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Optimal Monetary Rules: The Case of Brazil

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Abstract

Within a dynamic programming approach we derive an optimal rule for the central bank to attain it's inflation targeting goals. The short-run nominal interest rate is used as an instrument to achieve monetary objectives. The model is tested for the Brazilian economy and compared with results found for other countries. Evidence for the estimated feedback interest rule for the Central Bank suggests that the cost of reducing inflation in an open economy is lower than that of a closed economy.

JEL Classification: E43, E52.
Keywords: optimal Taylor rule, monetary policy, inflation targeting.

Resumo

Através de técnicas de programação dinâmica derivamos uma regra ótima para o Banco Central atingir suas metas de inflação. A taxa nominal de juros é utilizada como instrumento para atingir os objetivos de política monetária. O modelo é testado para a economia brasileira e comparam-se os resultados com encontrados para outros países. Evidência para regra de *feedback* encontrada sugere que os custos de reduzir a inflação em economias abertas é menor do que em economias fechadas.

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1. Introduction

Recently, several countries have been adopting a target inflation framework for monetary policy. New Zealand, Canada and United Kingdom have decided to employ an inflation targeting framework in the conduit of monetary policy and have successfully reduced their inflation rates and gained control on inflation[1]. It is often argued that an independent central bank is a key element for a successful monetary policy. The good performance in the maintenance of low inflation rates that the National Bank of Switzerland and the Bundesbank have had is mainly attributed to their high level of independence, and it has certainly strongly influenced the position of the system of European central banks toward an independent central bank.

Following this trend, other countries (e.g. Chile, Mexico, Argentina, Spain and France) have been granting a greater independence for their central banks allowing them to conduce monetary policy with much less government interference. The main goal is price stability and a common point among these countries has been the adoption of an inflation targeting framework. In Brazil, since mid-1999, six months after abandoning the fixed exchange rate regime, the Central Bank of Brazil has adopted an inflation targeting regime for the conduit of monetary policy.

The main purpose of this paper is to derive an optimal feedback rule based on the model proposed by Ball (1998) and to estimate a short run reaction function for interest rates for Brazil, for an open economy. The main assumption is that interest rates are the central bank's main instrument to reduce inflation and the level of activity.

Normally, models estimating IS-AS-type models use OLS regressions. In this paper we derive an optimal feedback rule and use the estimated coefficients from IS-AS equations to find an empirical relation between central bank's instrument and macroeconomic variables such as inflation, output gap and exchange rates. We suggest the use of two stage least squares using adequate instrumental variables to estimate these equations to overcome problems inherent to the nature of Brazilian macroeconomic variables[2]. We also compare our results with those found in the literature.

The plan of the paper is as follows. In the first section we derive a Taylor rule for the Brazilian economy. Section two presents empirical results. In the last section we conclude and give directions for further research.

2. The model

In this section an optimal monetary rule is derived for the Brazilian economy. We use the following IS equation:

$$y_{t+1} = a_1 y_t - a_2 i_t + a_3 e_t + u_{t+1} \qquad (2.1)$$

where y_t stands for the output gap, i_t is the real interest rate, e_t is the real exchange rate,

[1] For an interesting analysis of inflation targeting see Walsh (2001).

[2] Using instrumental variables for the terms containing lagged inflation is crucial because these terms are correlated with the residuals.

and u_t is a demand shock, assumed to be normally distributed.

The supply curve is represented by the traditional Phillips curve:

$$p_{t+1} = p_t + g\, y_t + m(e_t - e_{t-1}) + h_{t+1} \qquad (2.2)$$

where p_t is the inflation rate, Δe_t is the depreciation rate in the nominal exchange rate and h_{t+1} is the supply shock not correlated with u_{t+1}.

The policy maker chooses in instant t the interest rate i_t, and the state variable in instant t is:

$$z_t = g\, y_t + p_t + m\left(e_t - e_{t-1}\right) \qquad (2.3)$$

The optimal feedback rule will be given by:

$$q_t = X z_t \qquad (2.4)$$

where

$$q_t = a_1 y_{t_t} + a_2 i_t + m e_t \qquad (2.5)$$

Equations (1) and (2) can be rewritten as:

$$y_{t+1} = q_t + u_{t+1} \qquad (2.6)$$

and

$$p_{t+1} = z_t + h_{t+1} \qquad (2.7)$$

We assume that the central bank's loss function is given by:

$$L = \frac{1}{2} E_t \sum_{i=1}^{\infty} b^i \left[l\, y_{t+1}^2 + p_{t+1}^2 \right] \qquad (2.8)$$

The objective of the policy maker is to minimize this loss function subject to:

$$z_{t+1} = z_t + g q_t + h_{t+1} + g u_{t+1} \qquad (2.9)$$

Define the value function as:

$$V(z_t) = \min\ E_t \left[\frac{1}{2} (l y_{t+1}^2 + p_{t+1}^2) + b V(z_{t+1}) \right] \qquad (2.10)$$

replacing (2.6), (2.7) and (2.9) in the value function we obtain:

$$V(z_t) = \min_{q_t} \begin{Bmatrix} \frac{1}{2} l\, E_t(q_t + u_{t+1})^2 + \frac{1}{2} E_t(z_t + h_{t+1})^2 + \\ b\, E_t V(z_t + g q_t + u_{t+1} + g h_{t+1}) \end{Bmatrix} \qquad (2.11)$$

Solving problem (2.11) with respect to q_t gives the first order condition:

$$l\, q_t + g b V_z E_t(z_{t+1}) = 0 \qquad (2.12)$$

Applying the envelope theorem with respect to z_t obtains:

$$V_z(z_t) = z_t + b V_z E_t(z_{t+1}) \qquad (2.13)$$

Multiplying (2.13) by g, substituting in (2.12), taking this expression one-step forward and the expectations

$$E_t V_z(z_{t+1}) = z_t + g q_t - \frac{l}{g} E_t(q_{t+1}) \qquad (2.14)$$

Replacing (2.14) in (2.12):

$$q_t = -\frac{gb}{l + g^2 b} z_t + \frac{b\, l}{l + b g^2} E_t(q_{t+1}) \qquad (2.15)$$

When the policy is established in instant t, z_t is the state variable and thus the optimal policy rule has a quadratic form $q_t = X z_t$. Therefore

$$E_{t+1}(q_{t+1}) = X E_t(z_{t+1}) = X(1 + gX) z_t \qquad (2.16)$$

replacing this expression in (2.15) obtains the following quadratic form:

$$l\, b g X^2 - (l - b\, l + g^2 b) X + g b = 0 \qquad (2.17)$$

Stability requires $|1 + 2g(1 + a)X| < 1$. Hence, the solution for (2.17) is given by:

$$X = \frac{(l - b\, l + g^2 b) \pm \sqrt{(l - b\, l + g^2 b)^2 + 4(g^2 b^2 l)}}{2 b g l} \qquad (2.18)$$

remembering that:

$$z_{t+1} = z_t + g q_t = (Xg + 1) z_t \qquad (2.19)$$

After some algebraic operations the product of the roots is:

$$X_1 X_2 = -\frac{1}{l} < 0 \tag{2.20}$$

The root of interest is the one that satisfies the stability condition, that is the negative root X_2. Finally, replacing X_2 in (2.4) gives

$$q_t = \frac{(l - bl + g^2 b) - \sqrt{(l - bl + g^2 b)^2 + 4(g^2 b^2 l)}}{2bgl} z_t \tag{2.21}$$

We can derive the optimal rule for the interest rate

$$i_t = \frac{a_1 g X_2}{a_2} y_t + \frac{a_3}{a_2} \Delta e_t + \frac{X_2}{a_2} p_t + h \frac{X_2}{a_2} e_t \tag{2. 22}$$

3. Empirical Results

For the econometric analysis we have used quarterly data and our sample begins in the first quarter of 1994 and ends in the last quarter of 2001. All variables are in natural logs. As a proxy for the output gap we have estimated a Hodrick-Prescott filter and used the difference between observed GDP and the filtered series. The inflation rate is given by IPCA. The interest rate is given by SELIC which is the instrument that the central bank uses to achieve it's price stability goals.

According to the results found in table 1 both the lag of the output gap and lagged interest rate are significant in explaining current output gap, and the sign of the coefficients are in line with the expected sign. We used as instruments a dummy for the Russian crisis, three lags for the interest rate and four lags for the government spending.

Table 1. IS equation - Closed Economy

Variables	Coefficients	p-value
y_{t-1}	0.34** (0.1697)	0.04
i_t	-0.06* (0.0117)	0.00
Adjusted R^2 = 77%		

Standard errors are given in parenthesis
* Rejection of the null with 99% confidence
** Rejection of the null with 95% confidence

Table 2 presents empirical results for the Phillips equation. Both lagged output gap and inflation are significant in explaining current inflation. We have used as instruments a dummy for the Russian crisis, six lags for the inflation rate and two lags for government spending.

Table 2. Phillips equation - Closed Economy

Variables	Coefficients	p-value
y_{t-1}	0.34** (0.014)	0.029
p_{t-1}	0.60* (0.023)	0.000
Adjusted R^2 = 90%		

Standard errors are given in parenthesis
* Rejection of the null with 99% confidence
** Rejection of the null with 95% confidence

Applying Augmented Dickey and Fuller tests the null of a unit root for the output gap, interest rates and inflation is rejected. Results for these unit roots are available upon request from the authors.

In order to derive the optimal policy rule for the Brazilian economy we assumed b =0.7 and l =1, which are the intertemporal discount factor and the relative weight of output gap in the loss function. After replacing this parameters and coefficients in table 1 and 2 one obtains

$$i_t = 5{,}5 y_t + 4{,}2 p_t \qquad (3.1)$$

Our results are quite different from those found in Taylor (1993) and Ball (1998) and are more in line with those found in Walsh (1997).

Table 3. Comparison of optimal rules - Closed Economy

Coefficients	y_t	p_t	y_{t-1}
Taylor (1993)	0.50	1.50	-
Walsh (1997)	4.37	1.26	1.59
Authors	5.5	4.2	-
Ball (1998)	0.80	1.46	-

The coefficient on the output gap is similar to that found in Ball (1998), while the coefficient on inflation is much higher than that of the rest, which suggests that the central bank of Brazil has to increase it's interest rates much more than developed countries in order to counterbalance an increase in inflation.

In tables 4 and 5 we present results for an open economy.

Table 4. IS equation - Open Economy

Variables	Coefficients	p-value
y_{t-1}	0.36** (0.168)	0.04
e_{t-2}	-0.04** (0.018)	0.05
i_t	0.06* (0.014)	0.00
Adjusted R^2 = 75%		

Standard errors are given in parenthesis
* Rejection of the null with 99% confidence
** Rejection of the null with 95% confidence

Table 5. Phillips equation - Open Economy

Variables	Coefficients	p-value
y_{t-1}	0.08** (0.05)	0.02
Δe_t	0.07** (0.01)	0.03
p_{t-1}	0.65* (0.038)	0.00
Adjusted R^2 = 64%		

Standard errors are given in parenthesis
* Rejection of the null with 99% confidence
** Rejection of the null with 95% confidence

Replacing the results one obtains the optimal rule:

$$i_t = 5.2 y_t + 0.3 p_t + 0.6 e_{t-1} + 0.2 \Delta e_t \qquad (3.2)$$

To the best of our knowledge, most research on developed countries has estimated different optimal feedback rules, making comparisons more difficult. As we can see, the coefficient on inflation has decreased to 0.3. Thus, the nominal interest rate is increased more than five-to-one with increases in output gap. The cost to reduce inflation seems to be lower in an open economy, which is an argument in favor of commercial liberalization.

4. Conclusions

In this paper we have presented an optimal policy rule for the central bank to achieve it's monetary policy goals, derived using a dynamic programming approach and a dynamic loss function. We estimated IS-AS equations using two stage least squares and fitted an optimal feedback rule for short run interest rates for both a closed and open economy.

We have found that the feedback rule behaves differently from similar rules estimated for developed countries. For the open economy evidence suggests that interest rates needs to raise less than a one-to-one with inflation (while the contrary happens within a closed economy). Thus, it is found that within an open economy the central banks have much more power to reduce inflation than within a closed economy. This issue will be left for further research.

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