Analyzing COPOM's Decisions

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ABSTRACT

This paper aims at modeling the conduct policy of the interest rate by the Monetary Policy Committee of the Central Bank of Brazil (COPOM), following methodologically a statistical framework developed by Engle & Russel (1998) and used by Hamilton & Jordà (2002) in studying the decisions of the Federal Reserve of the United States. The results, once we observe the period from January 2002 to July 2010 with a weekly frequency, suggest that *COPOM* is influenced by government expenditures and that it has a forward-looking behavior, holding onto the expectations of the Gross Domestic Product (GDP) and the official inflation of the country. In addition to this relevant evidence in the discussion of the balance between fiscal and monetary policies in Brazil, Brazilian monetary authority theoretically possesses a behavior which is aligned to that observed in practice, though it presents a greater sensitivity to macroeconomic variations.

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1 INTRODUCTION

The Brazilian economy possessed strong inflationary levels during the military governments and even during its recent democracy in the 80s, when from 1994 it began to experience a period of economic stability with the adoption of the *Plano Real*, on which context it appeared propitious to the creation of the Monetary Policy Committee of the Central Bank of Brazil (COPOM) in 1996. Following a worldwide trend towards greater transparency in the decision making process and the ease of communication with the general public, from the adoption of the target regime for the Inflation in Brazil in 1999 this committee began to define the SELIC rate value – benchmark in the fixed income segment, whose name refers to the Special System of Clearance and Custody (*Sistema Especial de Liquidação e Custódia*) – in order to keep inflation at the levels determined by the National Monetary Council (*Conselho Monetário Nacional* - CMN).

In order to support this evolution in the Brazilian economy, we observe wide, extensive and well-founded literature on the conduct of monetary policy, which was previously interested in addressing the instability period as in Holanda (1987), where the inflationary aspects vis-à-vis public finances are analyzed, or again in Holanda (1991), where the unsuccessful attempt to control inflation in the early 90s is studied.

Specifically on this less turbulent phase, Pastore & Pinotti (1999) affirm about the apparently incomplete stability, in view of the inflationary inertia driven by the exchange rate regime and the absence of a fiscal austerity counterpart.

Now under the Target Regime and the Fiscal Responsibility Act, Bonomo & Brito (2002) model the inflation forecast based on a macroeconomic structural framework, holding not only to Taylor's traditional rule, as well as the effects of a combination between inflation and real exchange rate. Bonomo *et al.* (2003) suggest modeling through evolutionary games of the relationship between inflationary inertia and the coordination problem associated with the limited rationality of economic agents. Commenting further on the performance of this system in Brazil, it is worth mentioning Ferreira & Jayme Jr. (2005) and Teles & Nemoto (2005), whose results indicate to an evolution of the credibility of Brazil's Central Bank to fight inflation.

More recently, literature has directed greater attention on agencies responsible for deciding the respective interest rates on savings, such as the Feredar Open Market Committee (FOMC) in the United States, the Central Bank Council in Germany or COPOM in Brazil,

aiming to demonstrate what influences the direction and the magnitude of these decisions. In this context, Portugal & Silva (2009) suggest, from the calibration of a backward-looking macroeconomic structural framework associated with the optimization of the loss function of the Central Bank of Brazil, that interest rates react in a contemporary way to changes in inflation, deviation of the Gross Domestic Product (GDP) relative to potential output and exchange rate fluctuations, in addition to the obvious concern with the smoothing factor on the changes of the targets for interest rates. Conceptually aligned, Caetano *et al.* (2011) propose the modeling of the SELIC target by COPOM, taking into consideration aspects associated with the non-stationary, obtaining a well specified model.

Quite common in this kind of study composing this empirical literature has been the use of a macroeconomic approach, based on quarterly data or even less frequently, in spite of the monetary decisions such as the definition of the interest rates being taken in meetings with characteristically regular over time spacing, taking place on a monthly basis till 2006 or every 45 days since then. Thus, this study aims to add to this literature by modeling COPOM's decision in the conduct of policy interest rates decision in Brazil from data with a weekly frequency.

Following methodologically Hamilton & Jordà (2002), whose application analyzed the behavior of the Federal Reserve Bank (FED), this study aims to accommodate this proposed technique to the reality of a developing economy, which recently experienced a period of economic stability, making it possible to add by proposing subsidies to answer questions on the Brazilian case, such as: when, in what direction and to what extent COPOM decides to change the basic interest rate? Which variables are taken into account? What is the probability that the target rate would change the following week given the available set of information today? Would it be possible to show a backward or forward-looking behavior by the monetary authority?

Thus, without abiding in the variables of political character, but only the economic and financial ones, we make use of the Autoregressive Conditional Hazard (ACH) modeling, a generalization of the Autoregressive Conditional Duration (ACD) by Engle and Russell (1997 and 1998) which is able to incorporate a instrumentalization in order to condition the framework of the probability of changing the SELIC target before the most diverse information available. Following that, we make use of the ordered probit, to predict in which direction and magnitude such changes occur.

Bu applying this to the reality of an economy with different characteristics from the American one is done precisely by adaptations, especially with regard to the variables used with the supposed ability of influencing decision making processes of monetary policies. This definition for Brazil is based on the learning of other monetary studies for this economy and explicit signs in the minutes of the COPOM meetings. The study also highlights, in terms of time series, the existence of relevant forecasting series, in view of the forward-looking aspect, only available from 2002.

In short, the results suggest that SELIC's decision be taken by a committee with a behavior theoretically forward-looking with regard to future fluctuations in production and inflation in the country. Such a committee appears to still being concerned about the increased expenditures by the National Treasury. We can also observe that in thirty five out of the fifty six changes of the SELIC target rate carried out by COPOM over the analyzed period, the framework turns out to be able to properly shape the direction of change, being in general the order of magnitude change lower than the one actually practiced by COPOM.

The study is divided so that Section 2 is a review of monetary policy, addressing the adoption of the Inflation Target Regime in Brazil. The third section presents the methodology, while the results are described in section 4. In the fifth section, the final considerations are presented.

2 INFLATION TARGET REGIME IN BRAZIL

From the recent experience in other countries, it is evident that a gradual, predictable and controlled increase in prices of goods and services consists of an indicator of economic stability and a precondition for economic growth.¹ In short, a scenario with inflation under control allows economic agents to make more efficient allocational decisions, influencing even the distribution of income, since inflation consists of taxing in which its incidence is greatest on the poorest.

In the case of the Brazilian economy, after experiencing a long period with fixed exchange rate regime, and several crises, such as the debt crisis in the 80s and the economic downturn in the 90s, it is evident that until the mid-90s the country had presented numbers of hyperinflation, with the average annual inflation between 1986 and 1994 of 842.5%, reaching a peak of 82.39% per month in March 1990, as seen in the IPCA index (National Index of Consumer Price) in Figure 1.

¹ See Mankiw (2000) on the trade-offs between inflation and real variables such as growth and unemployment.

Thus, in order to take advantage of the benefits of a society with low and predictable price swings, and on account of an unsustainable and explosive scenario of the evolution of prices of the basic goods, Brazil follows, in a similar manner to various economies, the New Zealand experience in the 90s, beginning to adopt from January 1999 the floating exchange rate regime, macroeconomic foundation so that on the 2nd of June 1999, the country would follow the Inflation Target Regime. This regime had an associated target with the IPCA, an indicator defined and widely disclosed by the National Monetary Council (*Conselho Monetário Nacional* - CMN), composed by the Minister of Finance, Minister of Planning and the President of the Central Bank of Brazil.

Figure 1 - Evolution of the monthly variation of the National Index Wide National Consumer's Price Index (IPCA) ^a

^aSource: Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatísticas* - IBGE).

According to Figure 2, this monetary regime has been characterized by the adoption of one digit targets with annual correction bands, in the order of 2% or 2.5% above and below the center, thus allowing the central bank flexibility in controlling the IPCA, a benchmark index which measures the variation in the cost of the representative consumption basket of the population with an income up to 40 minimum wages in 12 metropolitan areas.

Figure 2. Inflation targets, limits and the observable IPCA (% per year)^{a, b}

^a Source: DEPEC-BACEN (Central Bank). ^b In the case of the year 2010, the IPCA is reported in the year up until July.

In this regime, the instrument used by the monetary authority in controlling the inflation target is the systematic definition of the basic interest rate of the economy, the SELIC rate, i.e., the average rate of daily financing, backed by federal securities in the Special System of Clearance and Custody, and their possible bias, low, high or neutral. This is possibly the primary role when the scheduled or special meetings of the Monetary Policy Committee (COPOM), board established on June 20, 1996 and formed by the president of the Central Bank and its directors. With regards to the meetings of this committee (see Table 1), the first one took place on 25 and 26 June 1996, and up until July 2010, 152 meetings had taken place, of which only three were extraordinary.

Table 1 - COPOM's Meetings

Year	Nº	Date	Interval (days)	Year	Nº	Date	Interval (days)	Year	Nº	Date	Interval (days)	Year	Nº	Date	Interval (days)	Year	Nº	Date	Interval (days)					
1996	1	st 25-jun	26-jun	-	1999	32	nd 17-Jan	18-Jan	32	2002	67	th 22-Jan	23-Jan	34	2005	104	th 18-Jan	19-Jan	34	2008	132	nd 22-Jan	23-Jan	48
	2	nd 29-jul	30-jul	33		33	rd 3-Mar	4-Mar	44		68	th 19-Feb	20-Feb	27		105	th 15-Feb	16-Feb	27		133	rd 4-Mar	5-Mar	41
	3	rd 20-ago	21-ago	21		34	th 13-Apr	14-Apr	40		69	th 19-Mar	20-Mar	27		106	th 15-Mar	16-Mar	27		134	th 15-Apr	16-Apr	41
	4	th 22-set	23-set	32		35	th 18-May	19-May	34		70	th 16-Apr	17-Apr	27		107	th 19-Apr	20-Apr	34		135	th 3-Jun	4-Jun	48
	5	th 22-out	23-out	29		36	th 22-Jun	23-Jun	34		71	st 21-May	22-May	34		108	th 17-May	18-May	27		136	th 22-Jul	23-Jul	48
	6	th 26-nov	27-nov	34		37	th 27-Jul	28-Jul	34		72	nd 18-Jun	19-Jun	27		109	th 14-Jun	15-Jun	27		137	th 9-Sep	10-Sep	48
	7	th 17-dez	18-dez	20		38	th 31-Aug	1-Sep	34		73	rd 16-Jul	17-Jul	27		110	th 19-Jul	20-Jul	34		138	th 28-Oct	29-Oct	48
						39	th 21-Sep	22-Sep	20		74	th 20-Aug	21-Aug	34		111	th 16-Aug	17-Aug	27		139	th 9-Dec	10-Dec	41
						40	th 5-Oct	6-Oct	13		75	th 17-Sep	18-Sep	27		112	th 13-Sep	14-Sep	27					
						41	st 9-Nov	10-Nov	34		76	th 13-Oct	14-Oct	25		113	th 18-Oct	19-Oct	34					
						42	nd 14-Dec	15-Dec	34		77	th 22-Oct	23-Oct	8		114	th 22-Nov	23-Nov	34					
											78	th 19-Nov	20-Nov	27		115	th 13-Dec	14-Dec	20					
											79	th 17-Dec	18-Dec	27										
1997	8	* 21-jun	22-jun	34	2000	43	rd 18-jan	19-jan	34	2003	80	th 21-Jan	22-Jan	34	2006	116	th 17-Jan	18-Jan	34	2009	140	th 20-Jan	21-Jan	41
	9	* 18-fev	19-fev	27		44	th 15-fev	16-feb	27		81	st 18-feb	19-feb	27		117	th 7-mar	8-mar	48		141	st 10-mar	11-mar	48
	10	* 18-mar	19-mar	27		45	th 21-mar	22-mar	34		82	nd 18-mar	19-mar	27		118	th 18-apr	19-apr	41		142	nd 28-apr	29-apr	48
	11	* 15-abr	16-abr	27		46	th 18-abr	19-apr	27		83	rd 22-apr	23-apr	34		119	th 30-may	31-may	41		143	rd 9-jun	10-jun	41
	12	* 20-mai	21-mai	34		47	th 23-mai	24-may	34		84	th 20-may	21-may	27		120	th 18-jul	19-jul	48		144	th 21-jul	22-jul	41
	13	* 17-jun	18-jun	27		48	th 19-jun	20-jun	26		85	th 17-jun	18-jun	27		121	st 29-aug	30-aug	41		145	th 1-sep	2-sep	41
	14	* 22-jul	23-jul	34		49	th 18-jul	19-jul	28		86	th 22-jul	23-jul	34		122	nd 17-oct	18-oct	48		146	th 20-oct	21-oct	48
	15	* 19-ago	20-ago	27		50	th 22-ago	23-aug	34		87	th 19-aug	20-aug	27		123	rd 28-nov	29-nov	41		147	th 8-dec	9-dec	48
	16	* 16-set	17-set	27		51	st 19-set	20-sep	27		88	th 16-sep	17-sep	27										
	17	* 21-out	22-out	34		52	nd 17-out	18-oct	27		89	th 21-oct	22-oct	34										
	18	* 29-out	30-out	7		53	rd 21-nov	22-nov	34		90	th 18-nov	19-nov	27										
	19	* 18-nov	19-nov	19		54	th 19-dez	20-dec	27		91	st 16-dec	17-dec	27										
	20	* 16-dez	17-dez	27																				
1998	21	* 27-jan	28-jan	41	2001	55	th 16-jan	17-jan	27	2004	92	nd 20-jan	21-jan	34	2007	124	th 23-jan	24-jan	55	2010	148	th 26-jan	27-jan	48
	22	* 3-mar	4-mar	34		56	th 13-fev	14-feb	27		93	rd 17-feb	18-feb	27		125	th 6-mar	7-mar	41		149	th 16-mar	17-mar	48
	23	* 14-abr	15-abr	41		57	th 20-mar	21-mar	34		94	th 16-mar	17-mar	27		126	th 17-apr	18-apr	41		150	th 27-apr	28-apr	41
	24	* 19-mai	20-mai	34		58	th 17-abr	18-apr	27		95	th 13-apr	14-apr	27		127	th 5-jun	6-jun	48		151	st 8-jun	9-jun	41
	25	* 23-jun	24-jun	34		59	th 22-mai	23-may	34		96	th 18-may	19-may	34		128	th 17-jul	18-jul	41		152	nd 20-jul	21-jul	41
	26	* 28-jul	29-jul	34		60	th 19-jun	20-jun	27		97	th 15-jun	16-jun	27		129	th 4-sep	5-sep	48					
	27	* 1-set	2-set	34		61	st 17-jul	18-jul	27		98	th 20-jul	21-jul	34		130	th 16-oct	17-oct	41					
	28	* 9-set	10-set	7		62	nd 21-ago	22-aug	34		99	th 17-aug	18-aug	27		131	st 4-dec	5-dec	48					
	29	* 6-out	7-out	26		63	rd 18-set	19-sep	27		100	th 14-sep	15-sep	27										
	30	* 10-nov	11-nov	34		64	th 16-out	17-oct	27		101	st 19-oct	20-oct	34										
	31	* 15-dez	16-dez	34		65	th 20-nov	21-nov	34		102	nd 16-nov	17-nov	27										
						66	th 18-dez	19-dec	27		103	rd 14-dec	15-dec	27										

As reported in this table, up until 2005 these meetings took place at an approximate monthly basis frequency, except for the months of October in 1997, 1998, 1999, and 2002, in time which these meetings occurred during periods shorter than two weeks and in March 1999 time which there was no meeting for over a month and a half. As of 2006, there were only eight annual meetings, which last for two days. Normally, during Tuesday sessions a comprehensive analysis of the economic situation is presented, covering several inflation indices, the analysis of time series for the purpose of labor market comparisons, economic activity, consumer confidence index, consumer expectations, the capacity utilization rates, credit and default, foreign trade and balance of payments, external environment and money market. On Wednesday, proposals for the interest rate are proposed, being followed by votes and a subsequent dissemination.

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3 ECONOMETRIC MODELING

3.1 THE AUTOREGRESSIVE CONDITIONAL HAZARD MODEL

High frequency data tend to be irregularly spaced in time. To work with this type of time series, one possibility is to derive a kind of point process, that is, a stochastic process that builds random points in time and are called arrival times. Thus, consider the arrival times where $0 < t_0 < t_1 < \dots < t_n$. In the present study, t_n corresponds to the n -th change of the SELIC in the considered time interval.

To this set of time arrivals it is common to associate it with the step function $N(t)$. In this study, the step function also carries out the discrete count changes in the benchmark interest rate over time.

In an objective description of the Autoregressive Conditional Duration model (ACD), define $u_n = t_{n+1} - t_n$ as an interval between the n -th and the $n + 1$ -th changes in the SELIC target rate. Be ψ_n the expected time of duration of u_n considering the past observations $u_{n-1}, u_{n-2}, \dots, u_1$. Engle & Russell (1998) proposed the following specification for frameworks that follow an ACD (r, m) as an use of the step function $N(t)$:

$$\psi_{N(t)} = \varpi + \sum_{j=1}^m \alpha_j u_{N(t)-j} + \sum_{i=1}^r \beta_i \psi_{N(t)-i} \quad (1)$$

An extreme useful generalization of the ACD consists in the Autoregressive Conditional Hazard (ACH), a framework that allows answering the same questions raised when the use of the ACD is associated with changes in the SELIC rate, but incorporating information not only intrinsic to the process in question, but others associated directly or indirectly, of financial or macroeconomic nature, that may be important in the decision making of policy makers, for example.

Without loss of generality, assume that the time interval is chosen so that no observed duration is lower than one period and the probability of occurrence of more than one event at a time is insignificant.

We can generalize the relationship (1) as an ACH (r, m) as:

$$\psi_{N(t)} = \varpi + \sum_{j=1}^m \alpha_j u_{N(t)-j} + \sum_{i=1}^r \beta_i \psi_{N(t)-i} + \delta Z_{t-1} \quad (2)$$

where Z_{t-1} corresponds to a vector of known variables on $t-1$.

The relation (1) summarizes a statistical framework *ad hoc* titled ACD which allows modeling discrete time duration of a random variable whose change, regardless of the magnitude or direction, is associated with the history of observed durations, as well as the history of durations expected by the framework itself. The relation (2) describes the ACH generalizes incorporating the possibility of testing the individual and the whole explanatory power of the exogenous observable variables to the duration to be modeled.

A very useful and relevant concept in this modeling consists in the Hazard rate, which is defined as the conditional probability that the interest rates change in week t given the set of information available in $t-1$, Γ_{t-1} , being expressed by $h_t = P(N(t) \neq N(t-1) | \Gamma_{t-1})$.

Suppose initially that the only information that we have until the time $t-1$ are the dates of the previous changes in interest rates. Thus, the Hazard rate would not change until there was a new change in interest rates. The Hazard rate of the model ADC (I, I), for example, it

would be expressed by $h_t = 1/\psi_{N(t-1)}$. As for the respective Hazard rate of the ACH (1, 1) model, it would be given by:

$$h_t = [\psi_{N(t-1)} + \delta Z_{t-1}]^{-1} \quad (3)$$

The robustness of the routines of maximization demands that the following restrictions on the parameters are met: $\alpha_j \geq 0, \beta_i \geq 0$ e $0 \leq \sum_{i=1}^r \beta_i \leq 1$, while the stationarity is associated with $\sum_{j=1}^m \alpha_j + \sum_{i=1}^r \beta_i < 1$. In relation to issues associated to the estimation of these frameworks, for a vector of θ parameters, we make use of the current conditional log likelihood function given by $L_1(\theta_1) = \sum_{t=1}^T x_t \log(h_t) + (1 - x_t) \log(1 - h_t)$, where x_t is a binary dummy that assumes the unit value in the event of change in the target rate at t and zero otherwise.²

3.2 CHANGE FORECAST IN THE SELIC TARGET RATE: THE FRAMEWORK OF ORDERED PROBIT

Once the ACH framework allows us measuring the probability of a change in the SELIC target rate taking place in the following week and that variables affect this probability, to predict the SELIC rate value is to determine in which direction this change will occur and what its magnitude in each week, being associated with this change the same set of variables used in the empirical exercise about the likelihood of change, which will be described in detail in Section 4.

These changes will be seen as marks and the respective time series obtained from the ordered pairs, marked point process is such that, the first coordinate corresponds to the points where the interest rate was changed and the second coordinate corresponds to the size of the change. Thus, we define the mark or the size of the change in t , by y_t . The set Γ_{t-1} containing the information available in $t-1$ includes x_{t-1} , variable associated or not with the change in the target, the very magnitude of this change, y_{t-1} , and a vector of variables that influence the decision of the Central Bank.

We can write the distribution of the joint probability of x_t and y_t as:

$$f(x_t, y_t | \Gamma_{t-1}; \theta_x, \theta_y) = g(x_t | \Gamma_{t-1}; \theta_x) \cdot q(y_t | x_t, \Gamma_{t-1}; \theta_y), \quad (4)$$

² Seeking greater clarification on the estimation of the ACD, see Engle and Russell (1998) and Pacurar (2006). As for greater details on the formalization of relations between the specifications of the maximum likelihood of the ACD and ACH functions can be seen in Hamilton and Jordà (2002).

where $g(\cdot)$ corresponds to the function of probability of change associated with the econometric model of the ACH, whilst $q(\cdot)$ is associated with the characteristic function of the Probit about the direction and order of the magnitude of the change. Both probability functions are parameterized by the vectors θ_x and θ_y , respectively.

Whereas changes in interest, that is, the marks occur in discrete amounts, we suggest the use of the ordered response model as in Hausman, Lo & MacKinlay (1992). In this context we estimate here the Ordered Probit model, a technique used in empirical studies of dependent variables that assume only a finite amount of values that can be ordered, which consists of a generalized linear regression model for cases where the dependent variable is discrete. This framework is shown capable of capturing the impact of relevant variables considering discretization and irregular time intervals.

Take ω_{t-1} as a vector of observed variables in the week before t . Assume hypothetically, the existence of a random non-observable variable y_t^* that depends on ω_{t-1} in the following way: $y_t^* = \omega_{t-1}'\varphi + \varepsilon_t$, where $\varepsilon_t | \omega_{t-1} \sim i.i.d. N(0,1)$. When the Central Bank decides to change the interest rate, it has available k different discrete amounts to choose from. Set the possible changes in the target as of $s_1, s_2, \dots, s_k$, which, without loss of generality, may be increasingly ordered. Considering $x_t = 1$, i.e., change in interest rates at t , the observed change in interest rates, y_t , will be related to the random non-observable variable y_t^* as follows:

$$y_t = \begin{cases} s_1, & \text{se } y_t^* \in (-\infty, c_1] \\ s_2, & \text{se } y_t^* \in (c_1, c_2] \\ \vdots & \\ s_k, & \text{se } y_t^* \in (c_{k-1}, +\infty) \end{cases}, \quad (5)$$

where $c_1 < c_2 < \dots < c_{k-1}$ correspond to the limits endogenously identified in the estimation. Take $\Phi(z)$ as the function that determines the probability of a standard normal variable assuming a value lower or equal to z , so that in this case the probability of the interest rate changing in a s_j value is expressed by:³

³ For details on the maximum likelihood estimation via this process, see Hamilton & Jordà (2002).

$$P(y_t = s_j | x_t = 1, \omega_{t-1}) = P(c_{j-1} < \omega_{t-1}'\varphi + \varepsilon_t < c_j) = \begin{cases} \Phi(c_j - \omega_{t-1}'\varphi), j = 1 \\ \Phi(c_j - \omega_{t-1}'\varphi) - \Phi(c_{j-1} - \omega_{t-1}'\varphi), j = 2, \dots, k-1 \\ 1 - \Phi(c_j - \omega_{t-1}'\varphi), j = k-1 \end{cases} \quad (6)$$

4 EMPIRICAL EXERCISE

4.1 DATA BASE

The main variable in question is the SELIC rate adopted in Brazil. Thus, Table 2 presents the schedule of changes in the target rate, where the period of validity of each rate, the rate value, the size of the change and its duration in days. With regards to the data frequency aspect, just as seen in Hamilton & Jordà (2002), we should consider a time unit, such that the probability of there being more than one change in the interest rate in this period of time would be very negligible. It is also essential to pay attention not to choose a time interval too great in order not to lose important date of the sample. There is the historical evidence that meetings have occurred at intervals of less than two weeks and that during the period between January 2002 and July 2010, and the period of a rate's shortest duration was of 21 days, that is, at no time two changes are observed within the same week, so therefore the time unit used here is weekly.

It is possible to observe that over the fourteen years of the COPOM, more precisely from its first meeting, on 25 and 26 of June 1996, up until the 152nd meeting on 20 and 21 of July 2010, on average, SELIC is kept constant throughout 52 calendar days, almost two months, this duration being very volatile, with the standard deviation of almost 50 days. Looking at the extreme lengths, this rate has been maintained for a period of up to 280 days, between the 23 July 2009 until 23 April 2010, in which it remained in its lowest ever level

during the period under review, 8.75% per annum, possibly motivated by uncertainty regarding the recovery of the post-financial crisis economy, which had ground in August 2007, but whose real effects are strongly felt only during 2008. As for the 08 and 12 May 1999, stability was kept for only five consecutive days in a period of exchange rate instability.

The rate went through an average variation of 0.15%, with a volatility of 7.6% and fluctuations between -6.5% in March 5 1998, and 22.25% in October 31 1997, this volatile behavior being typical only for the past decade, revealing that most of the changes are of absolute order of magnitude at 0.25%, 0.50% and 0.75% from 2002. The SELIC rate fluctuated between 8.75% and 45% per annum, having assumed an average value of 20.20% from June 1996 till July 2010.

Table 2 - Schedule for Changes in the SELIC Target Rate

Year	Nº	Date	Interval (days)	Year	Nº	Date	Interval (days)	Year	Nº	Date	Interval (days)	Year	Nº	Date	Interval (days)	Year	Nº	Date	Interval (days)					
1996	1 st	25-jun	26-jun	-	1999	32 nd	17-jan	18-jan	32	2002	67 th	22-jan	23-jan	34	2005	104 *	18-jan	19-jan	34	2008	132 *	22-jan	23-jan	48
	2 nd	29-jul	30-jul	33		33 rd	3-mar	4-mar	44		68 th	19-fev	20-fev	27		105 *	15-fev	16-fev	27		133 *	4-mar	5-mar	41
	3 rd	20-ago	21-ago	21		34 th	13-abr	14-abr	40		69 th	19-mar	20-mar	27		106 *	15-mar	16-mar	27		134 *	15-abr	16-abr	41
	4 th	22-set	23-set	32		35 th	18-mai	19-mai	34		70 th	16-abr	17-abr	27		107 *	19-abr	20-abr	34		135 *	3-jun	4-jun	48
	5 th	22-out	23-out	29		36 th	22-jun	23-jun	34		71 st	21-mai	22-mai	34		108 *	17-mai	18-mai	27		136 *	22-jul	23-jul	48
	6 th	26-nov	27-nov	34		37 th	27-jul	28-jul	34		72 nd	18-jun	19-jun	27		109 *	14-jun	15-jun	27		137 *	9-set	10-set	48
	7 th	17-dez	18-dez	20		38 th	31-ago	1-set	34		73 rd	16-jul	17-jul	27		110 *	19-jul	20-jul	34		138 *	28-out	29-out	48
						39 th	21-set	22-set	20		74 th	20-ago	21-ago	34		111 *	16-ago	17-ago	27		139 *	9-dez	10-dez	41
						40 th	5-out	6-out	13		75 th	17-set	18-set	27		112 *	13-set	14-set	27					
						41 st	9-nov	10-nov	34		76 th	13-out	14-out	25		113 *	18-out	19-out	34					
						42 nd	14-dez	15-dez	34		77 th	22-out	23-out	8		114 *	22-nov	23-nov	34					
											78 th	19-nov	20-nov	27		115 *	13-dez	14-dez	20					
											79 th	17-dez	18-dez	27										
1997	8 *	21-jan	22-jan	34	2000	43 *	18-jan	19-jan	34	2003	80 *	21-jan	22-jan	34	2006	116 *	17-jun	18-jun	34	2009	140 *	20-jan	21-jan	41
	9 *	18-fev	19-fev	27		44 *	15-fev	16-fev	27		81 *	18-fev	19-fev	27		117 *	7-mar	8-mar	48		141 *	10-mar	11-mar	48
	10 *	18-mar	19-mar	27		45 *	21-mar	22-mar	34		82 *	18-mar	19-mar	27		118 *	18-abr	19-abr	41		142 *	28-abr	29-abr	48
	11 *	15-abr	16-abr	27		46 *	18-abr	19-abr	27		83 *	22-abr	23-abr	34		119 *	30-mai	31-mai	41		143 *	9-jun	10-jun	41
	12 *	20-mai	21-mai	34		47 *	23-mai	24-mai	34		84 *	20-mai	21-mai	27		120 *	18-jul	19-jul	48		144 *	21-jul	22-jul	41
	13 *	17-jun	18-jun	27		48 *	19-jun	20-jun	26		85 *	17-jun	18-jun	27		121 *	29-ago	30-ago	41		145 *	1-set	2-set	41
	14 *	22-jul	23-jul	34		49 *	18-jul	19-jul	28		86 *	22-jul	23-jul	34		122 *	17-out	18-out	48		146 *	20-out	21-out	48
	15 *	19-ago	20-ago	27		50 *	22-ago	23-ago	34		87 *	19-ago	20-ago	27		123 *	28-nov	29-nov	41		147 *	8-dez	9-dez	48
	16 *	16-set	17-set	27		51 *	19-set	20-set	27		88 *	16-set	17-set	27										
	17 *	21-out	22-out	34		52 *	17-out	18-out	27		89 *	21-out	22-out	34										
	18 *	29-out	30-out	7		53 *	21-nov	22-nov	34		90 *	18-nov	19-nov	27										
	19 *	18-nov	19-nov	19		54 *	19-dez	20-dez	27		91 *	16-dez	17-dez	27										
	20 *	16-dez	17-dez	27																				
1998	21 *	27-jan	28-jan	41	2001	55 *	16-jan	17-jan	27	2004	92 *	20-jan	21-jan	34	2007	124 *	23-jun	24-jun	55	2010	148 *	26-jan	27-jan	48
	22 *	3-mar	4-mar	34		56 *	13-fev	14-fev	27		93 *	17-fev	18-fev	27		125 *	6-mar	7-mar	41		149 *	16-mar	17-mar	48
	23 *	14-abr	15-abr	41		57 *	20-mar	21-mar	34		94 *	16-mar	17-mar	27		126 *	17-abr	18-abr	41		150 *	27-abr	28-abr	41
	24 *	19-mai	20-mai	34		58 *	17-abr	18-abr	27		95 *	13-abr	14-abr	27		127 *	5-jun	6-jun	48		151 *	8-jun	9-jun	41
	25 *	23-jun	24-jun	34		59 *	22-mai	23-mai	34		96 *	18-mai	19-mai	34		128 *	17-jul	18-jul	41		152 *	20-jul	21-jul	41
	26 *	28-jul	29-jul	34		60 *	19-jun	20-jun	27		97 *	15-jun	16-jun	27		129 *	4-set	5-set	48					
	27 *	1-set	2-set	34		61 *	17-jul	18-jul	27		98 *	20-jul	21-jul	34		130 *	16-out	17-out	41					
	28 *	9-set	10-set	7		62 *	21-ago	22-ago	34		99 *	17-ago	18-ago	27		131 *	4-dez	5-dez	48					
	29 *	6-out	7-out	26		63 *	18-set	19-set	27		100 *	14-set	15-set	27										
	30 *	10-nov	11-nov	34		64 *	16-out	17-out	27		101 *	19-out	20-out	34										
	31 *	15-dez	16-dez	34		65 *	20-nov	21-nov	34		102 *	16-nov	17-nov	27										
						66 *	18-dez	19-dez	27		103 *	14-dez	15-dez	27										

1 In the period from 01/07/96 to 03/04/99, COPOM fixed the Basic Rate of the Central Bank (TBC) and from 03/05/99, with its extinction it began to publish the target for the Selic rate for monetary policy purposes. 2 From 02/01/98, interest rates became fixed in annual expression. * As of June 2, 1999, we adopted the regime of Inflation Targeting. ** As of 2006, COPOM meetings are held every 45 days.

From January 2002, the same rate assumes an average value of 16.55%, with a much more stable behavior, with its volatility at 4.4%, fluctuating from 8.75% to 26.50% per annum.

With regards to the variables used with alleged ability to influence monetary policy decision making, we propose an adaptation of the base originally used in Hamilton & Jordà (2002). The descriptions of the explanatory variables are reported in Table 3.

Table 3 - Detailed Description of the Explanatory Variables ^a

Code	Description
Monetary variables	
<i>copom</i>	Dummy variable that associates or not the occurrence of COPOM's meetings in the current week.
<i>di</i>	The SELIC interest rate defined by the COPOM revised weekly (% per annum)
<i>m2g</i>	The final balance growth rate for the period of the broad money supply, M2, revised monthly
Inflation Metrics	
<i>dinf</i>	Inflation deviation (measured by the IPCA/IBGE) accumulated over the year compared to the current inflation target, revised monthly (% per annum)
<i>infac</i>	accumulated inflation over the last 12 months measured by the IPCA/IBGE (% per annum)
Product Metrics	
<i>dpib</i>	Gross Domestic Product deviation from potential GDP (Hodrick-Prescott filter), revised quarterly (% per annum)
<i>pibg</i>	Growth rate compared to the respective period of the previous year, associated with cumulative quarterly series throughout the year and seasonally adjusted gross domestic product
National Accounts	
<i>expg</i>	Growth rate compared to the respective period of the previous year, associated with cumulative quarterly series throughout the year and seasonally adjusted exports
<i>impg</i>	Growth rate compared to the respective period of the previous year, associated with cumulative quarterly series throughout the year and seasonally adjusted imports
<i>consg</i>	Growth rate compared to the respective period of the previous year, associated with cumulative quarterly series throughout the year and seasonally adjusted household consumption
Public Finances	
<i>govg</i>	Growth rate compared to the respective period of the previous year, associated with cumulative quarterly series throughout the year and seasonally adjusted government consumption

govpib Total net debt of the consolidated public sector (% of GDP)

Exchange Rate Matrics

camm Monthly exchange rate, based on the closing price of the PTAX period (% per annum)

cama Annual exchange rate, based on the closing price of the PTAX period (% per annum)

Labour Market

des Monthly unemployment rate measured by the ratio between the total number of idled people and the economically active population

Expectations

exp_pi
b Expectation revised quarterly of the real GDP growth for the next 12 months (% per annum)

exp_inf Expectation revised monthly from the inflation measured by the IPCA/IBGE for the next 12 months (% pa)

^aSource: Central Bank of Brazil

In an empirical exercise, it would be ideal to make available a disaggregated database and the most extensive enough in temporal dimensions and cross section. For the Brazilian economy, given that the expectations series are available only from January 2002, we decided to limit this as the beginning of the sample, and the month of July 2010 as the last one. Thus, we defined a set, with a weekly frequency over the period from January 2002 until July 2010, more specifically the first week analyzed set between 03 and January 9, 2002 and the last between 22 and 28 July 2010, in a total of 447 weeks. All the time series used were taken from the Central Bank of Brazil.

This adaptation to the Brazilian reality is strictly necessary, in keeping with the availability of existing proxy variables series and by expanding this group, focusing on variables used in other recent empirical work in Brazil, as well as the analyzes done in public minutes disclosed after COPOM's meetings.

In details, we made use of 17 variables: monetary in nature, capable of measuring accumulated inflation or deviations related to the target, seasonally adjusted metrics of accumulated GDP and its deviations related to its potential value, growth rates component aggregates of national accounts, public finance indicators, accumulated changes in the foreign exchange market, variables on the labor market and product and inflation expectations series for the next 12 months.

It is important to observe that the data used must be compatible with the period in which they are disclosed to the public in general. For example, we consider the Wide National Consumer's Price Index – WNCPI (*Índice de Preços do Consumidor Amplo -IPCA*) of a given month to be disclosed with an interval from nine to fifteen calendar days, according to the calendar made available by the Central Bank itself, as well as information about the labor market, which are made public only after three weeks and the national accounts in 70 calendar days. So when we consider the first or second week of a given month, the regarded IPCA is the one reported in the previous month. Information on production, imports, consumption, exports and Government expenditures in the last quarter 2008 for example, will only be taken into account by COPOM in the week between 12 and March 18, 2009.

Finally, figure 3 reports the evolution of the IPCA, the main variable which we believe to play an indisputable role in the COPOM's monetary decisions, in its various versions, be it a deviation from the target accumulated over the previous 12 months, or projected for the following year.

Figure 3 - IPCA (% pa): cumulative deviation throughout the year in relation to the inflation target, inflation in the last 12 months and inflation expectations for the next 12 months ^a

a For the year 2010, the IPCA of 3.10% corresponds to the accumulated value observed from January to July this year.

A first intuitive observation based on this figure is the reduction over time of orders of magnitude and especially in the oscillation of the series of deviations from the inflation target, a heading that only begins to mark to guide the conduct of monetary policy by adopting the Inflation Target regime. In line with this evidence, a shift in one year of the accumulated inflation series would allow the observation of the apparent long-term relationship between this series and the expectation, confirming the predictive ability of this series published in the reports, Focus of the Central Bank.

4.2 RESULTS FOR THE ACH

When the estimation of an ACD or ACH model, we should observe some details, bearing in mind the trade-offs between efficiency and consistency, as well as the additional assumptions about the behavior of the variables in question. In this context, according to Pacurar (2006), just as in Engle & Russell (1998), Engle (2000), and Engle & Russell (2002), the ACD framework has common characteristics to those observed in the framework proposed in Bollerslev (1986), the Generalized Autoregressive Conditional Heteroskedastic (GARCH). That is, the ACD is considered as a counterpart of the GARCH for duration of data at high frequency.

The results by Lee & Hansen (1994) and Lumsdaine (1996) support that under conditions believed to be reasonable, the estimator properties almost maximum likelihood of a GARCH (1.1), such as obtaining consistent estimators and asymptotically normal, are maintained in case of a framework EACD (1.1) proposed by Engle & Russell (1998).⁴ Under certain conditions accepted in this literature, Lee & Hansen (1994) prove a corollary that allows the ACD model to be estimated as a GARCH, being necessary in order to estimate via almost maximum likelihood, impose restrictions on the conditional mean of the dependent variable, the source of duration, $u_N(t)$.

By holding onto the set of explanatory variables, we decided to carry out a procedure on Eviews of the backward type, that is, testing the variables in different subsets with all 17 together, 16 to 16, ..., 2 to 2, and with only 1. Regarding the ACH (r, m) model specification possibilities, we opted for a parsimonious strand, in which we tested the ACH (0.1), the ACH (1.0) and the ACH (1.1). Thus, as in a GARCH (1.1), which proves able to remove the dependency on the squares of returns, an ACD or a low order ACH also seems to satisfy this criterion in the case for temporal dependence on durations.

⁴ The term EACD refers to an ACD where the probability distribution function is exponential.

Considering the three ACH's specifications in all estimations made to the accompanying sets of five or more explanatory variables, we identified insignificance in all estimated parameters, with values between -1.030 and -1.060 for the statistical log of likelihood. For virtually all sets tested this metric assumed value considerably higher in module when using the ACH specification (1.1). As in Jordà & Hamilton (2002), only estimations containing small groups of variables, among which, the cumulative inflation (*infac*), inflation expectations (*expinf*), the occurrence of the COPOM meeting (*COPOM*) and growth in the issuance of M2 (*m2g*), presented significance of the coefficients when using the specifications ACH (1.0) and ACH (0.1). Being limited therefore, only to the specifications in which there was significance of all coefficients, and following we opted for modeling with the greatest value of statistics in log likelihood, we defined by the specification that only the occurrence of the COPOM assembly was considered as relevant in a ACH (1.0) framework, as the results listed in Table 4.

The estimation of parameter α which showed insignificance at 5% for most of the specifications, suggests a negligible degree of persistence in serial correlation of durations, whilst the β associated with the discrepancy $\psi_{N(t)-i}$ with a value of 0.875 allows evidencing that the stationary condition is satisfied, as well as the restrictions imposed on maximizing numerical routines previously presented.

The hazard rate value regardless of the instrumentation, would be 16.55%, while by incorporating the occurrence of COPOM meetings, the only relevant explanatory variable in the better specified framework, the hazard rate given by the relation (3) would be given 21,23%. Thus, we characterize an expected and intuitive increase in the probability of there being a change in the SELIC rate in weeks with the COPOM meeting vis-à-vis weeks without them. This is an increase of probability, of which the magnitude appears to be lower than expected, but not necessarily negligible.

Table 4 - Estimation of ACH Framework (1.0) During the Period from January 2002 to July 2010^{a, b}

$$ACH(r, m) : \psi_{N(t)} = \varpi + \sum_{i=1}^r \psi_{N(t-i)} + \delta_c Z_{t-1}$$

Parameter	Variable	Estimated Value	Standard Error	P-value
β	$\psi_{N(t-1)}$	0,875*	0,264	0,001
ϖ	constant	1,334*	0,557	0,017
δ_c	COPOM _{N(t)}	-1,334*	0,256	0,000

^a Log likelihood statistics = -1.035,108. ^b Definition of the explanatory variables: COPOM_{N(t)} corresponds to the dummy variable associated with the occurrence of the COPOM meeting in the current week. * Significant parameter at 5%.

It is important to observe that there are no changes to the SELIC target on behalf of the Central Bank of Brazil, since 1998, unless it is in a week when meetings take place with the committee, unlike the previous years where all the changes observed in the years 1996 and 1997 were settled in one or two weeks after the meeting taking place.

With regard to diagnostic tests considered as standard in this type of statistical modeling, there is violation of the assumptions of gaussianity and homoscedasticity residuals, which can interfere with the estimation of efficiency, being however commonly found in literature.

4.3 RESULTS FOR THE PROBIT

Most of the changes adopted for the SELIC target rate were of absolute magnitude at 0.25%, 0.50% and 0.75%, especially from 2002 onwards. Thus, we made the choice of marks, or possible theoretical changes in interest rates at 0.25% as suggested by Hamilton & Jordà (2002), however, greater amplitude becomes possible: 3 marks up or down, that is, varying from 0.75% to +0.75%. All reductions with higher order of magnitude 0.75% are accounted for in the same category, as well as all increases higher than 0.75%, regardless of the value itself, whether 1.0% or 2.0%, for example.

In order to determine the intervals corresponding to each possible variation in the change in interest rates, the explanatory variables used in the Probit model were exactly the same ones as in the exercise described in the previous subsection, reported in Table 3.

According to the results, coefficients associated with the explanatory variables were significant at 5% only when the estimation of parsimonious frameworks containing: the increase in Government expenditure (*govg*), GDP deviations in relation to potential GDP (*dpib*) and inflation expectations (*expinf*) and GDP (*exppib*) both for the next 12 months. All

other variables appeared significant isolated or jointly. However, with particular regard to the specification with greater value for the statistical likelihood, we identified the relevance with significance at 1% individually and jointly of the variables that measure two expectation series and government expenditure growth only. The results of this framework are reported in Table 5.

Table 5 - Estimation of the Probit Model During the Period from January 2002 to July 2010^{a, b}

Log likelihood condition function of the marks:				
$L_{\theta} = \sum_{t=1}^T P(\omega_{t-1}; \theta, \theta_0 = (\varphi', \varphi_1', \dots, \varphi_{i-1}'))$				
Explanatory variables				
Parameter	Variable	Estimated Value	Standard error	P-value
$\varphi_{\text{exp_gdp}}$	$\text{exp_gdp}_{N(t)-1}$	0,310	0,089	0,001
$\varphi_{\text{exp_inf}}$	$\text{exp_inf}_{N(t)-1}$	0,199	0,043	0,000
$\varphi_{\text{gov_g}}$	$\text{gov_g}_{N(t)-1}$	0,156	0,047	0,001
Wald's test ($\varphi_{\text{exp_gdp}} = 0, \varphi_{\text{exp_inf}} = 0, \varphi_{\text{gov_g}} = 0$) tat. F = 13,154 (P-value = 0,000)				
Annual percentage variation limits on the SELIC interest rate				
Limit		Estimated Value	Standard error	P-value
c1		0,499*	0,438	0,255
c2		0,861	0,434	0,047
c3		1,028	0,433	0,018
c4		4,495	0,513	0,000
c5		4,581	0,516	0,000
c6		4,949	0,530	0,000
Wald's test ($c_i = 0, i = 1, \dots, 6$): Stat. F = 87,874 (P-value = 0,000)				

^a Statistical log likelihood = -238,952. ^b Definition of the explanatory variables: $\text{exp_gdp}_{N(t)-1}$ corresponds to the expected revised quarterly real GDP growth for the next 12 months, $\text{exp_inf}_{N(t)-1}$ corresponds to the expected revised monthly inflation measured by the IPCA/IBGE for the next 12 months, whilst $\text{gov_g}_{N(t)-1}$ corresponds to the growth rate compared to the respective previous year's period, associated with cumulative quarterly series throughout the year and seasonally adjusted government consumption. All these series are from the Central Bank of Brazil. * Parameter not significant at 5%.

Intuitively, we identify that increases in any of these variables in question implies the expected increase in the SELIC rate, making the framework more sensitive to the forecast of production, whose average value over the period was 3.39% per annum, with a coefficient of 0.31.

Sensitivity to expected inflation, which averaged 5.31% per annum, was 0.2, while the parameter associated with Government expenditure (mean of 3.11% per annum) was 0.16. More interestingly, in the framework of ordered Probit used with weekly frequency, during

the period from January 2002 to July 2010, COPOM seems to have a forward-looking characteristic regarding production and the inflation of the country, being important the apparently absent balance in recent years between fiscal and monetary policies, since the increased spending by the National Treasury would also be pushing the central Bank to adopt a contractionary monetary policy. Except for α_1 , all other coefficients are individually significant at 5%, result corroborated as from Wald's test for the six jointly coefficients. Once again, we rejected the hypothesis of normality of residuals, generating estimators possibly less efficient.

4.5 RESULTS OF THE FORECAST

Figure 4 illustrates the performance of the SELIC expected exercise period ahead, during the period from January 2002 to July 2010, being that the model used only for SELIC forecasts during weeks in which COPOM's meetings took place, minimizing the error associated with the model that allows changes within weeks without meeting. Based on the SELIC time series (gray) and the prediction by the statistical framework estimated in this study (dotted black) we obtained an order of 0.3358% forecast error.

There is a difficulty in establishing comparisons with results for the Brazilian economy, bearing in mind that comparison with quarterly results are neither that valid nor informative, for example. Even if we are not dealing with an adequate theoretical reference, the error obtained here was less than 0.3421% obtained when using the strategy to always use the latest value of the SELIC, as a forecast. These results are qualitatively and quantitatively robust in the scenario where we use the model every week, regardless of whether or not COPOM's meetings are being held.

In thirty five out of the fifty six changes in the SELIC target rates implemented by COPOM, the model correctly suggested the direction of change, so being in general the order of the change magnitude lower than the one actually practiced by COPOM. In 30 meetings where there was no change in the rate, the model predicted changes in directions, which would be mostly observed in future meetings, characterizing the Central Bank designed by the model, as being more sensitive to macroeconomic and financial variations, reacting more frequently and with less intensity than in practice, but aligned on the contractionary or expansionary nature of monetary policy.

Figure 4 - In-sample forecast one period ahead of the SELIC rate based on ACH and Ordered Probit models during the period from January 2002 to July 2010

5 CONCLUSIONS

The object of interest of this paper is a consequence of monetary policy in force after the *Plano Real* in 1994, period in which Brazil experiences an economic scenario of stability, with a controlled evolution in price developments. Thus, following Jordà & Hamilton (2002) methodologically, in order to model and understand the reaction of the Central Bank in SELIC interest rate decision, the main results obtained, suggest that the committee responsible for monetary policy in Brazil appears to have a forward-looking behavior in relation to the production and inflation in force in the country, besides worrying about the apparently absent balance in recent years between fiscal and monetary policies, since the increased expenditures by the National Treasury would also be pushing the Central Bank to adopt a contractionary monetary policy. Partially, this evidence on the forward-looking bias corroborates with Caetano et al. (2011), according to which, COPOM considers variables such as the deviation of inflation expectations as being twelve-step ahead in relation to the target, the consumer confidence index, lagged interest rate, as well as the ratio of public sector primary surplus / GDP and formal employment.

According to the forecast exercises within the sample, the Brazilian monetary authority in practice would be in line with that described by the theoretical model proposed here, being however, more sensitive to these macroeconomic and financial variations, reacting more frequently and with less intensity than that which we really observe. Once again, the result corroborates the evidence obtained from Caetano et al. (2011), which suggest that there is a high degree of “conservatism” in making COPOM’s decisions.

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