WP/15/170

IMF Working Paper

A Model for Monetary Policy Analysis in Uruguay

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INTERNATIONAL MONETARY FUND

 WP/15/170

IMF Working Paper

Western Hemisphere and Research Departments

A Model for Monetary Policy Analysis in Uruguay[1]

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July 2015

Abstract

Uruguay has recently reverted to a money targeting (MT) framework in the context of a disinflation strategy. We develop a quantitative model for monetary policy analysis incorporating money targets in the policy framework while also retaining a central role for interest rates in the transmission of policy. We use the model to show that tight financial conditions for a period may be necessary for inflation to converge to the middle of the target band. We also discuss various aspects of the MT framework. Two issues stand out. Excessive focus on hitting money targets can result in undesirable changes in the policy stance; while targets that incorporate elements of money demand forecasting are superior to targets that are excessively smooth or do not adjust for base effects.

JEL Classification Numbers: E52, E58, F47, O23

Keywords: Monetary Policy, Money Targeting, Forecasting

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[1] We thank Andrew Berg, Oya Celasun, Heedon Kang, and participants at a seminar at the Banco Central del Uruguay for comments and suggestions. Pranav Gupta, Michele Andreolli and John McCoy provided superlative research assistance.

Contents

I. INTRODUCTION

The inflation rate in Uruguay has remained above the upper bound of the target range in recent years. Starting from 6 percent in 2008-09, both headline and core inflation drifted upwards to about 9 percent through much of 2014, significantly exceeding the 3-7 percent inflation target range. Headline inflation eased to 8¼ percent at the end of 2014, but core CPI inflation remained around 10 percent.[2]

In July 2013, the Central Bank of Uruguay (BCU) switched from using the overnight interest rate as the operational target to announcing reference ranges for the growth of a monetary aggregate within its inflation targeting (IT) framework. The change was aimed to facilitate a disinflation process: the new money targeting (MT) framework envisages a gradually declining path for money growth consistent with a declining path for inflation. At the inception of the framework, the BCU announced its intention to reduce M1 + growth from an average of about 14 percent in the previous year to 8 percent by mid-2015 to bring inflation to the mid-point of the inflation band.

The new framework has delivered a significant tightening in the monetary policy stance, but underlying inflationary pressures have persisted. Since the introduction of money growth targets, M1+ growth declined to near 8 percent by 2014Q3, faster than the BCU announced originally. Moreover, the peso interest rates have risen by 400–500 basis points above the levels prior to July 2013. However, major currency depreciation spurred in part by the Fed's tapering announcement in mid-2013 fueled inflation and created an important challenge for the disinflationary effort within the new framework.

While the recent volatile external economic environment makes it difficult to assess the efficacy of this framework in anchoring expectations, the first quarters of its implementation highlighted some operational and design challenges. The declining path of money growth announced by the BCU was meant to signal the central bank's commitment to a disinflation path and the medium-term inflation objective, but it did not specify the mechanisms by which inflation would decrease. Money demand has proven difficult to predict, and the M1+growth rate has undershot the reference range in four out of the six quarters of implementation. Moreover, the design of the M1+ target revealed a caveat: setting a smooth path for year-on-year growth could lead to a carry-over of past errors in predicting money demand, as the growth rate is applied to the M1+ level one year ago.

In this paper we develop a macroeconomic model that can provide a quantitative underpinning to the MT framework and be used as an analytical framework for policy analysis. We calibrate the model to the Uruguayan economy and run a number of policy-relevant exercises. First, we filter data through the model to provide a structural interpretation of inflation dynamics in recent years, with an emphasis on the role of monetary policy (both pre-MT and in the quarters following its adoption). The objective is to understand why the previous framework did not succeed in stabilizing inflation and to draw the conclusions to help inform the design of successor regimes. Second, we use the model to

[2] Core CPI inflation excludes fruit, vegetable, and administered price inflation.

construct a macroeconomic projection for Uruguay, with a focus on the paths for money growth and short-term interest rates that are needed to steer inflation back to the target over the medium term. Third, we use the model to study how the implementation of MT can affect the stance of policy.

Implicit in the model and its projection is the idea that the central bank needs to have a view about the level of short-term interest rates required to help stabilize inflation. This is the case regardless of whether the central targets monetary aggregates, though the latter regime presents some additional challenges, namely the consistency between designing and hitting money targets and steering interest rate toward their desired levels. Our model provides a framework for thinking about such consistency.

The main results are as follows. We find that accommodative monetary policy accounts for a part of the inflationary and aggregate demand pressures observed during the pre-MT period. Following the adoption of MT, policy has become tighter, though large exchange rate depreciation contributed to further increases in inflation. Going forward, bringing inflation back to the center of the target range will require tight policies for the foreseeable future, both in terms of higher nominal and real interest rates and low broad money growth.

A second set of results relates to the design of the money targeting framework. Tight monetary policy does not imply stricter adherence to money targets (i.e., greater efforts by the central bank to hit the targets). A counterfactual exercise shows that greater target adherence would have resulted in a loosening of policy at a time when the opposite was needed. Money targeting therefore needs to be flexible, with interest rates playing a gauging role when assessing the stance of policy.

In addition, the design of targets needs to incorporate improved money demand forecasting, since large errors in predicting money demand may generate large and persistent changes in the policy stance. This can be the case with excessively smooth targets, especially if these are set on year-on-year growth, which is the case for Uruguay. With the help of the model, we show that the macro implications can be sizeable.

The rest of the paper is organized as follows. Section II presents a brief discussion of Uruguay recent monetary history. Section III describes the model. Section IV presents policy-relevant exercises, and section V concludes.

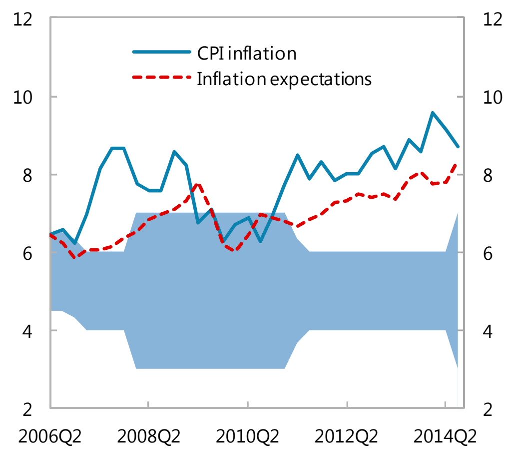
II. Uruguay: Monetary Policy in 2005-14

Money targeting for Uruguay is not new: in 2005-07 the BCU's policy framework had elements of money targeting along with exchange rate management and an inflation objective. The BCU paid considerable attention to the stability of the exchange rate. There was a target range for inflation set by the Macroeconomic Coordination Committee (CCM) composed of representatives from the Ministry of Finance and the BCU's Board of Directors at its quarterly meetings. At the same time, the BCU targeted the growth for M1 to meet the inflation target. Additionally, the BCU used the monetary base as an internal operational target for liquidity management and daily open market operations. Surplus liquidity was drained from the system through reserve requirements and the issuance of BCU securities.

As inflation consistently remained above the target range, the BCU in September 2007 switched to using the short-term interest rate as an operational target within an IT framework. The BCU had raised the monetary policy rate several times in 2007-2009 in an effort to tame the inflationary pressures. The main open market instruments of the BCU over this period were the REPO operations to provide liquidity and primary issuance of BCU securities to absorb liquidity. Several empirical studies (by the IMF and the BCU) suggest that after the introduction of the policy rate as the main operational target the pass-through from the policy rate to both lending and deposit rates increased.[3]

However, monetary policy management was complicated by the continued appreciation of the peso from late 2007 till mid-2013 and surging portfolio inflows between early 2012 and mid-2013. Significant sterilized intervention by the BCU to purchase foreign exchange boosted the international reserves but did not seem to break the appreciation trend. Thus, appreciation pressures began to limit the willingness to further raise interest rates to tackle above-target inflation, since the positive nominal interest differential versus other emerging market economies was seen as the main driver of surging portfolio inflows. The BCU resorted to using non-interest policy tools to contain inflation while not exacerbating peso appreciation pressures: it raised average reserve requirement rates and introduced marginal reserve requirements for bank deposits. Also, it set reserve requirements on nonresident purchases of government securities to discourage portfolio inflows.

Inflation Target Range and Expectations [/1]
(Y-o-y, In Percent)

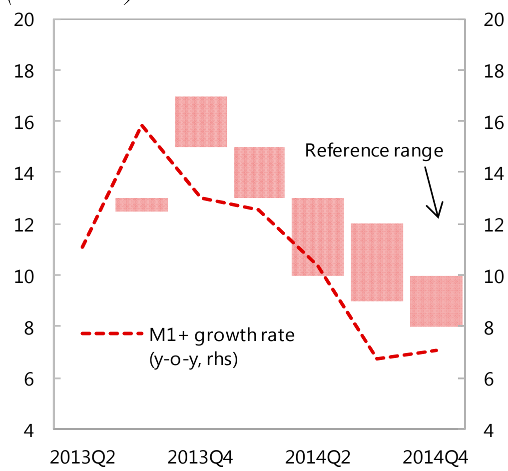


Sources: BCU; INE (Instituto Nacional de Estadistica); and IMF staff calculations.
1/ BCU Survey, median of expected inflation for the 12 months ahead.

In the face of these challenges, in June 2013 the BCU announced that it would abandon its short-term interest rate target and reverted to using money growth as an operational target within the IT framework. The short-term policy interest rate target was replaced with the monetary aggregate (M1 plus saving deposits (M1+)) trajectory as a reference indicator with a target band for the year-on-year (yoy) growth rate of M1+ for each quarter being set at the beginning of the quarter. At the inception of the framework, the BCU also announced its intention to reduce M1 + growth from an average of about 14 percent in the previous year to 8 percent by mid-2015. Simultaneously, the BCU widened the inflation target band from 4–6 to 3–7 percent. The set of monetary policy instruments since then has been limited to the auctions of BCU securities, reserve requirements and a liquidity window to cover daily shortfalls at a punitive rate.

[3] See Licandro, Gerardo and Miguel Mello (2012), and Acosta-Ormaechea (2011).

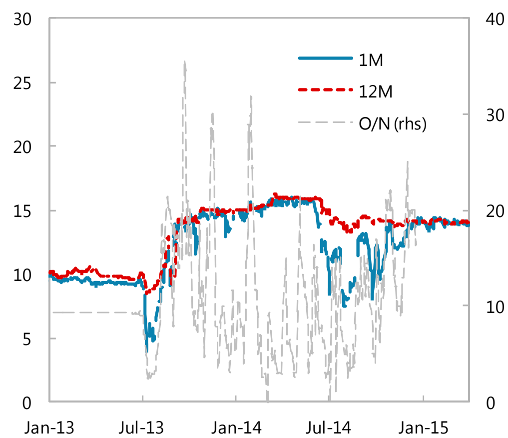
M1+ Growth Reference Ranges and Outturns
(In Percent)



Sources: BCU; and IMF staff calculations.

The new framework has resulted in a significant decline in money growth rates. The initial M1+ targets set by the BCU for 2013H2 represented a broadly unchanged pace of monetary expansion relative to 2013H1 but a slower one than in the last two years. The M1+ growth in the first quarter of the new framework exceeded the target range set for this period, as the BCU and the market were adjusting to the new operational framework, spurring uncertainty about the intended policy stance. In the next quarters, however, the growth of M1+has mostly come in below the target ranges and declined to near 8 percent by 2014Q3, faster than the BCU announced originally. Whether this outcome reflects a contractionary policy stance or endogenous development in the demand for money is difficult to assess and requires looking at domestic interest rates as well. We will use our model to address this question.

Markey Interest Rates
(In Percent)



Source: Bolsa Electrónica de Valores del Uruguay S.A.

There was also a significant upward shift in the yield curve. The peso interest rates have risen by 400–500 basis points above the levels prior to July 2013 to 14-15 percent, though with some intra-year variations.[4] The increase in real yields was comparable. The overnight interest rate, however, has fluctuated widely (in a range from 2.5 percent to almost 40 percent), especially in the first couple of months of the new framework, largely reflecting the learning period for the new framework.

Implementation of money targeting within an IT framework faces challenges that put additional premium on monetary policy analysis and medium-term forecasting by the central bank. Money targets are less indicative of the intended monetary stance than an interest rate target and call for an additional communication effort. Setting a smooth path for M1+ yoy growth could facilitate communication, but lead to a carry-over of past errors in predicting money demand, as the growth rate is applied to the M1+ level one year ago. Moreover, volatile money demand makes it hard to hit the money targets. Thus, it is important that the policymaker relies on a well-crafted analytical framework to calibrate the policy stance appropriately—to react to new shocks, analyze the

[4] As the change in the operational framework coincided with the Fed's tapering announcement, the initial increase in interest rates reflected both external and domestic factors.

deviations of money growth from the reference range and to correct for past errors in predicting money demand.

III. THE MODEL

The model we present is similar to those used for monetary policy analysis and medium-term forecasting in many central banks, but it has been extended to include a role for money targets, and calibrated to capture the specifics of Uruguay.[5] These frameworks are based on new-Keynesian open economy models, which embody the view that aggregate demand and monetary policy matter for output dynamics and inflation in the short run.[6] At their core, they consist of a forward looking IS equation, a hybrid Phillips curve, a monetary policy rule and an uncovered interest parity equation. The present model extends the standard framework by including a money demand equation, and a policy regime in which the authorities set money targets in advance.

The model emphasizes the level of short-term interest rates (current and expected) as the main variable through which monetary policy can influence aggregate demand, the exchange rate, and inflation. The key guiding principle underlying the design of policy is the Taylor principle, the idea that real interest rates need to increase when (expected) inflation exceeds the target. The model provides a framework for setting money targets that are *ex-ante* consistent with the desired level of interest rates, i.e., consistent at the time these targets are set. Ex-post, deviations between targets and actual money growth are inevitable, though the central bank can try to steer money growth toward its target within the quarter by injecting or withdrawing liquidity and influencing short-term interest rates. The degree to which interest rates adjust in response to same-period target misses is referred to as *target adherence*. We will study how the design of the target and the degree of target adherence can affect the stance of policy in the presence of shocks to money demand.[7] Note that, unlike interest rates, monetary aggregates do not play a direct role in the transmission of policy in the model. We will provide some empirical evidence below that is supportive of this assumption.

A. Output and Real Interest Rates

Quarterly output is divided into gap and potential, $y_t = \bar{y}_t + ygap_t$, where potential output $\bar{y}_t$ follows an autoregressive process of order one in first differences: $\Delta\bar{y}_t = \rho_{\bar{y}}\Delta\bar{y}_{t-1} + (1-\rho_{\bar{y}})\Delta\bar{y} \quad + \varepsilon_t^{\bar{y}}$.[8] The output gap is given by a hybrid IS curve. It depends on real monetary conditions (rmc_t) and foreign demand ($ygap_t^*$), as well as past and future output gaps:

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[5] See Berg, Karam, and Laxton (2006) for an overview of these models and their use in central banks. The model presented here builds on Andlre et al (2014) and Berg, Portillo, and Unsal (2010).

[6] See Clarida, Gali, and Gertler (1998) and Gali and Monacelli (2002), among many others.

[7] See Berg, Portillo, and Unsal (2010).

[8] All quarterly growth rates are annualized, i.e., $\Delta\bar{y}_t = 4(\bar{y}_t - \bar{y}_{t-1})$.

$$ygap_t = \beta_1 ygap_{t-1} + \beta_2 ygap_{t+1} + \beta_3 rmc_t + \beta_4 ygap_t^* + \varepsilon_t^{ygap}, \tag{1}$$

Real monetary conditions are composed of the real interest rate gap ($rrgap_t$)—the difference between actual real interest rates ($r_t - E_t[\pi_{t+1}]$) and neutral real interest rates $\overline{rr}_t$—and the real exchange rate gap ($zgap_t = z_t - \bar{z}_t$): $rmc_t = (1-\beta_4)rrgap_t + \beta_4 zgap_t$.[9]

B. The Philips Curve

Quarterly (annualized) inflation ($\pi_t = 4(P_t - P_{t-1}$), where $P_t$is a headline price index is the sum of two components, a persistent component π_{1t} and noise $\varepsilon_t^{\pi noise}$: $\pi_t = \pi_{1t} + \varepsilon_t^{\pi noise}$. The noise component captures sudden, temporary, changes in inflation that are unrelated to the state of the economy and the underlying inflationary pressures, and are unlikely to endure.

The dynamics of π_{1t} are instead given by a hybrid Phillips curve:

$$\begin{aligned}(\pi_{1t} - \bar{\pi}) = {} & \alpha_1(\pi_{1t-1} - \bar{\pi}) + \alpha_2(\Delta s_t - \Delta\bar{s}_t) + (1-\alpha_1-\alpha_2)(\pi_{1t+1} - \bar{\pi}) \\ & + \alpha_3 ygap_t + \alpha_4 zgap_t + \varepsilon_t^{\pi_1}\end{aligned} \tag{2}$$

where $\bar{\pi}$ is the inflation target, Δs_t is the quarterly (annualized) nominal depreciation rate of the exchange rate, and $\Delta\bar{s}_t$ is the depreciation rate consistent with both the domestic and foreign inflation targets and the equilibrium real exchange rate $\Delta\bar{z}_t$: $\Delta\bar{s}_t = \Delta\bar{z}_t + \bar{\pi} - \bar{\pi}^*$.

The above specification merits a few comments. First, it implies the long-run Phillips curve is vertical, so that there is no long-run output/inflation tradeoff. Second, depending on parameter α_1 it allows for inflation to be considerably backward-looking, which can capture indexation practices. Third, the Phillips curve allows for an immediate impact from nominal depreciation (pass-through) above and beyond equilibrium levels ($\Delta\bar{s}_t$), possibly reflecting dollarization of the economy and imperfect policy credibility. Finally, inflation depends on real marginal costs that depend on the domestic output gap ($ygap_t$) and the real exchange rate gap ($zgap_t$, where under-valuation, $zgap_t > 0$, is inflationary), and by supply shocks with more persistent effects ($\varepsilon_t^{\pi_1}$).[10]

C. Uncovered Interest Parity and Real Exchange Rate Dynamics

Exchange rate dynamics are driven by an uncovered interest rate parity condition:

[9] Neutral real interest rates $\overline{rr}_t$ follow an AR(1) process: $\overline{rr}_t = \rho_{\overline{rr}}\overline{rr}_{t-1} + (1-\rho_{\overline{rr}})\overline{rr} + \varepsilon_t^{\overline{rr}}$. Equilibrium real exchange rates $\bar{z}_t$ also follow an AR(1) process in first differences: $\overline{\Delta z}_t = \rho_{\overline{\Delta z}}\overline{\Delta z}_{t-1} + (1-\rho_{\overline{\Delta z}})\overline{\Delta z} + \varepsilon_t^{\overline{\Delta z}}$.

[10] Although this equation can be derived, for the most part, from micro-foundations, it should not be thought of as invariant to the monetary policy framework. For example, the degree of backward indexation and exchange rate pass-through is more likely to be higher in economies that have not fully succeeded in establishing a nominal anchor.

$$\Delta s_{t+1}^{e} = -\theta_1(i_t - i_t^{*} - prem_t) + (1-\theta_1)\Delta\bar{s}_t + \varepsilon_t^{s}, \tag{3}$$

where Δs_{t+1}^{e} is the expected rate of quarterly nominal depreciation (in annualized terms). θ_1 captures the strength of the effect of interest rates on the exchange rate, and it is allowed to deviate from 1 (to improve the model's empirical fit). Δs_{t+1}^{e} is given by: $\Delta s_{t+1}^{e} = 4\big(\theta_2 E_t[s_{t+1}] + (1-\theta_2)\big(s_{t-1} + 1/2(\Delta\bar{s}_t)\big) - s_t\big)$. If $\theta_2 < 1$ the expected nominal depreciation deviates from rational expectations. ε_t^{s} captures temporary shocks to the exchange rate, while $prem_t$ is the country risk premium: $prem_t = \rho_{prem}\ prem_{t-1} + (1-\rho_{prem})\overline{prem}_t + \varepsilon_t^{prem}$. Shocks to the risk premium (ε_t^{prem}) have persistent effects on the exchange rate. Finally, the equilibrium risk premium is consistent with neutral real interest rates in both countries and the equilibrium real exchange rate appreciation: $\overline{prem}_t = \overline{rr}_t - \overline{rr}_t^{*} - E\big[\Delta\bar{z}_{t+1}\big]$.

D. Money Demand

We use a specification that potentially allows for both short-run and long-run dynamics in the demand for real money balances m_t ($m_t = M_t - P_t$). Quarterly (annualized) real money demand growth is given by an error correction equation:

$$\Delta m_t = \delta_1 \Delta y_t - \delta_2(i_t - i_{t-1}) - \Delta v_t - \delta_3 mcorr_{t-1} + \varepsilon_t^{\Delta m}\ . \tag{4}$$

Equation (4) states that changes in demand for real money balances Δm_t depend on changes in output y_t, the annualized nominal interest rate i_t, velocity v_t, and the real money gap $mcorr_t$. We define $mcorr_t$ as a deviation of real money balances from its long run value: $mcorr_t = m_t - \delta_4 y_t + \delta_5 i_t + v_t$. v_t denotes (or is closely related to) trend velocity, and it follows an AR(1) in first differences with drift: $\Delta v_t = \rho_v \Delta v_{t-1} + (1-\rho_v)\Delta v \quad + \varepsilon_t^{v}$.

Note that there are two types of shocks to money demand: shocks with temporary effects on the level of desired real money balances ($\varepsilon_t^{\Delta m}$), with persistence inversely related to the coefficient on the error correction term (δ_3), and shocks with persistent effects on the *growth rate* of desired real money balances (ε_t^{v}).

E. Monetary Policy

We adopt a general specification to characterize monetary policy in Uruguay, with several components. The first building block is an unobserved interest rate that follows a standard forward-looking Taylor rule:

$$i_t^{Taylor} = \gamma_1 i_{t-1}^{Taylor} + (1-\gamma_1)\big(\bar{\imath}_t + \gamma_2(\pi_{4,t+2} - \bar{\pi}) + \gamma_3 ygap_t\big) + \varepsilon_t^{Taylor}, \tag{5}$$

where $\bar{\iota}_t$ is the neutral nominal interest rate ($\bar{\iota}_t = \overline{rr}_t + \bar{\pi}$), and $\pi_{4,t+2}$ is the expectation for the yoy inflation rate two quarters ahead.[11] This level of interest rates will serve as a reference both before and during the money targeting period.

Since it is unlikely that monetary policy followed the prescription implied by such a rule in recent years, we make two additional assumptions to take the model to the data. First, throughout the entire period (both pre- and during MT) we assume that interest rates deviate from the rule by a volatile and persistent term (dev_t):

$$i_t \ = i_t^{Taylor} + dev_t, \tag{6}$$

where $dev_t = \rho_{dev} dev_{t-1} + \varepsilon_t^{dev}$. The above specification plays two roles. On the one hand, it helps match the data, since it does not require observed interest rates in Uruguay to follow the above rule. On the other hand, once the model is used to produce a projection for the Uruguayan economy, it provides an interest rate path consistent with the rule.[12]

For the money targeting period, we make the additional assumption that the central bank also steers interest rates to bring yoy money growth ($\Delta M_{4,t}$) closer to its target ($\Delta \bar{M}_{4,t|t-1}$):

$$i_t \ = i_t^{Taylor} + \gamma_4 \left(\Delta M_{4,t} - \Delta \bar{M}_{4,t|t-1} \right) + dev_t \tag{7}$$

The above specification implies that positive target deviations (when actual money growth exceeds the target) elicit an increase in interest rates, as the authorities tighten policy to steer money growth toward the target. γ_4 captures the importance of money targets in the frameworks: the higher γ_4, the more aggressive authorities are in response to money target deviations. γ_4 therefore captures the degree of money target adherence.

The above specification is perfectly consistent with a money targeting framework. An equivalent representation is the following:

$$\Delta M_{4,t} = \Delta \bar{M}_{4,t|t-1} + \frac{1}{\gamma_4} \left(i_t \ - i_t^{Taylor} \right) - \frac{1}{\gamma_4} dev_t \tag{8}$$

According to this representation, the authorities allow for deviations in money growth from the target whenever interest rates deviate from the Taylor prescription; $1/\gamma_4$ measures the

[11] The targeting of inflation two quarters ahead reflects a tradeoff between two factors. On the one hand, monetary policy should be forward-looking, and targets should be set on expected inflation. A typical horizon, both in operational models such as these and in practice, is expected inflation four quarters ahead. On the other hand, central banks with incomplete credibility cannot rely exclusively on expectations of (declining) future inflation as a basis for policy, as it could imply a looser monetary policy stance. In this case, targeting more immediate inflation may be required.

[12] The rule constrains the way inflation expectations are endogenously formed, which could possibly lead to overly optimistic disinflation scenarios if inflation is very forward-looking. This risk is partly addressed in the model by having a sufficiently backward-looking Phillips curve.

extent to which the level of interest rates influences the central bank decision on money growth.[13] For instance, the policymaker would bring the rate of money growth below the target, if the interest rate i_t is below i_t^{Taylor}. We describe the setting of money targets next.[14]

F. The Setting of Money Targets

We model the money targeting framework as follows. First, we assume the central bank sets a target for yoy growth, i.e., for ΔM_4. Second, we assume the money target for period *t* is set one quarter in advance (at time *t-1*). These assumptions imply that the authorities have information up to time t-1 when setting the target, including data on nominal and real money balances. Given data up until time t-1, and a forecast for quarterly inflation next quarter, the target for yoy money growth $\Delta \bar{M}_{4,t|t-1}$ also implies a target for quarterly nominal and real money growth $\Delta \bar{M}_{t|t-1}$ and $\Delta \bar{m}_{t|t-1}$:

$$\Delta \bar{M}_{4,t|t-1} = \frac{1}{4}\left(\Delta \bar{M}_{t|t-1} + \Delta M_{t-1} + \Delta M_{t-2} + \Delta M_{t-3}\right), \tag{9}$$

$$\Delta \bar{m}_{t|t-1} = \Delta \bar{M}_{t|t-1} - E_{t-1}[\pi_t] \tag{10}$$

Finally, we assume that the target for quarterly real money growth ($\Delta \bar{m}_{t|t-1}$) implied by the headline money target number ($\Delta \bar{M}_{4,t|t-1}$) is consistent with a forecast for money demand using the money demand equation above, up to an error term $\varepsilon_{t-1}^{\Delta \bar{m}}$:

$$\Delta \bar{m}_{t|t-1} = \delta_1 E_{t-1}[\Delta y_t] - \delta_2 (E_{t-1}[i_t] - i_{t-1}) - E_{t-1}[\Delta v_t] - \delta_3 mcorr_{t-1} + \varepsilon_{t-1}^{\Delta \bar{m}} \tag{11}$$

The term $\varepsilon_{t-1}^{\Delta \bar{m}}$ serves two purposes. First, it can be used to incorporate any additional information about the future demand for monetary aggregates that is not explicitly modeled here, e.g., changes in M1+ stemming from fiscal operations, the effects of macro-prudential tools, or other measures. Second, when filtering data through the model, it can help match the actual, observed, money targets with the ones implied by the above equation.

The above specification implies that the money target is consistent with the interest rate intended by the monetary authorities ($E_{t-1}[i_t]$). This is the way in which money targets and interest rate policy are *ex-ante consistent*. Ex-post however, money target misses will reflect

[13] In our analysis we focus on broad money (M1+ in the case of Uruguay) and abstract from base money. In practice, money-targeting central banks derive targets for both broad and base money, by making assumptions about the money multiplier, which is the ratio of broad money to base money. Modeling the dynamics of both monetary aggregates can enrich (but also complicate) the analysis of monetary policy in these regimes. We abstract from base money targeting partly for simplicity but also because these targets are not publicly available.

[14] We nest both pre- and money targeting periods within the same model by assuming that money targets equaled actual money growth during the pre-MT period ($\Delta \bar{M}_{4,t-1} = \Delta M_{4,t}$), which cancels the MT term in the interest rate equation.

forecast errors in money demand, stemming from both forecast errors in inflation, output, and interest rates, and unexpected and exogenous changes in demand:

$$\left(\Delta M_{4,t} - \Delta \bar{M}_{4,t|t-1}\right) = \frac{1}{4}((\pi_t - E_{t-1}[\pi_t]) + \delta_1(\Delta y_t - E_{t-1}[\Delta y_t]) - \delta_2(i_t - E_{t-1}[i_t]) - \\ -(\Delta v_t - E_{t-1}[\Delta v_t]) + (\varepsilon_t^{\Delta m} - \varepsilon_{t-1}^{\Delta \bar{m}})).$$

This completes the presentation of the model.[15]

G. Consistency between the Model and the MT Framework in Uruguay

We acknowledge that the above framework may not perfectly coincide with all aspects of the framework in Uruguay. The model is consistent with the Uruguay experience in that: (i) targets are set in advance, using information up to *t-1*, and, as will be shown below, (ii) there are large and persistent deviations between target and actual money growth, which indicates that the degree of target adherence is part of the policy response, and that adherence is typically far from complete.

The assumption that the money target is a forecast of money demand consistent with a desired interest rate policy is harder to prove. On the one hand, the Central Bank has at times referred to the stance of policy implied by the money targets as contractionary by showing that nominal interest rates have increased, which suggests some analytical consistency between money target setting and desired interest rates. On the other hand, the path of money targets since end 2013 displays a very gradual path that is likely to be inconsistent with pure money demand forecasting.[16]

H. On the Role of Monetary Aggregates in the Model

As discussed earlier, monetary aggregates do not play a direct role in the transmission of monetary policy, i.e., they do not appear directly in either the IS equation or the Phillips curve. Such a role is reserved to the interest rate and the exchange rate. This approach is consistent with most macro models going back to IS-LM or Mundell-Fleming, but it does raise the question of whether it is the right modeling approach for Uruguay.

We address this question with two regressions. First, we follow Bernanke and Blinder (1993) and run a regression of quarterly GDP in levels on two lags of quarterly GDP, the price level, nominal money balances, the nominal exchange rate, and the one month interest rate on BCU securities, for the period 2004:I-2014:III. We then perform marginal significance tests (F

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[15] The model also includes a foreign block, in which foreign output, inflation and interest rates are determined endogenously. When constructing a projection, the forecast for these variables is taken from the Global Projection Model (GPM) Network (see http://www.cepremap.fr/en/modelling/gpm/).

[16] There is evidence, however, that targets are not set mechanically. For example, the setting of money targets in 2013:3 and 2013:4 took into account some base effects: money demand was expected to grow for reasons unrelated to the policy stance and had to be accommodated, i.e., reflected in higher money targets. See Banco Central del Uruguay, "Informe de Politica Monetaria, Tercer Trimestre 2013."

tests) for the hypothesis that either M1+ or the interest rate can be excluded from the regression. We find that the interest rate is a much better predictor of economic activity (much lower marginal significance level) than monetary aggregates, which are found not to be statistically significant. We interpret this evidence as supportive of the idea that monetary aggregates are not informative of the stance of policy once interest rates are included in the analysis, which is consistent with our model.

Second, we regress yoy inflation on one lag of itself, lagged output gap obtained with the HP filter, lagged yoy M1+ growth, and lagged real money gap (also obtained with the HP filter), for the period 2004:I-2014:III. The last term is based on p-star models of inflation, which posit that the difference between the real money stock and the long-run equilibrium real money stock can contain information about future inflation (Gerlach and Svensson (2003)). In the case of Uruguay, we find that the estimated coefficient on the real money gap is insignificant, while the coefficient on money growth is negative and significant, implying that an increase in money growth is associated with a *decrease* in inflation. Overall, we believe this evidence does not support a more direct role for monetary aggregates in the model.[17]

IV. Policy-Relevant Exercises

We now present various model–based exercises for Uruguay. We begin by describing the calibration and our data set. We then present three policy-related exercises. First, we filter data through the model to recover a model-based interpretation of the recent macro dynamics. Second, we produce a projection for Uruguay starting from 2014Q4. Third, we conduct some counterfactual simulations.

A. Calibration

The ability of the model to interpret data and produce a reasonable medium-term projection crucially depends on its calibration. Our choice of parameters (presented in Table 1) is based on the following considerations.[18] First, we assessed the calibration of the model by comparing the model's impulse response functions with empirical evidence from a structural VAR estimated for Uruguay.[19] We focused on two shocks: a shock to the risk premium for

[17] It is worth pointing out that the estimated coefficient on the output gap is also negative but not significant. We interpret this finding as arguing against the use of purely statistical procedures for estimating the output gap. Note that in our model, the output gap is estimated using all of the macro variables, including the dynamics of inflation.

[18] We do not present the calibration of the foreign block, for the sake of brevity.

[19] The VAR includes: a trade weighted measure of foreign output, the US CPI, the Fed Funds Rate, the EMBI spread, domestic output, the nominal exchange rate, the core price index, and the interest rate for one-month BCU securities. The VAR is run in levels, and features two lags of each variable and block exogeneity for the foreign variables. Shocks to the EMBI spread is identified recursively (ordered fourth); the monetary policy shock is identified as a combination of the shock to the interest rate (ordered last) and the nominal exchange (ordered sixth), as discussed in the text.

Table 1. Uruguay: Model Calibration

Parameter	Value	Parameter	Value	Parameter	Value
Potential Output		Uncovered Interest Parity		Shocks (Standard Deviation)	
$\Delta\bar{y}$	3.5	θ_1	0.6	$\sigma_{\bar{y}}$	0.02
$\rho_{\bar{y}}$	0.3	θ_2	0.55	$\sigma_{\overline{rr}}$	0.0135
Equilibrium Real Interest Rate		Money Demand		$\sigma_{\bar{z}}$	0.05
$\overline{rr}$	3	δ_1	1	σ_{ygap}	0.2
$\rho_{\overline{rr}}$	0.1	δ_2	1.5	$\sigma_{\pi noise}$	0.09
Equilibrium Real Exchange Rate		δ_3	0.3	$\sigma_{\pi 1}$	0.08
$\Delta\bar{z}$	-1.5	δ_4	1	σ_s	0.25
$\rho_{\bar{z}}$	0.8	δ_5	0.5	σ_{prem}	0.1
Output Gap		$\Delta\bar{v}$	0.5	$\sigma_{\Delta m}$	0.01
β_1	0.85	ρ_v	0.5	σ_v	5
β_2	0.10	Monetary Policy		$\sigma_{\Delta\bar{m}}$	8
β_3	0.04	γ_1	0.7	σ_{Taylor}	0.04
β_4	0.1	γ_2	2.5	σ_{dev}	4
β_5	0.1	γ_3	0.2		
Phillips Curve		γ_4	0.25		
α_1	0.65	ρ_{dev}	0.5		
α_2	0.035				
α_3	0.11				
α_4	0.8				

emerging market assets (captured by the EMBI spread), and a shock to monetary policy. Matching the model dynamics with the VAR evidence requires some work. The model has been designed in part to provide a useful policy recommendation going forward and not solely to replicate past policy responses, which may have been overly procyclical in response to capital flows, that is somewhat accommodative in episodes when capital inflows contributed to exchange rate appreciation pressures.[20] The EMBI shock is therefore reproduced in the model by a combination of three shocks (a shock to the risk premium ε_t^{prem}, a shock to monetary policy ε_t^{Taylor} and a shock to foreign output).

With regards to the monetary policy shock, it is well known in the VAR literature that standard identification techniques have a hard time generating an immediate appreciation in response to a policy tightening, what is sometimes referred to as the "exchange rate puzzle."[21] The same is true for the case of Uruguay. To ensure consistency between the model and the VAR, we identify the monetary policy shock as a combination of: (i) a positive shock to interest rates, and (ii) a nominal appreciation that is broadly consistent with the model.[22] Under the above restrictions the model does a good job of replicating the VAR evidence, as shown in Figure 1.

A second source of calibration is the ability of the model to produce a coherent characterization of recent macro dynamics in Uruguay, e.g., produce estimates of potential output and trend real exchange rates that are consistent with the IMF's assessments of demand pressures or exchange rate misalignment. Such considerations dictated the choice of parameters and standard deviations for the processes for potential output and the equilibrium real exchange rate. In addition, in the case of some of the standard deviations, the calibration was chosen to allow the model flexibility in matching the data and constructing estimates of unobserved variables. This was the case for the standard deviation to ε_t^{dev}, the shock to the deviation between the actual level of interest rates and the level implied by the Taylor rule. The standard deviation of this shock was set sufficiently high so that estimates of the Taylor-implied rates were not overly influenced by the observed interest rates. Finally, in the case of money demand, the calibration was chosen to replicate the joint behavior of interest rates and money growth in recent years.[23]

A third source of calibration was the model's ability to produce a reasonable forecast, in this case a forecast which inflation converges to the target over the medium term (under four years). The assumption is that a return to the target in four years would reflect the

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[20] See Caballero and Krishnamurty (2003) for a discussion of the factors behind such procyclicality in EMs.

[21] See Sims (1992), Eichenbaum and Evans (1995), and Gorodnichenko (2006).

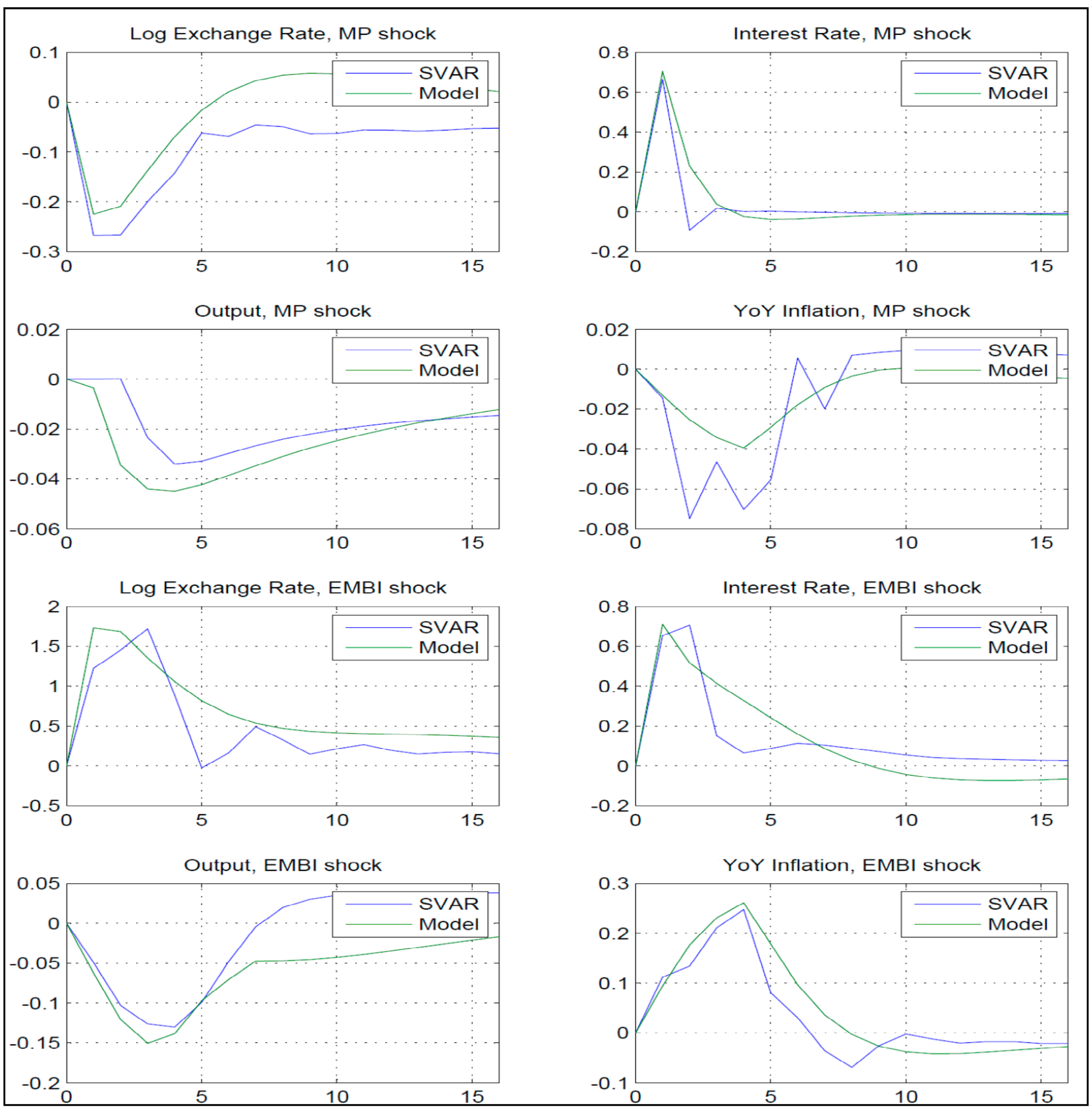
[22] An alternative proposition that increases in interest rates may lead to a nominal *depreciation,* if debt dynamics are considered unsustainable has received some attention in the macro literature, e.g., in the case of Brazil in 2002 (Blanchard (2005). We do not believe these dynamics are at play in Uruguay, given the improvement in overall debt levels and its composition in recent years.

[23] It also draws on Brum et al (2010).

policymakers' preferences about the relative weights to inflation and output stabilization. Producing such a forecast required monetary policy to be somewhat more aggressive (in terms of the response to inflation in the interest rate rule) than what is often assumed in these models.

With regards to money targeting parameter, the degree of MT target adherence $\boldsymbol{\gamma_4}$ was set at 0.25. This calibration implies that a 4 percent deviation between realized money growth and its target results in a short-term interest rate that is 100 basis points higher/lower than the rule prescription. We believe this calibration provides a reasonable compromise between the MT framework and the guidance provided by the interest rate rule. We explore an alternative calibration below.

Figure 1. Uruguay: Impulse Response Functions (Model and SVAR).



Source: Model-based simulation and VAR-based estimates.

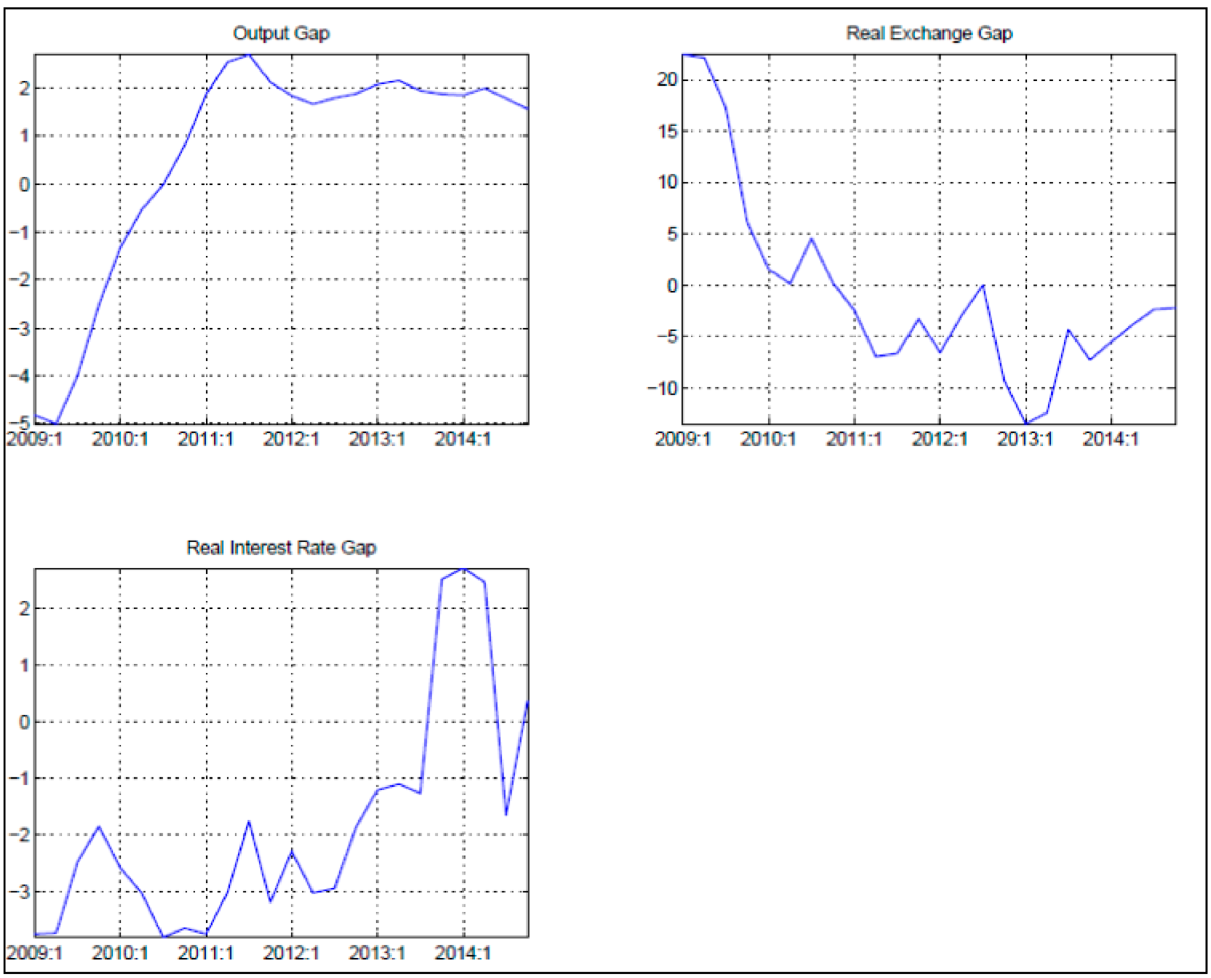
B. Data

The data is quarterly and covers the period 2007-14. The dataset includes GDP, a measure of core inflation, the peso/U.S. dollar exchange rate, the interest rate of one-month BCU securities, the measure of M1+ targeted by the BCU, the mid-point of the M1+ target band, U.S. inflation, and a trade-weighted measure of foreign output. The data set also includes a BCU survey-based measure of inflation expectations (for year on year inflation four quarters ahead, $\pi_{4,t}^{Survey}$). This variable is used as a noisy indicator of true (unobserved) model-based expectations. Specifically the model was extended to include the following relationship:

$$\pi_{4,t+4|t} = \pi_{4,t}^{Survey} + \varepsilon_t^{Survey}. \tag{12}$$

The latter variable helps provide further discipline on the model results, as it forces the model's interpretation of the data to be broadly consistent with the inflation surveys.

Figure 2. Uruguay: Model-Based Gap Estimates



Source: Model-based simulations.

C. Filtration Results

We filter the data set through the model with the help of the Kalman smoother.[24] On the basis of the data observed, the calibration of the model and the standard deviations of the shocks, the Kalman smoother produces estimates of: (i) the unobserved variables in the model (measures of potential output, equilibrium real interest rates and real exchange rates, the Taylor-rule-implied interest rate), and (ii) estimates of the shocks. The former are used to construct gap estimates, while the latter estimates can then be used to provide a shock-decomposition of the variables of interest. We provide a brief discussion of each of these in turn.

Figure 2 presents model-based estimates of the output gap, the real exchange rate gap and the real interest rate gap. Starting from a position of considerable slack following the global financial crisis, Uruguay began to experience an expansion in aggregate demand. The output gap became positive and reached a peak of 3 percent in 2011. The expansion in aggregate demand is associated with a large persistent negative real interest rate gap (when the real interest rate is below its equilibrium level) through the pre-MT period. It also coincides with a sustained appreciation of the peso (with the exception of the tapering episode in which the real exchange rate depreciated) and the opening of a sizeable real exchange rate gap with the real exchange rate being above its equilibrium level.

Figure 3 compares the observed short-term interest rate with the "notional" interest rate implied by the interest rate rule. Short-term rates stayed below the rule-implied rate through most of the pre-MT period, consistent with an accommodative monetary policy. Interest rates increased considerably with the adoption of money targeting, though they fell short again at the end of 2014.

Figure 3 also displays the decomposition of yoy inflation dynamics (measured as deviations from the inflation target) in terms of the structural shocks estimated with the Kalman smoother.[25] The red line shows the path for inflation. Starting from a two percent deviation by 2009, inflation started to drift up through 2014.The figure shows that monetary policy shocks (the green area) have provided a persistent stimulus to inflation. The worsening external conditions observed since mid 2013 (the increase in emerging market risk premia associated with the tapering episode, and which resulted in the large depreciation of the peso as well as other emerging market currencies) have also contributed.[26]

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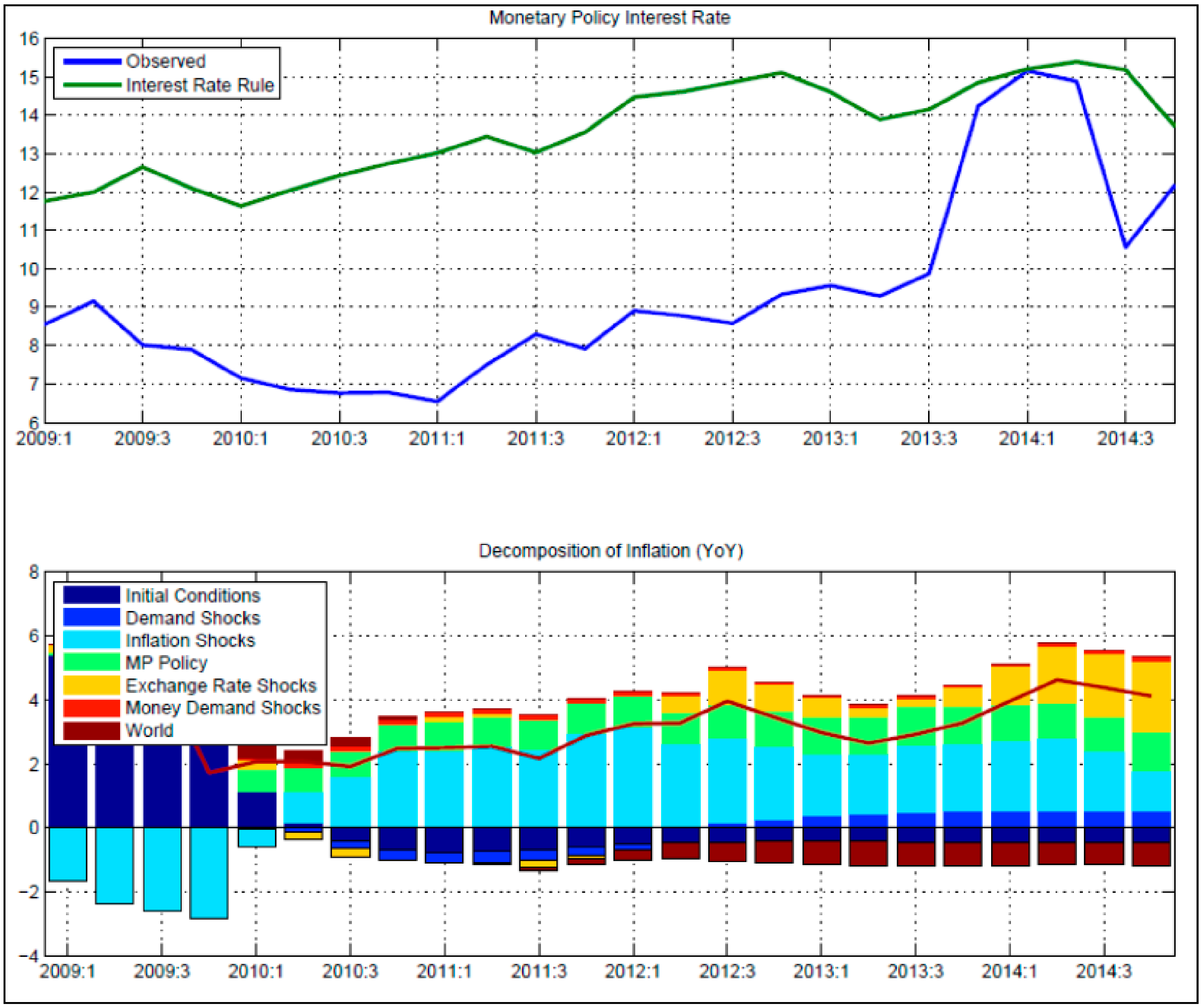
[24] See Hamilton (1994), Ch. 13, for a thorough presentation and discussion. We use IRIS, a Matlab interface designed for confronting models with data and making projections. See http://iristoolbox.codeplex.com/.

[25] Shocks have been grouped into six categories: demand (shocks to the output gap), inflation (shocks to the Philips curve and to the noise component), monetary policy (shocks to the Taylor rule and to the deviation term), exchange rate shocks (shock to UIP and risk premia), money demand shocks, and shocks to the rest of the world.

[26] Shocks to inflation account for an important share of inflation dynamics. This simply reflects the limitations of the model in accounting for all of the inflation dynamics, as movements in inflation that are not consistent with the macro co-movement implied by the model will be reflected in either $\varepsilon_t^{\pi_1}$ or (especially) $\varepsilon_t^{\pi noise}$.

Figure 3. Uruguay: Model Filtration Results



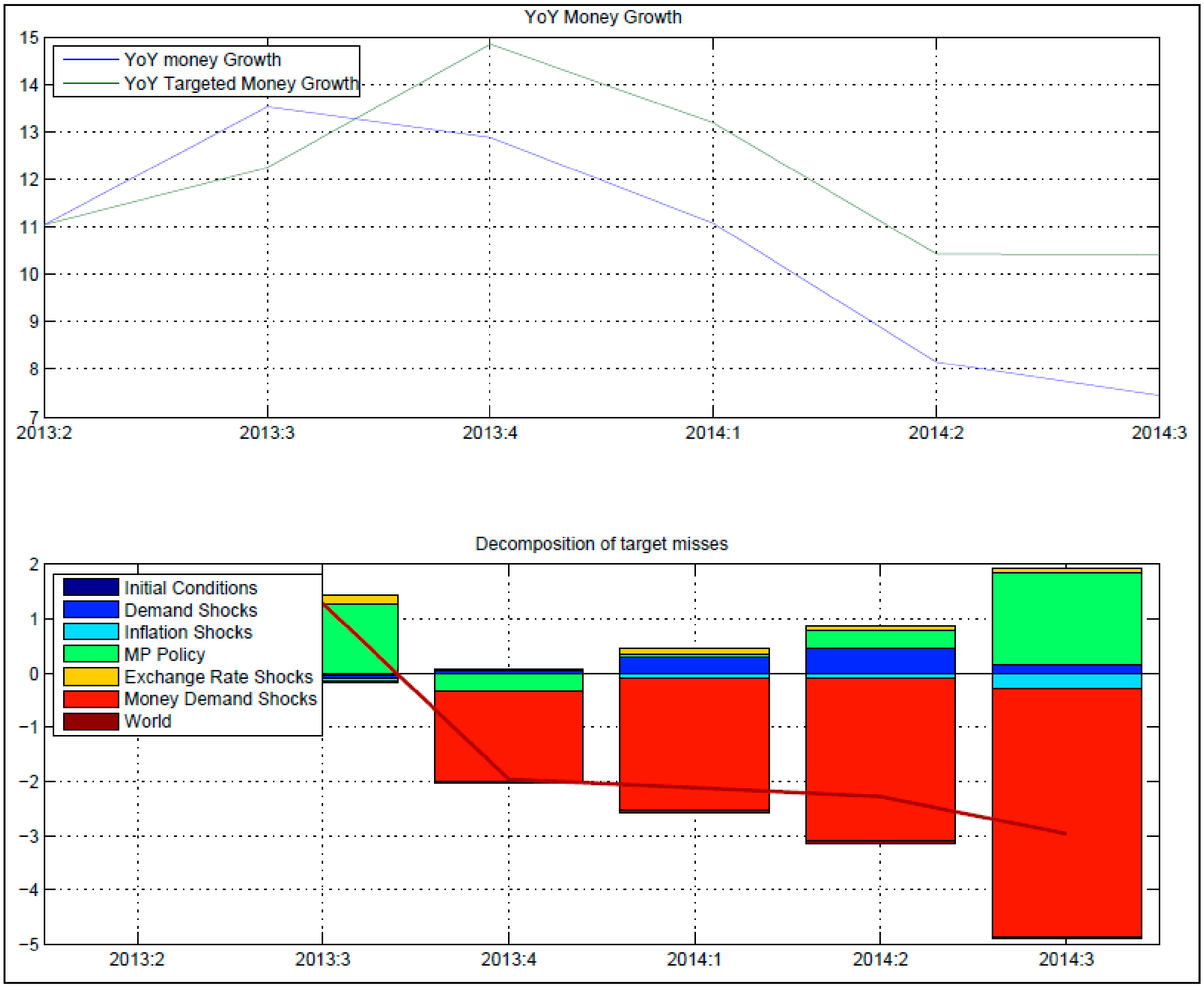
Source: Model-based simulations.

Figure 4 provides similar shock decomposition for money target misses, i.e., the deviations between the targeted level of money growth (the center of the target range) and actual money growth. As previously discussed, money growth has fallen below the target over the last few quarters. According to the model, most of the target misses reflect money demand shocks, with monetary policy shocks playing a small role.

Discussion

The two panels in Figure 3 tell a similar story for the pre-MT period: interest rates below the Taylor prescription coincide with monetary policy shocks contributing to inflation (the green bars). After the adoption of money targeting however, the two panels seem to diverge. The policy misalignment is largely corrected, yet monetary policy shocks continue to contribute to inflation. Despite the apparent contradiction, the two are consistent. The shock decomposition graph shows the contributions of the history of monetary policy shocks to inflation up to time t. Even after policy becomes appropriately tight, and there are no new monetary policy shocks, old shocks continue to play a role going forward. This is because inflation is sufficiently backward looking, so it will take some time for the effects of old shocks to disappear. To put it another way, inflation is high today partly because it has been high in the last few years.

Figure 4. Uruguay: Model Filtration Results



Source: Model-based simulations.

A related point is that the shock decomposition does not tell the whole story regarding the role of monetary policy. In the model there is an important distinction between monetary policy shocks and the monetary policy rule. The shocks are helpful to make sense of the past, but it is the rule that ensures that inflation converges back to the target.[27]

[27] Interest rates higher than the Taylor prescription would generate negative policy shocks, which could help reduce inflation faster (and would reduce the green bars in the second panel), but doing so could imply an excessively tight policy.

D. Projection

Figure 5 presents model-based macro projections for Uruguay starting in 2014:4. Given the path of the economy, the Kalman-smoother-based estimates of the structural shocks and unobserved variables, and a path for external variables, the model is simulated to create macro projections for Uruguay.[28] The projection is conditional on the model's calibration, including the specification of monetary policy. It must be stressed that the projections indicate possible paths for the economy out of a continuum of possibilities. This is the case even if policy behaves according to the policy rule specified in the model, as there is considerable uncertainty regarding the macro shocks and the structure of the economy (including the behavior of money demand).

In light of this uncertainty we present three projections. The first, baseline, projection, is one in which the forecast is purely model-based with the exception of the path of the risk premium term, $prem_t$, for the period 2015:1-2016:3. This variable has been tuned to capture external financial pressures, corresponding to one fourth (1/4) of the pressures experienced during and following the "*taper tantrum*" episode (2013:2-2014:4). This judgment is meant to capture our assessment that the external environment for emerging markets may be less favorable going forward, reflecting uncertainties related in part to the normalization of monetary policy in advanced economies. The two alternative projections capture: (i) a pessimistic scenario in which external pressures on the exchange rate are half as big as during the 2013-2014 period, and (ii) a benign scenario in which these pressures are not present at all and the economy benefits from disinflation forces stemming from lower oil prices.[29]

Figure 5 presents the baseline projection. Starting from a level of around 9 percent in 2014:4, core inflation would decrease and reach 5 percent by end 2019. The inflation path is consistent with a considerable nominal and real appreciation in the short run, which has an immediate disinflationary impact and strengthens the peso further above the equilibrium level, and a subsequent nominal depreciation required to bring the real exchange rate back in line with its equilibrium value. The inflation path also reflects a sustained contraction in aggregate demand, which reduces inflationary pressures and brings GDP below potential.

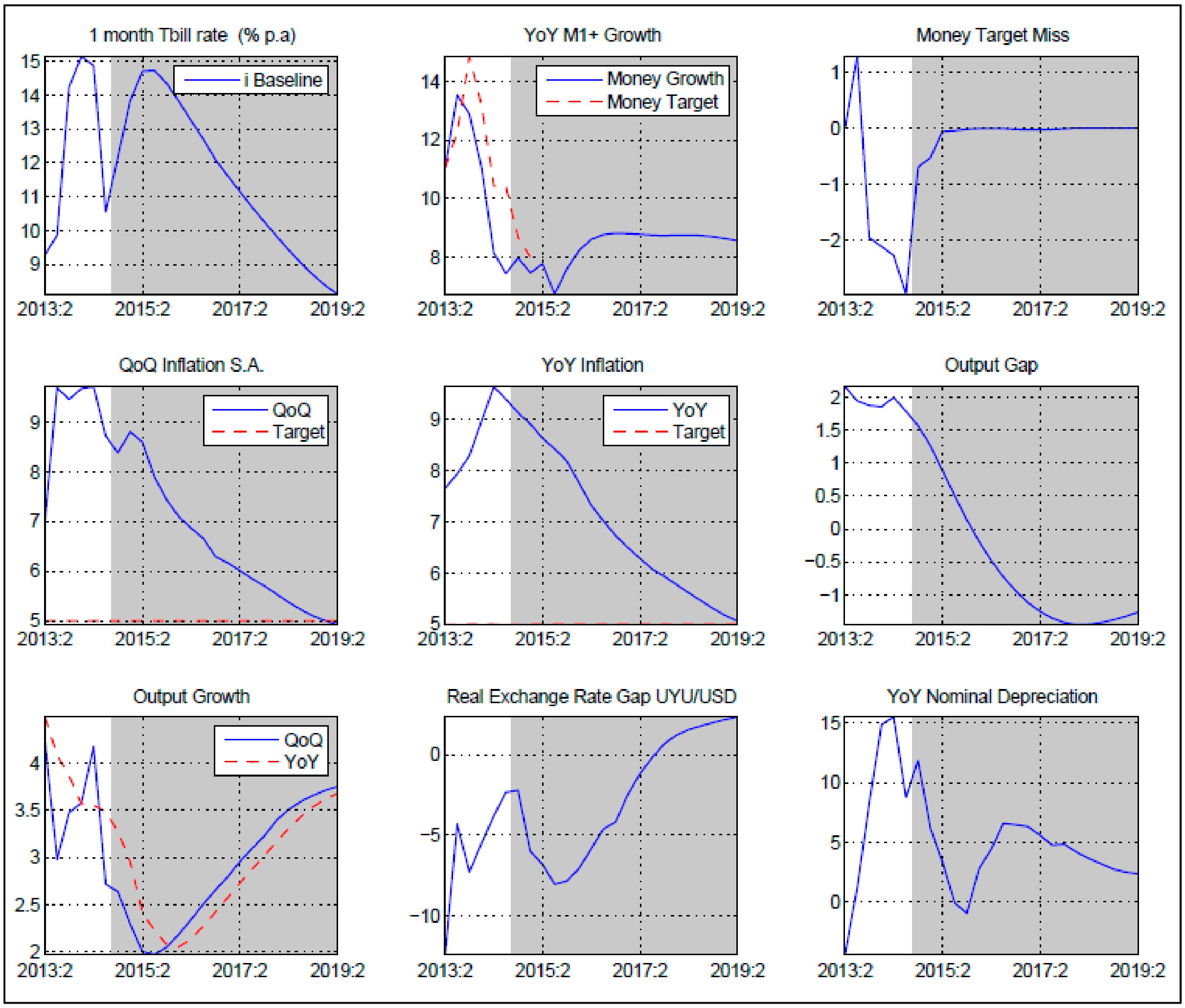
The projection for inflation, output and the exchange rate is consistent with a large tightening of monetary policy. Short-term rates would increase to close to 15 percent by mid-2015, from an average of 12.5 in 2014:4, and would stay above 14 percent through mid 2016. Interest rates would start to decline as inflation is brought down, and would converge to their long run level of 8 percent by 2019. In addition, money growth would stay below 8 percent for some time, before increasing to closer 9 percent around 2016 as policy is loosened and

[28] The path for external variables is taken from the Global Projection Model (GPM) Network (see http://www.cepremap.fr/en/modelling/gpm/).

[29] These disinflationary forces are modeled as a sequence of negative shocks to the Phillips curve in 2015 that result in a cumulated decline in yoy inflation of 40 basis points.

growth resumes. Given the structure of the model, the deviation between money targets and actual money growth would not weigh on the stance of policy after the first quarter of 2015.

Figure 5. Uruguay: Baseline Projection

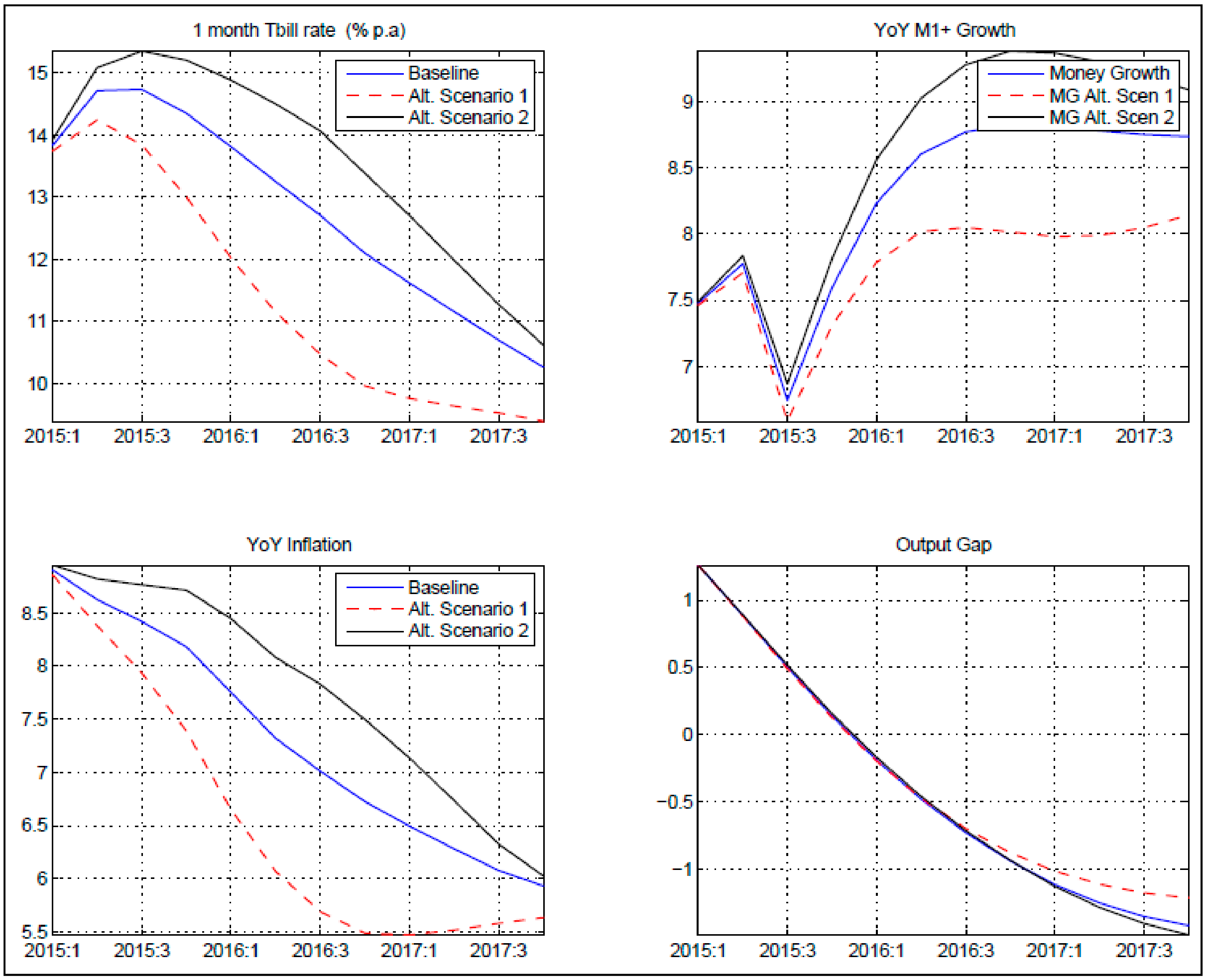


Source: Model-based simulations.

Under the benign scenario (Alt Scenario 1 in the Figure), inflation would fall much faster, reaching 7 percent, one full year before the baseline. The faster decline in inflation would allow for a smaller tightening of interest rates, which would still need to be around 14 percent through much of 2015.[30] Money growth would also be lower, due to lower inflation. Note that the effect on the output gap would be similar to the baseline, due to the small value of the interest elasticity in the IS curve (consistent with the level of financial dollarization).

[30] The sharp decline in oil prices has already started affecting Uruguay's economy. However, the pass-through of lower crude oil prices to end-user prices is expected to be partial due to the need to shore-up the operating balance of the state-owned petroleum company.

Figure 6. Uruguay: Alternative Scenarios



Source: Model-based simulations.

Under the pessimistic scenario (Alt Scenario 2), the disinflation is more protracted and costlier in terms of the increase in interest rates, which must stay above 15 percent until mid 2016. The policy tightening coincides with an increase in money growth relative to the baseline. Again, the path of the output gap does not differ considerably from the other scenarios.

Two conclusions can be drawn from this exercise. One, disinflation is costly when inflation is backward looking and inflation is considerably above target. Second, the path of money growth reflects development in nominal variables and is likely to be uninformative about the stance of policy. It can be higher or lower than the medium term target even though policy is appropriately tight. We explore the money targeting framework in more detail in the exercises below.

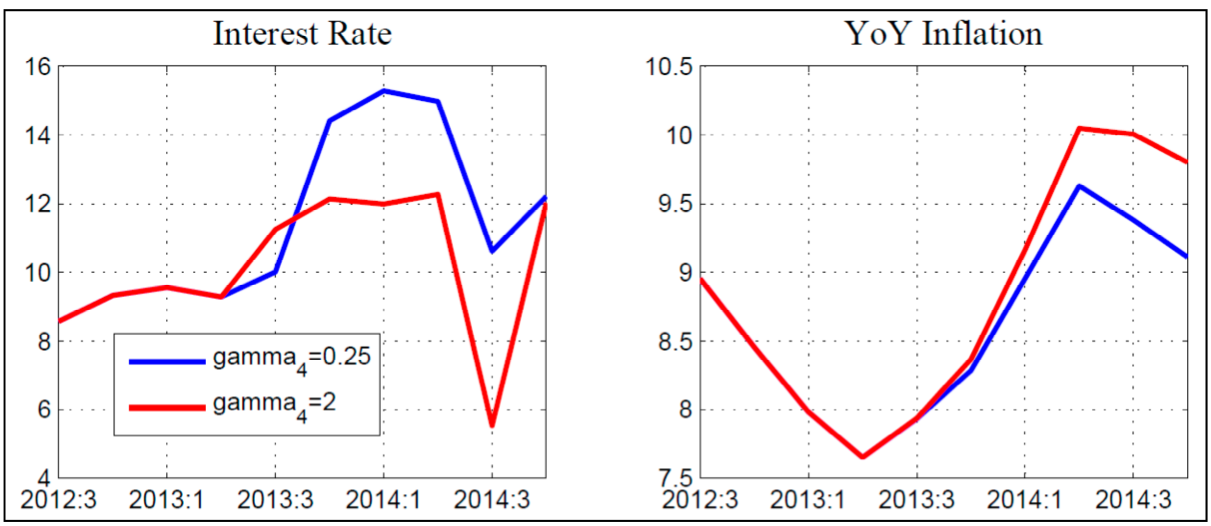
E. Money Targeting Analysis

We now present two exercises related to the money targeting framework. These exercises are meant to illustrate the role of: (i) target adherence, and (ii) the design of money targets.

The Role of Target Adherence

Target adherence (γ_4) is one of the key parameters in the framework. Figure 7 plots two interest rates: the observed short-term rate and a counterfactual rate. The latter is generated by simulating the model with the shocks estimated from the filtration exercise but with an alternative calibration in which adherence to money targets is much stronger ($\gamma_4 = 2$, instead of $\gamma_4 = 0.25$ in the baseline calibration). Under the counterfactual simulation, stronger adherence to money targets would have resulted in much lower interest rates during the last year than those observed. As a result, policy would have become more accommodative, and inflation would have been higher. This exercise highlights that excessive concern with hitting targets can derail the inflation stabilization process (when money growth targets are set too high relative to money demand to be consistent with a disinflation process).

Figure 7. Uruguay: Counterfactual simulation.



Source: Model-based simulations.

The Design of Money Targets

We conclude the model-based exercise with the analysis of alternative ways of designing money targets. Our assumption in the model is that money targets correspond to a forecast of money demand consistent with the desired interest rate policy. In this case the targets reflect all information available up until time *t-1*.

We now explore two alternative rules. First, we assume that the policy rule is still as (7) but the setting of the year-on-year money growth target follows a different rule. It is now constant, equal to the long-run money growth:

$$\Delta\bar{M}_{4,t|t-1} = \Delta\bar{M} = \Delta\bar{y} + \Delta\bar{\pi} - \Delta\bar{v}.$$

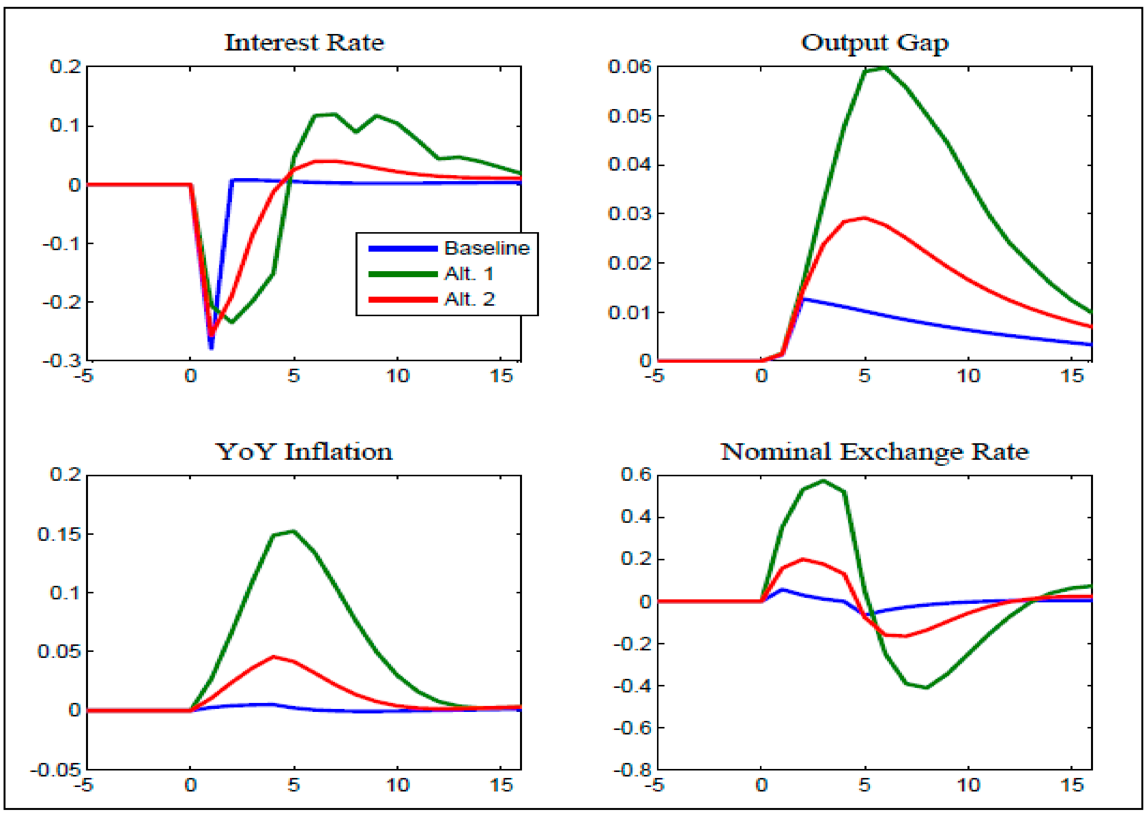
The second alternative is the money growth that is targeted by the central bank is the (annualized) quarterly growth rate:

$$i_t \ = i_t^{Taylor} + \gamma_4\left(\Delta M_t - \Delta\bar{M}_{t|t-1}\right) + dev_t,$$

with the money target set as: $\Delta\bar{M}_{t|t-1} = \Delta\bar{M} = \Delta\bar{y} + \Delta\bar{\pi} - \Delta\bar{v}$.

We simulate a positive shock to velocity growth ε_t^v (a decrease in money demand) and assess the cost of targeting money under three money setting rules. To ensure that the three settings are comparable, we set $\gamma_4 = 2$ in the baseline and in the first alternative scenario, and $\gamma_4 = 0.5$ in the second alternative scenario. Simulations of the model under the three specifications are presented in Figure 8.

Figure 8. Uruguay: Shock to money demand under alternative money targeting rules



Source: Model-based simulation.

Following the shock, interest rates fall, since we assume that the central bank does not perfectly accommodate the change in money demand. Under the baseline specification, this is a one off as the money target—the money demand forecast for next period—is immediately revised to accommodate the higher growth rate of v. As a result, the effect on the exchange rate and on output and inflation is minimal.

Instead, under the two alternative scenarios, the policy mistake is more costly. Money targets are not revised, so persistent changes in money demand also have more persistent effects on interest rates. The exchange rate depreciates more on impact and output and inflation fluctuate more as a result. Note that the alternative scenario in which the authorities target year-on-year money growth—scenario 1—results in even larger and more persistent policy errors. This is because the same shock has more persistent effects on year on year money demand growth, due to base effects.

The above exercise illustrates that, to the extent money targets are used at all, these need to be set in a way that minimize the costs from policy errors. The best way to minimize these policy errors is to incorporate money demand forecasting in the design of targets. At the very least, money targets need to be set in a way that reduces the risk of base effects leading to and large and persistent policy slippages.

V. Conclusions

We have presented a model for monetary policy analysis for Uruguay that includes money targets in the policy framework while maintaining a central role for short-term interest rates in the analysis of policy. The model simulations under the baseline assumptions on the economic environment suggest that to achieve a gradual disinflation, monetary policy conditions will have to be kept tight for some time with the output declining somewhat below potential. In addition, we have discussed the role of money target design and adherence for the performance of the new framework. Finally, our paper has shown that the practice of monetary policy can benefit from more structural analysis such as ours, including in money targeting frameworks.

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