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A Bayesian-Estimated Model of Inflation Targeting in South Africa

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Abstract

This paper estimates a small dynamic macroeconomic model for the South African economy with Bayesian methods. The model is tailored to assessing the impact of domestic as well as external shocks on inflation within an inflation targeting framework, by incorporating forward-looking behavior of private agents and of the monetary authority. The model is able to display important empirical features of the monetary transmission mechanism that have been found in other studies. It helps to integrate the short-term inflation outlook into a consistent medium-term framework and to design the policy response for various shocks that affect inflation.

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I. INTRODUCTION

Until recently, South Africa had been quite successful in bringing inflation under control. Following the sharp depreciation at the end of 2001, inflation peaked at 11.3 percent in October 2002.[2] The subsequent appreciation of the rand and monetary tightening led to a steady decline of inflation and inflation remained within the official target range of 3 to 6 percent for several years. At the same time, continuous improvements in the South African Reserve Bank's (SARB) inflation targeting framework strengthened its credibility and inflation expectations became much better anchored. More recently however, energy and food price shocks, together with a thriving economy, have contributed to higher inflation.

Indeed, recent international experience with inflation targeting, as discussed for example in Roger and Stone (2005) and Mishkin and Klaus Schmidt-Hebbel (2007), provides some support for the view that inflation targeting is associated with an improvement in overall economic performance. Inflation targeting tends to help countries achieve lower inflation in the long run, experience smaller inflation response to oil-price and exchange-rate shocks, strengthen monetary policy independence, improve monetary policy efficiency, and obtain inflation outcomes closer to desired levels.

However, several authors, including Calvo (2001) and Mishkin (2004) have pointed to the specific difficulties that emerging market economies may face in conducting inflation targeting. First, credibility issues may weaken the design of optimal macroeconomic policy in these countries, and may reduce the effectiveness of monetary policy. Second, weak institutions may lead to currency substitution or liability dollarization, or even fiscal dominance, largely reducing the capability of the monetary authorities to effectively target inflation. Third, large exchange rate and other external shocks complicate the conduct of monetary policy, by introducing substantial volatility.

South Africa is not particularly affected by the first two types of issues. Macroeconomic polices have been impressive and currency substitution or liability dollarization are virtually absent. In particular, the sharp depreciation of the rand in 2001-02 has proven that there is certainly no "fear of floating". However, like many other emerging market countries, South Africa implementation of the inflation targeting strategy is often challenged by large exogenous—often external—shocks. In the typical environment in which many emerging markets operate—small open economies well integrated within a globalized world—an essential tool for policymaking lies in a coherent forward-looking framework for assessing the effect of external and domestic shocks on inflation, and for gauging the appropriate policy response.

To this purpose, this paper estimates with Bayesian methods a small dynamic macroeconomic model for the South African economy. The estimated model can help assess—within an inflation targeting framework—the impact on inflation dynamics of the

[2] It is unclear, however, if and to what extent the sharp depreciation of the rand at the end of 2001 was a fully exogenous event or may have been in part due to the monetary policy stance in 2001.

main domestic and external factors, such as those arising from exchange rates, domestic prices, and domestic as well as external demand. It is also able to display important empirical features of the monetary transmission mechanism in South Africa, and helps evaluate the policy response to shocks that affect inflation. The model incorporates the central features of inflation targeting, including forward-looking behavior of private agents and of the monetary authority. As such, it embodies the basic principle that the fundamental role for monetary policy is to provide an anchor for inflation and inflation expectations. At the same time, it offers a consistent framework for understanding and interpreting inflation developments and for evaluating the central inflation forecast.[3] Indeed, in an inflation targeting framework, a sound inflation forecast is key to successful monetary policy.

The particular specification of the model follows closely the one developed by Berg, Karam and Laxton (2006a, 2006b) for the Canadian economy. However, fitting the parameters to the South African economy with conventional, classical estimation methods is a big challenge, given the simple structure of the model and developments in South Africa over the past decades, involving several structural breaks. Therefore, the model is estimated employing Bayesian methods. These methods generally provide more robust estimates, although potentially less efficient, and allow for the consideration of other information, that is not necessarily contained in the time series of the model's variables.

The remainder of the paper is organized as follows. Section II describes the model. Section III presents the estimation results. Section IV illustrates the response of the main macroeconomic variables to various shocks, on the basis of the estimated model. Section V concludes.

II. A SMALL OPEN ECONOMY MODEL

The model features a small open economy encompassing forward-looking aggregate supply and demand—as in the recent models with microfoundations developed by, among others, Woodford—as well as stylized lags in the monetary transmission channel. It includes internal shocks as well as external shocks from the rest of the world (here represented by the U.S), which is kept exogenous. The model is setup to represent the economy at a quarterly frequency and is mainly driven by four key equations: aggregate supply, aggregate demand, uncovered interest parity, and the monetary reaction function. Definitions and equilibrium relations complete the model. The properties of the key parameters are discussed in the Appendix, which also presents their values and the steady-state assumptions.

The aggregate supply is described by a "New Keynesian Phillips" curve:[4]

$$\pi_t = \alpha_\pi \pi 4_{t+4} + (1-\alpha_\pi)\pi 4_{t-1} + \alpha_Y ygap_t + \alpha_z (z_t - z_{t-1}) + RES_t^\pi ,$$

[3] Woodford (2003) presents comprehensive theoretical foundations for models encompassing these features.

[4] For a detailed derivation of the following equations within a dynamic general equilibrium framework, see for example Svensson (2000), Walsh (2003), and Woodford (2003).

with

$$\pi_t \equiv 400[\ln(cpi_t) - \ln(cpi_{t-1})]$$

$$\pi 4_t \equiv 100[\ln(cpi_t) - \ln(cpi_{t-4})]$$

$$z_t = s_t + \ln(cpi_t^*) - \ln(cpi_t)\ .$$

where $\pi 4_t$ is the annual inflation rate, $\pi 4_{t+4}$ is the model-consistent inflation expectation four quarters ahead, π_t is the annualized quarterly inflation rate, $ygap_t$ represents the output gap (defined as the difference between actual and potential output), z_t is the log of the real exchange rate (an increase represents a real depreciation), cpi_t is the consumer price index, and s_t is the log of the nominal exchange rate (measured as local currency per 1 unit of foreign currency).[5] A residual captures other temporary exogenous effects that are not explicitly modeled, such as supply or oil shocks. Thus, this augmented Phillips curve specification includes the output gap, the rate of real exchange rate depreciation, and both expected and past inflation levels. Expected inflation enters the equation due to the assumption of staggered price-setting (see Calvo 1983), while indexation schemes or the presence of irrational price setters can offer a rationale for the backward-looking inflation component (see Steinsson, 2003). This somewhat stylized lag structure leads to a substantial degree of inertia in the inflation process, a phenomenon which is observed empirically. The real exchange rate reflects the effect of imported goods' prices on inflation in an open economy.

Aggregate demand is modeled as follows:

$$ygap_t = \beta_{ygap}^{Lead}\ ygap_{t+1} + \beta_{ygap}^{Lag}\ ygap_{t-1} - \beta_{RRGAP}\,(RR_{t-1} - RR_{t-1}^{Equi.}) + \beta_{ZGAP}\ zgap_{t-1} + \beta_{ygap*}\ ygap_t^* + RES_t^{YGAP}\ .$$

Domestic output gap ($ygap_t$) depends on both expected and past realizations of the domestic output gap, the lagged gap between the real interest rates (RR_t) and its equilibrium value (RR^{equi}), the lagged gap ($zgap_t$) between the real exchange rate and its equilibrium value, and the foreign output gap ($ygap^*_t$). A residual captures other temporary, exogenous effects (such as fiscal policy or other demand shocks).[6] Only deviations of real interest rates, the exchange rate, and domestic and foreign demand from long-run equilibrium levels matter (not their levels). The effect of past demand on current demand can be ascribed to, for example, habit persistence in consumption or adjustment costs of investment. Future domestic demand can reflect the effect of intertemporal smoothing, or of forward-looking investment choices.

[5] The consumer price index employed in the paper is the measure targeted by the SARB (CPIX), which excludes interest payments on mortgage loans.

[6] As the model is tailored to represent short-run dynamics and the monetary transmission mechanism, there is no explicit formalization of the supply side of the economy. Hence the dynamics of the output gap mainly reflect movements in the demand side of the economy.

The uncovered interest rate parity condition in real terms determines the real exchange rate:

$$z_t = z^e_{t+1} - (RR_t - RR^*_t - RiskP^{Equi.}_t)/400 + RES^{LZ}_t ,$$

with

$$z^e_{t+1} = \delta z_{t+1} + (1-\delta) z_{t-1}$$

and $RiskP^{Equi.}_t$ reflecting the equilibrium level of the domestic risk premium (the foreign real return, RR^*_t, is assumed to be risk-free). [7] A residual captures other temporary, exogenous effects, such as exogenous exchange rate shocks. The model displays Dornbusch-style overshooting with $\delta = 1$. However, in this case, the exchange rate predicted by the model would tend to be excessively volatile compared to the data. Therefore, it is common to assign to δ a value less than one, although this would imply a deviation from fully rational expectations.

The monetary authorities are assumed to set the short-term nominal interest rates (RS_t) according to the following monetary policy rule (or reaction function):

$$RS_t = \gamma^{Lag}_R RS_{t-1} + (1-\gamma^{Lag}_R)[(RR^{Equi.}_t + \pi 4_t + \gamma_\pi (\pi 4_{t+4} - \pi 4_{t+4}{}^{Target}) + \gamma_{YGAP}\, ygap_t] + RES^{RS}_t .$$

where $RR^{Equi.}_t$ is the equilibrium real interest rate (see the Appendix for a derivation) and $\pi 4_{t+4}{}^{Target}$ is the inflation target 4 quarters ahead. A residual captures other temporary, exogenous effects, such as policy mistakes.

In an inflation targeting framework, the inflation forecast plays a crucial role in determining the policy rate. Any expected deviation of inflation from its target triggers a response of the nominal policy rate. The respective coefficient of these deviations (γ_π) has to be larger than one (Taylor Principle) to ensure stability of the model.[8] In this case, the real interest rate increases if inflation is expected to be above target, and vice versa. While inflation is the primary target, the output gap is also included in the reaction function reflecting the fact that the monetary authorities are not indifferent to output developments. Past levels of the policy rate are included in the reaction function to account for partial-adjustment dynamics in the interest rate, resulting for example from the preference of the monetary authorities for interest rate smoothing. Such a preference has been empirically found to be high (high γ^{Lag}_R) in estimations of these models, possibly reflecting the resilience to respond aggressively to shocks in light of the uncertainty surrounding the persistence of the shocks.

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[7] Some normalization is required: the interest rate term needs to divided by 400, because the interest rates and the risk premium are measured in percent at annual rates while changes in the logarithms of the exchange rate are quarterly.

[8] This strictly holds if there is no interest rate smoothing.

III. Bayesian Estimation of the Model

We estimate the model using Bayesian methods, which have the advantage of working reasonably well in short samples, and are therefore particularly suitable for South Africa, given the large structural break experienced at the end of the apartheid regime in the early 1990s.[9] The main estimation sample is 1994-2005, to capture the full post-apartheid period, but results are quite similar when replicated only for the more recent period since the announcement of the inflation targeting regime in 2000. We use data for nine series. CPIX inflation (π_t) is from the SARB. Three other series are derived from the IFS dataset: short term nominal interest rate (RS_t, three-month government bonds), the bilateral real exchange rate versus the U.S. (z_t), and the U.S. short term real interest rate (RR_t*, the nominal interest rate on the three-month U.S. treasury bills minus the one-year inflation rate). The Appendix describes how we derived the remaining five series: the domestic output gap ($ygap_t$), the U.S. output gap ($ygap_t$*), the real exchange rate gap ($zgap_t$), the equilibrium domestic real interest rate ($RR_t^{Equi.}$), and the inflation target ($\pi 4_{t+4}^{Target}$).

Given a set of observables Y^T over a sample period T and a set of priors $p(\theta)$, the posterior density of the model parameters θ is given by:

$$p(\theta \mid Y^T) = \frac{L(\theta \mid Y^T)\, p(\theta)}{\int L(\theta \mid Y^T)\, p(\theta)\, d\theta}$$

where Y^T is the above set of nine variables and θ is the vector of eighteen parameters.[10]

A summary of the assumptions regarding the distribution of the priors for the parameters of the model and for the shocks can be found in Table 1. The type of distribution is chosen on the basis of the range of admissible values for the parameters (the beta distribution ranges between 0 and 1, while the gamma and inverted gamma ones are positive). The prior values for mean and standard deviations are guided by the following criteria. First, country-specific knowledge about structural parameters or estimates available in other studies are employed. Second, model parameters are chosen to reflect some stylized facts of the monetary transmission mechanism. Third, parameters for similar models of other countries provide a benchmark (in particular, the Canadian model prepared by Berg, Karam, and Laxton, 2006a and 2006b, which has been refined over several years). Fourth, the intuition behind the

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[9] For recent applications of Bayesian estimation methods to much more comprehensive DSGE models see for example: Smet and Wouters (2003) for the euro area, Smet and Wouters (2005) and Julliard et al. (2006) for the U.S., and Elekdag et al. (2005) for Korea. A broad discussion of the methodology and related issues is offered by An and Schorfeide (2007). For general references on Bayesian estimation, see Koop (2005) and Lancaster (2004).

[10] In addition to the twelve parameters of the model, we also estimate the steady state real interest rate and the autoregressive terms for the five observable variables that are exogenous to the theoretical model (see the Appendix).

economic effect of the parameters of the model (described in the Appendix) has also guided the assessment of the suitability of the priors for the South African economy.

On the basis of these priors, we search for the posterior modes using Sims' algorithm and check that a local optimum is found at these modes. Starting from these modes, we estimate the parameters by drawing from the posterior density using the Metropolis-Hastings algorithm with 500,000 replications. The acceptance rate for each draw was around 30 percent and convergence was achieved on the basis of the Brooks and Gelman (1998) criterion.

Table 2 reports the estimates for the posterior mean and the 90 percent confidence interval (for the reader interested in the frequentist interpretation of the result). Figure 1 presents the prior and posterior distributions for selected parameters. The most notable characteristics of the estimation are that: inflation is reasonably forward looking (0.44 is the coefficient of lead inflation); and interest rates are highly sluggish (0.75 is the coefficient of lagged interest rate in the monetary reaction function). Data seem to be informative about most parameters, apart from the ones reflecting the inflation and output weights in the monetary reaction function. This is not surprising as the inflation targeting regime has been adopted only recently, and implies that the monetary reaction function is mainly calibrated via priors than estimated via data. The calibration for such a function is based on the Taylor rule, evidence for other countries adopting inflation targeting, and the objective of obtaining a reasonable policy and economic response to shocks.

It is interesting to note that the data and theoretical moments are actually similar. Table 3 compares the standard deviations of the four main variables in the 1994-2005 sample with those implicit in the estimated model. The moments are remarkably similar for the nominal interest rate and the change in real exchange rate, while they are somewhat lower in the data than in the model for inflation and output gap.

We also checked whether the results were robust to a different sample, a richer lag structure, or different priors. First, we estimated the model in a more recent sample (2000-2005), given that the inflation targeting regime was announced in 2000. Most parameters were very similar: the main difference, quite surprisingly, is visible in the less forward looking component of inflation in the 2000-2005 sample. The data are again not particularly informative about the monetary reaction function. Second, we also estimate a model with richer dynamic structure, to check whether the simulated response to shocks would be substantially different (see the Appendix for details on the richer dynamic structure). The parameters are generally similar, but the richer model has a lower marginal data density, which suggest that the more parsimonious model is preferred (as the two models are estimated on the basis of the same dataset, the marginal data density can allow us to compare them, by providing a summary indication of whether the use of additional parameters is justified on the basis of a better fit). Third, we tried different priors and the final results were generally similar.

IV. SHOCK SCENARIOS

A. The Monetary Transmission Mechanism

The response of inflation, the output gap, and the exchange rate to a monetary policy shock in the model is consistent with the evidence found in other empirical studies of the monetary transmission mechanism (Figure 2).[11] In particular, the model's features are broadly consistent with the core forecasting model of the SARB (2007) which is a macroeconometric model with 18 structural equations. Considering deviations from the equilibrium solution of the model (control), a 100 basis point shock to the interest rate lowers domestic demand, appreciates the exchange rate, and, consequently, prices fall. To counter the fall in prices and the slowdown in output, the central bank lowers interest rates which fall below control about a year after the shock occurred. The effects on inflation and output peak several quarters after the initial monetary contraction. The effect on the exchange rate is relatively small. The monetary tightening results in an immediate nominal appreciation of less than one percent and nominal appreciation peaks at about 1.5 percent two quarters later.[12]

B. Exchange Rate, Price, and Demand Shocks

Shocks to the exchange rate have relatively moderate effects on inflation (Figure 3).[13] An exchange rate shock that causes an unanticipated immediate appreciation of ten percent lowers inflation by about 0.6 percentage points one year later. Monetary policy reacts immediately by lowering interest rates by about 30 basis points, and the cumulative response amounts to 100 basis points after one year. Output falls by about 0.6 percentage points below potential, also with about a one-year lag and then recovers.

A price shock would require a relatively strong policy response (Figure 4). Exogenous price shocks could be interpreted as international oil or food price shocks. A price shock that initially raises the annualized quarterly inflation rate by one percentage point, requires an increase in the nominal interest rate of about 140 basis points above the baseline after three quarters. This would increase the real interest rate by about one percentage points for several quarters. The associated output cost would be quite sizable, with the output gap peaking at about a negative 1 percentage point of GDP after two years and remaining in negative territory for about five years. This is mainly due to the inflation inertia in the model.

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[11] Smal and de Jager (2001) find a transmission lag of a monetary policy shock to inflation in South Africa of about 6-8 quarters.

[12] In an empirical study for Australia, Canada, New Zealand and the U.K., Kearns and Manners (2005) find that an unanticipated tightening of 25 basis points immediately appreciates the nominal exchange rate by 0.2 to 0.4 percent.

[13] With Dornbusch-style overshooting ($\delta = 1$), the effects of exchange rate shocks on inflation and output would be even less persistent.

Exogenous demand shocks could be interpreted as changes in the fiscal policy stance that is not explicitly modeled here. A positive demand shock of one percent of GDP (Figure 5) will raise the output gap. Inflation would increase only moderately (0.2 percent after about 1 year), as a tightening of the monetary policy stance would bring the policy rate by almost half of a percent. This would dampen demand and lead to a (nominal and real) exchange rate appreciate by about 2 percent in two years.

V. Conclusions

This paper employs Bayesian methods to estimate a dynamic small open economy model for the South African economy. The model is tailored to the analysis of the effect on inflation of domestic and foreign shocks under an inflation targeting regime. It embodies the basic principle that the fundamental role for monetary policy is to provide an anchor for inflation and inflation expectations. Although model and estimation uncertainties are bound to be large in these exercises, the estimated model is able to display important empirical features of the monetary transmission mechanism and can help assess the dynamic response of the main macroeconomic variables to shocks. Overall, the model can serve as a useful policy tool: it helps to integrate the short-term inflation outlook into a consistent medium-term forward-looking framework, and to design the policy response for various shocks that affect inflation.

Table 1. Priors

Parameter	Mean	Distribution	Standard Deviation
α_π	0.250	beta	0.10
α_y	0.300	gamma	0.10
α_z	0.150	beta	0.05
β_{yld}	0.050	beta	0.02
β_{ylg}	0.700	beta	0.05
β_{rr}	0.120	gamma	0.03
β_z	0.050	gamma	0.01
β_f	0.200	gamma	0.05
γ_{lg}	0.500	beta	0.10
γ_π	2.000	gamma	0.30
γ_y	0.300	beta	0.05
δ	0.500	beta	0.10
λ_1	0.800	beta	0.05
λ_2	0.800	beta	0.05
λ_3	0.800	beta	0.05
λ_4	0.500	beta	0.25
λ_5	0.700	beta	0.10
RR steady state	3.500	gamma	1.00
sd of supply shock	2.000	inv. gamma	∞
sd of interest shock	2.000	inv. gamma	∞
sd of demand shock	1.000	inv. gamma	∞
sd of exchange rate shock	3.000	inv. gamma	∞
sd of $ygap^*$	0.500	inv. gamma	∞
sd of RR^*	1.000	inv. gamma	∞
sd of $zgap$	5.000	inv. gamma	∞
sd of RR^{equi}	0.300	inv. gamma	∞
sd of $\pi 4^{target}$	0.500	inv. gamma	∞

Source: Author's estimate.
Note: "sd" stands for standard deviation and "inv" for inverse.
See the Appendix for an explanation of the λs .

Table 2. Estimates: Posterior Distribution

Parameter	Mean	90% Confidence Interval	
α_π	0.434	0.233	0.631
α_y	0.228	0.105	0.339
α_z	0.146	0.076	0.208
β_{yld}	0.043	0.016	0.068
β_{ylg}	0.746	0.682	0.809
β_{rr}	0.086	0.055	0.117
β_z	0.027	0.019	0.035
β_f	0.143	0.091	0.194
γ_{lg}	0.700	0.607	0.793
γ_π	1.932	1.433	2.401
γ_y	0.283	0.207	0.360
Δ	0.434	0.372	0.498
λ_1	0.877	0.830	0.922
λ_2	0.879	0.838	0.921
λ_3	0.804	0.739	0.872
λ_4	0.982	0.967	0.998
λ_5	0.991	0.986	0.996
RR steady state	3.422	2.263	4.540
sd of supply shock	2.657	2.172	3.104
sd of interest shock	1.286	1.058	1.513
sd of demand shock	0.579	0.471	0.687
sd of exchange rate shock	6.291	5.157	7.346
sd of $ygap^*$	0.482	0.401	0.559
sd of RR^*	0.541	0.451	0.628
sd of $zgap$	5.557	4.651	6.414
sd of RR^{equi}	0.212	0.176	0.246
sd of $\pi 4^{target}$	0.205	0.169	0.241

Source: Author's estimate.
Note: "sd" stands for standard deviation.
See the Appendix for an explanation of the λs.

Table 3: Comparing Second Moments

	Data	Model
$\pi 4_t$	1.8	2.5
RS_t	3.2	3.4
$Ygap_t$	0.9	1.3
$z_t - z_{-1}$	6.5	6.4

Standard deviations of 1994-2005 sample versus model generated series.

Figure 1. Prior and Posterior Distributions: Selected Parameters

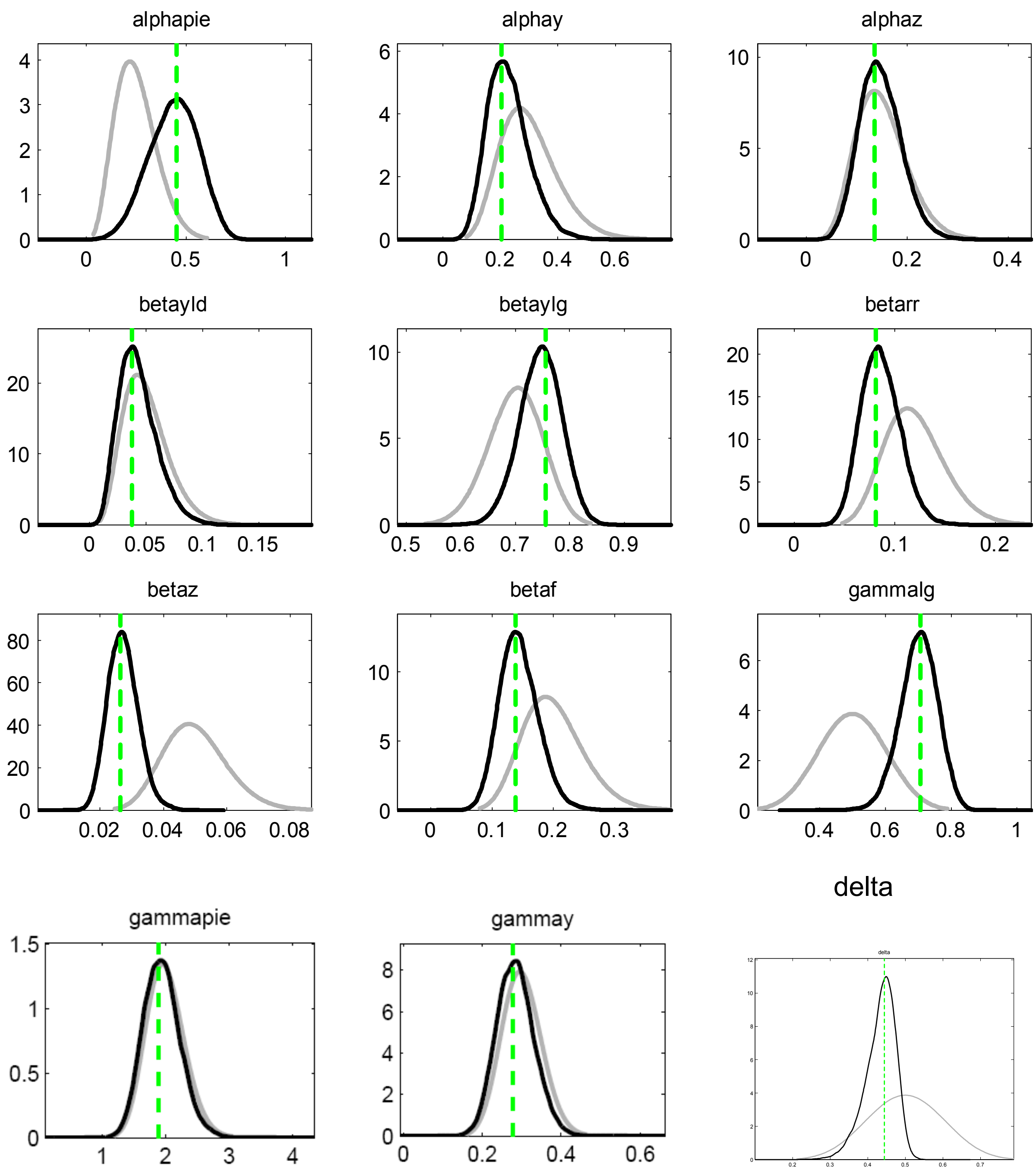


Figure 2. Interest Rate Shock
(*deviations from control*)

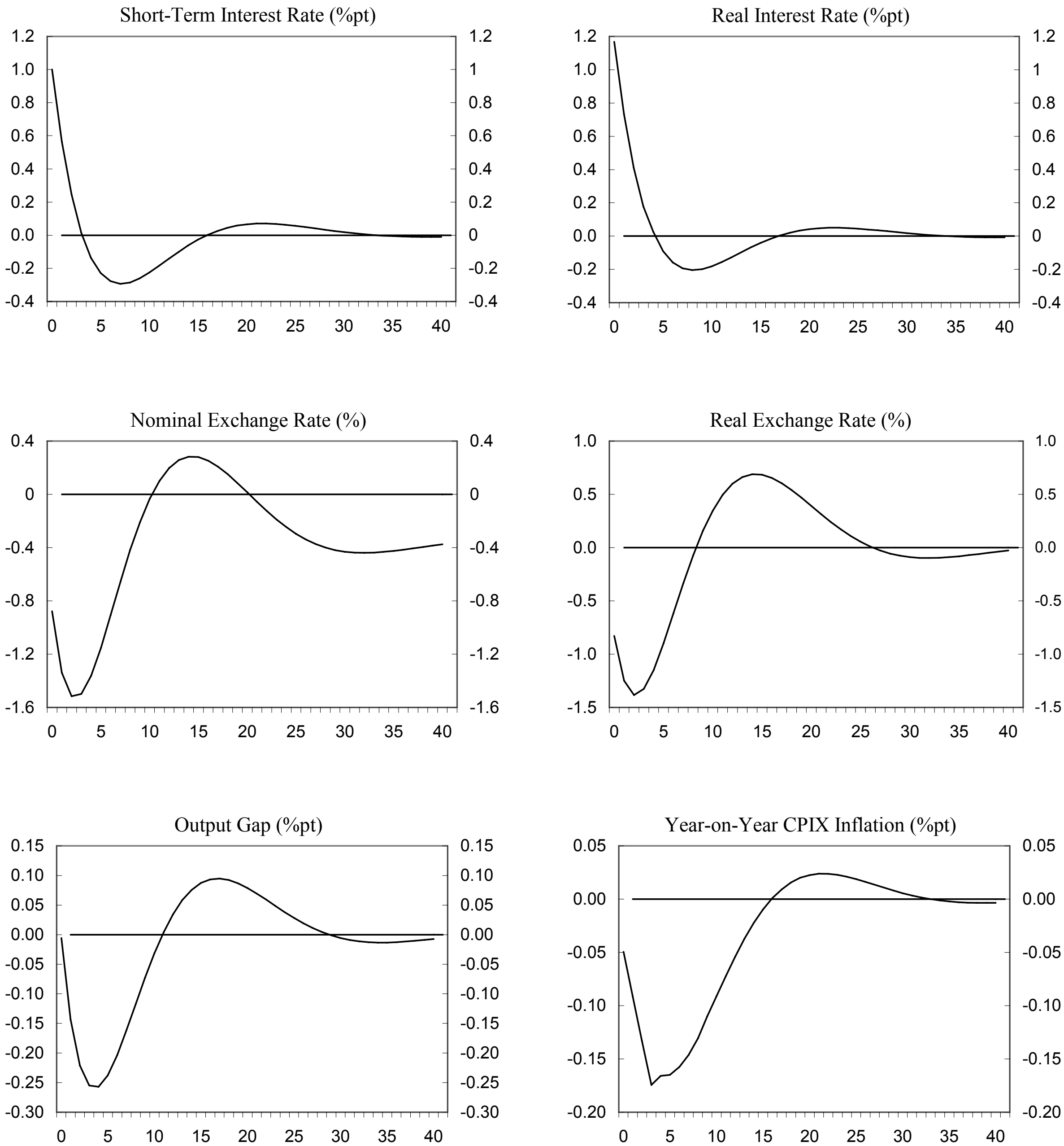


Figure 3. Exchange Rate Shock
(*deviations from control*)

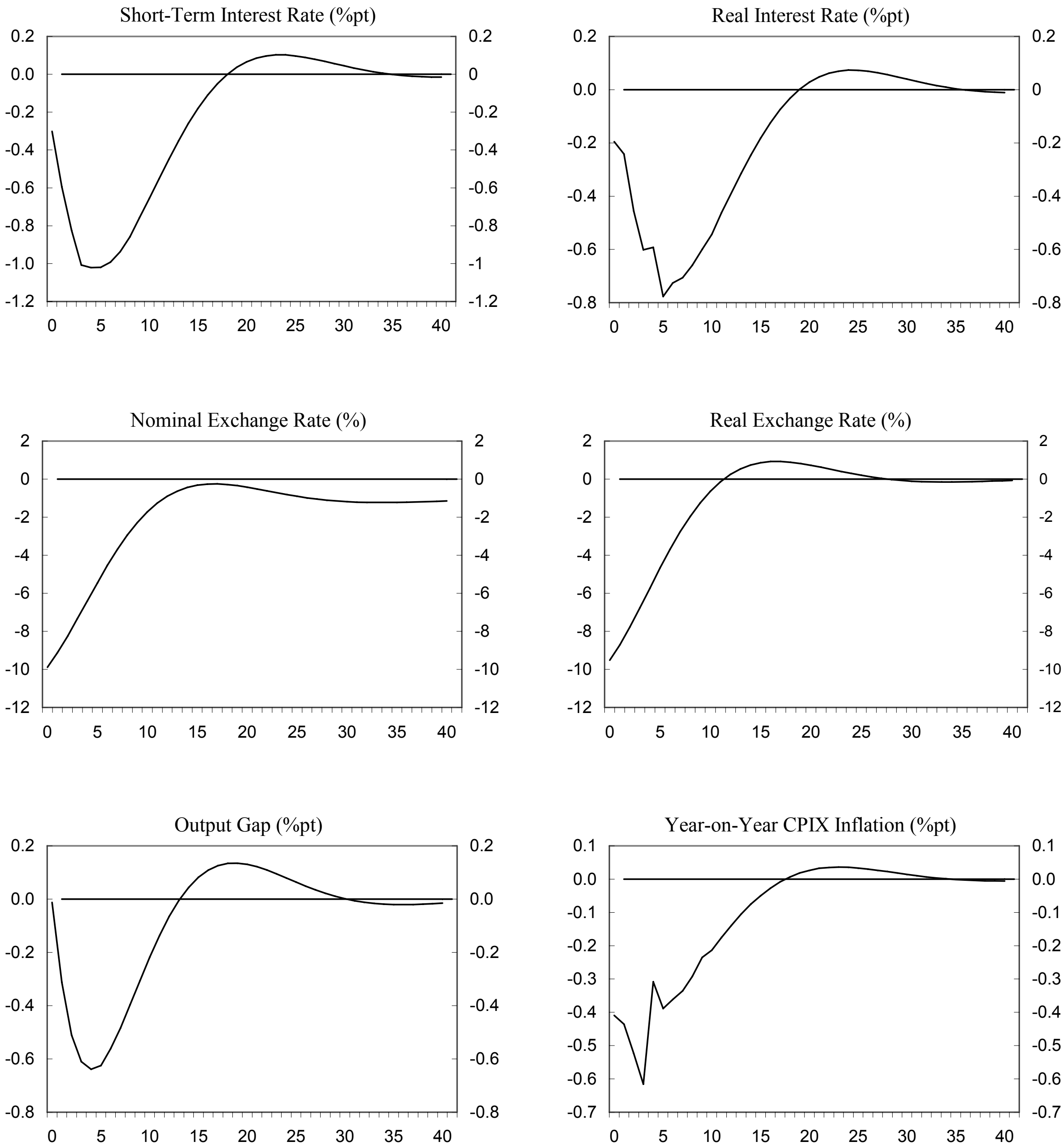


Figure 4. Price Shock
(*deviations from control*)

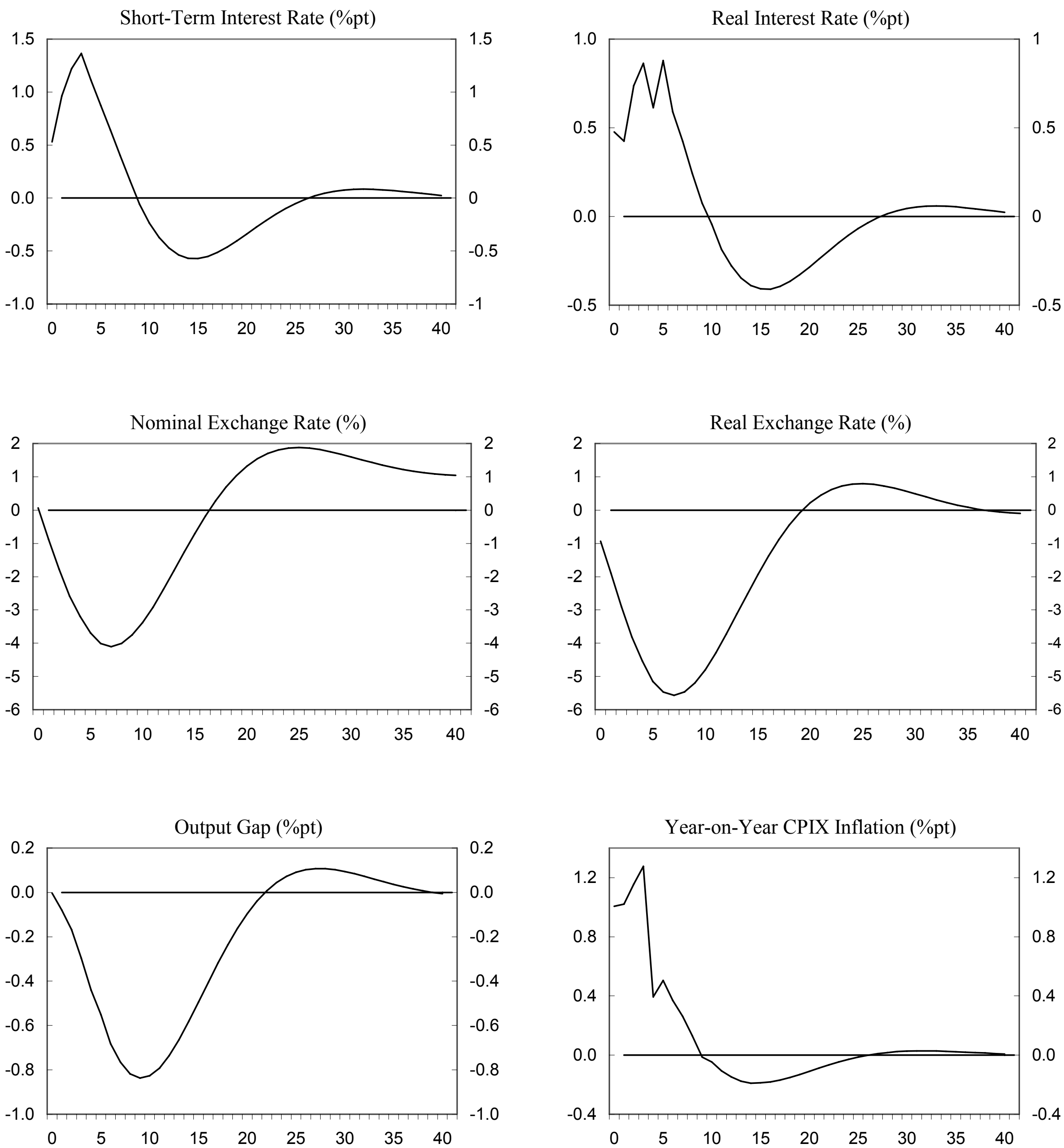
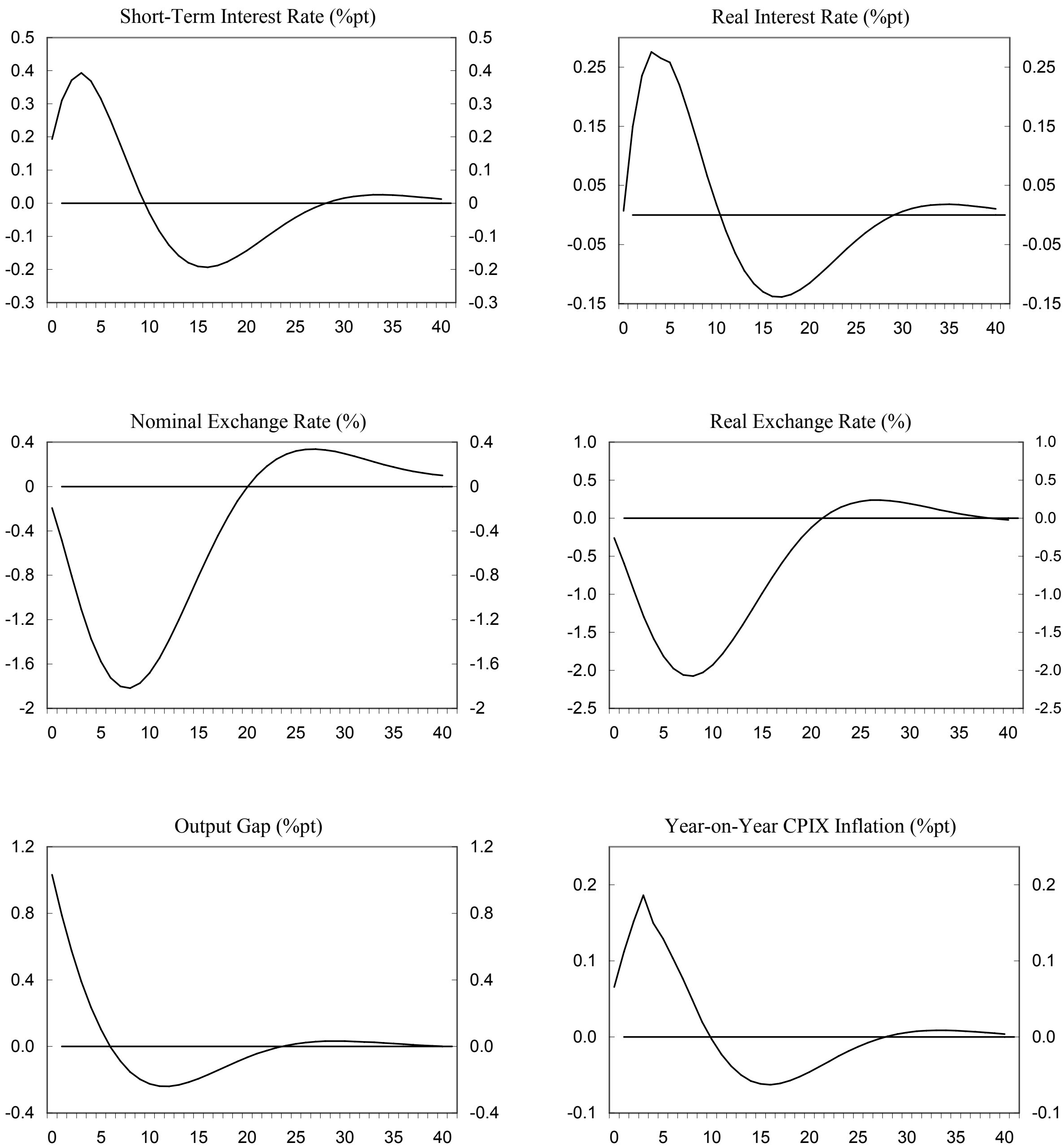


Figure 5. Demand Shock
(*deviations from control*)



APPENDIX

1. The Role of Parameters in the Model

1.1. Phillips Curve

- α_π (1-α_π) determines the importance of forward (backward) looking components in inflation expectations. For example, a larger wage indexation to past developments would imply a lower α_π. Note that the lower α_π, the more difficult it is for the monetary authorities to change inflationary patterns, as the effect of inertial inflationary behavior is stronger.

- α_Y increases with the responsiveness of inflation to the output gap (it increases, for example, with the number of firms that adjust prices every period).[14] Hence, the larger α_Y, the smaller would be the sacrifice ratio (i.e. the cumulative loss in output as a percent of potential output necessary to permanently bring down inflation by 1 percentage point).[15]

- α_z relates directly to the weight of imported goods in the CPI basket and the pass-through of foreign-currency prices (and hence also the nominal exchange rate) onto the domestic-currency prices of imports.[16]

1.2. Aggregate Demand Curve

- The output gap tends to exhibit substantial inertia (high β_{ygap}^{Lag}) which is normally lower in developing than in industrial countries, while the effect from lead output (β_{ygap}^{Lead}) is usually limited.

- The effect of interest rates is crucial for the monetary transmission mechanism, as a larger β_{RRgap} would imply a more effective monetary policy.

- The effects of exchange rates (β_{Zgap}) and of foreign output (β_{ygap*}) tend to be larger in more open economies.

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[14] Woodford (2003) shows also how it would decrease with the degree of strategic complementarity of pricing decisions amongst producers, as more firms would tend to mimic price stickiness behavior.

[15] The sacrifice ratio is about one in this model.

[16] A prior of about 0.15 can be derived from a weight of imports in the CPI of about 30 percent and an immediate pass-through of about 50 percent.

- Significant lags in the transmission of monetary policy imply that the sum of β_{RRgap} and β_{Zgap} should be relatively small compared to β_{ygap}^{Lag}.

1.3. Monetary Policy Reaction Function

Reliable estimates of monetary policy reactions function are notoriously difficult to achieve. The task is even more complicated in the case of South Africa, given the short time period during which inflation targeting has been implemented. In fact, the model parameters represent more policy choices about a temporary trade-off between inflation and output fluctuations rather than empirical laws.

- A key parameter in this function is γ_{π}, which captures the degree of aggressiveness of monetary authorities. Hence, a higher value for γ_{π} implies that the authorities will respond to a given inflationary shock with a larger change in interest rate. This normally tends to frontload the output costs.

- The parameter γ_{R}^{Lag} measures the degree of aversion of authorities to alter the interest rates, so that a higher coefficient implies a slower monetary reaction to a given shock.

- Orphanides (2003) and others have argued that in light of the high degree of uncertainty about the output gap and substantial real-time measurement errors in output, the parameter on the output gap (γ_{YGAP}) should be rather small.

1.4. The Uncovered Interest Parity

- The parameter δ (with $0<\delta<1$) determines the degree to which exchange rate expectations are forward looking as opposed to backward looking. A value closer to 1 implies much more forward looking expectations and make the exchange rate react much more in response to anticipated changes in fundamentals. As discussed in the text, a value equal to 1 delivers a standard uncovered interest parity condition and Dornbusch-style overshooting.

2. Steady State and Forecast Assumptions

The long-run steady state values for the variables of the model are chosen as follows:

- $\pi 4_t^{Target}$ = 4.5 percent (the mid-point of the inflation targeting range)

- RR_t^* = 2.25 percent (historic average for the U.S. real short-term interest rate),

- $RiskP_t^{Equi.}$ = 1.25 percent, close to the spread in the last few years of the sample.

In steady state, these figures imply a real interest rate of about 3.5 percent and a nominal short-term rate of about 8 percent. All gaps that measure deviations of actual variables from their long-run equilibria are by definition zero. The real equilibrium exchange rate is held constant.

3. Estimation Assumptions about Nonobservables

- The domestic and foreign output gaps ($ygap_t$ and $ygap_t$*) are calculated as the respective difference between actual and the HP trend (with a smoothing parameter of 1600). To avoid the notorious end-of-sample problems of the HP filters, the series for actual output in South Africa is assumed to converge to a long run potential output growth of 4.0 percent.

- The real exchange rate gap ($zgap_t$) is calculated as the difference between the actual real exchange rate and the equilibrium one. The latter is evaluated as the HP filter of the real exchange rate, but it is imposed that actual and equilibrium are equal in 2005q2, by using the LRX filter (a more sophisticated version of the HP filter) described in Appendix IV of Berg, Karam and Laxton (2006b).

- The South African equilibrium real interest rate ($RR_t^{Equi.}$) is assumed to be equal to 1 percent in 1994 because of capital control (1 percent is approximately the average since 1970) and to reach 3.5 percent from 2007q4 onwards. In between these dates it is smoothed using the using the LRX filter.

- The South African risk premium ($RiskP_t^{Equi.}$) is assumed to be the gap between the South African and the U.S. equilibrium real interest rate (the latter being assumed at 2.25, the historical average).

- The inflation targeting regime was announced in 2000 and started in 2002 with a target range of 3-6 percent. For the estimation purposes, we implicitly assume that the monetary authorities have been setting the interest rate with a criterion that is similar to inflation targeting throughout the sample. The inflation target ($\pi 4_t^{Target}$) is assumed to be given by the HP filter of actual inflation until end-2000 (by then, the actual inflation was close to the upper side of the range, 6 percent). Since 2001, it is assumed that the target progressively declines towards the middle of the range, 4.5 percent (more precisely, the inflation target is given by the LRX filter passing through: 6 percent in 2001q1, 5.5 percent in 2003q1, 5 percent in 2004q1, 4.5 percent in 2005q1). Note that in the estimation based on the 2000-05 sample, assumptions related to years before 2000 are irrelevant.

4. Estimation Assumptions about Variables Exogenous to the Theoretical Model

In the Bayesian estimation, the variables that are exogenous to the theoretical model (foreign output gap, foreign interest rate, real exchange rate gap, the equilibrium real interest rate, and the inflation target) are assumed to mean revert to their equilibrium or steady state value via an autoregressive pattern: X=λ*X(-1)+(1- λ)*Xbar, where X represents the five variables above and Xbar their steady state. Hence in addition to the twelve parameters of the model, we also estimate five λ autoregressive terms, one for each variable, λ_1 to λ_5 respectively. As a consistency check, we also allow for the steady state real interest rate (towards which the equilibrium real interest rate converges at a rate equal to λ_4) to be stochastic, and we estimate it (*RR steady state* in Tables 1 and 2); the estimation confirms a figure close to 3.5, consistent with the forecast assumptions. Hence we estimate a total of eighteen parameters.

5. The Model with Richer Dynamics

The richer model encompasses three additional terms: a second lag for inflation in the aggregate supply equation, to better account for inflation inertia; a lag of the change in the real exchange rate into the same equation, to better account for pass-through; a second lag of the real interest rate gap into the aggregate demand equation, to better capture the monetary policy transmission mechanism.

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