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New macroeconomic consensus and inflation targeting: Monetary Policy Committee directors' turnover in Brazil

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Abstract

The main objective of this paper is to estimate a Central Bank reaction function that accounts for the effects of directors' rotation of the Brazilian COPOM (Monetary Policy Committee). The reaction function proposed is assumed to be the mechanism for inflation targeting policy. It accounts for the COPOM rotation to examine COPOM's policy credibility. The empirical analysis use monthly data from 2001 to 2008 to estimate a structural vector auto-regression (SVAR) in order to learn about the long run effects. The SVAR results suggest that the turnover of the COPOM board of directors affects inflation expectation and interest rate of the Brazilian economy in the long run. This means that the turnover causes economic agents to increase their expectations about inflation, resulting in increases of the rate of change of the interest rate level. This break in credibility leads to an additional cost to society through higher future interest rates to be paid by government bonds.

JEL classification: E52; E58

Keywords: Monetary policy; New consensus macroeconomics; Interest rates; Central Bank

Resumo

A política de metas de inflação tem sido implementada em vários países para atingir estabilidade de preços. No entanto, a literatura aponta que a rotatividade dos dirigentes do Banco Central interfere nas decisões sobre as metas e seus vieses. Assim, este trabalho estima o efeito da rotatividade dos diretores do Comitê de Política Monetária (COPOM) sobre a determinação da taxa de juros, utilizada como instrumento para atingir as metas de inflação no Brasil, com dados mensais de 2001 a 2008. Então, um modelo de vetores auto-regressivos estruturais (SVAR) é estimado para a economia brasileira. Além disso, a análise empírica inclui testes exogeneidade em bloco, funções impulso-resposta e decomposição da variância. Os resultados indicam significância para a variável rotatividade dos diretores no longo prazo que leva os agentes a aumentarem suas expectativas de aumento da taxa de inflação

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demandando aumentos maiores da taxa de juros da economia. Esta quebra de credibilidade da politica monetária devida ao aumento das mudanças na diretoria do COPOM leva a aumentos maiores no longo prazo da taxa de juros a serem pagas nos títulos do tesouro. Em resumo, causa um aumento no custo social da economia.

Palavras chave: Política Monetária; Novo Consenso Macroeconômico; Taxas de Juros; Banco Central

1. Introduction

Since July 1999, Brazil has adopted inflation targeting as its monetary policy regime. This policy uses the nominal interest rate as a mechanism to affect real and nominal economic variables. The COPOM (Monetary Policy Committee) focuses on nominal interest rate to control future expectations about inflation and, thus, achieve price stability and control inflation. By announcing its inflation target range, they believe that the interest rate policy will not cause expectations to go wild and, thus, lose control of the inflation target. This mechanism of controlling expectations, in our view, depends upon COPOM members' permanence in their positions in order for the monetary policy to have credibility. The replacement of COPOM members may lead economic agents to see as a weakening of the inflation target policy[1] and, thus, inflation may not converge to the expected rate proposed by the previous COPOM members.

This paper examines this proposition by verifying the importance of COPOM directors' turnover for inflation target policy. This paper also investigates the role played by variables like output gap, inflation target level, rate of change in inflation, and output gap expectations for the inflation target policy in Brazil. The empirical analysis brings as innovation the use of SVAR-Structural Vector Auto Regression, which is a technique that is able to account for causality.

The COPOM inflation target policy follows a theoretical model known as *dynamic stochastic general equilibrium (DSGE)*. This model is based on Gali (2008) and Woodford (2008), as well as the contributions made by Goodfriend and King (1997), McCallum (1999, 2001, 2005), Clarida et al. (1999), Meyer (2001) and Goodfriend (2004, 2005). The model contains a reaction function that supposedly combines key macroeconomic variables that enables policy makers to set interest rate level. This paper focuses on this reaction function by adapting it to consider the turnover of COPOM members.

In addition to this introduction, the paper is divided into six sections: Section 2 is the theoretical framework; Section 3 exhibits some empirical evidence on the estimation of the reaction functions; Section 4 presents the empirical methodology; Section 5 discusses the econometric results; and, finally, Section 6 outlines final considerations.

2. Monetary policy rules in the new macroeconomic consensus

The new macroeconomic consensus, which provides tools for many Central Banks worldwide, is formally described in the pioneering work of Clarida et al. (1999) together with improvements made by McCallum (1999, 2001, 2005), Meyer (2001) and Arestis and Sawyer (2002a,b,c, 2006). This new consensus also includes reasoning from open economy models and monetary policy rules, as discussed in Arestis (2007) and Angeriz and Arestis (2007). According to Meyer (2001), this new consensus is represented by a dynamic model with three equations. This set of equations is flexible enough to accepted new formulations like ours without losing its main characteristics and objective of a Central Bank's reaction function. In this way, equations may differ in the number of variables or the number of lags used, however the model remains essentiality the same. The three equations of the consensus model are (i) an equation of aggregate demand; (ii) a Phillips curve, and (iii) a Monetary Policy Rule. The first equation follows the structure of the traditional IS curve with the difference that it comes from an intertemporal optimization framework. It relates product responses to changes in the real interest rate. The second equation is the relative price adjustment, which specifies the behavior of inflation in response to variations in production capacity and expectations; and, finally, the third equation is a monetary policy rule similar to the one in Meyer (2001).

We start with the model developed by Clarida et al. (1999) because it is the specification that provides the foundation for this new monetary arrangement. This model's main proposition is that monetary policy plays a key role

[1] Cukierman (1992).

in determining short-term economic activity by advocating the presence of temporary nominal price rigidities as in the traditional IS-LM model. Therefore, the model is based on a dynamic general equilibrium framework with money and temporary nominal rigidities in prices. The final equations to be presented are obtained by solving the process of optimizing decisions of firms and consumers.

Formally, defining π_t as the inflation rate in period t and i_t the nominal interest rate, the behavior of the economy can be represented by two equations, one on the demand side, called the IS curve, and the other on the supply side, the Phillips curve.[2]

$$x_t = -\varphi(i_t - E_t\pi_{t+1}) + E_t x_{t+1} + g_t \tag{1}$$

$$\pi_t = \lambda x_t + \beta E_t\pi_{t+1} + u_t \tag{2}$$

where π_t is the inflation rate at period t, defined as the percentage change in the price level between $t-1$ and t; x_t is the output gap; $E_t\pi_{t+1}$ is the expected inflation rate at period t over $t+1$ inflation; $E_t x_{t+1}$ is the expected output gap at t over period $t+1$ output gap; R_t is the short-run nominal interest rate. In Addition, g_t and u_t are errors terms obeying the following structures, respectively:

$$g_t = \mu g_{t-1} + \hat{g}_t \tag{3}$$

$$u_t = \rho u_{t-1} + \hat{u}_t \tag{4}$$

$0 \leq \mu, \rho \leq 1$, g_t and u_t are independent and identically distributed random variables (*i.i.d*), with mean zero, variances σ_s^2 and σ_u^2, respectively.

The main characteristic of this new IS curve is the dependence of aggregate demand with respect to changes in expectations about the product and the interest rate. Therefore, an expected increase in the output would raise current output because individuals will prefer to smooth future consumption. However, the negative effect of the increase in the interest rate would occur from agents' intertemporal substitution between consumption and savings. That is, a rise in the interest rate can raise the level of savings at the expense of present consumption.

The Phillips curve in Eq. (2) is derived from an explicit optimization problem in a context of monopolistic competition, in which each firm sets its price level subject to future adjustments. The main difference of this proposition in relation to the original Phillips curve is the inclusion of the variable regarding future expected inflation rate, $E_t\pi_{t+1}$. So, this is a forward looking process instead of the traditional backward looking process, $E_{t-1}\pi_t$. Also, note that the coefficient of the output gap is decreasing in the degree of rigidities in prices and u_t represents possible supply shocks.

To close the model specification we need a core equation that determines interest rate, which is in our case the COPOM reaction function. In the model proposed by Clarida et al. (1999) there is an innovation in relation to the traditional Taylor Rule (1993). More precisely, inflation expectation is explicit and a forward-looking process.

$$i_t^* = \alpha + \gamma_\pi(E_t\pi_{t+1} - \bar{\pi}) + \gamma_x x_t. \tag{5}$$

As highlighted by the authors, this monetary policy rule responds to the expected inflation rather than to past inflation. The innovation makes it more consistent with the overall model represented by Eqs. (1)–(4). Hence, Eq. (5) is the focus of our next section and of our empirical work.

3. Empirical evidence on reaction functions estimates

A seminal work about monetary policy rules with inflation targeting is Taylor (1993). It highlights the determination of the interest rate as a monetary instrument to achieve the inflation target. According to the author, policymakers should identify relevant variables for the economy's price stability. By managing the interest rate in response to changes in these variables, policymakers would achieve price stability in the economy. The first estimates made by Taylor (1993) considered a simple linear reaction function that expressed the behavior of interest rates. His estimates for the United States for the period 1987–1992 had as main characteristic explaining variables like the deviation of inflation from its

[2] According to the authors, Eq. (2) comes from the identity $Y_t = C_t + G_t$, where C_t and G_t are household consumption and government expenditures, respectively. Then, it can be written as a log-linear Euler equation to consumption: $Y_t - e_t = -\varphi(i_t - E_t\pi_{t+1}) + E_t(y_{t+1} - e_{t+1})$ such that $e_t = -\log(1 - G_t/Y_t)$ comes exogenously. After that, taking an output gap definition and making $g_t = (\Delta Z_{t+1} - \Delta e_{t+1})$ result in Eq. (2).

equilibrium value (or target), and the deviation from real output relative to its potential level. The proposed function was:

$$i_t = \pi_t + r^* + 0.5(\pi_t - \pi*) + 0 + 0.5(y_t), \tag{6}$$

where i_t is the Federal Funds interest rate; $r*$ is the equilibrium real interest rate; π is the inflation rate (from GDP deflator); $\pi*$ is the inflation target; and y is the percentage deviation of real output in relation to the potential output (output gap).

The author's empirical results show that the predicted interest rate was a close approximation to the actual interest rate in the U.S. economy for the period 1987–1992. Note that Taylor points to a target or equilibrium inflation rate of 2%. The U.S. Federal Reserve (Fed) would respond to deviations from the actual inflation rate from the equilibrium level of 2% and to deviations of output based on a backward-looking process. Despite his notorious contribution, the Taylor's Rule (1993) lacked variables that account for future expectations about inflation and output. To address this deficiency, several studies have modified slightly the Taylor's reaction function.

Among the pioneering works, Judd and Rudebush (1998) estimated a reaction function for the Fed during three different institutional presidents.[3] The purpose of work was to evaluate the hypothesis that the turnovers of central bank presidents might also influence monetary policy. Their first estimate was of Taylor's reaction function in order to use it as baseline. As expected, this function did not adhere well to the overall data sample. It means that each one of the Central Bank administration had its own way of conducting monetary policy. To adjust the reaction function to capture such change in administration, the authors assumed that the authorities did not react instantaneously to economic changes. This assumption led the authors to propose the following reaction function specification

$$\Delta i_t = \gamma\alpha - \gamma i_{t-1} + \gamma(1+\lambda_1)\pi_t + \gamma\lambda_2 y_t + \lambda_3 y_{t-1} + \rho\Delta i_{t-1}. \tag{7}$$

Lagged interest rate and its change (i_{t-1}, Δi_{t-1}) and the output gap (y_{t-1}) were added to the new function in order to capture past behavior or the autoregressive process of the interest rate. By using OLS – Ordinary Least Squares estimates the results obtained by the authors showed to be different from the Taylor model. For the period Greenspan, the coefficient of the lagged output gap was not significant. However, as expected the lagged interest rate did show to be significant. The coefficient estimate of 0.42 led to the conclusion that the monetary policy conducted indeed obeyed a more gradual process. Thus, the monetary policy conducted was more smoothing than in previous periods. The results also reinforced that each administration had its own monetary policy conduct. In other words, there is no single rule for all administrations. Although the changes did not affect the Central Bank credibility since price stability was guaranteed; it, however, demanded from agents' new learning on the execution of the monetary policy for each administration. Do the change cause any extra cost to society in terms of high interest rates? Unfortunately, their study does not answer this question.

A broader research conducted by Clarida et al. (2000) focuses on evaluating the monetary policy before and after Paul Volker (the breaking period was 1979). They propose a reaction function that considers the deviation from expected inflation or the interest rate deviation from a target one. Though not formally assumed in their paper, this can be seen as a way of comparing the Central Bank's Credibility in the two periods. The reaction function specification follows a linear relationship:

$$r_t^* = r^* + \beta\left(E\left\{\frac{\pi_{t,k}}{\Omega_t}\right\} - \pi^*\right) + \gamma E\left\{\frac{X_{t,q}}{\Omega_t}\right\}, \tag{8}$$

where r_t^* is the nominal interest rate of period t; $\pi_{t,k}$ represents the percentage change of the price level between periods t and $t+k$; π^* is the inflation target; $X_{t,q}$ is a measurement of the proportion of the output gap from period t to $t+q$; E is the expectation operator; Ω_t is the information set available to the individuals; and r^* is the desired interest rate when the inflation and output do not deviates from their respective goals. The authors indicated that the interest rate behavior is measured by the sign and the size of the coefficients (β) and (γ).

Nevertheless, Clarida et al. (2000, p. 153) point out limitations of such a reaction function. First, the specification assumes an instantaneous change in the interest rate. Second, it ignores any smoothing changes in the interest rate over

[3] The authors subdivided the sample into three periods. The period over which the Fed was conducted by Arthur Burns (1971:Q1–1978:Q1), Paul Volcker (1979:Q3–1987:Q2) and Alan Greenspan (1987:Q3–1997:Q1).

time. Third, it reflects constant and systematic change in the Fed's conduct of monetary policy in response to actual economic conditions. Fourth, it assumes that the Fed has total control over the interest rate in keeping it around a desired level. To overcome these limitations the authors made additional assumptions by bringing the expected autoregressive process of the interest rate back into the equation. More precisely,

$$r_t = (1-\rho)\{r^* - (\beta-1)\pi^* + \beta\pi_{t,k} + \gamma X_{t,q}\} + \rho(L)r_{t-1} + \varepsilon_t. \quad (9)$$

They also use the generalized method of moments (GMM) to obtain estimates of the parameters (α, β, γ, ρ). The method was applied to data that was divided into two periods. The first considers the years 1960:1 to 1979:2. This period includes the following Fed's Chairmans: William M. Martin, Arthur Burns and G. William Miller. The second period represented by the years of 1979:3 through 1996:4 corresponds to the administrations of Paul Volcker and Alan Greenspan.

Their results can be summarized as follows: (i) the inflation and output gap expectation do play a role, especially when considered the forward looking process; (ii) the authors identified significant changes in the conduct of monetary policy between the periods of pre and post 1979; (iii) the estimate for the coefficient associated with expected inflation is significant in both periods, but below the unit in the period before Volcker, around 0.83, and greater than unity for the Volcker–Greenspan period, 2.15; (iv) the coefficient (γ) related to the output gap is significant in both periods, but negligible in the Volcker–Greenspan period; and (v) the coefficient (ρ) that captures the smoothing effect of the monetary policy being conducted showed to be significant; hence it confirms that the Fed did practice smoothing procedure in setting up the interest rate in both periods.

Again, the results state that changes in Central Bank administration did impose changes in monetary policy, especially when both periods of administration are compared. Precisely, before 1979 the interest rate was not adjusted enough to meet agents expectation, therefore there was constant rise in inflation expectations. This can be interpreted as the Central Bank's lack of credibility before economic agents. However, in the Volcker–Greenspan period, the Fed increased the interest rate more intensely in response to successive increases in inflation expectations, thus meeting agents' expectations. Thus, Central Bank's credibility plays an important role in determining price stability in the U.S. economy.

The results above suggest that sometimes administration changes do improve the Central Bank credibility as in the U.S. case post 1979. However, changes in the Brazilian monetary administration have yet to been fully examined.

Regarding Brazil, there are some studies on Central Bank reaction function. Minella et al. (2002, 2003)'s reaction function captured the effect or the lagged effect of the interest rate over aggregate demand. This effect can be seen as a weighted average of the deviations of present and future inflation expectations. The major objective of this reaction function was to see how long the effect of actual interest rate policy lasts. The weighted average of the deviation of expected inflation from the target for this year may be losing relevance when looking the lagged ones. However, forward looking measures of this variable may be gaining importance. This innovative way of viewing inflation expectation is represented by the following reaction function

$$i_t = (1-\phi)i_{t-1} + \beta(\alpha_0 + \gamma_1 X_{t-1} + \beta D_j) + V_t, \quad (10)$$

where *Dj* is the deviation between the expected inflation from the inflation target, and the nominal interest rate is a function of the lagged output gap and the lagged interest rate. The reaction function (10) is estimated for the period July 1999 to June 2002. The authors main results are (i) the COPOM adjusts the interest rate gradually, since the smoothing coefficient is around 0.8; (ii) the coefficient of the output gap is not statistically significant when using inflation expectations of the market and has an inverted signal when using inflation expectations; (iii) the coefficient of the deviations of inflation expectations in relation to the inflation target are far superior to the unit; (iv) when exchange rate was included, its coefficient was not significant. Therefore, the authors point out that during the period analyzed, the BCB – Brazilian Central Bank policy showed a forward-looking attitude, i.e., responding quickly to deviations of inflation expectations from the target previously established. In sum, the Central Bank credibility was not so high because the inflation expectation of the target was superior to the unit. This indicates that agents were expecting inflation to rise in the future.

Using a model close to the ones represented by Eqs. (1)–(4) and with Eq. (5), Freitas and Muinhos (2002) estimate a model based on three equations. An IS curve, a Phillips curve and interest rate rule a *la* Taylor, which can be divided into two, one traditional Taylor rule and a rule called optimal rule. The authors obtained the following results: (i) the lagged interest rate impacts negatively the output gap; (ii) the lagged output gap affects the actual inflation rate negatively; (iii) the two lagged period of quantity of money affects inflation positively not the actual one; (iv) the Phillips curve has a direct effect on inflation rate, but it is not influenced by the exchange rate policy; and lastly, (v) the reaction function with optimal rule did not do well compared to the traditional basic Taylor rule; the last one presents more favorable results than those obtained via a optimal rule in explaining interest rate.

The optimal rule study did return in the paper written by Almeida et al. (2003). By using dynamic programming techniques, they derived a rule for optimal monetary policy conduct using an IS curve, a Phillips curve and a reaction function for a closed economy and an open economy. Estimates for the reaction function suggest that the BCB has to calibrate the rate of interest intensively to contain the rise of inflation compared to developed countries. When the reaction function considers the exchange rate, the authors suggest that the cost to curb inflation rate is lower compared to a closed economy. Thus, exchange rate is an important mechanism to help price stability in Brazil.

The importance of the exchange rate is also studied by Holland (2005). Empirically the author analyzed whether emerging countries, specifically Brazil, respond to exchange rate shocks via its reaction function. Inspired by the work of Clarida et al. (1998), the author assume that the interest rate is a function of the expected inflation, the output gap and the exchange rate, as can be seen in the following equation:

$$i_i = \phi\left[\alpha + \beta E\left[\frac{\pi_{t+n}}{\Omega_t}\right] + \gamma E\left[\frac{X_t}{\Omega_t}\right] + \zeta E\left[\frac{Z_t}{\Omega_t}\right]\right] + (1-\phi)i_{t-1} + V_i. \tag{11}$$

Using the GMM method, the results obtained indicate that the COPOM had an aggressive monetary policy conduct in curbing inflation during the period 1999–2005. First, the coefficient of the output gap was negative. One explanation given for such result was that the energy crisis was considerable in the period. Second, the exchange rate depreciation was not significant indicating that the monetary policy does not respond to the depreciation in the exchange rate.

Such contradictory results motivate Furlani et al. (2008) to estimate a reaction function for the Brazilian Central Bank using the Bayesian method. The question to be answered was very direct. Does the Central Bank alter its conduct on monetary policy due to changes in the exchange rate? The reported results by the authors suggest that there is no change in the conduct of monetary policy due to changes in the exchange rate. Besides this, they confirmed the results reported in the literature that inflation targeting regime reacts strongly to the output gap variable.

As we may see from the literature review, our proposed study on the effects of COPOM turnover as way of measuring monetary policy credibility do complement the existing ones in the literature. Nonetheless, the literature showed to us the importance of considering forward looking mechanism for expected inflation and output gap. Moreover, the exchange rate need not be considered based on the two last consistent results.

4. Empirical methods: the proposed reaction function

The proposed COPOM's reaction function for the Brazilian economy is as follow.

$$i_t = \alpha + \beta(\text{LDESVIO}) + \gamma(\text{GAPPIB}) + \delta(\text{EXPGAP}) + \text{ROTADIR} + \varepsilon_t \tag{12}$$

where i_t is the variation of the monthly Selic rate in log terms (Selic in log difference); LDESVIO is the variable that represents the deviation of market inflation expectations regarding inflation target for a given period t, which was composed monthly in order to compare it to the year inflation rate target; GAPPIB is the output gap in log terms; EXPGAP is the expectation of the output gap also in logarithm; and the ROTADIR variable is a dummy variable, whose goal is to capture the effect of turnover of at least one member of the Board of Governors of Monetary Policy Committee (COPOM in Brazil), with voting decision, in the period studied. An alternative approach is also utilized to measure turnover of COPOM directors. It is represented by ROTAPER, which is the percentage change in the number of directors from the previous meeting. Another important variable in the model is the log difference of the interest rate or its rate of growth change. This is used to make the model consistent with the new macroeconomic consensus described by our set of equations.

The empirical analysis is conducted using vector autoregression (VAR). In particular, structural VAR (SVAR) allows us to establish some degree of precedence among the variables based on the theoretical model result. In addition to the usual tests, we present the impulse-response functions. The format of the system of equations representing the SVAR model follows the one in Dias and Dias (2010).

The dataset covers the period between January 2001 and July 2008. We chose this period for two reasons, namely: (i) to dismiss the first two years of the inflation targeting regime, in order to analyze only the interval in which the

Table 1
Unit root tests.

Variable	Integration order			
	ADF	DF-GLS	PP	KPSS
LSELIC	I(1)	I(1)	I(1)	I(0)
GAPPIB	I(0)	–	I(0)	I(0)
EXPGAP	I(0)	I(0)	I(1)	I(0)
LDESVIO	I(0)	I(0)	I(1)	I(0)
ROTAPER	I(0)	I(0)	I(0)	I(0)

Source: Research dataset.

regime is already established as an anchor of monetary policy, and (ii) the availability of inflation expectation data; which began to be collected by COPOM in 2001.

Inflation rate (IPCA): Represents the change in the price level (CPI), which is the rate of inflation in 12 months (IBGE source), defined as the COPOM official price index of the inflation targeting regime.

Market inflation expectation (EXPIPCA): The variable inflation expectation is collected monthly by the Brazilian Central Bank from the main market players and made available through its Focus Report (*Relatório Focus*) since 2001.

Nominal interest rate (LSELIC): The nominal interest rate is the government bonds interest rate that is set by the COPOM. It is also known as the Selic rate.

Deviation of the inflation rate expectations (LDESVIO): Calculated as the difference between the inflation expectations of the market in relation to the inflation target for a given period *t*.

Output gap (GAPPIB): The output gap indicates the difference between current real output and potential output. The current and potential outputs are based on the Industrial Production Index – (IPI). The Hodrick–Prescott (HP) is applied to the current output series to obtain its tendency or trend series. The output gap is then the log of the current minus potential output.

Output gap expectations (EXPGAP): The expectation of the output gap refers to the expectation of the difference between current real output and potential output. The output gap expectation used in our calculation was obtained using the GDP expected growth rate predicted monthly by the market players. However, the growth rate of potential GDP is not available in the Brazilian macroeconomic databases. Thus, this variable was calculated based on the geometric interpolation methodology used by Gordon (2011).

The two variables used to represent COPOM members' turnover were obtained from the COPOM Report, which is made available after each meeting.

ROTADIR: Dummy variable whose goal is to capture the effect of turnover (replacement or rotation) of at least one member of the COPOM – Board of Governors of the Monetary Policy Committee. So it is one (1) if there is change in the members of COPOM otherwise zero (0).

ROTAPER: The percentage change of COPOM members.

5. Econometric results

Table 1 summarizes the unit root tests obtained from the methodology proposed by Dickey–Fuller (ADF), Phillips Perron (PP), Dickey–Fuller GLS (stochastically detrended variables) and KPSS. The results indicate that the output gap (GAPPIB), the expectation of the gap in GDP (EXPGAP), and the LDESVIO are stationary variables.[4] The variable LSELIC (interest rate) is non-stationary in level and stationary in first difference. For the sake of simplicity, we renamed the first difference of LSELIC to DLSELIC. The variable ROTAPER is stationary in level.

Table 2 presents the lag-order selection criteria. The VAR lag order selection was based on the Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike (AIC), Schwarz (SC) and Hannan–Quinn (HQ). The selection criteria indicate that the system of equations of the VAR should contain 1 (one) lag by SC and HQ criteria and 3 (three) lags by LR, FPE and AIC criteria. Initially, the equation considers the variables lagged DLSELIC, LDESVIO, EXPGAP,

[4] The authors subdivided the sample into three periods. The period over which the Fed was conducted by Arthur Burns (1971:Q1–1978:Q1), Paul Volcker (1979:Q3–1987:Q2) and Alan Greenspan (1987:Q3–1997:Q1).

Table 2
Wald tests for lag exclusion.

	DLSELIC	LDESVIO	EXPGAP	ROTAPER	GAPPIB	CONJUNTO
Lag 1	77.53430	117.6219	67.24501	6.456285	145.9562	438.2769
	[2.78e−15]	[0.000000]	[3.83e−13]	[0.264316]	[0.000000]	[0.000000]
Lag 3	15.35675	3.968047	2.902857	13.61565	26.59563	62.59917
	[0.008942]	[0.554026]	[0.714959]	[0.018244]	[6.84e−05]	[4.54e−05]
Degrees of freedom	5	5	5	5	5	25

ROTAPER and GAPPIB as explanatory variables. The Wald test for lag exclusion confirmed the significance of the first lag for the turnover variable. However, in order to have a balanced VAR the third lag was included in the model.

As a preliminary investigation, an unrestricted VAR model of Eq. (12) is estimated to identify temporal relationships among variables. Besides the described variables, we tested two dummy variables capturing specific effects separately: the Brazilian presidential elections of 2002 and the Energy Crisis occurred in the first semester of 2002. The VAR results indicate that both variables are not significant.

Although not shown, the VAR results suggest that the difference in the Selic rate (DLSELIC) in the first and third lags were significant indicating the presence of an autoregressive process. The coefficients for the previous month is −0.67 and for three months lag is +0.29. This also may indicate the parsimoniousness in conducting monetary policy by the COPOM. Another interpretation is that there is inertia in the composition of the Selic rate in the Brazilian economy that contributes to the persistence of its growth rate over time. The lags of the variable LDESVIO are also significant. It indicates that when market's inflationary expectations exceed the COPOM's inflation target, the Selic interest rate would be set higher, with a lag of up to three months of influence. Considering that the COPOM meetings occurs at every 40 or 45 days, this suggests that after each meeting agents adjust their expectations about inflation by taking into consideration the new interest rate.

The variable expectation of the output gap (EXPGAP) is significant in explaining variations in the Selic rate. Furthermore, lag one and three of the output gap (GAPPIB) were not significant in determining variations in the interest rate. This result is consistent with that of Piza and Dias (2006). Likewise, the turnover variable (ROTAPER) was not significant in the unrestricted VAR equation that explains interest rate changes. Thus, considering a short-run analysis made by the unrestricted VAR, the turnover of COPOM's directors has no short run impact on the behavior of the rate of change of the Selic. Yet, the F statistic for the unrestricted VAR model is 8.6 and a R^2 of 53%, which means that the variation in the Selic rate results from its own lagged values, the deviation of market expectations from the target, and the expectations of output gap. Another important condition is the VAR stability. The model is stable since all roots are within the unit circle, as shown in Fig. 1.

In the coming section, we present impulse-response functions and variance decomposition for the unrestricted VAR system.

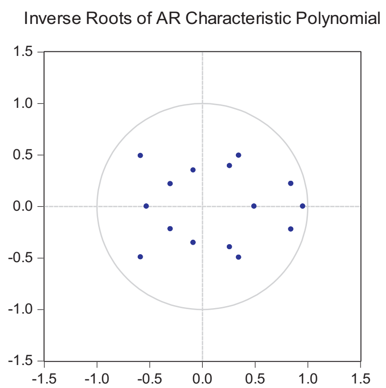

Fig. 1. VAR stability.

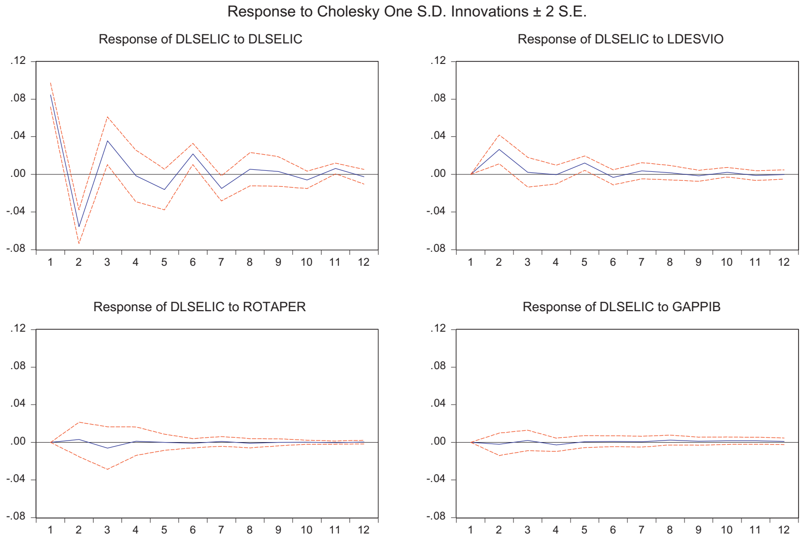

Fig. 2. Interest growth rate (Selic) response to shocks from the VAR variables.

5.1. Impulse-response functions and variance decomposition analyses

The analysis of the impulse-response functions aims at visualizing the response of a particular variable to shocks from system variables. If two variables are correlated over time and there is a stable relationship between them, it is expected that a shock in one variable spreads over the other variable. This shock is called innovation or impulse. Fig. 2 shows the behavior of the growth rate of the interest rate when there is a pulse in one of the other VAR variables. The impulse or innovation takes the size of two standard deviations (±2 s.d.) of each variable.

In the first graph of Fig. 2, the response of interest rate change to innovations in itself shows oscillations between negative and positive effects during the twelve months predicted. Therefore, any change in the interest rate takes a full year to be entirely absorbed.

The response of interest rates to the deviation of market's inflationary expectations (LDESVIO) is positive. This means that any inflationary expectation increase leads to an increase in interest rate change. Therefore, if inflation expectations deviate from the target level set by COPOM, the interest rate reacts increasing above average especially in the first six months. This behavior confirms the commitment of policymakers with the forward-looking hypothesis of the model. Hence, the deviations of expected inflation from the pre-announced target cause adjustment in the interest rates by the COPOM in order to mitigate any expected deviation.

The response of the growth of the interest rate to COPOM Director's turnover (ROTAPER) is showed in the first graph of the second line in Fig. 2. The changes are very dismal in the first two months and little more expressive in the third month. This indicates that the change in COPOM's directors does not affect the monetary policy credibility in the short term.

The last graph in Fig. 2 shows the response of the Selic growth rate changes due to changes in deviations of actual output from its potential, which account for the economic activity. The graph indicates that changes in economic activity did not lead to significant changes in the interest rate during the period analyzed.

In order to complement the impulse-response analysis, we perform the variance decomposition of forecasted errors for the unrestricted VAR estimates. It allows us to quantify the weight of each of the explanatory variables in determining the forecast error variance of the growth rate of the interest rate (DLSELIC) for a certain period. To save space, we omit the table with results and describe the main results for each variable below.

The analysis of variance decomposition of the forecasted error showed that much of the variance in the Selic rate occurs from shocks in itself, with a maximum value of around 91.16% in the second month. This result confirms the high inertia of the Selic rate reported in the economic literature. However, this strong participation is smoothed over the year to the value of 89.3%. Thus, it appears that the interest rate starts to respond more parsimonious to pressures or shocks from other macroeconomic variables.

Table 3
Granger causality/block exogeneity Wald test.

Exclusion	Qui-square	Degrees of freedom	Probability
Dependent variable: DLSELIC			
LDESVIO	17.69	2	0.0001
EXPGAP	5.53	2	0.0629
ROTAPER	0.13	2	0.9352
DGAPPIB	1.45	2	0.4827
Total	22.07	8	0.0048

Null hypothesis: exclude as exogenous variable in the equation of DLSELIC.

The largest influence on interest rate changes comes from market-inflation expectation deviations (LDESVIO). The variance decomposition demonstrates its total contribution accounts for 6.32% of the interest variation in any given year. The output gap (GAPPIB) variance decomposition shows a dismal participation of this variable in determining the variation in the Selic rate, the maximum value of the contribution is 0.22% after twelve months.

Lastly, we highlight the low significance of ROTAPER in explaining the variation in the interest rate. It reaches a maximum value of 0.36% in the last month of analysis. Thus, in the unrestricted VAR system the changes COPOM's directory seem to have little relevance for the credibility of the interest rate policy.

The Granger causality test or the block exogeneity Wald test is reported in Table 3. It verifies whether any of the endogenous variables included in the VAR model could be considered as exogenous in Granger sense. Only the result concerning the equation with variable DLSELIC as dependent is reported here.

The Wald test of block exogeneity is for the growth rate of the interest rate (DLSELIC) with the Granger causality running from the variables: LDESVIO, EXPGAP, ROTAPER and GAPPIB. When treated together, the equation variables can be considered determinants of the interest growth rate in the Brazilian economy. However, when considered individually, only the deviation of the inflation target could not be excluded as exogenous in the equation of DLSELIC, with probability of exclusion of 0.01%. The expectations of the output gap being excluded are only 6%. According to these results, all others variables should be treated as exogenous.

5.2. The SVAR analysis

The prior unrestricted VAR gives conclusions that are valid for the short run. The estimates of Eq. (12) produced in this section account for a long term relationship. Details of the SVAR estimates can be found in Dias and Dias (2010). The result of the SVAR is the following[5]:

$$y_t = \begin{bmatrix} \text{GAPPIB} \\ \text{ROTAPER} \\ \text{EXPGAP} \\ \text{LDESVIO} \\ \text{DLSELIC} \end{bmatrix} \quad C = \begin{bmatrix} +\underset{(0.018)***}{0.24} & 0 & 0 & 0 & 0 \\ -\underset{(0.008)***}{0.028} & +\underset{(0.005)***}{0.07} & 0 & 0 & 0 \\ -\underset{(0.28)***}{2.98} & \underset{(0.17)}{+0.17} & +\underset{(0.117)***}{1.55} & 0 & 0 \\ +\underset{(0.15)***}{1.46} & \underset{(0.0107)}{+0.061} & -\underset{(0.098)***}{0.54} & +\underset{(0.064)***}{0.84} & 0 \\ \underset{(0.009)***}{+0.038} & \underset{(0.009)*}{+0.015} & \underset{(0.009)}{-0.003} & \underset{(0.008)***}{+0.06} & \underset{(0.004)***}{+0.057} \end{bmatrix} \quad e_t = \begin{bmatrix} h_t \\ r_t \\ x_t \\ d_t \\ di_t \end{bmatrix} \tag{13}$$

The residuals normality test or the Jarque–Bera test is $\chi^2 = 1.84$ produces normal probability around 40%. Moreover, the unit root test for stationarity of the residuals is confirmed through the ADF and PP statistics of 8.58 and 11.15, respectively. The distribution might not be normal, but as required it is stable.

The SVAR Eq. (13) has to be interpreted in the following way: (1) along the diagonal the coefficients represent the effect of the variable on itself. For example, the coefficient 1.55, third line and column of the matrix result, is the

[5] The PP unit root test was statistically significant at borderline of 10% only.

impact of EXPGAP changes on itself; (2) column one represents the impact of GAPPIB on all the variables, being the first coefficient the column the impact on itself; (3) column two is the effect of ROTAPER on the remaining variables, again the second line coefficient 0.07 is its own impact; and so on for the remaining columns.

The output gap (GAPPIB) is considered as an exogenous variable that influences all others in the above estimate. This specification follows the reviewed literature findings.[6] It is also important to emphasize that this specification and results are consistent with economic theory.

The results show that the interest rate does stabilize or converge to its long-run value due to any change in the variables included in the model. An output gap increase or the increase in the output above its potential level leads to increases in ROTAPER, EXPGAP, LDESVIO and DLSELIC. Therefore, it influences the rate of change of the COPOM members; it raises the expectation of output gap increase; it causes the market inflation expectation to rise; and it causes the growth rate of change of interest rate to increase.

The COPOM directors' turnover influences EXPGAP, LDESVIO and DLSELIC. For the purpose of this paper, the most important variables are the following ones. Increases in the number of replacement of COPOM directors lead to an increase in the expected output gap (EXPGAP), coefficient of 0.17, which is significant at 1%. This means that agents foresee that actual output will surpass its potential level. In addition, agents expect that inflation may surpass its announced target level or band. The coefficient 0.061 on LDESVIO is also significant at 1%. Therefore, the influence on changes on the interest rate will increase DLSELIC, according to the positive coefficient of 0.015 that is significant at 1%.

How do we see the credibility impact on this model? We measure it through the influence of ROTAPER on the LDESVIO variable. The coefficient is positive and significant. This means that the turnover increases expected inflation close or above to its target level. This is an important result since it says that directors' turnover contributes to price instability over the long run in Brazil. In other words, inflation instability might be an outcome from directors' turnover in the long run. How serious is this matter for the conduct of monetary policy through interest rate determination? It is very serious since it leads to an increase in the rate of change in order to curb inflation expectations.

The EXPGAP increase lowers LDESVIO and it does not impact DLSELIC in the long run. This means that the business cycle does not affect interest rate changes or the monetary policy. Furthermore, the market inflation expectation (LDESVIO) has a positive impact on DLSELIC. It means that inflation is more important for monetary policy than output growth above its trend level.

The last column just states that over the long run the average change in the interest rate is around 0.057 or 0.57%. This is consistent with the changes in the interest rate set by the COPOM meetings. They normally increase or decrease the level of the interest by 0.25% up 0.50% points; rarely the COPOM takes any decision beyond those values.

To examine if the analysis performed is robust, we use the result from the unrestricted model where the expected output gap variable (EXPGAP) is not significant in affecting the interest rate growth in the long run. This variable is dropped in the new SVAR estimates represented by Eq. (14) below.

$$y_t = \begin{bmatrix} \text{GAPPIB} \\ \text{ROTAPER} \\ \text{LDESVIO} \\ \text{DLSELIC} \end{bmatrix} \quad C = \begin{bmatrix} \underset{(0.014)***}{+\ 0.18} & 0 & 0 & 0 \\ \underset{(0.008)***}{-\ 0.018} & \underset{(0.005)***}{+\ 0.072} & 0 & 0 \\ \underset{(0.15)***}{+\ 0.88} & \underset{(0.128)***}{+\ 0.29} & \underset{(0.08)***}{+\ 1.08} & 0 \\ \underset{(0.010)***}{+\ 0.032} & \underset{(0.009)***}{+\ 0.023} & \underset{(0.008)***}{+\ 0.067} & \underset{(0.005)***}{+\ 0.060} \end{bmatrix} \quad e_t = \begin{bmatrix} h_t \\ r_t \\ d_t \\ di_t \end{bmatrix} \tag{14}$$

The COPOM turnover effect is accounted for in column two. The effect on itself is 0.072 meaning that, on average, 7.2% of the directors were changed over the span period. The coefficient in LDESVIO is 0.29 and significant at 1%. It is bigger than the previous one indicating that changes in the COPOM's Board of Directors cause positive impact on inflation expectations. Moreover, it also leads to positive increase in the rate of change of the interest rate determined by the Board of Directors. This confirms previous results that the lack of credibility compromises the monetary policy conduct. Therefore, keeping board members seems to be a good policy to follow in order to prevent increases in inflation expectations, which – according to our results – demands further increases in interest rate level. Tests of normality

[6] Asterisks indicate the statistical significance of the coefficients at 10% (*), 5% (**) and 1% (***). For example Holland (2005) and Furlani et al. (2008).

and stationarity were executed to make sure the SVAR system of Eq. (14) is stable. The normality Jarque–Bera test indicated a $\chi^2 = 1.26$, with a probability of 53%. The unit root test points out stationarity of the residuals with statistics equal to 10.72 and 10.73 for the ADF and PP tests, respectively.

6. Conclusion

This paper discusses the current conduct of monetary policy adopted in Brazil within the context of the new macroeconomic consensus. We propose a reaction function that accounts for COPOM's credibility. The change in the COPOM directors is used to measure the long run credibility of the Brazilian Central Bank monetary policy. The equation system is estimated using the SVAR methodology to obtain long run coefficients.

The overall results of our proposed model indicate that COPOM directors' rate of change seems to influence the expected deviation of output gap, expected inflation and by extension the rate of change of the interest rate. The estimated effect is positive, indicating that the turnover increases the deviation of output from its potential level and brings together inflation rate above or closer to the expected rate, both conditions require increases in the rate of change or acceleration of interest rate increases. More precisely, changes in COPOM's directors occurred in the period have not contributed for price stability. The main long run outcome is further increases in interest rate. This result indicates that the change of COPOM directors affected the Brazilian Central Bank policy credibility with economic agents. In sum, directors' changes had a social cost through the payment of higher government bond's interest rate.

How to overcome the turnover problem? According to Rogoff (1985), the board of directors must have a formal contract that guarantees their compromise with price stability and acting independence. Hence, society should perceive them as independent from any government institution, otherwise the COPOM itself as institution will not have the desired credibility.

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