GV Invest
Short Studies Series

GV INVEST | 17

Evidence of monetary policy shift in Brazil

What does the partial lack of adherence of the Brazilian monetary policy to the Taylor Rule imply about undisclosed changes in the priorities of the government?

XX, 2018

Alexis Petri M Costa[1]

1. Introduction

The Taylor rule was proposed by John Taylor (1993) as a proxy to the United States' monetary policy. Though he goes at great lengths to acknowledge that monetary policy should not be as simple and naïve as a pocket-book rule, it gives us a tool against which to measure monetary policies of inflation-targeting countries. Although some deviation is expected, if a country's decision deviates often and more so as time goes by, some yellow flags should be expected from the market. Moreover, if such move comes without any formal communication, this can significantly hinder credibility, a key pillar of an efficient monetary policy (Montiel, 2011).

This paper aims at arguing, aided by the Taylor rule, that the Brazilian government indeed deviated from its inflation targeting policy. More specifically, this paper shows a consistent adherence to the Taylor rule, with a given set of parameters, up until January 2007. At this point, it's hard to pinpoint whether the parameters changed abruptly, or inflation targeting was fully abandoned.

The upcoming sections of this work are divided into the following order: section 2 reviews the related literature; section 3 develops the structuring of the data and tests them for robustness; section 4 analyses the results; and section 5 concludes.

2. Literature Review

This paper aims to reproduce the Taylor-like reaction function of the Brazilian Central Bank, using tools available in the current literature, and place the results under severe scrutiny. Taylor (1993), who originally proposed the rule, suggested only three variables: inflation, inflation target and output gap. Orphanides (1997) focused then on what the Fed had to work with, breaking away with the habit of looking at past variables, choosing forecasted variables instead. Minella et al. (2002) poses that same concern, using as the inflation variable the official forecast disclosed by the Brazilian Central Bank (BCB) in the quarterly

Inflation Report. They apply special effort to inflation, opening the paper with its drivers, including two-year targets for their regressions.

In this work, the robustness of the models was tested referring to Österholm (2005), who identified evidence of spurious regressions in his analysis. In opposition, important works, like Clarida, Galí and Gertler (2000), choose to explain why negative robustness tests were being disregarded.

An auxiliary tool for the Taylor rule, the smoothing factor, was brought by Orphanides (1997), as well as Clarida, Galí and Gertler (1997). In these works, the rule's equation is rearranged to account for the tendency of the Fed (and other central banks) to smooth out sharp interest rate changes, often leaving a portion of the past decision (hike or reduction) to the upcoming meeting. This inclination brings efficiency to the financial markets, for it reduces the need or cost of interest rate risk hedging. Differently from the aforementioned works, however, the smoothing factor did not bring any significant change to the analysis or to the misspecification results. Hence, a breakpoint analysis is done without such feature.

The breakpoint performed here aims at assessing whether there was a change in monetary policy. Judd and Rudebusch (1998) apply it to compare inflation aversion and output gap aversion of the Fed chairmen Arthur Burns (1970 – 1978), Paul Volcker (1979 – 1987) and Alan Greenspan (1987 – 2006), and find different coefficients. They set precedent for others, including some in the Brazilian academia. Barcellos and Portugal (2007) use the Taylor Rule approach to determine if there is a regime break between the BCB chairmen Armínio Fraga (1999 – 2003) and Henrique Meirelles (2003 – 2011), or between former presidents Fernando Henrique Cardoso (president of Brazil between 1995 and 2002, herein "FHC") and Luís Inácio Lula da Silva (herein "Lula"). Barcellos and Portugal use a dummy variable to conclude that such break did not occur in the examined period. By the time they wrote their article, there had not yet been a second term of Lula, nor a term of former president Dilma Vana Rousseff (herein "Dilma").

3. Data

The fixed rate regime was withdrawn in Brazil starting on January 1999. In June, decree 3088 established inflation targeting as the new monetary regime, with specific dates for determining the next year's target and tolerance bands, and for justifying any non-conformities, in an open letter from the BCB. With this in mind, the data for this work spans from July 1st, 1999, to June 30th, 2016.

The Taylor rule over which this work unwinds is represented by below equation. The independent variable of Taylor Rule regressions is the set short-term interest rate, or in this case, the target ceiling rate for overnight transactions of repurchase agreements with the BCB. These are set by a special committee (COPOM, Monetary Policy Committee, freely translating) that meets at specific dates, unevenly spaced.

$$(1) \qquad i_t = \alpha_0 + \alpha_1 \pi_t + \alpha_2 \pi_t^{gap} + \alpha_3 y_t^{gap} + \varepsilon_t$$

Being,

i: Target rate set by COPOM, known in Brazil as *Meta Selic*;

π: Expected year-end consumer inflation, to which the BCB target is set against (yearly percentage change of the Brazilian index *IPCA – Índice Nacional de Preços ao Consumidor Amplo*);

π^{gap}: Deviation from inflation target (expected end-of-period consumer inflation π minus end-of-period BCB-set target;

y^{gap}: Output gap;

ε: Error term.

Between June 1999 and July 2016, there were two meetings in which two different rates at once, for different time horizons. Since the set of information available was identical at each decision, the two different rates cannot be each considered two separate observations. In both cases however, there were short-lived rates which suggested an intermediate step into achieving the desirable rate. These two intermediate rates were thus excluded from the set.

The primary output series chosen was the monthly industrial production, seasonally adjusted, as measured by IBGE (Instituto Brasileiro de Geografia e Estatística). The output gap is the percentage difference between the aforementioned series in crude form, and that same series filtered by Hodrick-Prescott decomposition, in a way that a negative value of output gap means idle production capacity. Output gap was also evaluated from the IBC-Br as an alternative, which will be detailed further on.

Inflation and Inflation targets were extracted from public information disclosed by the BCB. Inflation forecasts were collected from the quarterly Inflation Report, elected to reflect the BCB's by-then expectations of year-ends. The concept behind forward-looking inflation is fairly simple, inflation targeting is by definition forward looking, and past inflation is not necessarily a good predictor of future inflation. For this work, each quarterly Inflation Report was read and analyzed, and the inflation series elected reflects the BCB's expectation at year-end. Different from Minella et al. (2002), targets other than current years are assumed to have no weight on the decision.

An alternative series for output gap is based on the IBC-Br index. The IBC-Br is released by the BCB as a measurement of production with monthly estimates for agriculture and cattle, industry and services. IBC-Br will also be tested for unit root and cointegration, and it will replace industrial production on the two best-fitting regressions. As it will be seen, this produces undesired results. Omitted from this work, all regressions were repeated with IBC-Br instead of industrial production, and results were incoherent every time. Worth noting, this series started being produced in 2010, and it was recalculated retroactively up to December 2002[2]. That means three and a half years less of data for the analysis, and the loss of all FHC period.

First the series are tested with the Chow test and Quandt-Andrews test at the base regression. Then, the series are split into two, and two regressions are done separately. Their coefficients are tested for equality of means through the Welch test. To ensure

an appropriate diagnosis, four regressions are tested and analyzed, starting without any form of regime break, and adding the breakpoint elements one by one.

The software used in section 3 was the PCGive and GARCH (for KPSS test only) modules of OxMetrics version 5.10, except the Chow test, Quandt-Andrews test, and Johansen tests on multiple regressors, for which Eviews 7 was used.

4. Results

The Quandt-Andrews test found a regime break in the constant, inflation gap and output gap starting around mid-2006. In March 27th, 2006, former Finance Minister Guido Mantega replaced his predecessor, Antonio Palocci. Mantega's term lasted from 2006 to 2015, and one shouldn't expect that change to instantly impact the guidelines of the Central Bank. After 2007, the US housing market collapsed and a crisis unwound. Indeed, the Chow test produced the rejection of the null of coefficient stability at a wide range of points in 2006 and 2007. To move forward, the breakpoint candidate chosen was January 2007[3], which is the start of the second term of former president Lula.

As a third test, two different regressions were run for two different time periods: from the beginning of the series until December 2006, and from January 2007 to the end of the series. The statistical significance of the equality hypothesis between each of the coefficients was evaluated (Welch's t-test), and there is sufficient evidence of a structural break. The results are as follows.

Table 1 Test for equality of averages between first and second periods of sample.

Series	Average 1P	Std Error 1P	Average 2P	Std Error 2P	Welch p-value
Constant	0.13475	0.01030	0.07549	0.00779	0.000000 **
Inflation	0.59553	0.18330	0.61383	0.13110	0.301999
Inflation gap≠	0.55551	0.15820	-	-	0.000000 **
Output gap	0.04950	0.03664	-0.03192	0.02716	0.000000 **

Note: ≠ Inflation gap turned out to be linearly dependent to inflation on the second period, and thus was excluded.
Note: Periods 1 (1P) goes from 1999 to 2006, period 2 (2P) goes from 2007 to 2016.
Note: One and two asterisks (* and **) stand for rejections at 5% and 1% respectively.

The Welch test rejected equality of means for all coefficients other than inflation. The constant being rejected comes to reinforce that the real interest target shifted at some point in between Lula I and Lula II. Inflation gap during the second period is linear dependent on inflation, and thus has to be removed from the second regression. Output gap also evidences a regime break. It shifts signs, though in neither regressions output gap is significant. The shown equality of treatment for inflation between periods one and two reiterates the validity of the Welch test in this context. If there is concern that hypothesizing equality may be too strong of a proposal, especially given that it assumes normality,

then failure to reject it for inflation offers comfort that this approach is not being excessively conservative. The Welch test reiterates January 2007 as the breakpoint.

From this point onwards, cropped series will be mentioned to be of "Period 1" or "Period 2", meaning from July 1999 to December 2006 and from January 2007 to June 2016, respectively. The regressions analyzed are:

- R#01: Base regression without any regime break;
- R#02: Base regression with addition of a dummy variable at the breakpoint;
- R#03: Regression #02 with cropped inflation gap and output gap;
- R#04: Regression #02 with cropped inflation gap and no output gap.

Results are summarized in Table 5 in the Appendix. The software used in section 4 was the PCGive module of OxMetrics version 5.10.

In the first regression, referring back to equation 1, there is visual evidence that, from a point onwards, a divergence appears between actuals and expected in the model. Evidence of misspecification is found. Firstly, the null of no autocorrelation of residuals is rejected at 1%, which is seconded by the Durbin-Watson for autocorrelated residuals. The DW statistic being significantly lower than the R2 is a sign of spurious regression. This effect will be observed repeatedly throughout this chapter, as it was in Österholm (2005). The null hypothesis of no ARCH effect on the squared residuals is also rejected. This is also observed in Salgado, Garcia and Medeiros (2005), and corrected with their non-linear threshold auto-regressive model. Residual normality is rejected by the Jarque-Bera test, with the sample correction suggested by Doornik and Hansen. There is also heteroskedasticity on the residuals, both by squaring the regressors and cross-product of the regressors. On the positive side, Ramsey's Regression Specification test cannot reject the null of all linear coefficients, against the alternative that powers of the independent variable have been omitted.

Following Österholm (2005), the series were tested for unit root and cointegration, to assess the likelihood of spurious regressions. For unit root, this work uses ADF (which has the null hypothesis of a unit root) and KPSS (which has stationarity as the null hypothesis). The results for the series used in this regression are summarized in the table below. The graphs of actual versus model can be found in the annex section.

Table 2 Unit root for R#01 series

Series	ADF	KPSS
Interest rate	No rejection	1%
Inflation	2%	5%
Inflation gap	5%	10%
Output gap	1%	No rejection

Being able to draw a conclusion about only the interest rate series and the output gap series, I(1) and I(0) respectively, the cointegration test was based on the residuals of this series, which seem to be stationary. On the other hand, all other

misspecification evidences found require this model to be improved.

The second regression (R#02) includes a dummy variable (Dswitch), segregating first and second periods. The dummy is found to be significant. It implies that the real interest rate target moved from 14.9% to 8.1%. Inflation gap moved to significance too, and with the correct sign. Output gap still has its sign inverted, and insignificant. Misspecification evidence is moderate. Residuals are normal and heteroskedasticity is reduced. Autocorrelation and ARCH effects are still present, and the regression is possibly spurious, as R2 jumps from 0.3443 to 0.8384, but DW moves from 0.11 only to 0.33.

In the third regression, inflation gap and output gap are included only until the breakpoint (cropped series), that is, during FHC's term and Lula's first term. The improvements seen strengthen the theory that monetary policy of Lula's first term was similar to the second term of FHC, and antagonized by his second term. The significance of output gap increases significantly, and its sign is now correct, implying that the BCB will expand monetary policy if there is idle production capacity. Improvement is clearer in the misspecification tests. Still, R2 is equal to 0.8475, and DW drops to 0.30. ADF also rejected unit root of residuals at 1%, and KPSS didn't reject stationarity, which imply cointegration.

Table 3 Unit root for R#03 series

Series	ADF	KPSS
Interest rate	No rejection	1%
Inflation	2%	5%
Inflation gap	5%	1%
Output gap	1%	No rejection

Note: Inflation gap and output gap series are cropped

A fourth regression removes output gap from the set of regressors. There is slight improvement in heteroskedasticity, but mixed results in the goodness of fit. The hypothesis of I(1) residuals was rejected at 1% through ADF, and I(0) couldn't be rejected by KPSS test, implying the I(1) regressors may be cointegrating after all.

At this point, it is hard to link to fundamentals the period during Dilma's term in which short-term interest rate targets were continuously reduced from 12.5% in July 2011 to 7.25% in October 2012. Finally, after four consecutive meetings at 7.25%, the SELIC target moved 700 basis points upwards to 14.25% in little over two years (19 meetings, in which only three produced target maintenance).

An alternative R#03 regression was tested by replacing the primary output gap series with IBC-Br gap, and it produces all significant coefficients.

Table 4 Regression results for regression with IBC-Br.

Variable	Coefficient	Std Error	p-value
Constant	0.14079	0.00754	0.0000**
Dswitch	-0.05024	0.00458	0.0000**
Inflation	0.35556	0.14030	0.0126*
Infl. gap P1	0.85664	0.16310	0.0000**
IBC gap	-0.23565	0.06645	0.0006**

Note: Infl. gap P1 stands for a cropped inflation gap series in which it assumes values only for the period between 2002 and 2006, and zero from 2007 to 2016.
Note: One and two asterisks (* and **) stand for rejections at 5% and 1% respectively.

Though all coefficients are significant, the sign on output gap is inverted. One possible explanation for the output gap is reverse causality: The impact of interest rates in output materializes in the following observations. Indeed, when a lead is added to IBC gap, R2 increases, from 0.8537 to 0.8674 (first lead), to 0.8833 (second lead), to 0.8950 (third lead). The p-value of all IBC gap coefficients in these regressions is maintained at 0. It would not be the case that rates increase because production is contracting. In fact, production is contracting once rates start to increase.

5. Concluding remarks

This paper finds robust evidence of a monetary policy change between the two periods (FHC and Lula I versus Lula II and Dilma). The linear dependency found between inflation and inflation gap suggests an abandonment of inflation targeting. There is overwhelming evidence of a breakpoint in which the target real interest rate drops abruptly, and the swing in COPOM-set interest rate can no longer be explained by inflation targeting.

Even though misspecification evidences do not disappear when the above proposition is tested, they are reduced when compared to the alternative hypothesis, which should serve as further proof of such change in the monetary policy.

6. References

BARCELLOS NETO, Paulo C. F. de; PORTUGAL, Marcelo S.. **Determinants of Monetary Policy Committee Decisions: Fraga vs. Meirelles**. *PPGE/UFRGS Text for discussion n.11,* 2007.

CLARIDA, Richard H.; GALÍ, Jordi; GERTLER, Mark. **Monetary Policy Rules in Practice: Some International Evidence**. *European Economic Review*, v. 42, n. 6, p.1033-1067, 1997.

CLARIDA, Richard H.; GALÍ, Jordi; GERTLER, Mark. **Monetary policy rules and macroeconomic stability: evidence and some theory**. *Quarterly Journal of Economics*, 115, pp. 147-180, 2000.

COSTA, Alexis P.. **An assessment of exchange rate impact over Taylor Rule determination in Brazil**. *EESP-MPFE: Dissertações, Mestrado Profissional em Finanças e Economia*, *http://hdl.handle.net/10438/17971, 2017.*

JUDD, John P.; RUDEBUSCH, Glenn, D.. **Taylor's Rule and the Fed: 1970 – 1997**. FRBSF Economic Review, n. 3, 1998.

MINELLA, André; FREITAS, Paulo S.; GOLDFAJN, Ilan; MUINHOS, Marcelo K.. **Inflation Targeting in Brazil: Lessons and Challenges**. *Banco Central do Brasil Working Paper Series*, n. 53, p.1-48, 2002.

MONTIEL, Peter. **Macroeconomics in Emerging Markets**. *Cambridge University Press*, second edition, 2011.

ORPHANIDES, Athanasios. **Monetary Policy Rule Based on Real-Time Data**. *Board of Governors of the Federal Reserve System*, 1997.

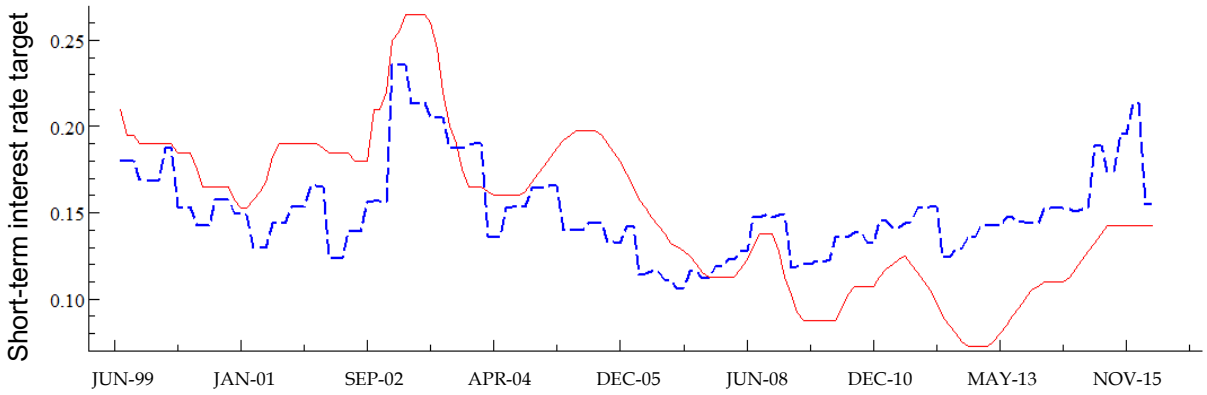
ÖSTERHOLM, Pär. **The Taylor Rule: A Spurious Regression?**. *Bulletin Of Economic Research*, v. 57, n. 3, p.217-247, 2005.

PACHECO, André S.. **A herança maldita do novo Banco Central**. *GV Invest Short Studies Series*, n. 1, 2016.

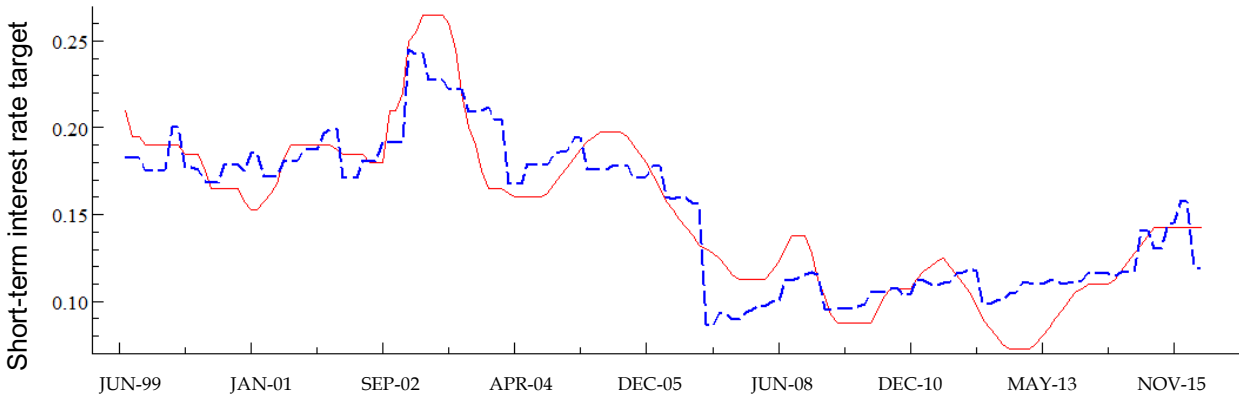
SALGADO, Maria José S.; GARCIA, Márcio G. P.; MEDEIROS, Marcelo C.. **Monetary policy during Brazil's Real Plan: estimating the Central Bank's reaction function**. *Revista Brasileira de Economia*, v. 59, n. 1, p.61-79, 2005.

TAYLOR, John B.. **Discretion Versus Policy Rules in Practice**. *Carnegie-Rochester Conference Series on Public Policy*, n. 39, p.165-214, 1993

7. Anexo

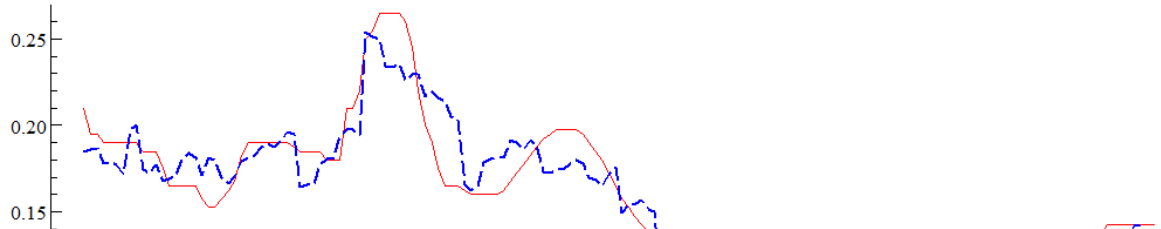


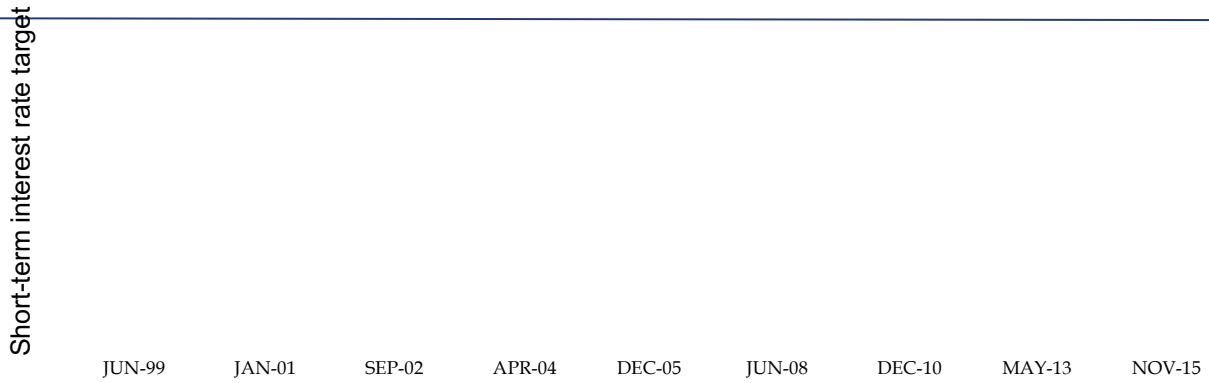
Graph 1 Actual SELIC target (continuous) versus R#01 regression results (dashed).
Note: Please mind that the y axis starts at 7% instead of 0%.



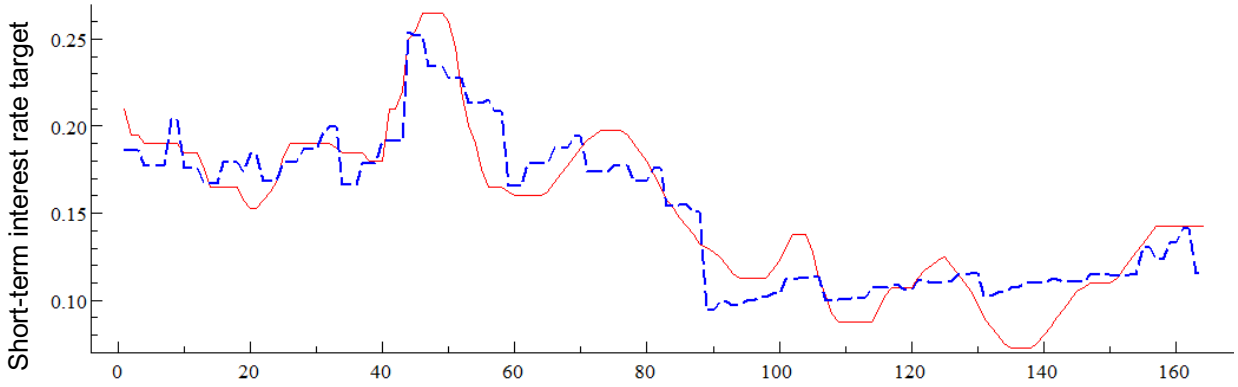
Graph 2 Actual SELIC target (continuous) versus R#02 regression results (dashed).
Note: Please mind that the y axis starts at 7% instead of 0%.

As opini ıente as da
FGV-EE





Graph 3 Actual SELIC target (continuous) versus R#03 regression results (dashed).
Note: Please mind that the y axis starts at 7% instead of 0%.



Graph 4 Actual SELIC target (continuous) versus R#04 regression results (dashed).
Note: Please mind that the y axis starts at 7% instead of 0%.

Notes

[1] Alexis Petri Magalhães Costa has a M.Sc. in Economics from Escola de Economia de São Paulo (FGV) and B.S. in engineering from Escola Politécnica (USP).

[2] The construction of this series also implies that the COPOM had an accurate forecast of what the month-end figure would be. Currently, this series is disclosed with two months lag, meaning that the December month-end official numbers would be available by mid-February. It will be shown that this did not turn out to be a significant concern.

[3] There are six observations between March 2006 and January 2007, and seven observations between January 2007 and January 2008.