason the scale factor of 0.00035 is set in line with Benati and Mumtaz (2007). Using that initial data, the starting values for $h_{kj,t}$ in eqn. (22), $t = 0...T$ and $k = 1, 2, 3$ are obtained as the variances W in eqn. (22) and the priors for σ_k and $\mu_t = 0.0001$ with μ_t in eqn. (22) are set as inverse Gamma distribution. Because the marginal likelihood distributions of μ_t depend on unknown means and variances, if the parameters have an inverse Gamma prior distributions then the conditonal posterior distributions are also inverse Gamma distribution. The initial values for $a_{kj,t}$ in eqn. (21) are set equal to the absolute value of $(a_{kj}) \times 10$. In eqn. (21), the priors for S_1 is inverse Gamma distribution and S_2 is the inverse Wishart distribution. The initial values of $S_{10} = 0.001$ and $S_{20} = \left(\begin{smallmatrix} 0.001 & 0 \\ 0 & 0.001 \end{smallmatrix}\right)$ are set.

The priors of the policy rate variances ε_t in eqn. (17) are assumed to be inverse Gamma distribution. The shape and scale parameter of the inverse Gamma distribution is set to $\alpha = 2$ and $\beta = 1$ to have fairly loose priors. Conditional on A_t, H_t, and Q_t, using the Carter and Kohn algorithm, the variances of ε_t changes at each point in time when the Kalman filter is run.

This simulation exercise is repeated 100,000 times with a burn-in period of 99,000 being discarded. After discarding the samples in the burn-in period, the sample paths look stable, as shown in the left and right panels of Figure 14 for the baseline model and robustness check. This implies that the sampling method is efficient with low autocorrelation. All the estimation results below were, therefore, based on 1,000 draws of each parameter that follows.

4.3 Data and Descriptive Statistics

South African quarterly data over the period 1970:Q1 to 2014:Q4 and sourced from IMF International Financial Statistics (IFS) are used.[10] The variables used are the real GDP growth rate seasonally adjusted, the consumer price index inflation measured as a percentage change from the corresponding previous quarter, and the SARB policy rate measured as a per cent per annum, which is the repurchase rate (repo rate). The real GDP growth rate is used in the baseline estimates. In the robustness check, the real GDP growth rate is replaced with the output gap, using the Hodrick-Prescott (HP) filter to extract the output gap.

In Table 2, when analysing the estimates of the standard deviation and skewness show that the real GDP growth rate is characterised by low volatility relative to the output gap. This evidence supports the use of the real GDP growth rate in the baseline estimates instead of the output gap. The use of the real GDP growth rate is consistent with Orphanides (2001), who argues that ex post revised real GDP values may provide a misleading description of monetary policy conduct.

A cursory look at the descriptive statistics in Table 2 and the evolution of the variables plot in the bottom panel of Figure 1, suggest that movements in inflation and the repurchase rate are related. The expansion and recovery dynamics of inflation, the real GDP rate and the repurchase rate are consistent with the occurrence of global shocks and how the domestic economy was stabilised by the SARB. Between 1994 and 1998, the repurchase rate rose persistently and peaked in 1998, while the real GDP growth exhibits a downward trajectory. This is attributed to the 1994 election leading to capital outflows in the South African economy, and the Asian financial crisis in 1998.

In late 2001, inflation rose significantly and peaked in 2002. It then declined to an all-time low at the end of 2003. This coincided with the 9/11 terrorist attacks and resultant depreciation of the South African rand by approximately 20 per cent in nominal

[10] See, http://data.imf.org.

Table 2: Descriptive statistics of variables of interest

Variables	Mean	Median	Max.	Min	Std. Dev.	Skewness	Kurtosis	Prob.
Inflation	8.804	9.331	19.250	3.437	5.013	0.042	1.800	0.004
Output gap	0.182	0.214	8.208	-8.266	2.803	0.1335	3.869	0.045
Real GDP	3.210	3.456	9.378	-4.454	2.783	-0.304	2.797	0.214
Repo rate	10.172	9.00	21.250	2.350	4.690	0.403	2.028	0.003

Source: Author's estimation August 31, 2016. Sample size of 180, starting from 1970:Q1 to 2014:Q4.

terms. The SARB responded by increasing the repurchase rate cumulatively by 4.00 per cent between December 2001 and September 2002. Inflation trajectories peaked again in 2008. These also coincided with the financial crisis in 2008 and rising oil prices from 2006 that peaked in 2008. Responding to this, the SARB increased the repurchase rate cumulatively by 5.00 per cent between May 2006 and June 2008. With this trend, real GDP growth rates were not spared following similar trajectories over the sample period.

To sum up, all these factors may result in the possibility of changes in the SARB's policy preferences for inflation relative to output.

5 Empirical Results

In this section the results from the Kalman filter and Metropolis-Hastings estimates are reported. Tables 3 to 5 report the mean parameters of changes in SARB preferences, governors' policy parameters, and counterfactual preferences. Table 6 of Appendix A C provides detail baseline estimates of SARB preference parameters for the full sample use to simulate the path of the counterfactual estimates. The figures are reported in Appendix C. Figure 1 shows the time-varying parameter monetary policy regime changes and Figure 2 and 3 report governors' policy preferences and the central bank policy preferences of the two regimes. The estimated policy regimes innovations, time-varying dynamic responses and stochastic volatility of the structural innovations are shown in Figures 4 and 5. Figures 6 and 7 show the robustness check, whereas the counterfactual simulations are reported in Figures 8 to 13.

5.1 Baseline Results

5.1.1 SARB Policy Preferences

In Table 3, the magnitudes of inflation and real GDP growth rate parameters are 1.003 and 0.74, respectively over the full sample period. The inflation parameter is consistent with theory because it is greater than or equal to one ($\beta_{inf,t} \geq 1$). This implies that the SARB is active in fighting inflation, for the weight allocated to real GDP growth rate parameter is much greater than 0.50 as proposed by Taylor (1993). This shows that the SARB is also concerned with stabilising output.

Table 3: SARB policy preferences

	Inflation	Output
Full Sample		
Real GDP growth	1.0029	0.744
Output gap	1.3932	-0.3051
Policy Regimes		
Monetary aggregates regime	1.1157	0.3831
Inflation targeting regime	0.8574	1.1819

Source: Author's estimation August 31, 2016

The preferences of the SARB over inflation relative to the real GDP growth rate varies, as reported in Table 3 and the bottom panel of Figure 1. That is, the path of inflation parameter ($\beta_{inf,t}$) and the real GDP growth rate parameter ($\beta_{gdp,t}$) experience significant structural changes. From 1980 to 1998, the SARB followed Taylor's prescription of monetary policy conduct with minimal deviations. The weights attached to inflation and output are 1.12 and 0.38 over the period. When policy regime changes to inflation targeting, the preference parameters of inflation and output are reversed to 0.86 and 1.18, respectively. Since the inflation parameter is less than unity, this shows that inflation stability cannot be achieved. The reason for this is that policy fails to prevent the self-confirmed effects of inflation (see Clarida et al. (1999)).

When the two figures in Figure 1 are compared, it is found that the trajectory of the inflation parameter is similar to future inflation values (π_{t+1}), but its parameter changes in line with the repurchase rate. Thus, when the repurchase rate is high, the inflation parameter is also high. In the 1990s, inflation parameters and inflation values moved in the opposite direction most of the time, especially from 1990 to 2000. There were, however, small changes recorded around 2000 to 2005. In 1998, the inflation parameter reached its peak at 3.96 during the second quarter, when the repurchase rate was also at its peak. This was as a result of exchange rate shocks triggered by the Asian financial crisis over the period 1997 to 1998.

It can, therefore, be inferred that regime changes have a role to play on the weights the SARB attaches to inflation and output parameters. The switches in policy objectives point to the fact that, in future, policy preferences may change from flexible targeting as witnessed during the 2008 financial crisis in advanced economies. Similarly, this evidence supports the propositon that output growth and low inflation volatility is due to better monetary theories, minimal shocks in the economic environment, and the rule-based monetary policy practice adopted by the SARB.

5.1.2 Governors' Preferences

The top panel of Figure 1 shows that the weight on inflation rises around the appointment of De Kock. The weight continues to rise to 1.76 in the fourth quarter of 1984 before declining towards the end of the De Kock tenure, as reported in Table 6 of Appendix C. Though this coincides with political upheavals and poor sovereign risk rating in the 1980s, the economy was facing large gold price shocks as well as trade and financial sanctions. When Stals stepped in, the weight on the inflation parameter rose persistently and continued in the early years of Mboweni, averaging at 1.59. This is attributed to Stals's main objective of controlling inflation and the effects of large capital outflows prior to the 1994 elections.

During Mboweni's term, the weight on inflation declined until the first quarter of 2006. The weight on inflation began to rise from 0.02 to 0.59 in the first quarter of 2008, as shown in Table 6 of Appendix C. Further, the Mboweni era shows that the SARB was more concerned with output growth than inflation stability. This could be attributed to the fact that between 1989 and 1999 under Stals's tenure, the economy recorded an average growth rate of 1.31 per cent compared to 1.80 per cent average growth rate under De Kock that might have put pressure on Mboweni to stimulate the economy.

After Mboweni's tenure, Governor Marcus assumed office and the weight on inflation rose relative to output stability. The SARB switched its weights by allocating larger weights to inflation ranging between 0.66 and 1.23 over the period of 2009 to 2014 compared to output, which ranged between 0.16 and 0.62 over the same period as reported in Table 6 of Appendix C. Around this period, global uncertainty increased and this may account for a reversal in the SARB's preference for inflation to output. This implies that as economic uncertainty increases, policy authority pays particular attention to inflation stability relative to output growth.

Figure 2 supports this interesting evidence that when inflation rises, the weight attached to inflation also rises. What seems most surprising is during Stals's tenure, when inflation was declining, the weight attached to the inflation parameter was relatively high. The repurchase rate is, however, consistent with the weight on the inflation parameter. That is, when the repurchase rate reached its peak, the weight on inflation also reached its peak. This evidence is supported in Table 4, where Stals attached 1.59 and 0.38 to inflation and output respectively over the period 1989 to 1999 compared to Mboweni, who allocated 0.62 and 1.62 for inflation and output over the period 1999 to 2009.

Table 4: Policy preferences by governors

	Inflation	Output
Real GDP growth—baseline	1.0029	0.744
De Kock (1981-1989)	0.9198	0.4579
Stals (1989-1999)	1.5864	0.3813
Mboweni (1999-2009)	0.6183	1.6248
Marcus (2009-2014)	0.9146	0.4037

Source: Author's estimation August 31, 2016

It is also important to note that in an inflation targeting regime, Mboweni and Marcus's preferences for inflation and output are different, as reported in Table 4. This suggests that the prevailing economic conditions have larger effects on the design of monetary policy. This clearly has little evidence to support the debate that, because policy authorities around the globe adopted sound monetary policy, that led to stable inflation and output growth over an inflation targeting regime.

To further understand the role played by the estimated preference parameters, the policy dynamic responses to inflation and output were compared under the tenure of Mboweni and Stals. In Figure 4, a one-time discrete shift with the appointment of Stals and Mboweni was used. This implies that the SARB preferences under the Stals and Mboweni term are the same. The plot shows that a one unit policy shock on inflation in Stals's tenure was approximately 0.45 compared to 0.25 under Mboweni's term. The responses to output under the Mboweni term is approximately 0.60, while under Stals it was about 0.50. The striking feature is that over an inflation targeting regime, more weight was placed on output relative to inflation.

In general, it can be deduced that an inflation targeting regime encourages output growth more so than other policy regimes that have been pursued in previous years.

5.1.3 Policy Regimes and Dynamic Responses

The left panel of Figure 5 plots the estimated time-varying dynamic responses and stochastic volatility of the structural innovations. This could be described as a time-varying uncertainty. According to the estimated volatility in the left panel of Figure 5, uncertainty was high in the early-to-mid 1980s. During the transition from a monetary aggregates target to an inflation targeting regime, volatility increases in inflation and policy rate. Afterwards volatility declines considerably over the inflation target regime. When the monetary policy regime changed from a monetary aggregates regime to an inflation targeting regime in 2000, uncertainty surrounding the real GDP growth rate and the repurchase rate declined. This uncertainty surrounding the inflation rate declined after 12 quarters in 2003. Table 6 reinforces this conclusion, when uncertainty declines in relation to the magnitudes of inflation and output parameters in eqn. (16), the SARB targets the variable that is less prone to uncertainty. Finally, it is also found that, based on the stochastic volatility of the structural innovations, an effective monetary policy regime depends on the prevailing economic uncertainty and conditions.

The results from the time-varying dynamic responses in the right panel of Figure 5, suggest that monetary policy conduct evolves in the early 1980s. Monetary policy shocks to output and inflation vary over the entire sample period. These estimates tell an interesting story. For example in 2000, the policy responses to output was high at negative 2, it fell substantially in 2008 and by 2010 the responses were low at negative 4. Policy shocks to inflation were high in 1995 and there was a significant decline after 2000 through to 2008 and afterwards an increase in inflation responses. The volatility of the policy rate to structural shocks reveals two observations. First, it was stable through the 1990s then it rose at the end of 1998. Secondly, after 1999, there was a sharp decline in volatility of the policy rate. This is expected, in that policy mistakes of setting the policy rate may have been reduced. As pointed out by Cogley et al. (2010), policy authorities in the conduct of monetary policy learn over time how to set the policy rate.

Furthermore, Figure 3 reveals an interesting pattern of policy responses to real GDP and inflation over time. An inflation targeting regime is different, as the responses to real GDP growth rate are higher than a monetary aggregates targeting regime. In an inflation targeting regime, the SARB cares more about real GDP growth than inflation stability. But after the financial crisis in 2008, the responses of monetary policy to output were smaller, compared to inflation responses.

5.1.4 Consistency of Baseline Results with Other Policy Regimes

The results for the changes in the SARB preference parameters are very similar to those of Lakdawala (2016) and Belongia and Ireland (2016), findings which relate to the Federal Reserve Board (Fed). According to them, the Fed placed more weight on output stability relative to inflation stability from 2000 to 2007. It is found that the behaviour of the SARB monetary policy strategy was similar during the same period. The emphasis on output stabilisation increased significantly after inflation targeting from 2000 until 2005, then the trend reversed during the financial crisis of 2008.

Secondly, the governors' preferences are also consistent with an outcome that different governors may exhibit different monetary policy conduct. Mboweni's policy objectives might be different to those of De Kock and Stals'. The reason is that each governor faces different economic circumstances during their time in office that might shape their beliefs about monetary policy conduct. When Mboweni stepped in, though inflation was accelerating, output growth became a key concern for policy authorities. Therefore, output stability became an important objective to policy authorities as uncertainty associated with the state of the economy increased. This finding is also in line with Lakdawala (2016), who finds that there was a large rise in the weight on inflation with the Federal Reserve Board Chairman Volcker's term, similar to that of Stals's tenure.

The volatility of the structural innovations and dynamic responses of inflation and output are very similar to that of Primiceri (2005), Boivin (2005) and Kim and Nelson (2006) who found that from the middle part of their sample to the end period, inflation volatility was low. As Boivin (2005) suggest, monetary policy conduct changed significantly over the last three decades, but the effect of policy shocks to real activity were weak. This study confirms that the SARB policy changed over the sample period of 1980 to 2014. Further, Primiceri (2005) finds that different variances of policy shocks are important in examining comovements between inflation and output similar to this study findings. The fact that similar findings are obtained from different empirical settings, as well as, different countries is encouraging.

Another interesting piece of evidence is that this result is consistent with other studies in South Africa, as shown in Table 1. These studies suggest that the SARB allocates a positive weight to real economic activity during an inflation target regime. Ortiz and Sturzenegger (2007) and Naraidoo and Raputsoane (2015) obtain estimated parameters of 1.11 and 1.43 for inflation while output parameters are 0.27 and 0.60 over their sample period. Conversely, in this study 1.003 and 0.74 for inflation and output are obtained, respectively. Similarly, Alpanda et al. (2010) find that the SARB's preferences for inflation and output were 1.42 and 0.29 in their estimated optimal Taylor rule, and Peters (2016) finds that the SARB attaches significant weight to inflation. This is similar to what is found when the sample is split into monetary aggregates targeting and inflation targeting regimes, as shown in Table 3 and Figure 3. However, the time-varying parameter with stochastic volatility estimates reveal an important feature that is not found in these works cited above. The responses to inflation and output are both larger, and are important to characterise monetary policy regime changes. Again, this study unravels the behaviour of changes in the SARB's preferences in more interesting ways than that which traditional estimates are unable to discover.

Overall, the characterisation of the changes in central bank policy preferences is consistent with existing findings on issues of timing of the changes and changes in the central banks preference parameters.

5.2 Robustness Check

To gain further insight as to how monetary policy regime changes are carried out by the SARB and to check whether the baseline results are robust, two approaches are used. First, the output gap is used as an alternative measure of real economic activity to output growth. Secondly, the variances of policy shocks are split into three regimes to be in line with OLS estimates.

5.2.1 An Alternative Real Economic Activity—Output Gap

The top panel of Figure 6 is considerably different from the top panel of Figure 1. Thus, the output gap describes the SARB as an anti-inflation policy authority with negative weight allocated to output growth. However, the remaining estimates provide evidence that changes in SARB's preference parameters were much more substantial. In the left panel of Figure 7, the volatility in the policy innovations is much larger with respect to the output gap.

The main difference is that the volatility in the output gap is more pronounced and shows upward movement. The volatility in inflation rates decline consistently over the sample period, but after 2010 inflation volatility begins to rise. The results of volatility in policy rate is consistent with the left panel of Figure 5. Similarly, the responses to the output gap, inflation and repurchase rate in the right panel of Figure 5 show identical trends with the right panel of Figure 7.

5.2.2 Policy Regime Variances

In Figure 4, three regimes in the variances of the policy innovations are allowed for to detect whether the variances differ in policy innovations. The top panel is the first regime, starting from 1980:Q1 to 1989:Q2. The middle panel is the second regime starting from 1989:Q3 to 1999:Q3, and the bottom panel is the third regime from 2000:Q1 to present. The central message is that the variances of policy innovations are the same, but in 2000 the interval bounds are wide with respect to output compared to the 1980s and after 1989. In addition, the policy rate variance to inflation over the period 1980s is approximately negative 0.50 compared to negative 0.45 and 0.25 over 1989 and 2000, respectively. But the policy rate variance to policy rate remains at approximately 1.50 throughout the three regimes.

The conclusion is that the characterisation of monetary policy regime changes that emanate from the baseline results is robust to policy regime variances and output gap.

5.3 Counterfactual Simulations

In this section, an ex post simulation is undertaken to understand, first, what would have happened had Governor Stals's tenure continued? Secondly, it is supposed there was no policy regime change from a monetary aggregates regime to an inflation targeting regime in South Africa. Lastly, it is assumed that the policy authorities in South Africa had not responded to the impact of the financial crisis.

In answering the first question, inflation and output are simulated based on average value of the policy preferences over the tenure of Governor Stals. This is used to transform the observed inflation and output variables. Secondly, policy shocks are held to be constant, with the view that Stals has an anti-inflation bias. Figure 8 exhibits the simulated path of inflation and output and Table 5 shows the weights allocated to each counterfactual estimate.

Table 5: Counterfactual policy preferences

	Inflation	Output
Baseline—full sample		
Real GDP growth	1.0029	0.744
Governors' preferences		
Mboweni (1999-2009)	0.6183	1.6248
Counterfactual preferences		
Stals staying on	0.7976	0.7260
No policy regime change	0.8971	0.7875
Financial crisis	0.9458	0.6630

Source: Author's estimation August 31, 2016

The findings suggest that the simulated path of inflation would have been higher along with an increase in output growth, as reported in the bottom panel of Figure 8. The SARB would have attached higher weight to inflation, should Governor Stals have stayed on, relative to Governor Mboweni. However, the SARB would have preference for a lower weight on output, which is different to the baseline results as reported in Table 5. The volatility of the structural innovations reported in the top panel of Figure 9 suggests that the dynamic responses to inflation and output would have been lower, similar to the baseline results. However, the simulated stochastic volatility pattern in the bottom panel of Figure 9 do not exhibit similar trends. It can, therefore, be inferred that the structural innovations played a key role in the inflation targeting regime.

The second counterfactual simulation of no policy regime change is performed under the scenerio of holding the year 2000 sample constant. The notion that explicit inflation targeting regime communication takes four quarters to adjust economic agents' belief is acknowledged. Mean values of the weights over the monetary aggregates regime are used to adjust inflation and output variables. The monetary policy rate is adjusted by 100 basis points, similar to Gupta et al. (2010).

The simulation suggests that the weights on policy preferences and the dynamic responses would have been similar to the baseline empirical results with minimal deviations, as shown in Table 5 and Figure 10. On the contrary, the second panel of Figure 11 shows that the counterfactual volatility innovations vary substantially from the baseline findings. This confirms the proposal that the size of the structural innovations contribute to the design of monetary policy over the inflation targeting regime.

Lastly, a counterfactual analysis is conducted to assess the impact of the financial crisis in 2008. In doing this, the policy shocks impacting on the economy and the mean values of the preference parameters from 2000:Q1 to 2007:Q3 are fixed to benchmark the credit crisis in August 2007. Figure 12 suggests that the crisis would have had an adverse impact on a simulated path of output relative to inflation, had the SARB not responded. Similarly, the dynamic responses to output exhibit a drastic fall and an aggressive anti-inflation bias, as shown in the first panel of Figure 13. In the second panel of Figure 13, the structural innovations to inflation suggest persistence compared to the baseline results. This suggests that the financial crisis in 2008 would have had greater impact on inflation and output had the SARB not responded to the crisis.

6 Conclusion

This paper proposes that central bank preferences to target inflation and output vary over time. Moverover, different policy preferences by policy authorities may coincide with the term of a particular central bank governor. To examine these changes in central banks' preferences across time, a time-varying parameter approach was used, with the aim of revealing if and how the policy preferences have changed without splitting the sample. This study reveals that the data and the econometric technique support this proposal. The findings in this paper support the fact that the SARB's preference parameters change slowly and also coincide with most significant economic events. Such events include shifts in monetary policy regimes, different tenures of SARB governors, social unrest and periods in which the SARB is successfull in reducing inflation along with increase output growth.

It is found that monetary policy conduct is dynamic because weights attached to inflation and output are regime dependent. Further, under the tenure of different SARB governors, the weights allocated to inflation and output differ. Results also suggest that the size of the structural innovations volatility account for a larger part of policy responses to inflation and output. This evidence supports the argument that low volatility in inflation and output is as a result of minimal disturbances over the inflation targeting regime. Although based on different empirical approaches and also in different countries, the findings of the present analysis are comparable with existing research on policy regimes. In particular, changes in policy authority preferences is consistent with issues relating to timing of policy changes and changes in the weights the policy authority allocates to output and inflation.

Finally, it is important to note that a backward-looking time-varying policy regime is used. It would be interesting to use a forward-looking model with and without the interest rate smoothing to understand the monetary policy regime changes in a forward-looking environment. Secondly, it is important to establish the role played by changes in central bank policy parameters on economic performance. This is examined in our next research, to determine the role played by changing in central bank preferences on the evolution of macroeconomic outcomes.

Appendices

A Kalman Filter Algorithm

To estimate a time-varying parameter vector autoregression (TVP-VAR), the Bayesian statistical inference for β_t exploits the Kalman filtering in the following steps

$$\beta_{t-1}|y^{t-1} \sim N(\beta_{t-1}, V_{t-1|t-1}), \tag{24}$$

where $\beta_{t-1|t-1}$, and $V_{t-1|t-1,}$ are Kalman filtering proceeds using

$$\beta_{t-1}y^{t-1} \sim N(\beta_{t|t-1}, V_{t|t-1}), \tag{25}$$

where $V_{t|t-1} = V_{t-1|t-1} + Q_t$, Q_t enters the Kalman filtering formulae only at this stage, then eqn. (25) is respecified as

$$V_{t|t-1} = \frac{1}{\lambda} V_{t-1|t-1}. \tag{26}$$

Then Q_t will be estimated or simulated and λ is a factor $0 < \lambda \leq 1$. Eqn. (26) is observation j periods in the past with a weight of λ^j in the filtered estimate of β_t. Eqns. (25) and (26) means that if $\lambda = 1$ then there is a constant coefficient, implying that $Q_t = (\lambda^{-1} - 1)V_{t-1|t-1}$. To avoid constant coefficients, λ is set less than one—for quarterly data $\lambda = 0.99$. This results in a fairly stable model with a gradual change in coefficients that has features similar to those of Cogley and Sargent (2005).

B Independence Metropolis-Hastings Algorithm

For the selection of the densities within a setup of a time-varying parameter VAR, the generic candidate density is specified below

$$q(\Phi^{G+1}/\Phi^G) = q(\Phi^{G+1}). \tag{27}$$

The full details can be found in Jacquier et al (2002). In general, the acceptance probability formula does not simpify and is given as

$$\alpha = min(\frac{\pi(\Phi^{G+1}/q(\Phi^{G+1}/\Phi^G))}{\pi(\Phi^G)/q(\Phi^G/\Phi^G + 1)}, 1) \tag{28}$$

unlike the random walk MH algorithm, the independence MH algorithm candidate density generating is tailored to a particular problem at hand. The steps include: One: setting starting values of the model parameters

Two: drawing a candidate values of the parameters Φ^{G+1} from the candidate density generating

Three: computing the acceptance probability

$$\alpha = min(\frac{\pi(\Phi^{G+1}/q(\Phi^{G+1}/\Phi^{G}))}{\pi(\Phi^{G})/q(\Phi^{G}/\Phi^{G}+1)}, 1) \tag{29}$$

Four: if $\mu \sim U(0,1)$ is less than α retain Φ^{G+1}, otherwise retain the old draw.

Five: repeat the step 2-4 M times and base on inference on last likelihood draws.

C Estimated Results

Table 6: Detail baseline policy preference parameters—full sample

Period	Inf.	Out.	Period	Inf.	Out.	Period	Inf.	Out.	Period	Inf.	Out.
1980:Q1	0.294	0.111	1988:Q4	0.720	0.725	1997:Q2	1.689	0.383	2006:Q1	0.015	1.276
1980:Q2	0.154	0.486	1989:Q1	0.895	0.746	1997:Q3	1.897	0.309	2006:Q2	0.106	1.333
1980:Q3	0.277	0.170	1989:Q2	0.860	0.769	1997:Q4	2.281	0.195	2006:Q3	0.162	1.333
1980:Q4	0.196	0.356	1989:Q3	0.975	0.738	1998:Q1	2.651	0.330	2006:Q4	0.151	1.299
1981:Q1	0.396	0.102	1989:Q4	1.012	0.707	1998:Q2	3.960	-0.447	2007:Q1	0.135	1.289
1981:Q2	0.498	0.039	1990:Q1	1.178	0.519	1998:Q3	2.824	0.622	2007:Q2	0.410	1.215
1981:Q3	0.626	0.217	1990:Q2	1.193	0.512	1998:Q4	2.125	0.698	2007:Q3	0.487	1.255
1981:Q4	0.683	0.204	1990:Q3	1.308	0.450	1999:Q1	1.906	0.416	2007:Q4	0.542	1.244
1982:Q1	0.818	0.482	1990:Q4	1.341	0.442	1999:Q2	1.941	0.476	2008:Q1	0.587	1.221
1982:Q2	1.101	0.153	1991:Q1	1.232	0.359	1999:Q3	1.826	2.130	2008:Q2	0.548	1.217
1982:Q3	1.009	0.314	1991:Q2	1.201	0.390	1999:Q4	1.827	2.126	2008:Q3	0.550	1.217
1982:Q4	1.205	0.110	1991:Q3	1.151	0.399	2000:Q1	1.479	1.845	2008:Q4	0.866	0.992
1983:Q1	1.122	0.317	1991:Q4	1.116	0.398	2000:Q2	0.830	1.793	2009: Q1	1.156	0.512
1983:Q2	0.999	0.399	1992:Q1	1.087	0.408	2000:Q3	0.651	1.779	2009: Q2	1.134	0.562
1983:Q3	1.229	0.439	1992:Q2	1.038	0.407	2000:Q4	0.702	1.793	2009: Q3	1.256	0.462
1983:Q4	1.403	0.526	1992:Q3	1.040	0.405	2001:Q1	0.779	1.797	2009: Q4	1.239	0.451
1984:Q1	1.490	0.742	1992:Q4	1.107	0.255	2001:Q2	0.850	1.833	2010: Q1	1.102	0.156
1984:Q2	1.427	0.554	1992:Q4*	1.226	-0.231	2001:Q3	1.053	1.939	2010: Q2	1.171	0.362
1984:Q3	1.293	0.403	1993:Q1	1.366	-0.089	2001:Q4	1.164	2.028	2010: Q3	1.203	0.491
1984:Q4	1.757	0.258	1993:Q2	1.222	-0.333	2002:Q1	1.034	1.972	2010: Q4	1.144	0.398
1985:Q1	1.554	0.369	1993:Q3	1.356	0.091	2002:Q2	0.728	1.928	2011: Q1	1.073	0.345
1985:Q2	1.443	0.450	1993:Q4	1.292	-0.046	2002:Q3	0.516	1.958	2011: Q2	0.929	0.325
1985:Q3	1.266	0.632	1994:Q1	1.253	-0.037	2002:Q4	0.426	1.992	2011: Q3	0.804	0.337
1985:Q4	0.966	0.535	1994:Q2	1.514	0.355	2003:Q1	0.549	2.075	2011: Q4	0.735	0.333
1986:Q1	0.762	0.473	1994:Q3	1.290	0.437	2003:Q2	0.706	2.211	2012: Q1	0.764	0.328
1986:Q2	0.653	0.500	1994:Q4	1.198	0.336	2003:Q3	0.722	2.486	2012: Q2	0.791	0.353
1986:Q3	0.625	0.484	1995:Q1	1.243	0.376	2003:Q4	0.503	2.973	2012: Q3	0.801	0.361
1986:Q4	0.506	0.454	1995:Q2	1.283	0.365	2004:Q1	0.586	2.493	2012: Q4	0.741	0.379
1987:Q1	0.499	0.456	1995:Q3	1.677	0.677	2004:Q2	0.465	1.912	2013: Q1	0.825	0.372
1987:Q2	0.514	0.476	1995:Q4	2.193	0.342	2004:Q3	0.190	1.409	2013: Q2	0.864	0.416
1987:Q3	0.506	0.477	1996:Q1	2.180	0.302	2004:Q4	-0.032	1.329	2013: Q3	0.656	0.525
1987:Q4	0.540	0.487	1996:Q2	2.194	0.635	2005:Q1	0.021	1.423	2013: Q4	0.688	0.594
1988:Q1	0.541	0.488	1996:Q3	1.797	0.478	2005:Q2	-0.069	1.287	2014: Q1	0.700	0.588
1988:Q2	0.618	0.598	1996:Q4	1.609	0.422	2005:Q3	-0.005	1.312	2014: Q2	0.663	0.617
1988:Q3	0.697	0.676	1997:Q1	1.575	0.434	2005:Q4	0.053	1.378	2014: Q3	0.696	0.581

Source: Author's estimation August 31, 2016. Note: Inf=inflation and Out=output

Figure 1: Kalman filter estimates of time-varying policy preferences

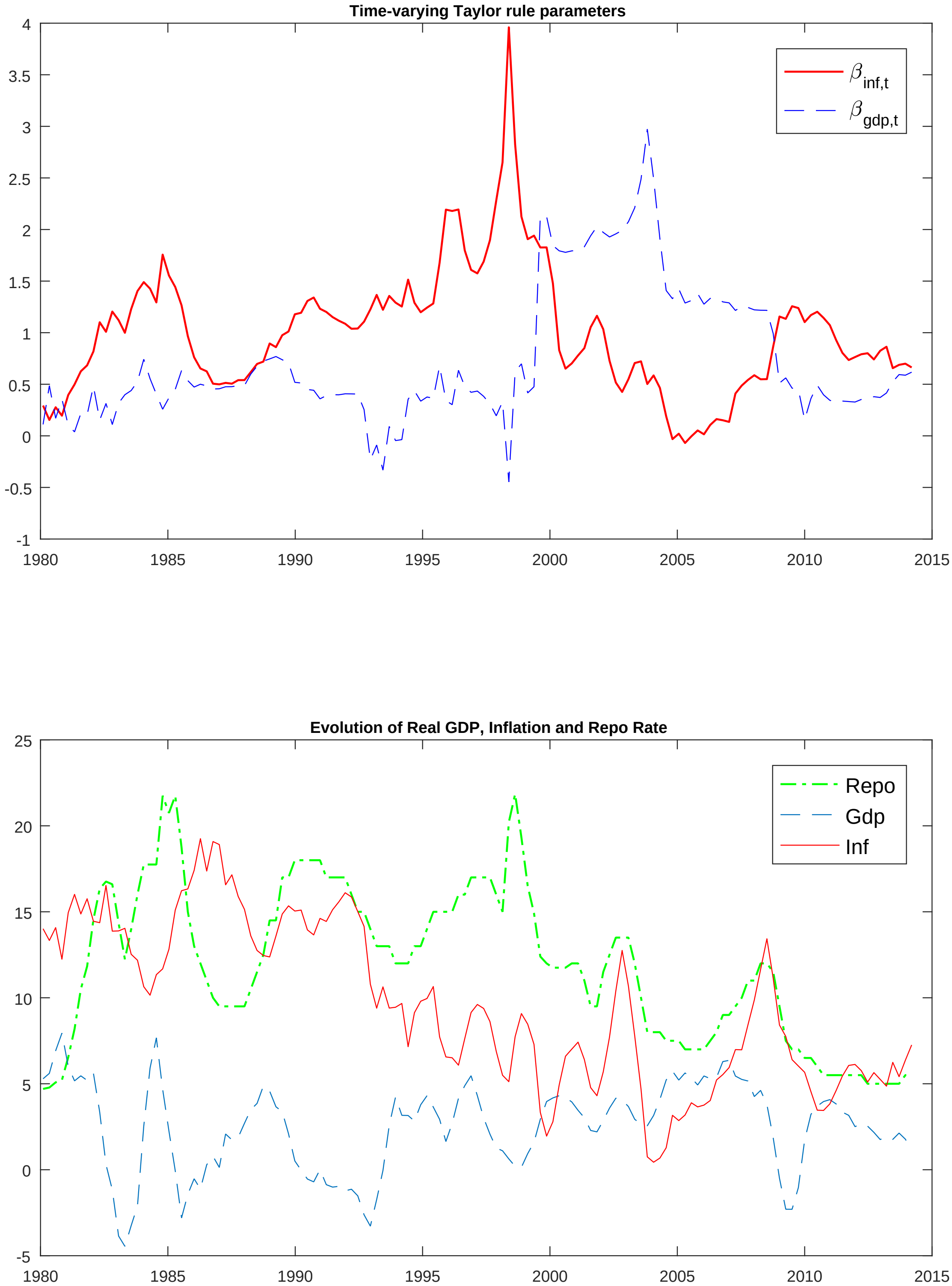


Figure 2: Governors' preferences

Note: Top left panel De Kock, top right panel Stals, bottom left panel Mboweni and bottom right panel Marcus

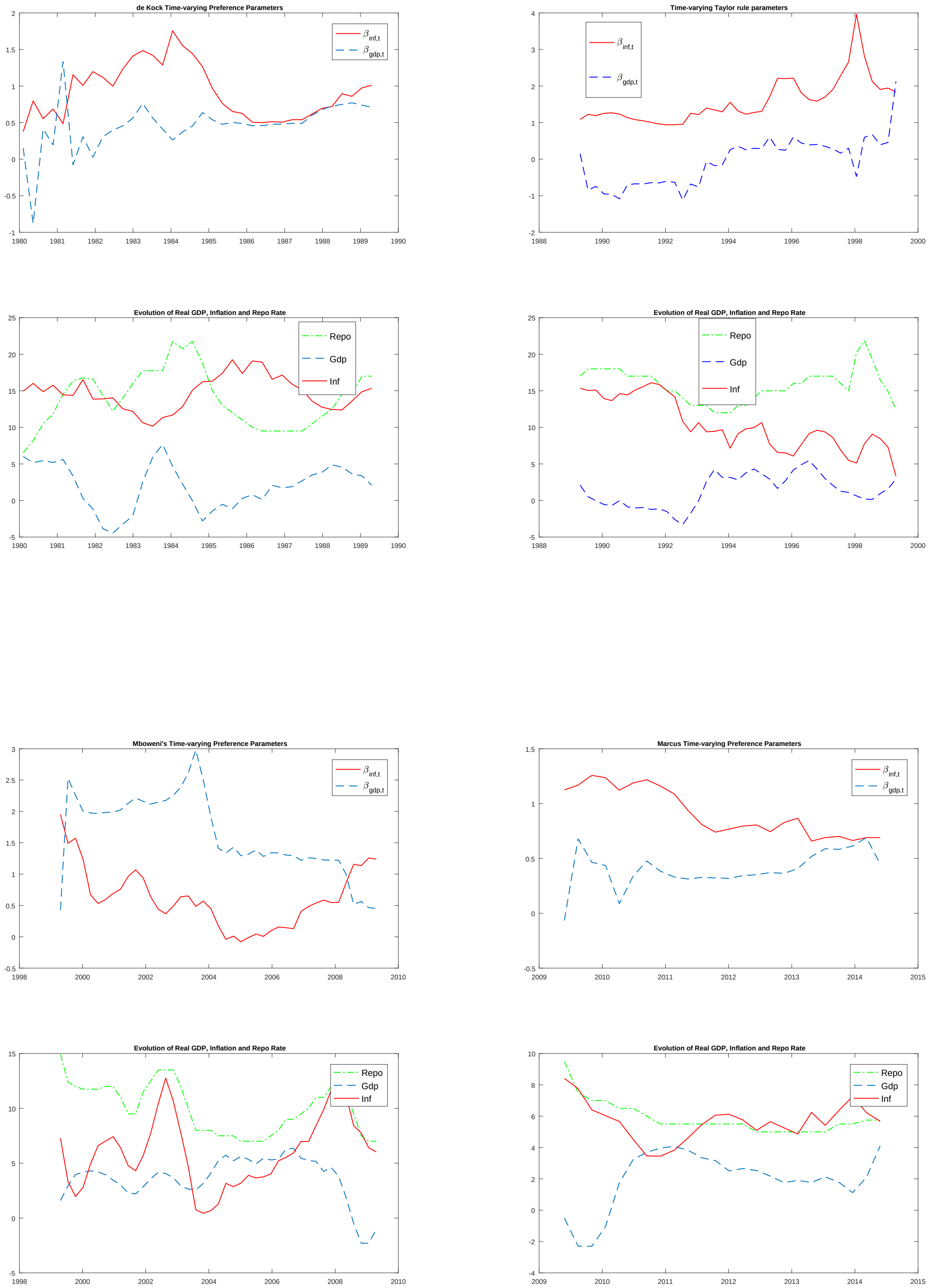


Figure 3: Policy regime changes preferences

Note: Left panel monetary aggregates targeting and right panel post-inflation targeting

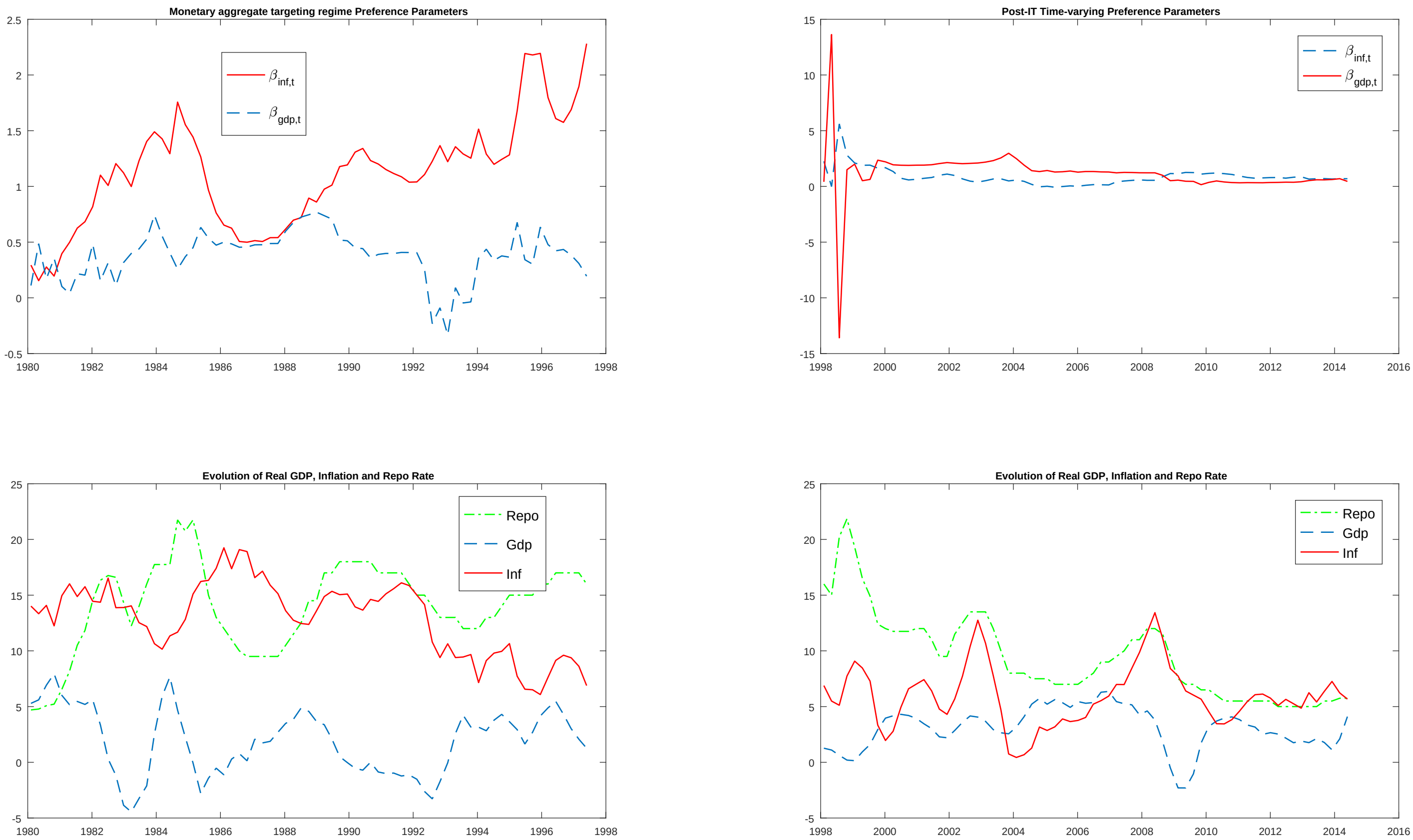


Figure 4: Policy regimes innovations

Note: Impulse response of inflation, output and repo rate to repo rate shock. Left panel inflation, middle panel real GDP and right panel repo rate

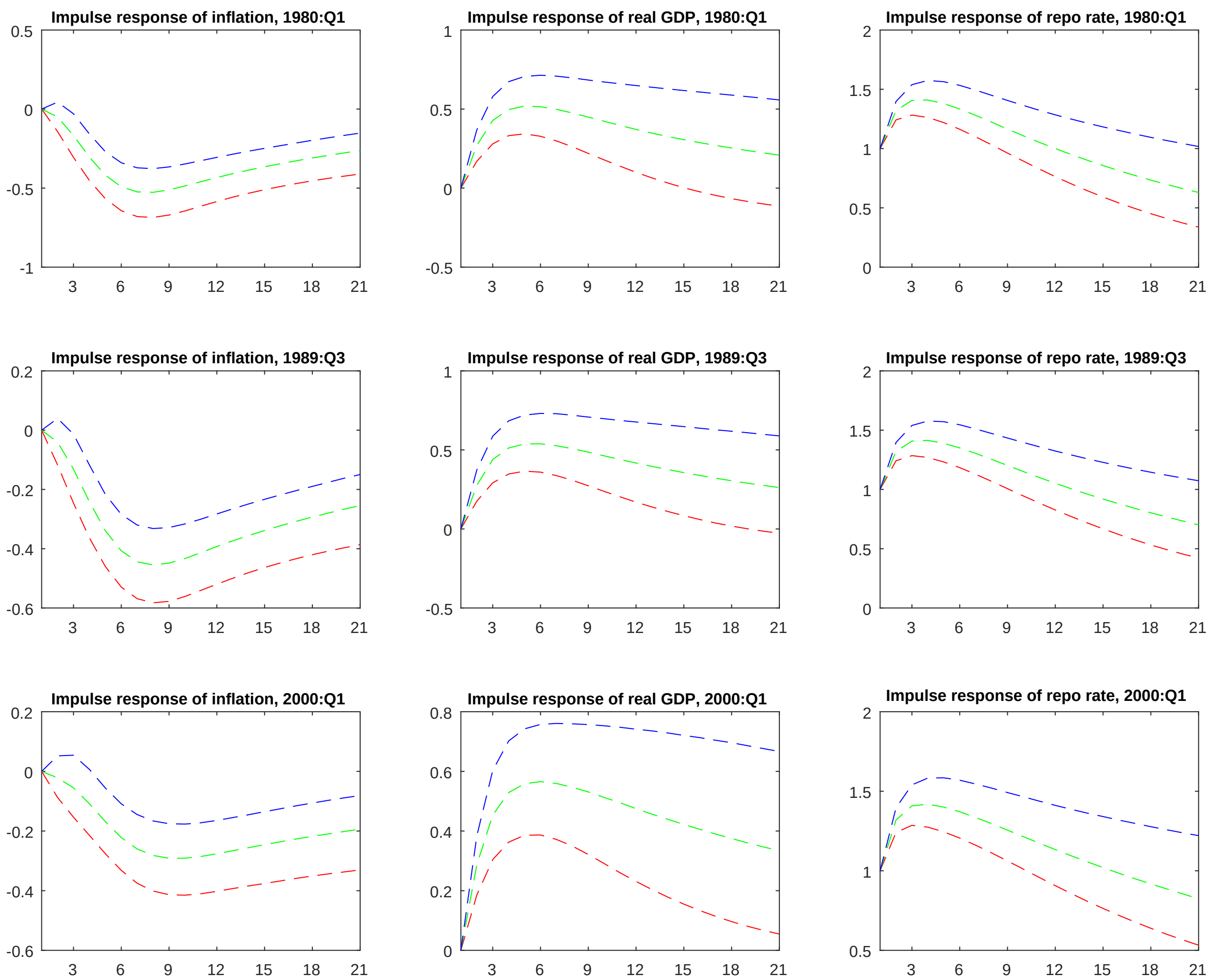


Figure 5: Baseline time-varying parameter VAR

Note: Left panel is stochastic volatility of structural innovations and right panel is time-varying dynamic responses

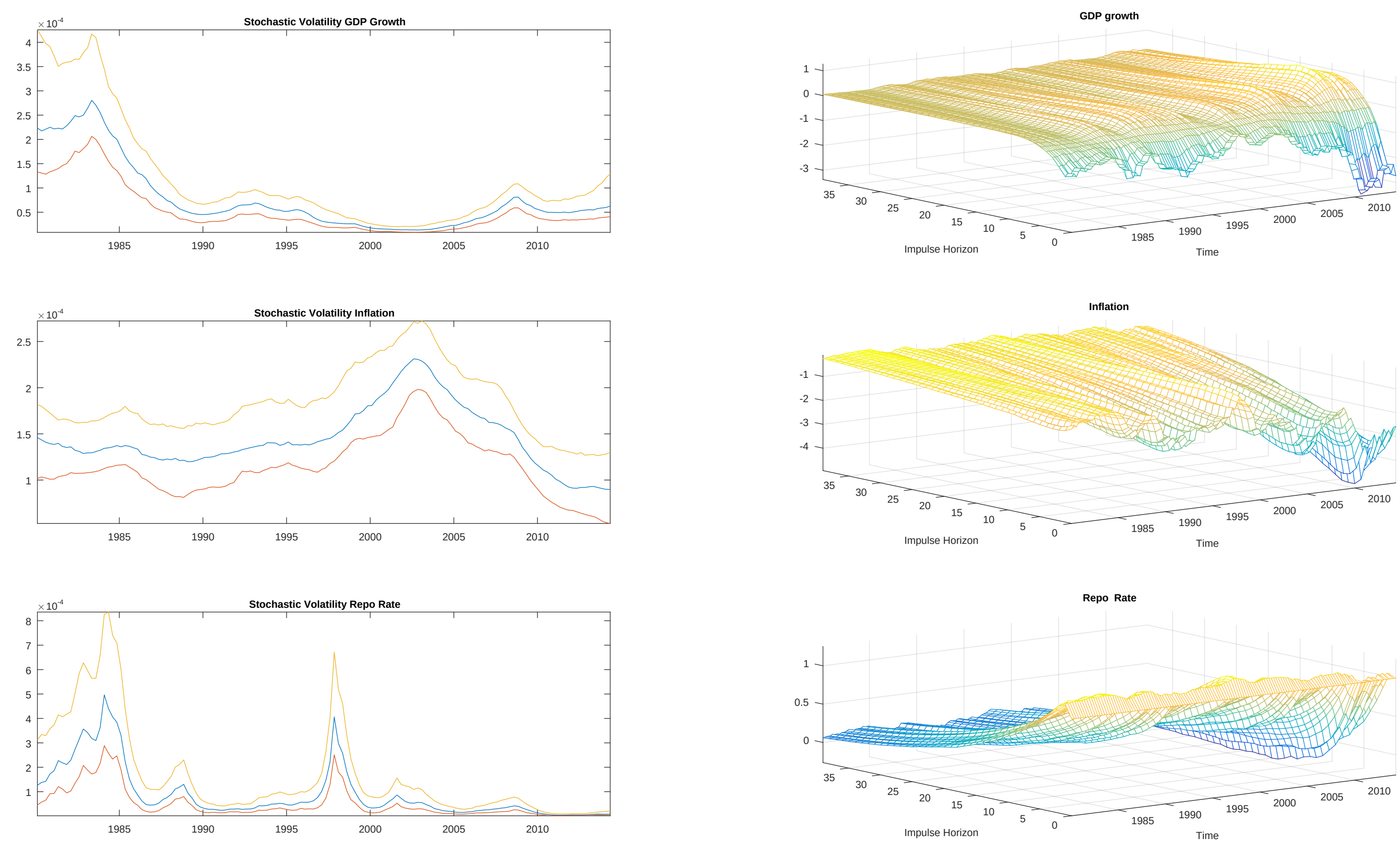
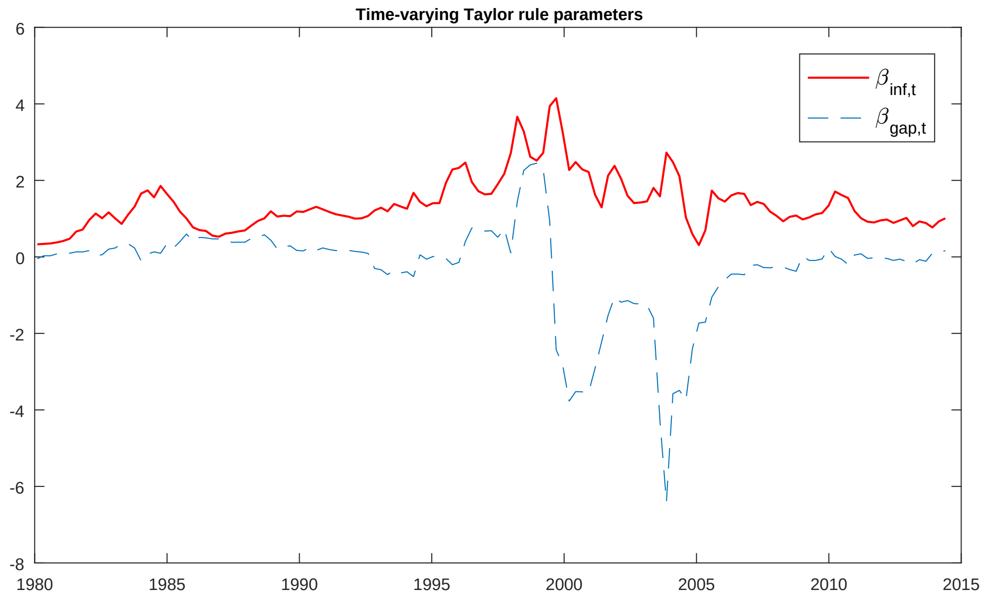


Figure 6: Robustness check: Kalman filter estimates of time-varying policy preferences

Note: Top panel is parameter estimates and bottom panel is evolution of observed variables



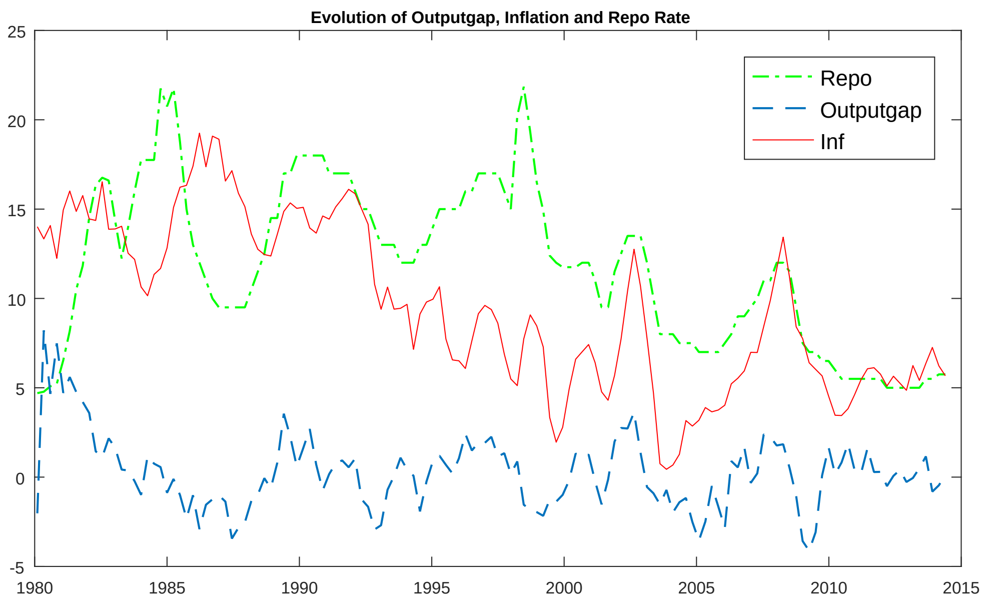


Figure 7: Robustness check: time-varying parameter VAR

Note: Left panel is stochastic volatility of structural innovations and right panel is time-vary dynamic responses

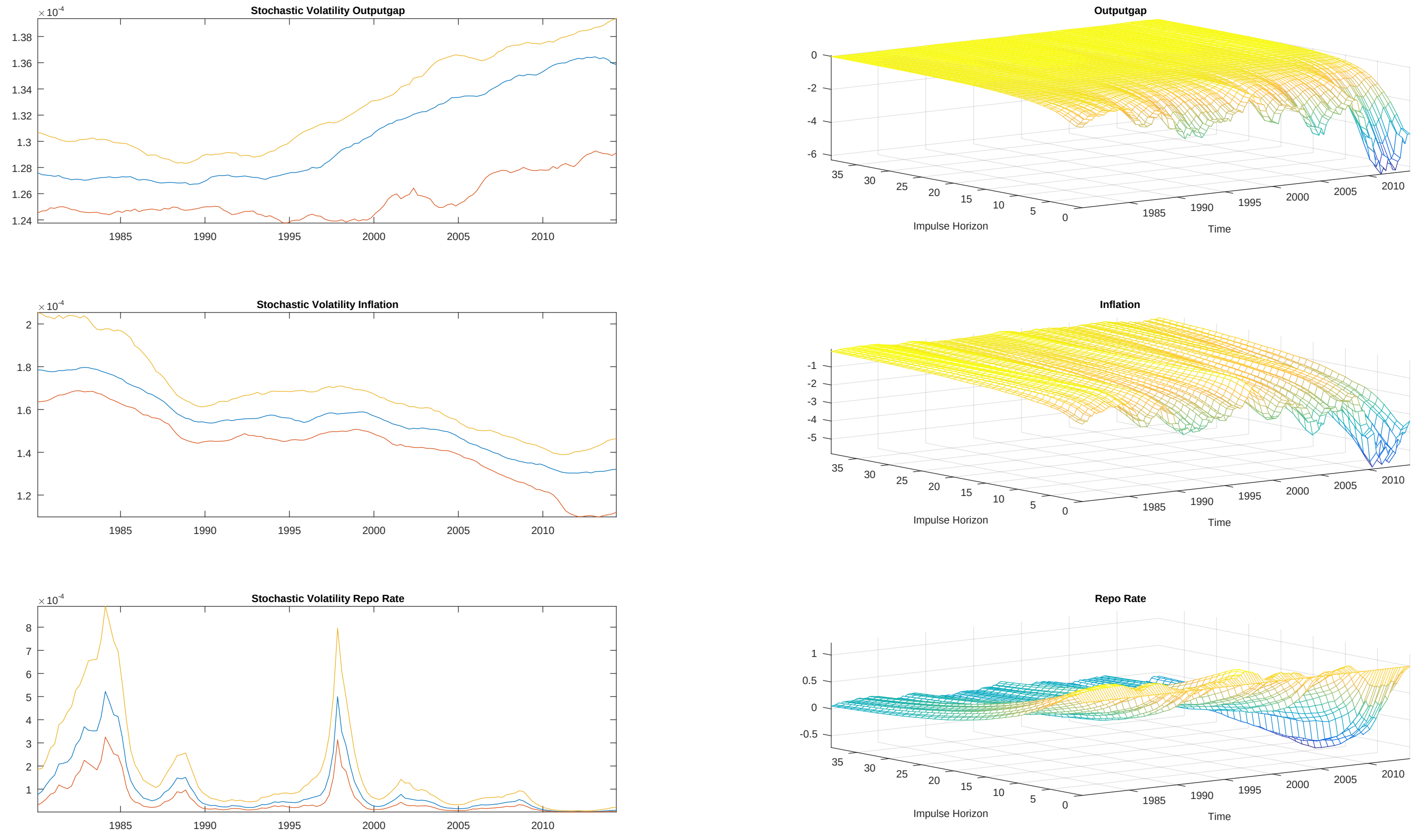
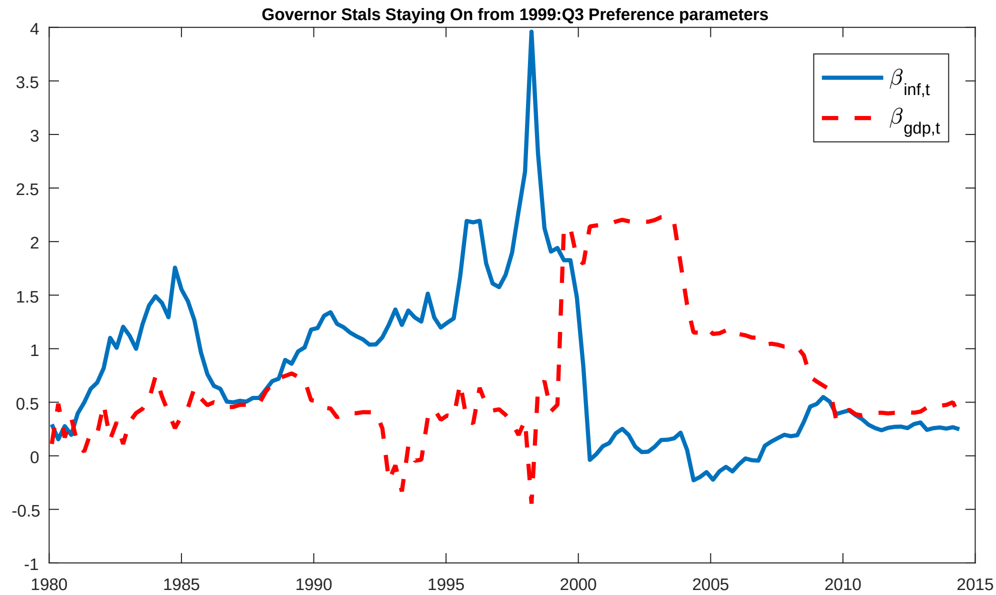


Figure 8: Counterfactual simulation of policy preferences, assuming Governor Stals had continued



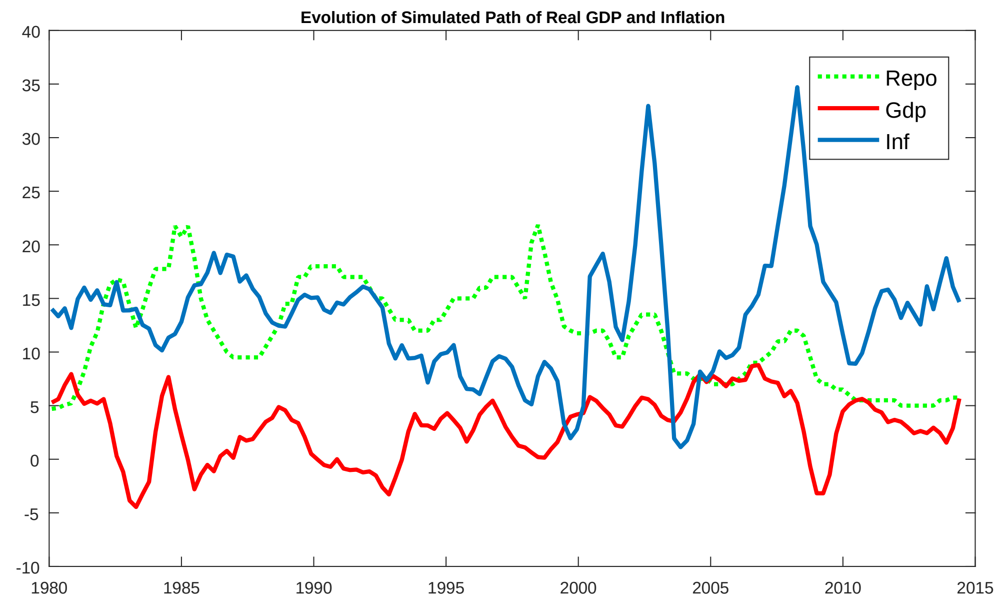


Figure 9: Counterfactual simulation of time-varying dynamic responses, assuming Governor Stals had continued

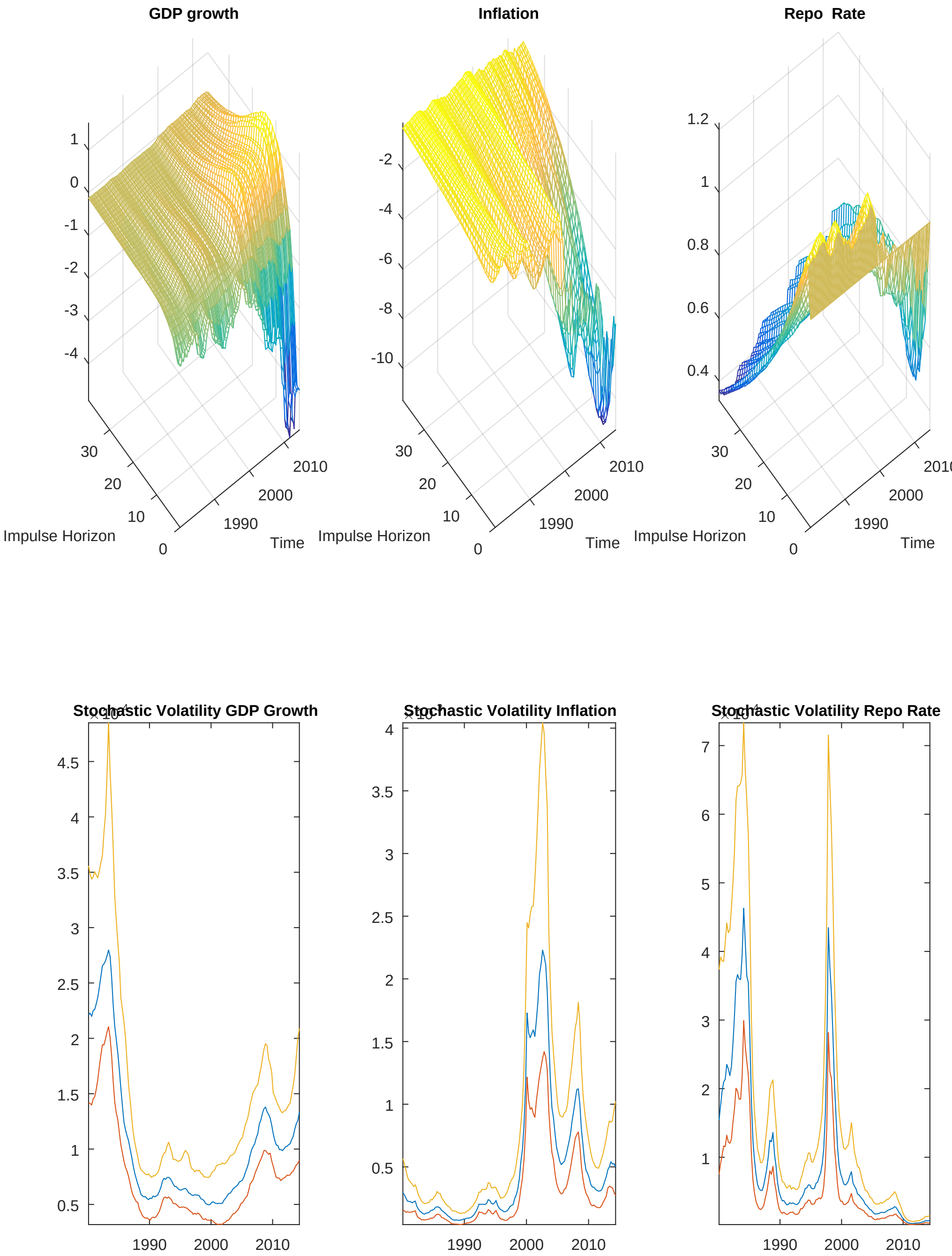
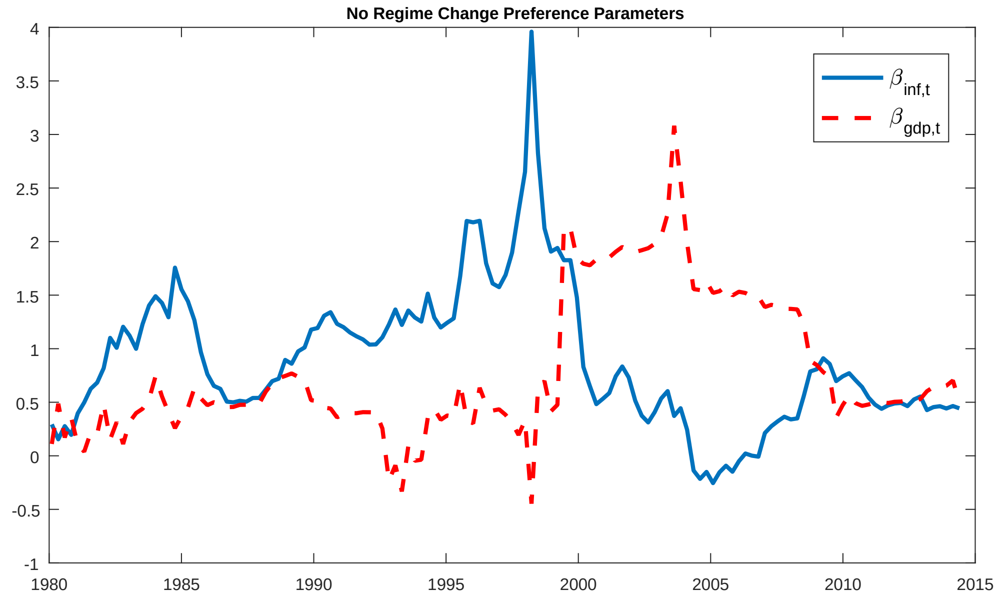


Figure 10: Counterfactual simulation of policy preferences, assuming no monetary policy regime change



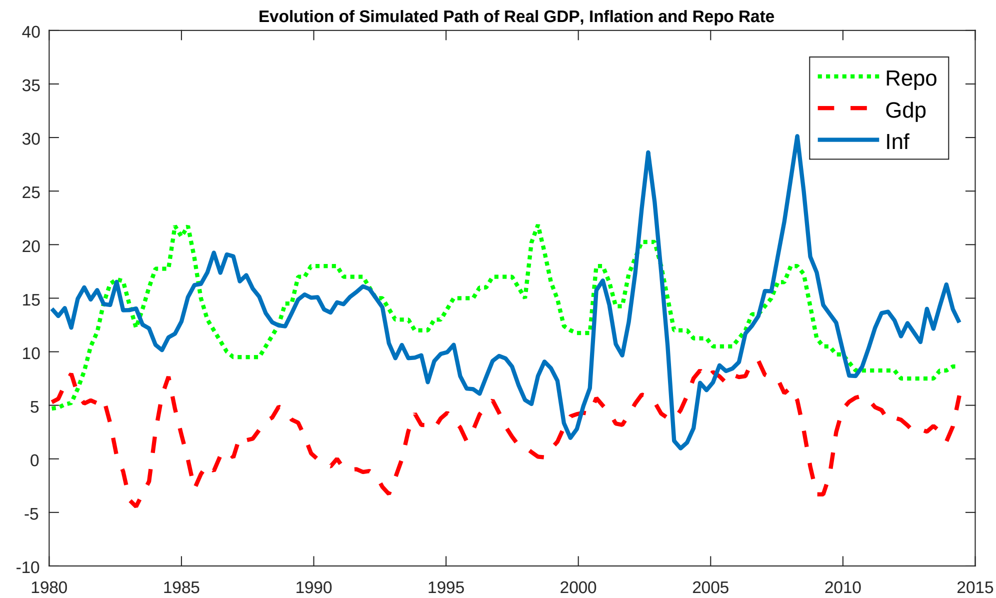


Figure 11: Counterfactual simulation of time-varying dynamic responses, assuming no monetary policy regime change

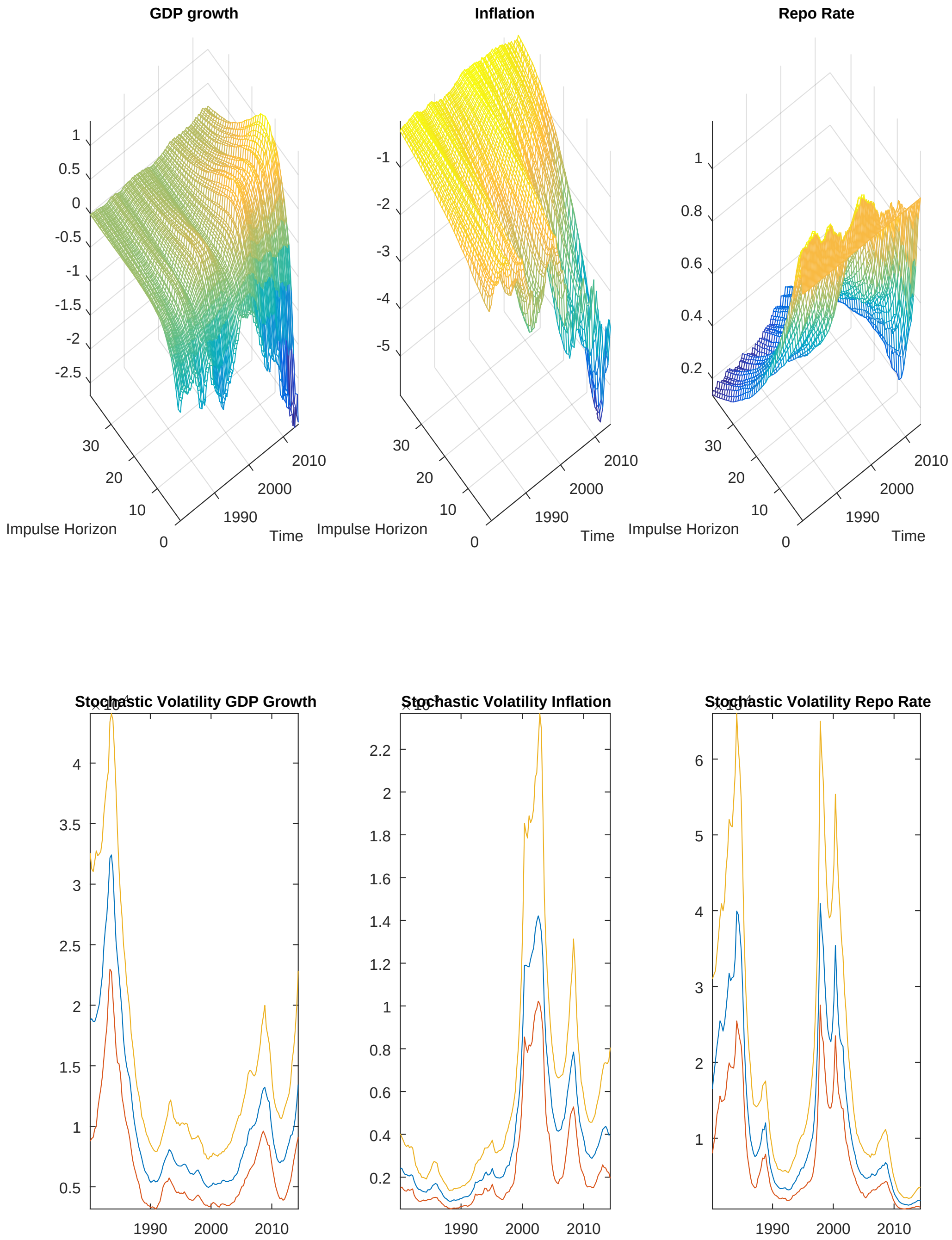
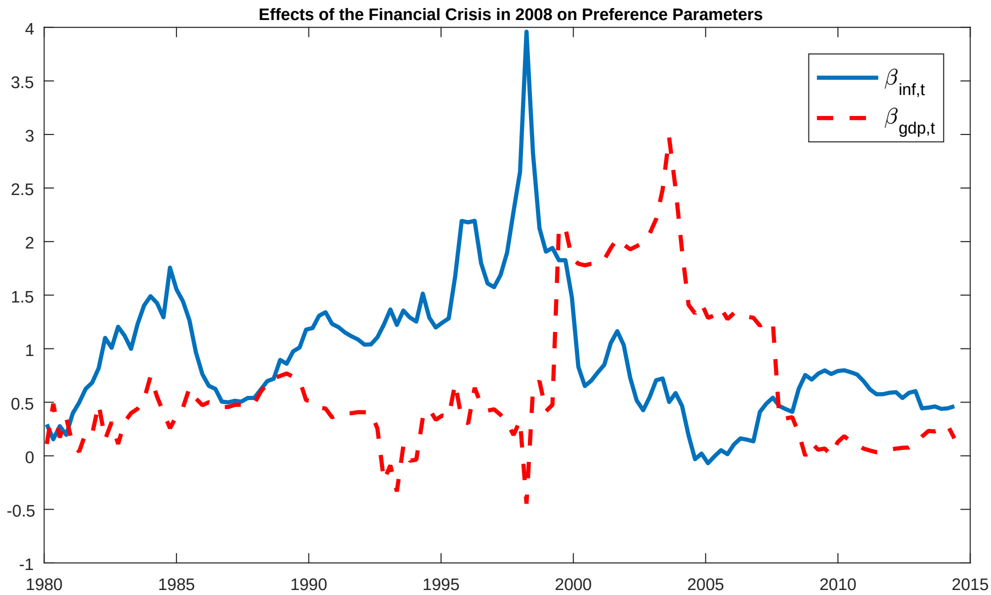


Figure 12: Counterfactual simulation of policy preferences, assuming SARB had not responded to the financial crisis



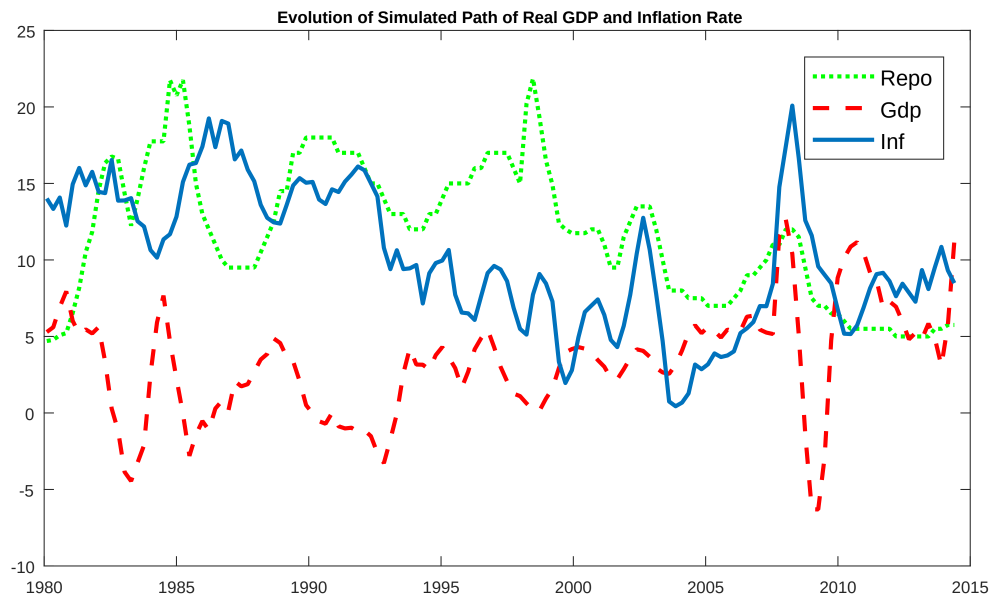


Figure 13: Counterfactual simulation of time-varying dynamic responses, assuming SARB had not responded to the financial crisis

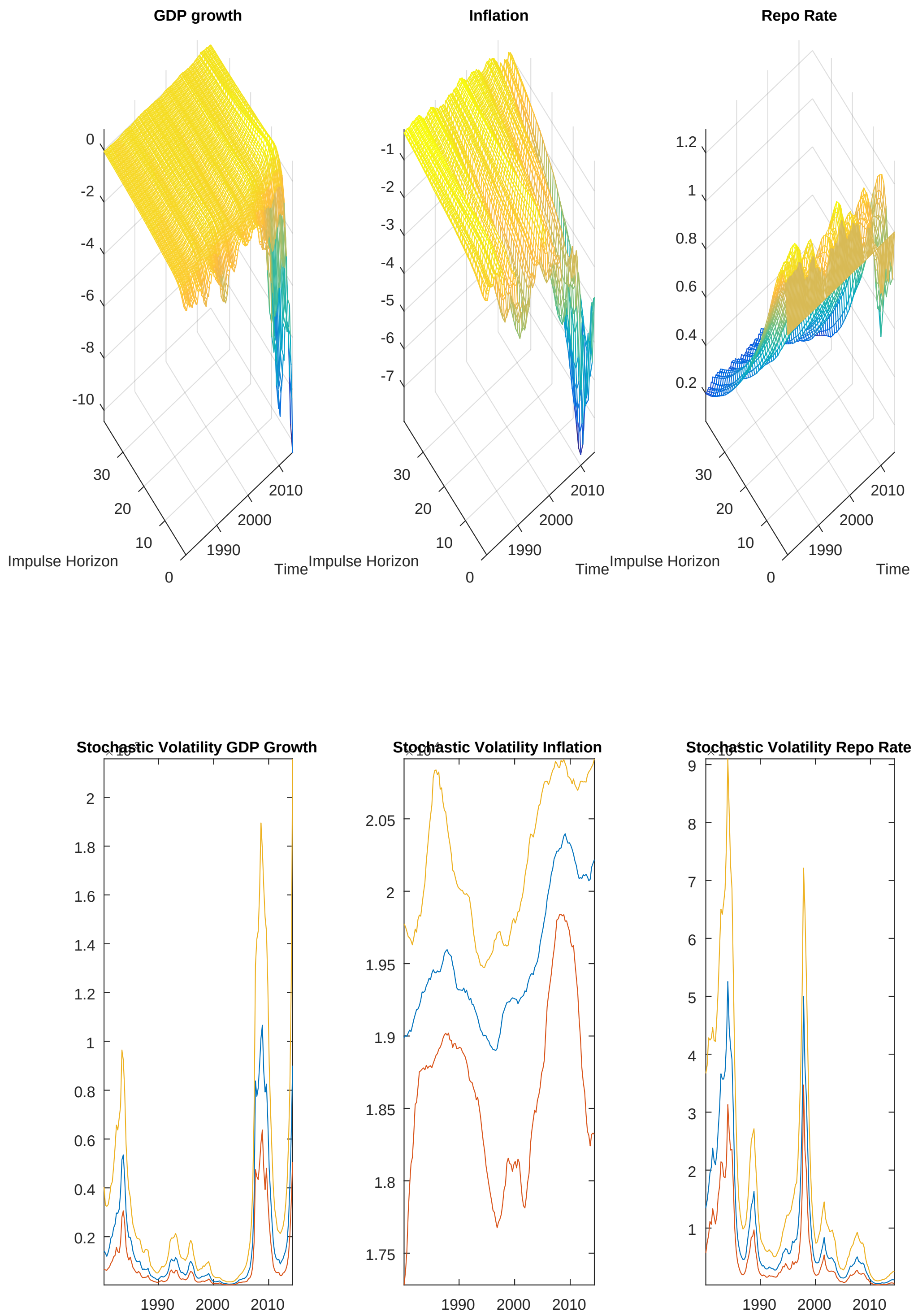
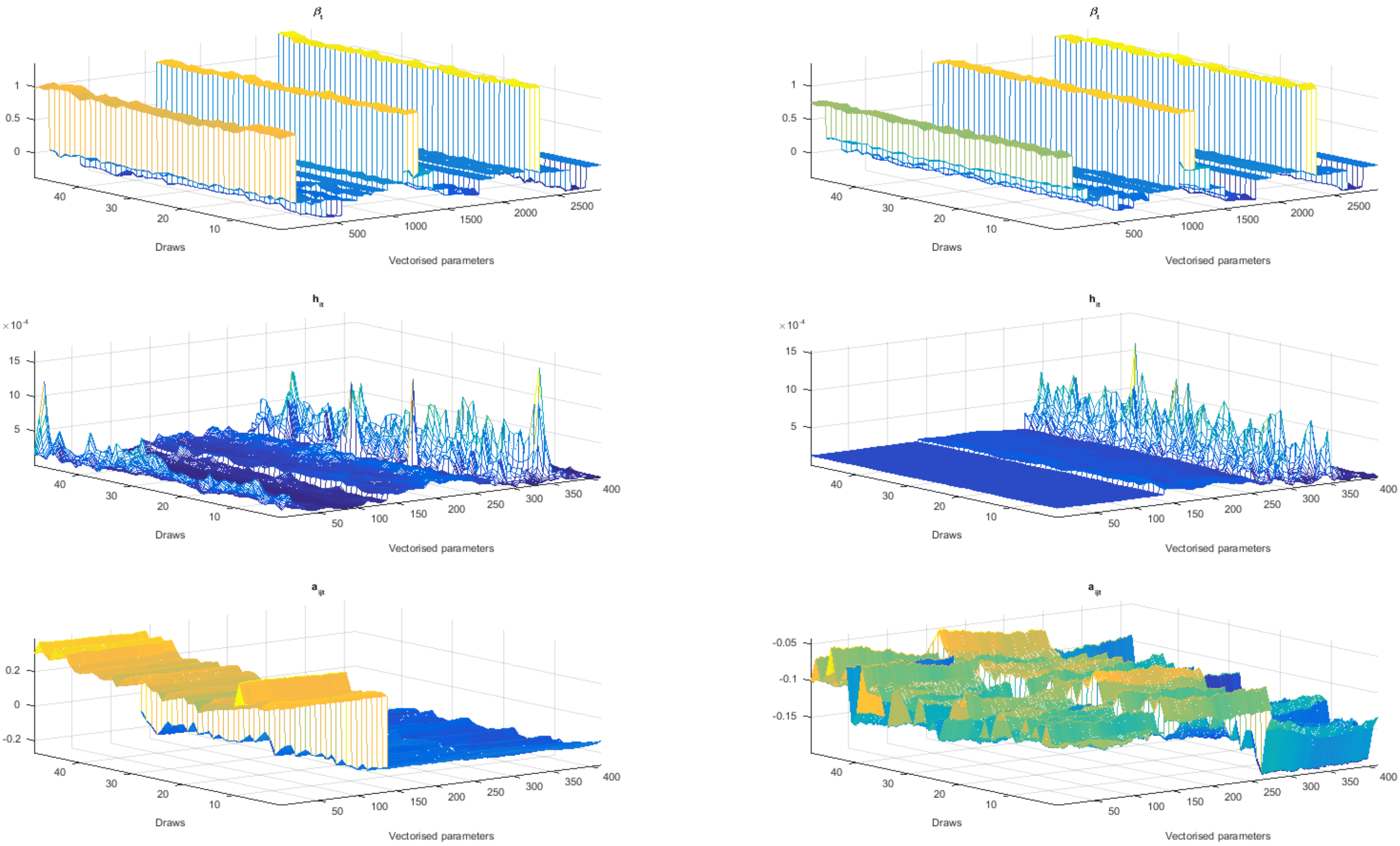


Figure 14: Recursive means for the key policy parameters

Note: Left panel real GDP growth rate and right panel output gap



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