PREFERENCES OF THE CENTRAL RESERVE BANK OF PERU AND OPTIMAL MONETARY RULES IN THE INFLATION TARGETING REGIME

Marcelo S. Portugal (UFRGS-Brazil)
Edilean K. da Silva (UFPB-Brazil)
Nilda M. C. Pasca (PUC-RJ-Brazil)

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1 Introduction

- Since the influential study by John B. Taylor (1993), interest rate rules have been commonly used to describe the behavior of monetary policy.
- Theoretically, monetary policy rules can be derived from the solution of a restricted intertemporal optimization problem in which the monetary authority tries to minimize the squared deviations of the objective variables from their respective targets.
- In this theoretical framework, monetary policy rule coefficients are convolutions of economic model parameters that restrict the optimization problem, as well as of parameters describing the monetary authority's preferences.
- As the estimated interest rate rules are just reduced form equations, the estimation of their coefficients do not directly reveal anything about the structural parameters of the monetary policy.

- Thus, a way to shed further light upon monetary policy decisions is by extracting the loss function preference parameters of the policymaker from the estimated interest rate rules.

- Obtaining the estimates for the monetary authority's preferences allows: i) knowledge of the variables that are included in the loss function; and ii) checking whether the economic results can be reconciled with the optimal monetary policy structure.

- The aim of the present paper is to estimate the preferences of the Central Reserve Bank of Peru in the current inflation targeting regime.

- To achieve that, we calibrate the loss function by choosing the preference parameter values from a wide range of alternative policies, which minimize the deviation between the simulated and actual paths of the interest rate.

- Most of the economic literature that seeks to estimate the monetary authority’s preferences and objectives has focused attention on the Federal Reserve.

- Salemi (1995), Ozlale (2003) and Dennis (2006) estimate the Fed’s preferences by ML, while Söderlind et al. (2002) and Castelnuovo and Surico (2003) estimate by means of a calibration exercise. The results obtained by these studies suggest that the Fed has placed considerable weight on interest rate smoothing and given lesser or unsubstantial importance to the output gap during the Volcker-Greenspan period.

- By utilizing a calibration strategy, Collins and Siklos (2004) show that the central banks of Australia, Canada, U.S. and New Zealand can be described as having an optimal inflation target, placing considerable weight on short-term interest rate smoothing and attaching sheer weight on output variability.

- Empirical studies on the preferences of the CRBP:

i) Goñi and Ormeño (2000), using GMM and monetary base as monetary policy instrument, found that the CRBP had a greater preference for inflation stabilization and for exchange rate depreciation.

ii) Bejarano (2001) demonstrated that the CRBP had a larger preference for inflation rather than for output variability.

iii) Rodriguez (2008) found evidence that the implicit inflation target has significantly decreased and that the Peruvian monetary policy may have been efficiently conducted in the last regime (1994:2-2005:4).

2 The theoretical model

Structure of economy

- In this paper, we consider a simple structural macroeconomic model for an open economy with backward-looking expectations. The four equations that form the model are:

$$\pi_{t+1} = \alpha_1\pi_t + \alpha_2\pi_{t-1} + \alpha_3\pi_{t-2} + \alpha_4\Delta q_t + \alpha_5 y_{t-1} + \xi_{\pi,t+1} \quad (1)$$

$$y_{t+1} = \beta_1 y_t + \beta_2 y_{t-1} + \beta_3 r_t + \beta_4 tt_t + \xi_{y,t+1} \quad (2)$$

$$q_{t+1} = q_t + \xi_{q,t+1} \quad (3)$$

$$tt_{t+1} = \gamma_1 tt_t + \xi_{tt,t+1} \quad (4)$$

where π is the annualized quarterly inflation rate, *q* is the nominal exchange rate, *y* is the output gap, *tt* is the terms of trade gap and *r* is the real interest rate. All variables are demeaned.

The Central Bank's problem and the optimal monetary rule

- The monetary authority seeks to choose $\{i_t\}_{t=0}^{\infty}$ so as to minimize:

$$E_t \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau} \qquad (5)$$

with

$$L_t = \lambda_{\pi}(\pi_t^a - \pi^*)^2 + \lambda_y y_t^2 + \lambda_{\Delta i}(i_t - i_{t-1})^2 \qquad (6)$$

subject to

$$X_{t+1} = AX_t + Bi_t + \varepsilon_{t+1} \qquad (7)$$

where δ is the discount rate, $\pi_t^a = (1/4)\sum_{j=0}^{3} \pi_{t-j}$ is the annual inflation, π^* is the inflation target and (7) is the state-space representation of the model (1)-(4).

- The monetary authority's preference parameters λ_{π}, λ_{y} and $\lambda_{\Delta i}$ show the importance attached to inflation stabilization, to the output gap and to interest rate smoothing.

- Solving the optimization problem (4)-(7), the Central Bank determines an optimal monetary rule that can be express by:

$$i_t = fX_t \qquad (8)$$

with $f = -(Q+\delta B^T PB)^{-1}(\delta B^T PA+W^T)$.

- Equation (8) shows that the nominal interest rate at time t is a linear function of the state variable vector, $X_t = [\pi_t \ \pi_{t-1} \ \pi_{t-2} \ \pi_{t-3} \ y_t \ y_{t-1} \ q_t \ q_{t-1} \ tt_t \ i_{t-1}]$.

- The coefficients in line vector f represent the convolutions of the monetary authority's preference parameters (λ_π, λ_y and $\lambda_{\Delta i}$) and the Phillips and IS curve parameters (α's and β's).

- In the current inflation targeting regime, the Peruvian monetary authority has apparently paid a lot of attention to the evolutionary behavior of the exchange rate.

- In the present study, this possibility is contemplated for the following reasons:

  i) the Peruvian currency is partially dollar-pegged;

  ii) monetary authority's interventions in the exchange rate market are believed to have a disguised precautionary motive – accumulation of international reserves to tackle negative external shocks

- Given these aspects, a second exercise was developed, where exchange rate smoothing, , is regarded as the fourth goal of the Peruvian monetary authority. In this case, the loss function is described as

$$L_t = \lambda_\pi(\pi_t^a - \pi^*)^2 + \lambda_y y_t^2 + \lambda_{\Delta i}(i_t - i_{t-1})^2 + \lambda_{\Delta q}(q_t - q_{t-1})^2 \qquad (9)$$

3 Empirical calibration strategy for Central Bank preferences

- In this paper, the calibration strategy used to identify the preferences of the Central Reserve Bank of Peru can be split into four stages:

  1) First, we estimate the parameters of each equation for structural model (1)-(4). These estimates enter system (7) and restrict the monetary authority's intertemporal optimization problem.

  2) We calculate the coefficients for optimal interest rate rule (8) and solve the optimization problem (5)-(7). Since changes in λ_π, λ_y and $\lambda_{\Delta i}$ yield different optimal policy rule coefficients, we solve the optimization problem for a wide array of alternative preferences.

  More specifically, we calculate the optimal policy rule for every possible combination of λ_π and λ_y on the interval [0.001-(1- $\lambda_{\Delta i}$ – 0.001)] in steps of 0.001 for a given value of the $\lambda_{\Delta i}$. We allow the preference parameter $\lambda_{\Delta i}$ to vary on the interval [0-0.95] in steps of 0.05.

3) We replace the values of the state variables observed in each optimal policy rule on a period-by-period basis and we calculate the nominal interest rate optimal path, given by.

4) Finally, we choose the Central Bank's preference values (λ_π, λ_y and $\lambda_{\Delta i}$) which minimize the squared deviation (*SD*) of the actual path from the optimal path of the nominal interest rate, i.e.,

$$SD = \sum_{t=1}^{T} \left[i_t - i_t(\lambda_\pi, \lambda_y, \lambda_{\Delta i}) \right]^2 \qquad (10)$$

- This calibration strategy allows us to obtain 10,480 monetary policy rules and to choose the loss function parameters that minimize the squared deviation of the optimal path from the actual path of the interest rate.

4 Results

Macroeconomic model estimates for Peru

- We estimate Phillips, IS and Terms of trade curves, shown in equations (1), (2) and (4), by using quarterly data for the 1999:1-2008:2 period. The variables used are:

  i) inflation rate (π_t): is the annualized quarterly inflation rate, measured by the consumer price index of the metropolitan region of Lima;

  ii) output gap (y_t): is the percentage difference between the quarterly seasonally adjusted real GDP, through X-Arima12, and the potential output obtained by the Hodrick-Prescott filter;

  iii) nominal interest rate (i_t) and real interest rate (r_t) : variable i_t is the annualized interbank nominal interest rate used as proxy for the monetary policy rate. Variable r_t is obtained from the difference between the nominal interest rate and the inflation rate;

iv) terms of trade gap (tt_t): is the percentage difference between the terms of trade index with the respective potential obtained by the Hodrick-Prescott filter;

v) nominal exchange rate (q_t) and nominal exchange rate depreciation (Δq_t) : variable q_t is calculated as 100ln(Q_t) where *ln* denotes the natural logarithm and Q_t is the quarterly mean of the monthly exchange rate, measured as the mean selling exchange rate for the period. Variable Δq_t is the percentage variation in the nominal exchange rate.

- Two dummy variables were included in the IS curve equation

i) the first dummy, ($d_{y,1}$ = 1 for 1999:04 and 0, otherwise), was inserted to capture the largest growth observed in domestic demand driven by increased private consumption in the fourth quarter of 1999

ii) The second dummy, ($d_{y,2}$ = 1 for 2002:02 and 0, otherwise), was inserted to capture the largest dynamism shown by the non-primary sector, increase in credit lines in the financial sector, and improvement in consumers' expectations, which stimulated economic activity in the second quarter of 2002.

- Two dummy variables ($d_{tt,1}$ = 1 for 2006:02 and 0, otherwise) and ($d_{tt,2}$ = 1 2007:02 and 0, otherwise) were added for the terms of trade equation in order to capture the large growth of the terms of trade due to an increase in export prices relative to import prices, corresponding to an increase in the price of metals such as copper, gold, zinc, among others.

- The Phillips, Terms of trade and IS curves was estimated by OLS and SUR. Given that different estimation methods yielded very similar results, the Table 1 shows only the OLS estimates.

Table 1
Parameter Estimate for the Macroeconomic Model

Phillips Curve		*IS Curve*		*Terms of Trade Curve*	
α_1	0.5839[a] (0.1572)	β_1	1.0295[a] (0.1517)	γ_1	0.7408[a] (0.0912)
α_2	-0.0391[ns] (0.1888)	β_2	-0.2797[c] (0.1526)	γ_2	11.771[a] (2.8537)
α_3	0.0456	β_3	-0.0653[ns] (0.0432)	γ_3	8.0182[a] (2.8849)
α_4	0.4096[a] (0.1243)	β_4	0.0561[d] (0.0339)		
α_5	0.3715[c] (0.2200)	β_5	3.3175[a] (1.0730)		
		β_6	2.4195[b] (1.0642)		

Notes: [a] Significant at 1%, [b] Significant at 5%, [c] significant at 10%, [d] significant at 11%, [ns] Non-significant.

- Results:

  i) in the Phillips curve, all the parameter estimates had the expected sign, but the second lag of inflation had a negative but statistically nonsignificant sign;

  ii) the coefficient that measures the impact of the output gap on inflation is significant. This result shows the key role of the output gap on inflation, acting as an important mechanism for the transmission of monetary policy;

  iii) the parameter estimate for the shift in the exchange rate regime suggests that, *ceteris paribus*, an increase by 1 percentage point in the nominal exchange rate depreciation implies an increase of around 0.41 percentage points in annualized inflation;

  iv) with regard to the IS curve equation, the lag coefficients of the output gap and of the terms of trade lagged one period were statistically significant. On the other hand, the coefficient of the real interest rate was not statistically significant.

Central Bank preferences

- To start the calibration process, we chose the parameter estimates of the macroeconomic model obtained by OLS and we assume that the discount factor, δ, is equal to 0.98.

- The results indicate that the loss function parameters that minimize the squared deviation between the optimal path and the actual path of the interest rate are λ_{π}=0.699, λ_{y}=0.001 and $\lambda_{\Delta i}$=0.3.

- This demonstrates that the CRBP has adopted a flexible inflation targeting regime and placed a heavier weight on price stability than on output gap stability.

- Moreover, we perceived that the monetary authority's concern with interest rate smoothing has been far deeper than with output stability.

- An interesting second exercise to be considered in the calibration process consists in knowing whether the CRBP has demonstrated any preference for nominal exchange rate smoothing.

- The results indicate that the loss function parameters (9) that minimize the squared deviation between the optimal path and the actual path of the interest rate are $\lambda_{\pi} = 0.68$, $\lambda_{y} = 0.01$, $\lambda_{\Delta q} = 0.01$ and $\lambda_{\Delta I} = 0.3$.

  The results found reveal that:

  i) the order of preference for inflation and interest rate smoothing has been maintained;

  ii) exchange rate smoothing has not played an important role in the CRBP's loss function.

Optimal monetary policy rule

- The parameter estimates of the macroeconomic model and of the loss function imply that the optimal monetary policy is given by:

$$i_t = 0.11\pi_t + 0.03\pi_{t-1} + 0.01\pi_{t-2} + 0.00\pi_{t-3} + 0.35y_t - 0.06y_{t-1} + 0.05\Delta q_t + 0.08tt_t + 0.76i_{t-1}$$

- This policy rule indicates that the nominal interest rate responds contemporaneously to changes in the inflation rate, output gap, terms of trade gap and exchange rate fluctuations.

- The monetary authority also responds to the lagged values of the inflation rate and of the output gap, although this response is weaker for inflation and for the output gap at time t.

- Another important result is concerned with the high value obtained for the autoregressive interest rate coefficient (0.76), which demonstrates the Peruvian monetary authority's concern with smoothing the interest rate.

- The optimal policy rule in the long-run, which is given by:

$$i = 0.595\pi + 1.199y + 0.225\Delta q + 0.346tt$$

- The results indicate that the long-term monetary rule responds strongly to the output gap, i.e., an increase of one percentage point in the output gap raises the interest rate by 1.199 percentage points

- However, an increase of one percentage point in the inflation rate pushes the interest rate up by 0.595 percentage points.

- The latter result shows that the Taylor (1993, 1998) principle is not satisfied.

- This result should be viewed with caution given that, in the case of a small open economy like that of Peru, other important variables in addition to output and inflation are taken into account in establishing the monetary rule (such as terms of trade and exchange rate depreciation).

Optimal path versus the actual path of the interest rate

- Figure 1 shows the optimal path of the interest rate associated with the Central Bank preferences obtained by the calibration strategy (*TXJO*) and the actual path of the interest rate (TXJ).

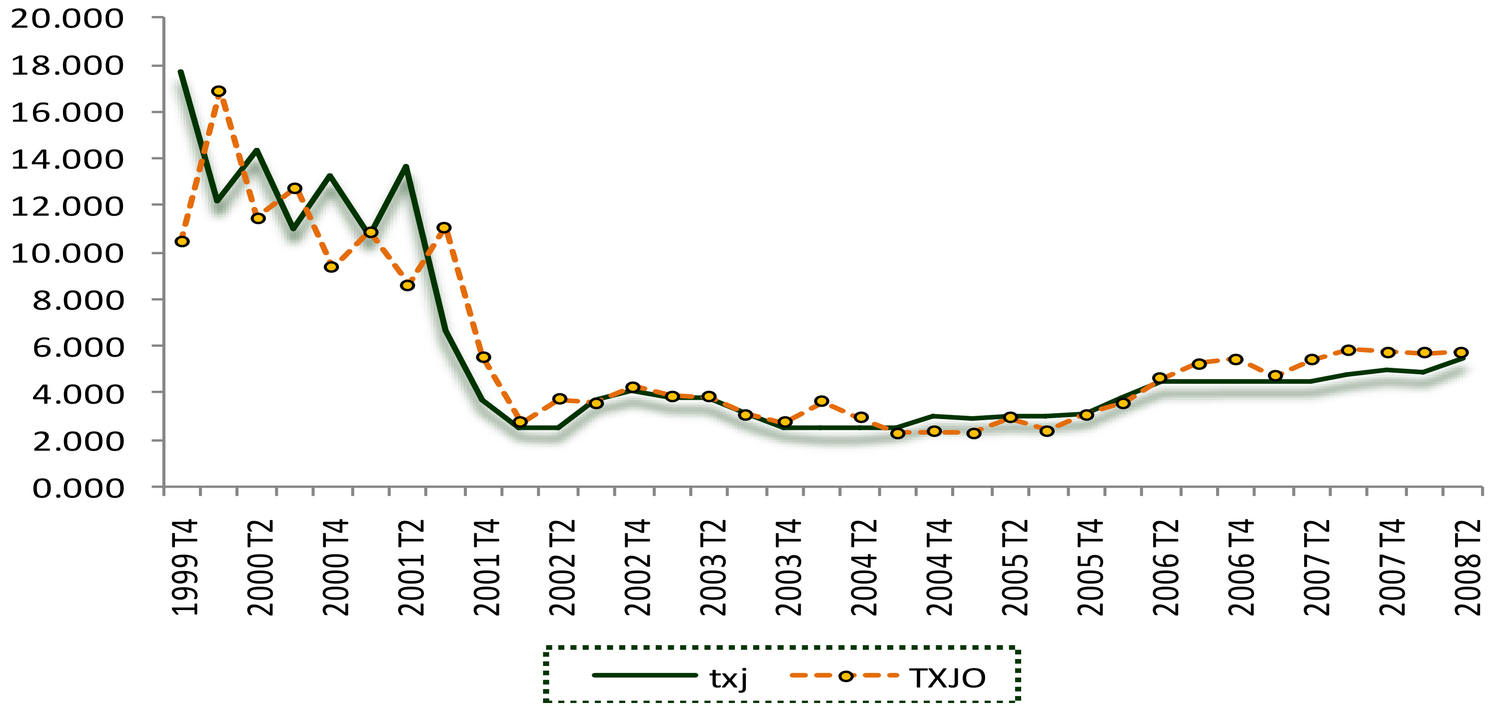

Figure 1 - Observed Interest Rate (TXJ) versus Optimal Interest Rate (TXJO)

- Some discrepancies between *TXJ* and *TXJO* can be observed. For example, the monetary authority with calibrated weights may have maintained the interest rate lower than the observed interest rate for the second and fourth quarters of year 2000 in response to lower expectations of exchange rate depreciation and inflation during that period.

- Another important difference arises between the second half of 2001 to the first half of 2002, when the monetary authority could have adopted an expansionary behavior to keep tabs on the marked deceleration of the inflation rate in that period.

- However, it is important to note that the observed interest rate increased at a slower pace than did the interest rate predicted by the optimal rule associated with calibrated weights.

- After 2002, the optimal path for the interest rate was very close to that of the observed interest rate. Despite that, some minor inconsistencies can be encountered after the second quarter of 2006, when the optimal interest rate is above the observed interest rate, reaching a maximum difference of 104 basis points in the third quarter of 2007.

- This piece of evidence suggests that the monetary authority with an optimal behavior could have maintained a more contractionary monetary policy in order to overcome the adverse outcomes of the macroeconomic environment, brought about by the strong dynamism of domestic demand and of substantial increases in international prices (food and fuel)

Comparison with alternative weights for the loss function

- We compare the monetary policy rule obtained from calibrated weights for the loss function with the rules associated with different weights. Table 3 summarizes the characteristics of the analyzed cases.

Table 3
Weights used in the CRBP's loss function

	Cases	λ_π	λ_y	λ_i
1.	Strict inflation targets (King, 1997)	1.0	0.0	0.0
2.	Flexible inflation targets (Rudebusch and Svensson, 1999)	0.4	0.4	0.2
3.	**Calibrated weights**	**0.699**	**0.001**	**0.30**
4.	Bechmark 1	0.5	0.5	0.0
5.	Bechmark 2	0.001	0.099	0.90

- Table 4 shows the optimal monetary rules for the five cases described above.

Table 4
Short- and long-term optimal monetary rules for different weights on the CRBP's loss function

	Case 1	Case 2	Case 3	Case 4	Case 5
Short-term optimal monetary rule					
ω_1	51.141	0.142	0.107	2.170	0.011
ω_5	65.837	0.515	0.346	14.233	0.039
ω_7	35.222	0.062	0.053	0.789	0.005
ω_8	2.885	0.135	0.082	1.592	0.014
ω_9	-2.613	0.677	0.763	-1.110	0.920
DQ	1.703E+06	171.97	161.43	21263.00	184.512
Long-term optimal monetary rule					
θ_1	16.010	0.600	0.595	1.619	0.191
θ_2	23.960	1.197	1.199	4.829	0.360
θ_3	9.748	0.192	0.225	0.374	0.061
θ_4	0.798	0.417	0.346	0.754	0.177

Figure 2 - Observed Interest Rate versus Optimal Interest

- Even though the visual inspection of optimal paths for the interest rate is informative, it is not necessarily conclusive.

- Because of that, we used the encompassing test proposed Chong and Hendry (1986). On this test, we specify the path of the interest rate resulting from the calibrated weights (case 3) vis-à-vis each of the four sets of weights shown in Table 3.

- We estimate the regression $i_t = \phi_1 i_t^* + \phi_2 i_t^{**} + e_t$, where *i** is the interest rate predicted by the calibrated weights and *i*** is the interest rate predicted by the opposing case. We discriminate between i* and i** using Wald statistics to test the null hypotheses H*:ϕ_1=1,ϕ_2 =0 and H**:ϕ_1=0,ϕ_2 =1.

- If the hypothesis H* is not rejected and the hypothesis H** is rejected, we say that the interest rate predicted by the calibrated weights predominates over the interest rate predicted by the opposing weights.

- The results of the encompassing tests are shown in Table 5.

Table 5
Comparison test for different optimal monetary rules: case 3 versus other cases

Cases	H*	H**
$i_t = \varpi_1 i_t^* + \varpi_2 i_t^{**} + \varepsilon_t$		
Calibrated weights versus strict target π	**0.1767**	175896.30
	(0.8388)	(0.0000)
Calibrated weights versus flexible target π	0.0423	1.1223
	(0.9587)	(0.3376)
Calibrated weights versus Bechmark 1	**0.0438**	2162.65
	(0.9572)	(0.0000)
Calibrated weights versus Bechmark 2	**0.0063**	2.3669
	(0.9937)	(0.1095)

- The weights of a strict inflation target are dominated by calibrated weights.

- The test confirms what the monetary authority did not use a zero weight for interest rate smoothing on the loss function (Bechmark 1).

- When calibrated weights are compared with that of the central bank which attached more weight upon interest rate smoothing, dominance is only observed at a significance level greater than 11%.

- The dominance of calibrated weights over those used for the flexible inflation rates (Svensson and Rudebusch (1999) is only considered at a significance level greater than 34%.

- Nevertheless, using the squared deviation obtained from the calibration exercise, it is possible to conclude that the CRBP conducted a monetary policy by giving preference to inflation stabilization.

5. Conclusions

- This paper aimed to shed further light upon the Peruvian monetary policy in the inflation targeting regime by way of calibration of Central Bank preferences.

- Our results show that the Central Reserve Bank of Peru has conducted a monetary policy that prioritizes inflation stabilization, but without disregarding gradualism in interest rates.

- On the other hand, concern over output stabilization has been minimal, revealing that the output gap has been important because it contains information about future inflation and not because it is considered a variable goal in itself.

- When the smoothing of the nominal exchange rate is considered in the loss function of the monetary authority, the rank order of preferences has been maintained and the smoothing of the exchange rate proved insignificant.

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