



**Banco Central de Venezuela
Vicepresidencia de Estudios**

A Small Scale Macroeconomic Model for Venezuela

Second Draft

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Abstract

In this paper we build a small scale macroeconomic model for Venezuela. The model consists of four building blocks: a price equation, an aggregate demand equation (IS curve), an exchange rate equation (UIP) and a policy rule. The first two equations are estimated using quarterly data for the period 1989-2001. The exchange rate is determined as an asset price by the uncovered interest rate parity condition and the policy rule is calibrated for alternative preferences of the central bank authorities. All the equations in the model are forward looking, which is an innovation for the Venezuelan case that allows us to include the effect of agent's expectations. We conduct simulation experiments to analyze the effect of different shocks on inflation, output, exchange rate and interest rates. We examine the impact of a permanent reduction of the inflation target with different degrees of credibility for the central bank, and alternative specifications for the interest rate rule. Then we look at the effect of a temporary public expenditure shock, and a temporary increase in the policy rate.

Síntesis

En este trabajo se elabora un modelo macroeconómico de pequeña escala para Venezuela. El modelo se fundamenta en cuatro bloques resumidos en una ecuación de precios, una ecuación de demanda agregada (curva IS), una ecuación para el tipo de cambio y una regla de política para la tasa de interés. Las primeras dos ecuaciones son estimadas empleando datos trimestrales para el periodo 1989-2001. El tipo de cambio se determina por la condición de la paridad descubierta de las tasas de interés y la regla de política de la tasa de interés es calibrada para amoldarse a preferencias alternativas de la autoridad monetaria. Todas las ecuaciones incorporan las expectativas de los agentes. Con el modelo se realizan experimentos con shocks de distinta naturaleza para analizar su impacto la inflación y el producto. Se examina el impacto de una reducción permanente del objetivo de inflación con distintos grados de credibilidad de la autoridad monetaria y especificaciones alternativas para la regla de tasas de interés. También se analiza el efecto de un incremento temporal en el gasto público y de un incremento temporal en la tasa de interés de política.

1. Introduction

Throughout most of the 1990's the exchange rate was the nominal anchor in the Venezuelan economy. In February 2002, the narrow exchange rate band regime was abandoned and a flotation regime adopted. This new framework brings challenges for the monetary authority in its role of controlling inflation, which requires, among other things, the development of models and indicators that help the decision making process of the monetary authority.

Among the variety of models employed in inflation targeting regimes to carry out policy analysis, small-scale macroeconomic models are widely used, since they allow a straightforward understanding of the transmission mechanisms of policy actions to variables of interest, such as inflation, output or the real exchange rate. Typically, these are stylized aggregate models that encompass an important degree of economic theory within a reduced number of equations. Their simplicity facilitates experiments with different assumptions regarding agents or policy makers preferences, represented by certain parameters in the model.

In this paper we build a model for the Venezuelan economy, in the spirit of Batini and Haldane (1999), Svensson (2000), Gómez (2002), and Martínez, Messmacher and Werner (2002). The model consists of four building blocks: a price equation, an aggregate demand equation (IS curve), an exchange rate equation (UIP) and a policy rule. The first two equations are estimated using quarterly data for the period 1989-2001. The exchange rate is determined as an asset price by the uncovered interest rate parity condition and the policy rule is calibrated for alternative preferences of the central bank authorities. All the equations in the model are forward looking, which is an innovation for the Venezuelan case that allows us to include the effect of agent's expectations.

We conduct simulation experiments to analyze the effect of different shocks on inflation, output, exchange rate and interest rates. First, we examine the impact of a permanent reduction of the inflation target with different degrees of credibility for the central bank, and alternative specifications for the interest rate rule. Then we look at the effect of a temporary public expenditure shock, and a temporary increase in the policy rate.

The paper is organized as follows: The next section contains the description of the model. Then, in the third section we discuss the transmission mechanisms implied by the model. In the fourth section we show the results of simulation exercises, and the last section has the final comments.

2. The Model

The model is set for a small open economy and consists of four building blocks: a price equation (Phillips curve), an aggregate demand equation (IS curve), an exchange rate equation (UIP) and a policy rule. For estimation purposes, we use quarterly data for the period 1989-2001. All variables are expressed in logs, except for the interest rates.

The model is forward-looking in all markets, including features from the New-Keynesian framework based on dynamic optimization models with nominal rigidities and imperfect competition in the spirit of Rotemberg and Woodford (1997), McCallum and Nelson (1999b), Clarida, Gali and Gertler (1999) among others. This may provide a richer analysis---compared to the traditional backward-looking IS-LM-AS specification---since aggregate behavioral equations are derived from intertemporal optimization by households and firms, incorporating expectations. Although we do not estimate the LM curve in the model, it does not affect our results. This is mainly because the LM curve would only give us the path of money, presumably determined by output, prices, interest rates and the exchange rate, which are derived from the other equations in the model where money does not intervene¹.

The model is solved simultaneously, allowing for more interactions among the variables, instead of solving it sequentially by blocks.

2.1 The Price Equation

We estimated the following inflation equation²:

$$\pi_t = \alpha_0 E_t \pi_{t+1} + (1 - \alpha_0) \pi_{t-1} + \alpha_1 (y_{t-j} - y_{t-j}^*) + \psi \Delta q_{t-j} \quad (1)$$

where π is the inflation rate, $E_t \pi_{t+1}$ represents expected inflation, y denotes output, y^* stands for potential output and q is the real exchange rate. Output is detrended with the Hodrick-Prescott filter. The real exchange rate is given by $q_t = \log(Q_t) + \log(P_t^*) - \log(P_t)$, i.e., the ratio of foreign prices in domestic currency and domestic prices, where P is CPI, P^* is US CPI, and the nominal exchange rate is Q_t . Equation (1) expresses that inflation dynamics are influenced by past inflation³, by inflation expectations, by demand pressures, and by external supply shocks captured by the real exchange rate.

Inflation expectations are given by

$$E_t \pi_{t+1} = \mu \pi_{t+1} + (1 - \mu) \pi^{tar} \quad (2)$$

where π^{tar} represents the inflation target the central bank sets, and $0 \leq \mu \leq 1$. What we pursue with this formulation is to include the effect of credibility of the central bank. The parameter μ can be thought as a measure of the credibility of the monetary policy:

¹ To derive the money equation, McCallum and Nelson (1999b) assume money enters in the consumer's utility function, but it is separable from consumption. Thus, it is not present in the Euler equation for consumption and hence money is not a determinant of aggregate demand. By the same token, the marginal conditions for money do not depend on consumption. Considering similar assumptions, this would be the case in our model.

² Within the New-Keynesian framework the price equation is derived from a log-linear approximation of the aggregation of firms decisions, that is, the relation between price and marginal cost. Output gap is included establishing a proportional relation between output gap and marginal cost. See Nelson and MacCallum (1999b) or Clarida, Gali and Gertler (1999).

³ The inclusion of lagged inflation is justified on empirical grounds, see Fuhrer (1996).

as μ tends to 1, the policy is less credible. As μ approaches 0, the target becomes more credible, so expected inflation looks more like the target.

For estimation purposes we assumed $\mu = 1$, so that $E_t\pi_{t+1}$ is proxied by π_{t+1} . We then estimated equation (1) by a two step procedure, following Galí (2000)⁴. First, we obtained estimates for α_0 by GMM, using contemporary and lagged values of the output gap and first differences of the real exchange rate as instruments. Then we imposed this estimate in an OLS estimation of (1) to obtain the coefficients of the output gap and the real exchange rate. We used two dummies to capture the effect of capital controls: one in 1994, at the beginning of the regime, and one in 1996, when it was abandoned. We also imposed dynamic homogeneity, which implies that there is no long run relationship between the output gap and inflation⁵. The results of the estimations are displayed in Table 1.

Table 1. Price equation

Variable	Coefficient	t-Statistic*	P-value
π_{t+1}	0.587197	3.933598	0.0003
$(y - y^*)_{t-4}$	0.084993	2.167576	0.0358
Δq_{t-2}	0.052559	2.572602	0.0136
Δq_{t-3}	-0.039067	-2.332028	0.0245

Sample Adjusted 1989:04-2001:03
 *Newey-West HAC Standard Errors & Covariance
 Adjusted R-squared 0.662320
 Serial Correlation LM Test: F= 0.508775 p-value=0.604977
 Jarque-Bera Normality Test: 24.158 p-value 0.0005
 White Heteroskedasticity Test: F=0.167835 p-value=0.993968
 The CUSUM and CUSUM of squares tests suggest parameter stability

The first row of Table 1 contains the results of the GMM⁶ estimation of α_0 . The rest of the rows correspond to the OLS estimation of (1) imposing $\alpha_0=0.587197$. The estimation results of (1) suggest that inflation is more influenced by expectations of future inflation than by past inflation. This may be a feature in high and moderate inflation countries, such as Venezuela. Inflation is also positively affected by the output gap with a lag of four quarters, and by the real exchange rate with two lags and three lags.

We also attempted to estimate an equation including an error correction term to account for a long run relationship between domestic prices and import prices in domestic currency. The error correction term was never significant, and the specification was not structurally stable. When we solved the full model imposing the long run relationship it presented convergence problems, so although it would be theoretically more appealing to include a price equation that contains a long run adjustment, it did not seem empirically appropriate to do so.

⁴ Galí (2000) establishes that by estimating inflation equations with forward looking terms by a two step procedure, first obtaining the inflation lags and leads coefficients by GMM and then imposing those estimates in an OLS regression to get the coefficients of the rest of the variables, we avoid biased results.

⁵ A Wald test for the null of the sum of the coefficients of π_{t-1} and π_{t+1} is equal to one could not be rejected. Thus, imposing the homogeneity restriction seems valid.

⁶ We used a HAC weighting matrix with Bartlett Kernel, Newey-West fixed bandwidth and prewhitening.

In future developments of this model, we would like to include a long run relationship, and possibly the effect of wage dynamics on prices, as long as restrictions with the data allow it.

2.2 Aggregate Demand

We estimated the following forward-looking version of the aggregate demand, loosely based on the log-linearization of the Euler equation of consumption, imposing the equilibrium condition that consumption equals output minus government expenditure and exports.

$$y_t - y_t^* = \beta_0 r_{t-j} + \beta_1 e_{t-j} + \beta_2 (y_{t+1} - y_{t+1}^*) + \beta_3 (y_j - y_{t-j}^*) + \beta_4 g_{t-j} + \beta_5 X_{t-j} \quad (3)$$

where $y - y^*$ is the output gap, r is the real interest rate, e is the deviation of real exchange rate from its trend, g is detrended public expenditure and X is a vector of variables intended to control for oil wealth. The variable g is assumed as an exogenous process. Output and the real exchange rate are detrended by the Hodrick-Prescott filter. The real interest rate is derived by the Fisher equation using future inflation, $1 + r_t = (1 + i_t)/(1 + \pi_{t+1})$, where i is the nominal loan rate⁷. The vector X includes variables such as oil prices, oil exports or oil exports income. Public expenditure is the sum of central government plus PDVSA (the state owned oil company) expenditure. Equation (3) was estimated by GMM and OLS---as Equation (1)---and controlling for seasonal effects. Results are displayed in Table 2.

Table 2. Aggregate Demand

Variable	Coefficient	t-Statistic*	P-values.
$(y - y^*)_{t-1}$	0.262117	3.125420	0.0037
$(y - y^*)_{t+1}$	0.538591	7.033464	0.0000
r_{t-1}	0.060319	2.612958	0.0129
r_{t-2}	-0.060415	-2.928250	0.0058
e_{t-2}	-0.060080	-1.455021	0.1541
e_{t-3}	0.079474	1.484504	0.1461
g_t	0.027851	2.006482	0.0522

Sample Adjusted 1990:04-2001:03
 *Newey-West HAC Standard Errors & Covariance
 Adjusted R-squared 0.846544
 Arch LM Test: F= 0.152176 p-value=0.698347
 White Heteroskedasticity Test: 0.454959 p-value 0.957480
 Jarque-Bera Normality Test: F=0.041596 p-value=0.979451
 The CUSUM and CUSUM of squares tests suggest parameter stability

Output gap is then influenced by a lag and a lead of itself, that is, policy actions that affect the expected output gap, also have an impact on current output gap. Interest rates have a lagged negative effect on the output gap. Misalignments of the real exchange rate from its equilibrium value (proxied in this simple version by its HP trend) also affect output gap, i.e., a real depreciation increases the output gap. When we included public

⁷ The nominal loan rate is an average of the different credit operations that banks perform, published by the central bank.

expenditure, none of the wealth variables were significant. This may be because oil wealth is canalized to the rest of the economy through public expenditure. It is also worth noticing that the impact of the exchange rate is more significant than the effect of the interest rates.

Under this specification the exchange rate is the adjustment variable that guarantees that in the long term the output-gap, is equal to zero for a given level of the public expenditure. It is worth noticing that the aggregate effect of the interest rate is very small in magnitude.

2.3 The Exchange Rate: UIP

The short run dynamics of the nominal exchange rate are determined by forward looking and risk-adjusted uncovered interest rate parity

$$i_t = i_t^f + E_t(\Delta \log(Q_{t+1})) + \varphi_t \quad (4)$$

This equation links the domestic nominal interest rates, i , to the foreign interest rate, i^f , the expected variation of the nominal exchange rate, $E_t(\Delta \log(Q_{t+1}))$, and the country risk premium, φ , so that risk-adjusted returns from holding assets in different currencies should be equal in expectations. For a given interest rate path, the nominal exchange rate can be solved as

$$\log(Q_t) = E_t \log(Q_{t+1}) - i_t + i_t^f + \varphi_t \quad (5)$$

In this model the domestic interest rate path is endogenously determined following a forecast based policy rule that will be explained in more detail in the next section. This specification implies that if the domestic interest rate is higher than the foreign interest rate in period t , the currency will appreciate today, which leads to an expected depreciation in $t+1$. We assume that the risk premium is exogenous, but it can also be endogenized in future works by relating it, for example, to the degree of indebtedness of the public sector.

2.4 The Policy Rule

We used the following forecast-based policy rule

$$i_t = \theta i_{t-1} + (1-\theta) \left[(\pi_t + r^*) + \lambda_0 (E_t y_{t+j} - y_{t+j}^*) + \lambda_1 (E_t \pi_{t+j} - \pi^{tar}) \right] \quad (6)$$

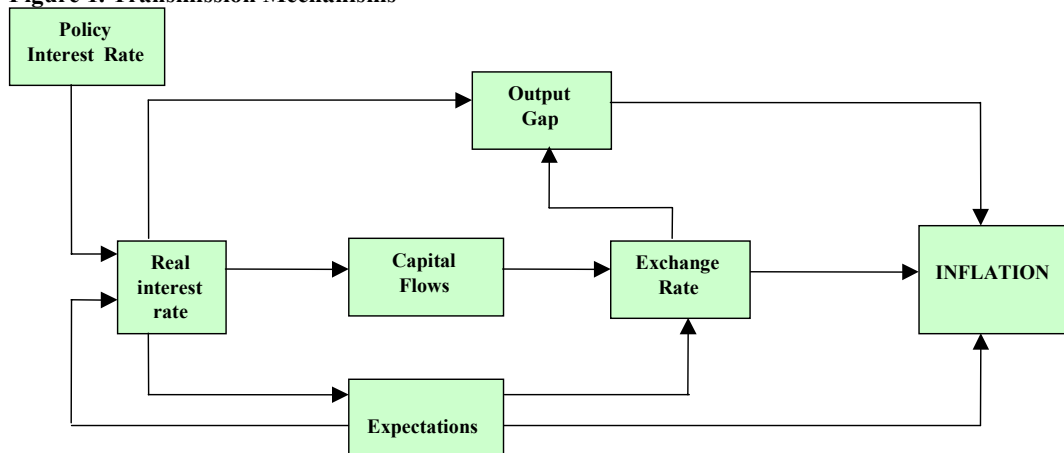
Where θ is a smoothing parameter, r^* is the steady state real interest rate, and λ_0 and λ_1 are feedback parameters with respect of expected output gaps and expected deviations of inflation from the target. For simulation purposes we take r^* as a constant. The parameters θ , λ_0 and λ_1 are calibrated, allowing for alternative preferences of the central bank authority. For simplicity, we also assume that any changes in the policy rate

are transferred on a one to one basis to the market rate. Unfortunately, we do not have enough data to estimate a yield curve, since we started to use interest rates as policy instruments barely since May 2002. As we gain more information in time, we should include a yield curve in the model.

3. Transmission Mechanisms

There are several channels of transmission for monetary policy actions in this model. This model incorporates three channels: aggregate demand, exchange rate and expectations. These are depicted in Figure 1.

Figure 1. Transmission Mechanisms



3.1 The aggregate demand channel

This channel reflects the traditional interest rate mechanism. Essentially, the policy rate affects the real interest rate, thereby affecting inter-temporal consumption and investment decisions. Changes in consumption and/or investment alter the output gap, which then affects inflation via the price equation. According to our estimates, an increase of the real interest rate negatively affects the output gap with a lag of two (2) quarters. A positive output gap has a positive effect on inflation after four (4) quarters.

3.2 The exchange rate channel

In open economies, the exchange rate affects inflation directly and indirectly. The exchange rate has a direct effect on inflation through the price of imports in domestic currency that, according to our estimates, takes place after 2 quarters. It also has an indirect effect through the aggregate demand: an increase of the exchange rate widens the output gap with 3 lags, implying pressures on inflation. An increase in the policy rate today increases capital flows, which tends to appreciate the real exchange rate, but as the economy returns to equilibrium--- in a flexible regime---agents expect the exchange rate to depreciate (UIP).

3.3 The expectations channel

The model incorporates agents' expectations via forward-looking terms in all equations. Current inflation in the price equation is affected by expected inflation, which has a larger weight on inflation today than past inflation as suggested by our estimates. Future inflation also affects the determination of the real interest rate, and expected nominal exchange rate is a determinant of the exchange rate today. The expected output gap affects the output gap today, which implies that policy actions that impact the output gap tomorrow also alter the output gap today.

For simplicity, the credit channel is not incorporated in this framework. In future developments, we may include the effect of changes in the credit supply following Nelson (2001), for example, by incorporating a money aggregate in the aggregate demand function to include effects that, due to market imperfections, are not captured by short term interest rate.

4. Simulation Exercises

In this section we examine the response of the main variables in the model to alternative shocks. We consider the following shocks: a transitory increase in the policy rate, a transitory increment of public expenditure, and the effect of lowering the inflation target under different preferences of the central bank authority and degrees of credibility.

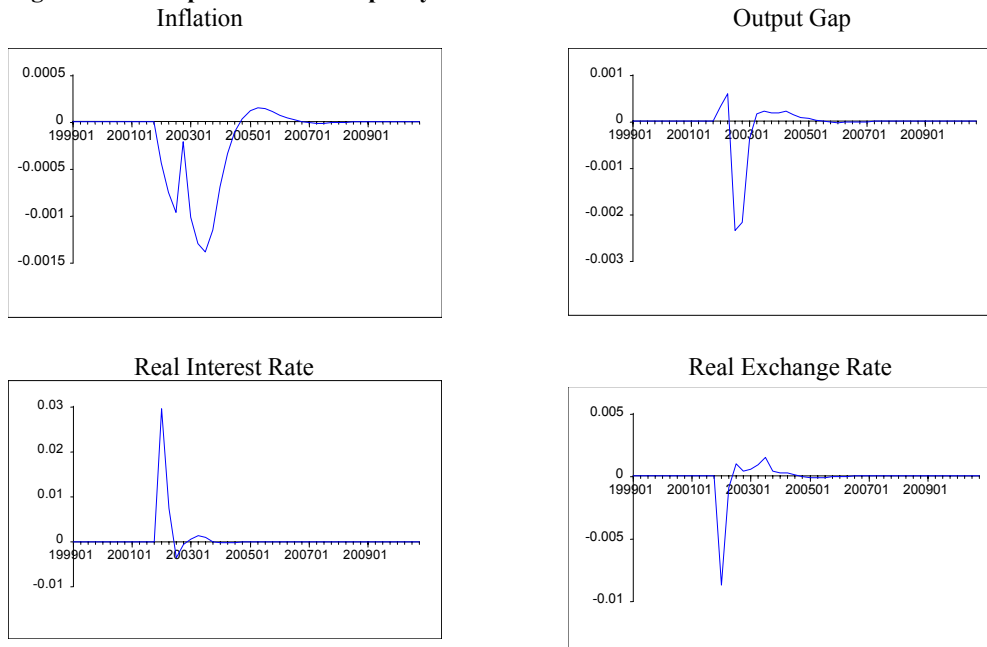
Our benchmark simulations use the following values for the policy rule:

$\theta = 0.6, \lambda_0 = 0.5, \lambda_1 = 1.5, j=2$ for output and $j=6$ for inflation. This implies that the rule is a forecast-based flexible inflation targeting. We also take $\mu = 1$ in the expectations equation, which implies no credibility, that is, the target does not affect inflation expectations at all.

4.1 A shock in the policy rate

Here we consider an increase of 100 bp in the policy rate for one quarter, letting the policy rule operate thereafter. The results are displayed in Figure 2.

Figure 2. A 100bp increase in the policy rate

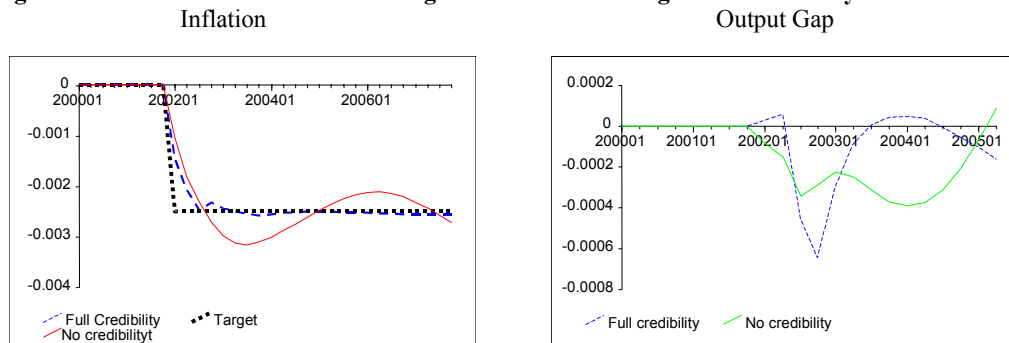


An increase in the policy rate rises the real interest rate, which reduces output (negative output gap), thereby contributing to diminish inflation. The increase in the nominal interest rate also generates an initial appreciation of the exchange rate that reduces the domestic currency price of imports and also net exports, which further shrinks output and inflation. The decrease of inflation reaches its maximum effect after 5 quarters and the largest drop in the output-gap is observed after 3 quarters. The effect in inflation lasts longer than the effects on output. Notice though, that both effects are rather small in magnitude.

4.2 Change in the Inflation Target

In Figure 3 we consider a permanent reduction of 1% in the inflation target with no credibility $\mu = 1$ and with full credibility $\mu = 0$.

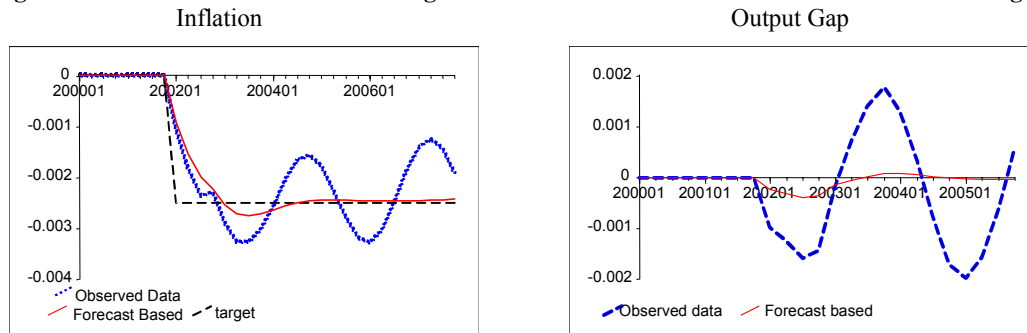
Figure 3. A reduction of the inflation target under different degrees of credibility



We observe from the simulation results that as the central bank gains more credibility, inflation reaches the target faster and with no overshooting. The cost in terms of output of reducing inflation is also smaller with more credibility. With no credibility, the sacrifice ratio (the sum of the output losses) is -0,0024 whereas with full credibility, it falls to -0,0015. Therefore, we may expect that as the central bank increases its credibility the cost of disinflation will fall in time.

In Figure 4 we show the path of inflation and output gap under a forecast based rule vs. a rule using observed data. For the alternative rule we use $j=0$ for inflation and $j=-2$ for the output gap.

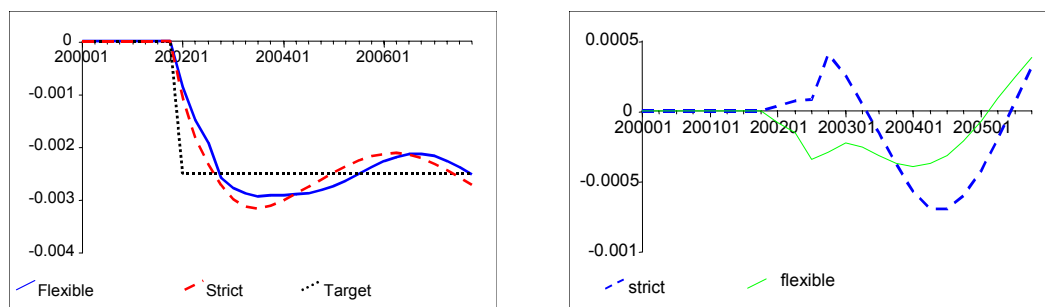
Figure 4. A reduction of the inflation target under a forecast-based rule and a backward-looking rule



This exercise confirms that using future information for the policy rule, i.e. making policy decisions based on forecasts or lead indicators, produces more stable paths for inflation and output than using current or past data on inflation and output.

In Figure 5 we consider alternative preferences for the central bank authority: $\lambda_0 = 0$ and $\lambda_1 = 2.5$, i.e. a strict inflation targeting.

Figure 5. A reduction of the inflation target under strict or flexible inflation targeting

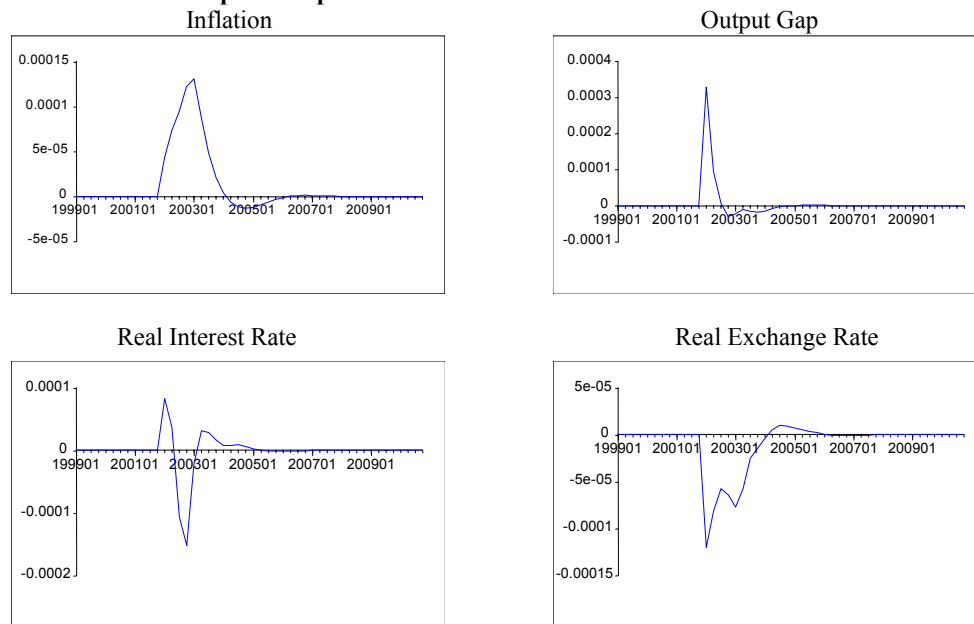


There does not seem to be much difference in the paths of inflation or output whether we set the interest rate rule based on inflation only (strict targeting), or if we set the rule to respond to inflation and output gap (flexible targeting). It only seems that the sacrifice ratio may be marginally lower with the flexible targeting.

4.3 A Shock in public expenditure

Since oil wealth is canalized to the rest of the economy through public expenditure, it is important to analyze its impact. In the following figure we consider a shock of 1% increase in public expenditure that lasts for one quarter.

Figure 6. An increase in public expenditure



The increase in public expenditure generates a positive output gap the quarter after the shock. Inflation increases, reaching a maximum with a lag of 4 quarters. Note that since this model does not capture any effect of public finances on interest rates, the increase in interest rates is a response derived from the policy rule to expected larger inflation rates and future positive output gaps. The rise in interest rates will eventually bring down both, output and inflation. The increase in the interest rates also appreciates the real exchange rate, which further helps to reduce the output gap and thus inflation. The effect of a public expenditure shock on output dies out rather fast, whereas its effects on inflation persist for about 8 quarters. This suggests that the real effects of public expenditure are small and short-lived.

4. Final Comments

In this paper we developed a small-scale macroeconomic model for the Venezuelan economy. We used the model to simulate the impact of different shocks on the path of key variables in the model, mainly inflation and output. In spite of its simplicity, the model captures the essential transmission mechanisms of monetary policy, which is a handy tool for policy makers, as it allows to visualize the effect of policy actions.

We may derive several implications from the simulation exercises. First, disinflation is more costly without credibility. Since the central bank is in a transition period, we expect to increase the degree of credibility over time, so that the temporary reduction of output due to the process of disinflation becomes smaller. The model also reflects the fact that a forecast based rule for the interest rate produces less volatility on output and inflation than a rule based on past information. This is an important result that policy makers should take into account. Having a strict targeting policy versus a flexible one does not seem to produce significantly different results in terms of output and inflation.

This model should be updated continuously, as we get more information. In future developments we may incorporate long run relationships in the aggregate demand and aggregate supply equation, a yield curve, endogenize other variables or do stochastic simulations. Our economy has suffered structural changes in the last decade, which may explain the non-significance of long-term relationships in the equations, so far, but we hope that in the future we will be able to include them.

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