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Reviewing Taylor rules for Brazil: was there a turning-point?

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Abstract. This article finds evidences highlighting that the Brazilian monetary policy is divergent from Taylor principles, from data over January 2005 to May 2013, and using regressions estimated by OLS and GMM. Especially, the inflationary expectations do not show robust effects on the Selic rate, while the inertial degree of the latter denotes a current pro-cyclical bias. Furthermore, the article tested for the effects of the Subprime crisis and the domestic currency undervaluation on the Selic level. The empirical results suggest that the Subprime crisis monetary authorities have preferred to stabilize or expand output, against the inflation stabilization, despite the Brazilian inflation target regime since 1999.
Keywords. Taylor rule; Selic rate; Brazil; OLS; GMM.
JEL. E17, E52.

1. Introduction

One of the most relevant issues in the monetary policy literature concerns with the Central Banks' strategy in setting the policy instrument over time. In general, monetary authorities adopt a short term interest rate as the main instrument in making monetary policy, in order to control output and inflationary dynamics in relation to their respective potential and target levels (Taylor, 1993; Ball, 1999; Blinder, 2006; Galí & Gertler, 2007). It has been verified that monetary policy rules are flexible and change over time, or according to countries' specific preferences; however, in a broad sense, basic interest rates depend on all the information dynamics that causes the inflationary process, which is the Central Bank's overriding goal in long term.

On the other hand, assuming that the monetary policy, under inflation targeting regime, is determined by exchange rates fluctuations is a controversial subject. By assumption, under inflation targeting the main goal of the Central Bank is to maintain the observed and expected inflation in convergence to the inflation target. Hence, the monetary authority does not need to be directly affected by the exchange rate movement, as the latter is freely governed by the foreign currency market (Obstfeld & Rogoff, 1995; Svensson, 1997). However, in empirical terms there is no contradiction between a credible inflation targeting regime and empirical correlations of policy interest rates with exchange rate movements, because such movements can imply changes of the consumer inflation dynamics forward by pass-through effects. This idea is consistent with the assumptions in Svensson (2000).

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Brazil has made an important effort to control inflation rates in the last decades. The 70's, 80's and the beginning of the 90's were years of hyperinflation and low output growth in the Brazilian economy. In turn, the Real Plan – i.e. a plan designed for stabilizing prices –, implemented in 1994, was able to reduce consumer inflation rates expressively, but the volatile international financial context of the second half of the 90's, marked by the Mexican, Asian Tigers and Russian financial disruptions, made more difficult to control inflation through exchange rate targets in Brazil. So, in 1999, it introduced the *inflation targeting regime* in order to combine a credible nominal anchor with a floating exchange rate. Since that period, the Brazilian Central Bank (BCB) has adjusted the basic interest rate (Selic rate) as its main instrument for taking the observed and expected inflation to the inflation target.

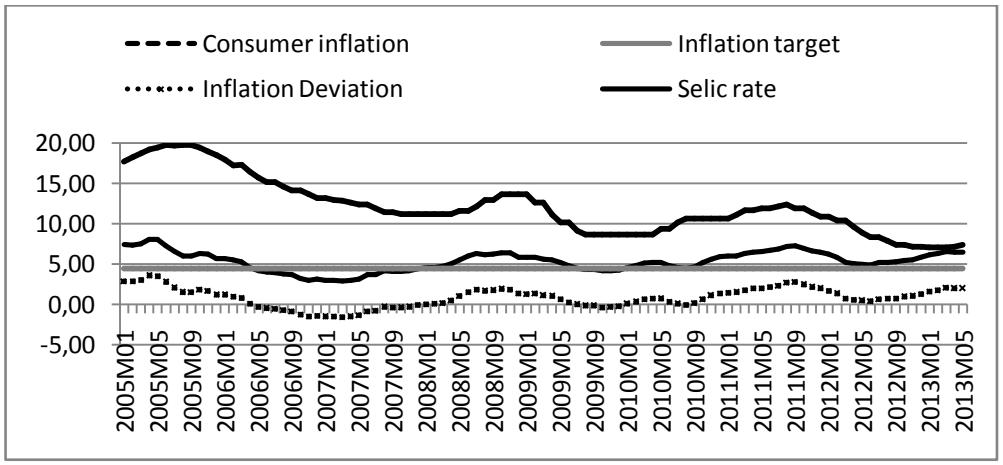
Since 2003 the Brazilian government has been conducted by the Workers' Party (Partido dos Trabalhadores - PT), a centre-left political party, which main announced goal was to eliminate income inequalities with a context of stable growth and prices. Luiz Inácio Lula da Silva was its first president, from 2003-2010, while Dilma Roussef started her government in 2011. It is important to highlight that Rousseff's government represented a kind of tuning-point for Brazil's monetary policy, which indeed could be observed from 2010 as an effort to make it more flexible (Modenesi, Martins, & Modenesi, 2012). However, Roussef's government maintained monetary and fiscal incentives that were implemented to offset the Subprime crisis' effects, despite an expressive economic recovery had been observed since 2010. In turn, it was actually from 2005 that the inflation target was definitely stabilized (at 4.5% per year measured by the *Broad National Consumer Price Index*). In such a context, we can regard 2005 as the year from which the Brazilian inflation targeting regime has been consolidated in formal terms.

Although such a consolidation has been performed at the institutional level, the observed consumer inflation has not converged to the inflation target in Brazil over the last years. As we can see in Graph-1, even though from around April 2006 to December 2007 Brazil had experienced a low inflation context, after that the annual consumer inflation rate has stayed generally above the target. Indeed, a simple mean calculated on the series of consumer inflation deviation is enough to show a positive value (about 0.85 or 85 basis points). Such a persistent positive deviation should be avoided particularly because the current Brazilian inflation target (an annual 4.5%) is not still an optimal long term target, at least if we look at the long term inflation rate in developed countries. Long term differences between the domestic inflation and the foreign inflation have expressive impacts that are translated into competitiveness gaps, among other things.

In turn, we can observe that the BCB has adjusted the Selic rate cyclically and with a general tendency of reduction over time. Indeed, the reduction of the difference between the Selic rate and the consumer inflation over time is clear, that is, the BCB has decreased the *ex post* real interest rate (Selic rate – consumer inflation) over such a period. However, there was not a structural downturn movement of the consumer inflation or inflation deviation at the same time. It suggests that, although the Selic rate cycle can be associated with the other variables' cycle, the decreasing Selic rate level over time could be associated with a discretionary decision of the BCB. Starting from 10.3% per year in January 2005, *the ex post* real Selic rate converged to 0.9 per year in May 2013 (Graph-2). This giant monetary impulse cannot be explained by the output and inflation dynamics, but will certainly impact such a dynamics. In turn, the *ex ante* real Selic rate (Selic rate – expected consumer inflation) had similar trend, but with values softly above

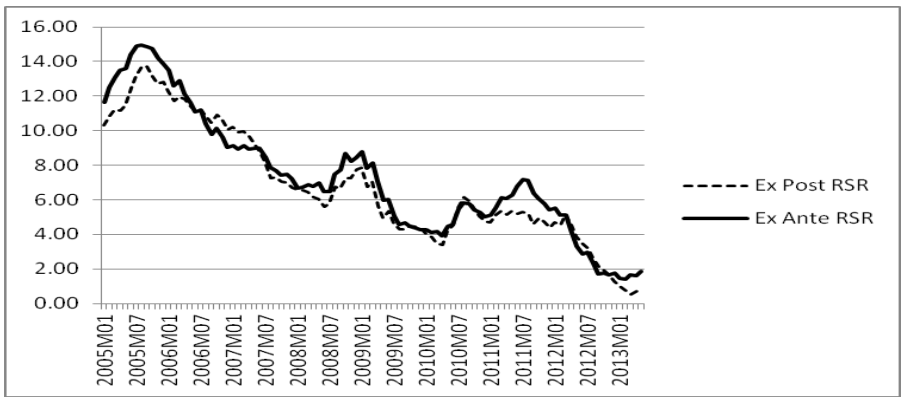
the *ex post* one. This is because the public probably expected an increase of the Selic rate forward due to the current and expected inflation deviation.

Thus, concerning the Selic cycle, how does the Brazilian Central Bank react to the main macroeconomic fluctuations over time? The literature on inflation targeting regimes associates optimal interest rate adjustments with the convergence of inflation to its target, even if transitory deviations occur due to shocks (Svensson, 1997). Therefore, an appropriate reaction of Brazil's basic interest rate is important because it can contribute to eliminate those observed deviations, thereby allowing for a lower long term inflation target.



GRAPH 1: *Consumer inflation, inflation target, inflation deviation and Selic rate in Brazil from Jan/2005 to May/2013*

In turn, the *pass-through* effect of exchange rate changes on consumer inflation is an important related issue. There has been a theoretical and an empirical literature regarding the causes of high or low pass-through effects across the countries (Edwards, 2006; Taylor, 2000; McCarthy, 2000). Despite possible different determinants on the pass-through degree, a more relevant question for this current article is whether the Central Bank should take exchange rate movements into account when adjusting its basic interest rate. As the main goal of the inflation target regime is to control consumer inflation over time, and consumer prices have sensibility to exchange rate changes, it would not be strange if Central Banks adjusted their basic interest rates facing such changes, so as to avoid inflation deviations in relation to the announced targets.



GRAPH 2: *Ex Post and Ex Ante Real Selic Rate (RSR) from January 2005 to May 2013*

One can highlight that through consolidating the inflation targeting regime, credibility gains can make Central Banks more autonomous against foreign factors, and so more committed to domestic factors such as consumer inflation and output dynamics. Indeed, such autonomy would be one of the advantages of the inflation targeting regime (Svensson, 1997; Bernanke & Mishkin, 1999) in comparison with other types of nominal anchors, such as exchange rate target regimes. Does that autonomy recently occur in Brazil?

Furthermore, in 2008 and mainly in 2009 Brazil was expressively affected by the international financial crisis (Subprime crisis). Was there any structural change of the Brazilian monetary policy as a consequence of such a period? All these questions can be answered by estimating the way the BCB reacts to domestic and foreign variables. In turn, observing estimated monetary policy rules it is possible to make some judgments about the quality of basic interest rate adjustments concerning what is expected in terms of an effective commitment to announced inflation targets over time.

The Section 2 presents a theoretical approach for dealing with monetary policy rules and some empirical evidences obtained for Brazil, while Section 3 shows the adopted data, the empirical strategy and the analysis of the results, which are compared to the empirical literature. At last, Section 4 presents the main conclusions, followed by the references and an Appendix.

2. Monetary policy rules approach: Taylor principles

A structural economic model under the inflation targeting regime is defined in Ball (1999a;b), Svensson (1999) and Galí & Gertler (2007), among others. The demand and output dynamics are expressed by a kind of stochastic IS curve, so that the output gap (y_t) depends on its past value, on the short term interest rate deviations in the past periods (i_{t-1}), on the past exchange rate deviation $(e_{t-1} - e_{t-2})$[i] and on a demand shock (ε_{1t}) with zero mean and constant variance:

$$y_t = b_1 y_{t-1} - b_2 i_{t-1} + b_3 (e_{t-1} - e_{t-2}) + \varepsilon_{1t} \quad (1)$$

Let b_1, b_2 and b_3 be positive parameters. In turn, the inflationary dynamics is presented through a Phillips curve, so that the inflation rate deviation (π_t) is caused by its past value (π_{t-1}), by the lagged output gap (y_{t-1}), by the current exchange rate deviation ($e_t - e_{t-1}$) and by a supply shock component (ε_{2t}) with zero mean and constant variance; a_1, a_2 and a_3 are also positive parameters:

$$\pi_t = a_1 \pi_{t-1} + a_2 y_{t-1} + a_3 (e_t - e_{t-1}) + \varepsilon_{2t} \quad (2)$$

The Central Bank adopts a monetary policy rule in line with the Taylor rule, in which the basic interest rate is a function of output and inflation deviations in relation to their desirable values. The equilibrium real interest rate is given by r^n and Π^T is the inflation target; c_1 and c_2 are positive parameters and ε_{3t} is a policy innovation shock:

$$i_t = r^n + \Pi^T + c_1 y_{t-1} + c_2 \pi_{t-1} + \varepsilon_{3t} \quad (3)$$

However, the literature shows that Central Banks have an inertial behavior with regard to the basic interest rate adjustments (Woodford, 2003; Blinder, 2006). That is, in order to define in each moment the new value for the basic interest rate, policymakers give weight to its past values. It would be a form of smoothing the monetary policy, thereby avoiding interest rate's abrupt movements and frequent reversions. Thus, the equation (3) receives an inertial component:

$$i_t = \rho i_{t-1} + (1 - \rho)\,[(r^n + \Pi^T) + c_1 y_{t-1} + c_2 \pi_{t-1}] + \varepsilon_{4t} \quad (4)$$

Given $0 \leq \rho \leq 1$ (the inertial coefficient), which gives weight to the past interest rate in determining the current interest rate formation, while ε_{4t} is the policy innovation shock in the inertial rule.

Some models have *forward-looking* nature, as the public's expectations gain importance in affecting the authorities' policy decisions. Haldane and Batini (1998), for instance, adopt the following instrument rule:

$$r_t = \rho\, r_{t-1} + (1 - \rho)\, r_t^* + \theta\,[E_t \Pi_{t+j} - \Pi_t^*] + \varphi\, y_{t-1} + \varepsilon_{5t} \quad (5)$$

Given $r_t = [i_t - E_t\Pi_{t+1}]$ the expected real interest rate, that is, the difference between the nominal interest rate (i_t) and the expected inflation rate in the period t ($E_t\Pi_{t+1}$) for t+1. The equilibrium real interest rate is given by r_t^*, the inflation target is Π_t^* and ρ, θ and φ are positive parameters. Clarida, Galí, and Gertler (1999), among others, adopt mainly *forward-looking rules*, instead of *backward-looking rules*, as a good description for the basic interest rate behavior in economies in which the price stability is the Central Bank's explicit or implicit target.

Although the equation (5) is presented in real terms (i.e. a real Taylor rule) for the interest rate, it is usual to test for monetary policy rules in nominal terms. Hence, we can define the nominal Taylor rule for an open economy by taking the exchange rate change into account. The coefficient c_3 expresses the sensibility of the basic interest rate adjustments to exchange rate changes. In theory, $c_3 > 0$ so that the monetary policy has a countercyclical behavior facing the *pass-through effect*, that is, the effect of exchange rate movements on the consumer inflation:

$$i_t = \rho i_{t-1} + (1 - \rho)\,[(r^n + \Pi^T) + c_1 y_{t-1} + c_2(\, E_t \Pi_{t+j} - \Pi_t^*) + c_3(e_{t-1} - e_{t-2})] + \varepsilon_{6t} \quad (6)$$

Another important feature of the Taylor rule such as (6) is related to c_2 value. The so-called Taylor principle defines c_2 as exceeding unity (Clarida et al. 1999) to make real interest rates moving counter-cyclically[ii]. When $c_2 > 1$ the real interest rate increases as a response to an increase of the expected inflation deviation. It clearly corresponds to $\theta > 0$ in (5).

3. Related empirical literature

In the international empirical literature, Clarida, Galí, & Gertler (2000) estimated the Taylor rule for the US economy through implementing OLS. The authors found that the FED's monetary policy became more aggressive ($\theta > 0$) from 1979 (post-Volcker period) than what was observed until this year (when $\theta < 0$).

These results that show a kind of a break in the US monetary policy from the Volcker's mandate are also found in authors such as Cogley & Sargent (2001) and Boivin (2006), although these last adopted different empirical methods in comparison with Clarida et al. (2000).

Specifically in relation to the Brazilian economy, Minella, de Freitas, Goldfajn, & Muinhos (2003) considered the expected inflation rate deviation in relation to the inflation target as a variable determining the monetary policy instrument, through a regression study for the period from Jun/1999 to Jun/2002. Moreover, it was tested a regression equation with two lags of the basic interest rate so as to

eliminate the serial autocorrelation problem, which was observed in the model with only one lag for the basic interest rate.

The authors attained the following main evidences: a) it was verified a high inertial coefficient (ρ) by varying between 0.7-0.8 or more; b) the output gap coefficient did not present statistical significance in general, and, in other cases, it presented a signal that diverged from the theory; c) the coefficient for the expected inflation component (such as θ), in general, obtained values higher than unity and significance at 1% level. This evidence is consistent with the Taylor principle, according to which a monetary policy that is efficient in controlling inflation dynamics, at low and stable levels, has a reaction that is higher than the (expected) inflationary variation; d) the authors also tested for the inclusion of an exchange rate as an explainable variable in the monetary policy rule, but its coefficient was not statistically significant.

Holland (2005), as well as Barbosa & Soares (2006), also found a counter-cyclical behavior of the Selic rate facing expected inflation changes, suggesting a monetary policy's appropriate response to make observed inflation convergent to targets. Concerning the exchange rate, theses studies have attained evidences showing a positive response of the Selic rate to an undervaluation of Brazil's Real against the US Dollar. In the same line, Furlani, Portugal, & Laurini (2010), by means of Bayesian methods, have obtained results of expressive positive responses of the Brazilian basic interest rate to an increase of exchange rates over time. Such evidences mean that, although Brazil does not determine a target for the exchange rate, the effects of the latter on observed and expected inflation can induce systematic reactions of the Selic rate in order to avoid persistent inflation deviations.

The Table-1 presents some relevant parameters' values in the literature for the Brazilian case with regard to Taylor rules, including also Modenesi (2008) and Nobre & Moreira (2014) as references to help in analyzing the empirical results that the current work will estimate forward.

TABLE 1: *Summary of some relevant parameters' values for Brazil*

Work/Parameter	Inertial degree	Expected inflation	Output gap	Exchange rate
Minella et al. (2003)	0.7 to 0.8 (***)	1.42 to 1.78 (**)	-0.47 to -0.25 (***)	Not statistic. Significant
Holland (2005)	0.45 to 2.46 (**)	2.33 to 4.35 (**)	-1.41 to -0.95 (***)	0.38[Ξ] (**)
Barbosa & Soares (2006)[Γ]	0.27 to 0.54 (***)	0.11 to 0.28 (***)	0.09 to 0.15 (***)	0.04 to 0.07 (***)
Modenesi (2008)	0.86 to 0.9 (***)	Not tested	0.32 to 0.35 (*)	Not tested
Furlani et al. (2010)[Ψ]	0.103 to 0.92 (**)	Not tested	4.66 to 5.41 (**)	4.61 to 4.85 (**)
Nobre and Moreira (2014)	0.99 (***)	0.17 to 0.19	-0.007 to -0.009	0.22

Notes: Significance level in parenthesis: (***), (**) and (*) mean, respectively, significant at 1%, 5% and 10% level. [Ξ] For nominal exchange rate depreciation; [Γ] Dependent variable: first difference for the basic interest rate; [Ψ] Through Bayesian methods. **Source:** Own elaboration.

4. Data, Integration Order and Empirical Strategy

All the variables below were collected for the time sample from January/2005 to May/2013 [iii] and their description and sources are shown in Table-2. We also consider the possibility of a structural break of the Brazilian monetary policy due to the Subprime crisis. To allow for such a possibility, we can include an additional

variable or a *dummy* variable (SUBPRIME). The Brazilian economy's GDP (Y) was the variable selected for defining the values of the dummy variable, thus giving 1.0 to the months in which the GDP presented strong contraction, and 0.0 to months in which it presented a behavior compatible with its historical trend. Hence, SUBPRIME was defined with 1.0 from November 2008 to November 2009. Otherwise, it presents 0.0.

TABLE 2: *Time series adopted into the empirical analysis: description and sources*

Series	Description and Sources
I	Brazilian basic and effective interest rate (SELIC) (source: www.bcb.gov.br)
EXP_P	Accumulated expected consumer inflation for 12 months forward (source: www.bcb.gov.br)
P	Accumulated consumer inflation in 12 months, by the *Broad Consumer Prices* (source: www.ibge.gov.br);
Y	Brazilian proxy for the GDP on a monthly basis, measured by the BCB (source: www.bcb.gov.br);
E	Brazilian nominal exchange rate of Real (R$) against US dollar (source: www.ipeadata.gov.br).
SUBPRIME	Dummy to capture effects of the Subprime crisis. Assumes 1.0 from Nov/2008 to Nov/2009; 0.0 otherwise.

Source: Own elaboration.

The first step with time series studies is to verify the integration order of the variables, that is, if they can be considered as stationary at level or if there exists the necessity for applying first differences or even higher differences to make them stationary. Hence, the *Augmented Dickey-Fuller* (ADF), the *Phillips-Perron* (PP) and the *Dickey-Fuller GLS* unit root tests were performed as a way for defining their integration order. As we can view in Table-3, the following time series can be regarded as presenting unit root in level: EXP_P, P and Y; in turn, the stationary variables in level are I and E.

TABLE 3: *ADF, PP and DF-GLS Unit root tests (statistics)*

	ADF[1]	PP[2]	DF-GLS	ADF[3]	PP[4]	DF-GLS	
Series	**Level test**			**1st Difference test**			**I(n)**
I	-4.1431***	-1.6846*	-3.9149***	-	-	-	I(0)
EXP_P	-3.0211	-3.1603*	-1.2966	-8.2066***	-8.1471***	-7.2775***	I(1)
P	-2.5326	-2.2911	-1.8617	-5.1519***	-5.1139***	-5.2509***	I(1)
Y	-2.1634	-2.3500	-2.2238	-9.3779***	-9.4367***	-8.6657***	I(1)
E	-2.5829*	-2.6650*	-1.3324	-	-	-	I(0)

Notes: (1) Only significant constant for P and E; (2) none significant component for I and only constant for E; (3) none for EXP_P and P and only constant for Y; (4) none for EXP_P and P and only constant for Y. Statistical significance at 10%(*), 5%(**) and 1%(***). **Source:** Own elaboration.

In such a case, as the time series are not jointly I(1), cointergation approaches are not appropriate in Engle and Granger (1987)'s view and the method of *Ordinary Least Squares (OLS)* can be adopted with the unit root variables (EXP_P, P and Y) in their first difference form, while the stationary ones (I and E) in their level form, thereby resulting in a short-term dynamics estimation. So, in order to estimate monetary policy rules or Taylor rules for the Brazilian economy, this work

implemented such a method. However, a better way to correct common problems of heteroscedasticy, residual autocorrelation and also endogeneity is by adopting the *Generalized Method of Moments* (GMM) (Hansen, 1982). Hence, we can specify, for robustness purposes, a sample of GMM regressions and compare their results with the previous OLS findings.

Before applying GMM estimates, we should observe if the *instrumental variables* are exogenous. Thus such instrumental series were defined from t-1 to earlier periods thereby matching this hypothesis, following Johnston (1984). Moreover, an analysis of *overidentification* was implemented (by means of the J-test), which aimed at testing for the correct specification of the instrumental variables (Gragg, 1983; Hansen, 1982).

5. OLS estimates and analysis

We can observe the specifications through OLS estimates in Table-4. All regressions have presented adjusted R^2 above 0.9. The OLS estimation was made by the Newey and West (1987) estimator[iv], which is consistent for correcting the existence of residual autocorrelation that was suggested by the LM test for all the specifications.

The inertial coefficient presents statistical significance at 1% in all models and its value stays from 0.992 to 1.013, thereby showing that the BCB implemented a high degree of gradualism to adjust the basic interest rate. Regarding the forward-looking coefficient, all the specifications generated estimates without statistical significance and their estimated values stay far from exceeding unity (i.e. the Taylor principle). In this respect, such a policy cannot be regarded as counter-cyclical, as it is not consistent with counter-cyclical movements of real interest rates (Clarida et al., 1999). In turn, the backward-looking component, relating D(P) to I changes, has presented statistical significance in Equations 1 and 3, and its estimates have positive values, including Equation 5. Despite these results, such estimates are also far from exceeding unity, thereby corroborating the pro-cyclical bias of the BCB over the studied sample.

Concerning the monetary policy's reaction to GDP dynamics, the associated parameter has not presented statistical significance and its value is negative in all models, that is, in contrast with the literature prediction: the BCB reacts pro-cyclically to GDP changes. Such strange empirical evidence regarding the output component is also found in other empirical works for Brazil, such as Minella et al. (2003) and Holland (2005).

With regard to the role of exchange rate movements, we can observe that such a variable does not impact the BCB's interest rate with statistical significance. Moreover, its estimated value is negative (Eq.3-Eq.6), showing that an undervaluation of the domestic currency is followed by a decrease of the Selic rate. This is also a contradictory response under the inflation targeting regime, as an undervaluation generally causes higher inflation levels (Edwards, 2006; Taylor, 2000; McCarthy, 2000). We can interpret this result in the following way: the BCB has an empirical preference for stabilizing or stimulating output changes in Brazil, so that when facing trade-offs regarding output-inflation stabilization, the monetary policy clearly demonstrates preference to output, which is consistent with a pro-cyclical reaction of the Selic rate. So, the pass-through effect has not been significantly taken into account by the BCB, at least at the moment of the Selic rate decision.

TABLE 4: *Selic interest rate (I_t): OLS-New & West estimates – January 2005 to May 2013*

Explanatory Variables	OLS-NW Estimates					
	Eq.1	**Eq.2**	**Eq.3**	**Eq.4**	**Eq.5**	**Eq.6**
C	-0.0812	-0.0119	0.4525	0.5881	0.4044	0.5014
	(0.2162)	(0.2202)	(0.4916)	(0.5349)	(0.4845)	(0.5222)
	[-0.3758]	[-0.0543]	[0.9205]	[1.0994]	[0.8348]	[0.9600]
I(-1)	0.9986***	0.9922***	1.0132***	1.0093***	1.0042***	0.9988***
	(0.0177)	(0.0181)	(0.0182)	(0.0186)	(0.0181)	(0.0173)
	[56.2825]	[54.7648]	[55.4739]	[54.2351]	[55.2130]	[57.6270]
D(EXP_P(-1))	0.2110	0.3950	0.1339	0.2923	0.1415	0.2703
	(0.2511)	(0.2618)	(0.2064)	(0.2205)	(0.2012)	(0.2032)
	[0.8405]	[1.5084]	[0.6489]	[1.3252]	[0.7033]	[1.3300]
D(P(-1))	0.4085**		0.3789*		0.3184	
	(0.1835)		(0.1962)		(0.2070)	
	[2.2252]		[1.9313]		[1.5381]	
D(Y(-1))	-0.0181	-0.0027	-0.0197	-0.0058	-0.0239	-0.0137
	(0.0227)	(0.0256)	(0.0266)	(0.0303)	(0.0329)	(0.0371)
	[-0.7970]	[-0.1067]	[-0.7389]	[-0.1922]	[-0.7249]	[-0.3717]
E(-1)			-0.3629	-0.4119	-0.2672	-0.2830
			(0.2459)	(0.2757)	(0.2419)	(0.2740)
			[-1.4755]	[-1.4938]	[-1.1045]	[-1.0329]
SUBPRIME(-1)					-0.2204	-0.2743
					(0.1571)	(0.1471)
					[-1.4031]	[-1.8647]
Adj. R-squared	0.9869	0.9861	0.9872	0.9865	0.9875	0.9871
F-statistic	1850.76	2325.81	1519.01	1803.77	1295.61	1504.64
Prob(F-statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LM (Prob:02 lags)	0.0005	0.0000	0.0024	0.0001	0.0029	0.0002

Note: () for standard error and [] for t-statistic; *** for statistical significance at1%, ** at 5% and * at 10%. **Source:** Own elaboration.

In turn, regarding the role of the Subprime crisis, we cannot verify statistical significance for its correspondent parameter, but it presents a negative value, suggesting that, broadly, if the BCB showed any change in its monetary policy conduction, the resulting response would be to decrease basic interest rates in Brazil, accompanied by several Central Banks from 2008 to 2009.

6. GMM estimates and analysis

The GMM estimates for those monetary policy rules are viewed in Table-5. The inertial coefficient maintained its statistical significance in all regressions and its value varies from 0.957 to 0.988, thus corroborating the previous estimates from OLS regressions and confirming the high degree of gradualism of the BCB. Concerning inflationary expectations, the GMM estimates obtain statistical significance for Equations 2 and 6, but their values are much less than unity, so that the monetary policy does not denote a counter-cyclical role in such an aspect. In such a case, the current estimates are closer to those of Barbosa & Soares (2006)

and Nobre & Moreira (2014) and diverge from those of Minella et al. (2003) and Holland (2005).

Regarding the back-warding component (P), the results are similar to those from OLS regressions in terms of statistical significance and coefficient values, thereby suggesting a pro-cyclical monetary policy. In turn, the output component maintained its non-significance and its negative signal, which also reinforce such monetary policy's pro-cyclical pattern. Hence, in such an aspect our estimates are closer to those of Minella et al. (2003) and Holland (2005) (that is, an undesirable pro-cyclical policy) and diverge from those of Barbosa & Soares (2006) and Modenesi (2008), which have found positive coefficients, but lower than the values for the other estimated components[v].

However, the GMM estimates (Table-5) brought some new features in comparison with the OLS ones (Table-4). Basically, we can highlight the significant role of the exchange rate and the Subprime crisis on Selic adjustments over time (Equations 3 to 6 in Table-5). On the one hand, exchange rate changes have statistically significant inverse correlation with Selic in Equations 3 and 4, if we do not control for Subprime effects. On the other hand, such inverse relations are not consistent with counter-cyclical responses to pass-through effects. As we viewed in the theoretical section, that coefficient should be positive under inflation targeting regimes.

Furthermore, if we control for Subprime effects (Equations 5 and 6), the correspondent coefficient presents statistical significance at 1% and negative value, confirming the OLS estimates in terms of coefficient values, but with higher values. While the OLS estimates have found values around 0.2 for the Subprime effect, the GMM estimates have obtained coefficients around 1.0. These findings demonstrate that the BCB had a preference for decreasing Selic rate especially from Nov/2008 to Nov/2009 as a way to offset the downturn movement of Brazil's GDP. It is important to highlight that all the models have presented high adjusted R^2 level and the J-statistics have not rejected the null hypothesis across the six regressions, corroborating the assumption of correct specification of the models (Craigg, 1983; Hansen, 1982). Besides, we also tested for a potential structural break on the behavior of the monetary policy as a consequence of the beginning of Rousseff's mandate, from January 2011. Thus, we adopted another dummy variable, assuming 1.0 from such a month to May 2013, and 0.0 otherwise. However, when we replaced the Subprime dummy by the Rousseff one, into both the OLS and GMM regressions, we did not identify statistical significance for the related coefficient, so that we can adequately regard the Subprime crisis as the true structural change over the last years concerning Brazil's monetary policy, and as the momentum of a deeper divergence from Taylor principles.

TABLE 5: *Selic interest rate (I_t): GMM estimates – January 2005 to May 2013*

Explanatory Variables	GMM Estimation					
	Eq.1	**Eq.2**	**Eq.3**	**Eq.4**	**Eq.5**	**Eq.6**
C	0.0197	0.2264*	1.0376***	1.4063***	0.1670**	0.9444**
	(0.1509)	(0.1237)	(0.3499)	(0.2357)	(0.5491)	(0.4316)
	[0.1309]	[1.8306]	[2.9653]	[5.9649]	[2.1253]	[2.1877]
I(-1)	0.9849***	0.9692***	0.9882***	0.9841***	0.9575***	0.9624**
	(0.0119)	(0.0098)	(0.0133)	(0.0133)	(0.0176)	(0.0157)
	[82.2524]	[98.7523]	[73.7942]	[73.6828]	[54.2355]	[60.9309]
D(EXP_P(-1))	0.2609	0.4004**	0.1683	0.1800	0.2123	0.1838***

	(0.1894)	(0.1932)	(0.1435)	(0.1353)	(0.1695)	(0.1641)
	[1.3676]	[2.0726]	[1.1732]	[1.3306]	[1.2522]	[1.1199]
D(P(-1))	0.3849***		0.2705**		-0.2237	
	(0.1121)		(0.1353)		(0.2340)	
	[3.4343]		[1.9997]		[-0.9559]	
D(Y(-1))	-0.0080	0.0031	-0.0217	-0.0197	-0.0262	-0.0253
	(0.0201)	(0.0180)	(0.0242)	(0.0241)	(0.0435)	(0.0403)
	[-0.3987]	[0.1734]	[-0.8968]	[-0.8178]	[-0.6023]	[-0.6288]
E(-1)			-0.5382***	-0.6914***	-0.3160	-0.2515
			(0.1553)	(0.1205)	(0.3405)	(0.2856)
			[-3.4638]	[-5.7364]	[-0.9281]	[-0.8837]
SUBPRIME(-1)					-1.1199***	-0.9882***
					(0.3039)	(0.2351)
					[-3.6848]	[-4.2021]
Adj. R-squared	0.9848	0.9845	0.9862	0.9862	0.9771	0.9799
J-stat	11.2576	13.4618	9.7851	10.9886	6.9621	7.6460
(J-Prob)	0.4219	0.3363	0.4595	0.4442	0.6410	0.6633

Note: The instrumental variables were I(-1), I(-3), I(-5), D(P(-1)), D(P(-3)), D(P(-5)), D(EXP_P(-1)), D(EXP_P(-3)), D(EXP_P(-5)), D(Y(-1)), D(Y(-3)), D(Y(-5)), E(-1), E(-3), and E(-5); () for standard error and [] for t-statistic; *** for statistical significance at1%, ** at 5% and * at 10%. **Source:** Own elaboration.

Therefore, taking both the OLS and GMM estimates into account, in general, the main remark is that the inertial coefficient presents higher magnitude than the estimates of the reviewed studies for the Brazilian case, except for some regressions made by Holland (2005), particularly in consistence with Nobre & Moreira (2014). This current evidence confirms the Brazilian Central Bank's conservative behavior and, in fact, expresses an increase of its inertial degree over the last years. Moreover, we obtained evidences confirming the pro-cyclical bias of the BCB, concerning the responses to GDP, inflationary expectations, observed inflation and exchange rate changes, thus making clear a kind of intertemporal inconsistence of the monetary policy. Finally, the Subprime crisis had an effective role in inducing lower Selic levels in Brazil, but controlling for such a role does not eliminate the pro-cyclical bias regarding the other factors.

7. Concluding remarks

Giving focus on the monetary policy's higher inertial coefficient estimated in this work, in comparison with previous works for Brazil, and the lower forward-looking component as well, it is possible to say the BCB has conducted its monetary policy in a worse way over the last years, thereby presenting a kind of turning-point that explains at least a part of the current inflationary deviations. Therefore, the main proposition is to calibrate the Brazilian monetary policy for a more activist (less gradual) policy, as well as more expressive responses of the Selic rate to expected inflation changes and output gaps.

In turn, with respect to exchange rate fluctuations, that is, the "mirage" of exchange rate targets, Obstfeld & Rogoff (1995) argued that monetary policy should not be conducted for controlling the exchange rate, although the latter can be useful in signaling important macroeconomic features for the Central Bank's decisions. The literature on inflation targeting regimes is controversial when the

subject is the role of exchange rate for the monetary policy strategy. For instance, Svensson (1997) argued that inflation targeting regimes should not have intermediate targets, such as exchange rates, but in a transitory period, and only if no conflict with the inflation target arises. On the other hand, Ball (1999b) suggests that under inflation targeting regime and opened economies, the Central Bank's optimal instrument rule is defined as a weighted sum of interest rate and exchange rate, thereby giving a direct role for the latter in making monetary policy, despite maintaining the long run inflation in convergence to the target is still the main goal of the monetary authority. In other words, "*All real-world inflation-targeting economies are quite open economies with free capital mobility, where shocks originating in the rest of the world are important, and where the exchange rate plays a prominent role in the transmission mechanism of monetary policy*.", as argued by Svensson (2000, p. 157).

However, this work has attained some evidences in contrast with the expected role of exchange rates into the Taylor rule, that is, the findings highlighted the pro-cyclical response of Selic levels to exchange rate fluctuations over time. Therefore, the BCB's preferences are for output stabilization or expansion and against inflation control, despite the existing inflation targeting regime in Brazil. Furthermore, although the Subprime crisis has presented an effect on Selic levels, by reducing them, such an effect did not change the pro-cyclical reaction of the BCB to the other relevant variables into the Taylor rule. Hence, we can conclude that the Brazilian monetary policy has experienced a kind of turning-point over the last years towards a worse nature, especially compared with Minella et al. (2003) and Holland (2005), which studied the first years of inflation targeting in Brazil and obtained results demonstrating a counter-cyclical response of the Selic rate.

Notes

[i] Thus, e_t is the nominal exchange rate, and its increase means a devaluation of the domestic currency *vis-à-vis* the foreign one.

[ii] However, we can regard *Taylor principles*, rather than *the Taylor principle*, as a more general definition, which includes the desired countercyclical response of the basic interest rate to all relevant variables ultimately determining inflation rates, and not only to expected and/or observed inflation.

[iii] Such a sample was adopted because in this period the Brazilian consumer inflation target was stable at 4.5% per year.

[iv] The New and West (1987) estimator is also consistent for correcting problems of heteroscedasticity in time series.

[v] The exception is Furlani et al. (2010), in which, by applying Bayesian methods, the output gap coefficient presents high positive values, thereby demonstrating an expressive counter-cyclical monetary policy. In such a context, it is possible to say at least that there is no consensus in relation to the empirical evidences for the Brazilian Central Bank's reactions to the output gap trajectory.

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