Monetary Policy Effects on the Yield Curve: the Brazilian experience from 2004 to 2008

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Abstract

This paper provides empirical evidence of the influence exerted by the Monetary Policy Committee of the Central Bank of Brazil (Copom) on the yield curve between 2004 and 2008. We show that macroeconomic surprises that lead agents to revise their inflation forecasts also prompt them to expect future movements in the Selic rate in a manner that is consistent with the Inflation Targeting regime. Nonetheless, if the Copom believes that the market has either over or under reacted to a particular piece of information, it may express its own view regarding the economic outlook by surprising the market with a different than expected change in the Selic rate. We also find that the longer end of the yield curve tends to steepen after a more aggressive than expected interest rate cut, and that international capital flows are the most important drivers of the long-term rates (a possible explanation for the Brazilian version of the interest rate "conundrum").

Key-words: Inflation Targeting, Yield Curve, Term Structure, Interest Rate Conundrum, Macroeconomic News Announcements.

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1 Introduction

Through open market operations, the monetary authority can control the opportunity cost of holding money, which is given by the short-term interest rate. However, the rates that actually influence consumption and investment decisions (and, consequently, output and inflation) are the medium- and long-term yields. In this regard, changes in the basic interest rate will affect aggregate demand only if they have an impact upon the term structure.

Modern central banks have been trying to establish a more effective way of communication with financial market participants that aims to reduce uncertainties about their future decisions on short-term interest rates. As stated by Bernanke (2004), *"to the extent that central bank talk provides useful guidance to markets about the likely future path of short-term interest rates, policymakers will exert greater influence over the longer-term interest rates that most matter for spending decisions."* This practice, known as "central bank talk" (see also Kohn and Sack, 2003), forces the monetary authority to be more transparent about its objectives, its strategies and its reading of the economic outlook.

In the case of the Brazilian economy, the monetary policy objective is well defined within the Inflation Targeting regime.[1] And according to Svensson (1997), *"[i]nflation targeting is shown to imply inflation forecast targeting."* That is, under this regime the strategy of the monetary authority is to monitor and control the expected rate of inflation. Bevilaqua, Mesquita and Minella (2006) described their experiences in the conduction of the Brazilian monetary policy after the 2002 crisis as a process of "taming" inflation expectations;[2] confirming that the strategy of the Central Bank of Brazil (BCB) is not different.

Obviously, transparency is necessary but not sufficient. Credibility is another essential ingredient for monetary policy. The market must both understand and believe in what the monetary authority is saying. If these two conditions are met, any qualitative or quantitative news that changes the market's expectations about future inflation will also induce them to anticipate future reactions of the monetary authority to a new scenario.

[1] See Bogdanski, Tombini and Werlang (2000) for details on the implementation of the Inflation Targeting regime in Brazil.

[2] From Bevilaqua, Mesquita and Minella (2006): *"the process of disinflation has been, and still is, a process of taming inflation expectations."*

This paper provides empirical evidence of the influence exerted by the Monetary Policy Committee of the Central Bank of Brazil (Copom) on the yield curve between 2004 and 2008. Our regression results suggest that macroeconomic surprises that lead agents to revise their inflation forecasts also prompt them to expect future movements of the Selic rate in a manner that is consistent with the Inflation Targeting regime. As a consequence, the yield curve will instantaneously move accordingly. More specifically, we find that the announcement of IPCA[3] or industrial production significantly above that of the market consensus will steepen the yield curve.

However, if the Copom believes that the market has either over or under reacted to a particular piece of information, it can express its own view regarding the economic outlook by surprising the market with a different than expected change in the Selic rate.[4] These corrective surprises (the difference between Copom's decisions actual and expected outcomes) have quite a strong effect on the yield curve with an "inverted U" shape. More specifically, the effect is larger on the middle range of the term structure. This shape is consistent with a steepening on the longer end of the yield curve after a more aggressive than expected interest rate cut: long-term rates do fall but by a lesser amount than medium-term rates.

Another interesting feature of the strong effect of the corrective surprises is that if the BCB reduces the Selic rate by less than what the market expects (and thus causing a positive surprise), interest rates for all maturities of the term structure could actually widen. This may perfectly be the Copom's intentions if the committee believes that the market is currently pricing too aggressive future rate cuts. Nevertheless, it is important for the monetary authority to bear in mind that in a limiting case a cut in the basic interest rate could instead have a contractionary effect on the aggregate demand.[5] We also find that even when Copom's decisions are expected (in the sense that the outcome is equal to the median forecast) there

[3] The official price index of the Brazilian Inflation Targeting regime.

[4] There are many ways in which the Copom may express a disagreement with market analysts regarding its reading of the economic scenario: speeches, interviews, the quarterly Inflation Report or the Copom minutes. However, these communication mechanisms are qualitative, and cannot be easily mapped into a quantitative measure of disagreement that is useful for our econometric exercise. See Rosa and Verga (2007) and Costa Filho and Rocha (2009) for some suggestions.

[5] If that is not the Copom's intention, a more dovish than usual statement accompanying the decision announcement could potentially help nullify this side effect.

will still be cases where a share of the analysts will be surprised. And even though these analysts do not represent a major part of the whole group, their reaction to their surprise could cause statistically significant changes in the yield curve.

While macroeconomic surprises (IPCA, industrial production and Copom's decisions) have better explanatory power for shorter maturities of the term structure, the exchange rate and sovereign risk premium explain most of the variance of the opposite end of the yield curve. Evidence that international capital flows are the most important drivers of longer term rates explain the Brazilian version of the interest rate "conundrum." The significant increase in foreign holdings of Brazilian assets during the beginning of the 2004 monetary tightening cycle reduced the sensitivity of the term structure with respect to the Selic rate.[6]

Previous papers have analyzed the effects of changes in the basic interest rate over the term structure. Cook and Hahn (1989) carry out this exercise for the Federal Reserve Board in the American economy. In a paper specifically about the Brazilian economy, Tabak (2004) highlights the market's capability of anticipating Copom's decisions to a certain extent. Our paper distinguishes itself by focusing not on Copom's decisions, but rather on the surprise caused by them. Other papers have already studied the effects of the communication of the monetary policy decisions on the yield curve. For instance, Kohn and Sacks (2003) show that official FOMC statements have an impact on the term structure that is similar to changes in the interest rate, but with some lags, and Costa Filho and Rocha (2009a) find that the interest rate volatility tends to decrease when the minutes of the Copom meetings are released. A more recent line of research maps the qualitative information contained in the communication of the central bank into a quantitative index, which provide mixed results: Rosa and Verga (2007) for the ECB and Costa Filho and Rocha (2009b) for the BCB.

Many studies explore important characteristics of the Brazilian term structure. Silveira and Bessada (2003) use principal components to analyze the Brazilian term structure variability. Lima and Issler (2003), Tabak and Andrade (2003) and Brito *et al* (2004) suggest that the Brazilian term structure of interest rates rejects the Rational Expectations Hypoth-

[6] From Bevilaqua, Mesquita and Minella (2006): *"As the balance of payments continued to improve and asset prices to rise, the link between the basic interest rate and market rates appeared to have become weaker than in previous cycles, in a Brazilian version of the yield curve 'conundrum.'"*

esis. Almeida and Vicente (2006) use options in the estimation of a dynamic term structure model. There are two papers that focus on forecasting. The first paper by Vicente and Tabak (2007) compares the predictive power of different models and observe the superiority of the exponential model proposed by Diebold and Li (2006). In the second paper, Almeida *et al* (2007) study the optimal rule for choosing loadings under the same model. Osmani and Tabak (2008) study the risk premium embedded in the yield curve and conclude that it is dependent not only on domestic factors (public debt composition and inflation volatility), but also on external factors (global liquidity). A final paper that deserves to be mentioned is by Carvalho and Minella (2009). Even though their focus is not on the term structure, but rather on the forecasts from the survey conducted by the BCB, they find a similar result: expectations regarding the Selic rate also move in a manner that is consistent with the Inflation Targeting regime.

The remainder of this paper is organized as follows. Section 2 translates the debate between monetary policy and the yield curve into a testable hypothesis. Section 3 briefly describes the data and empirical strategy used in this paper. Section 4 discusses the results and, finally, Section 5 concludes the paper.

2 Monetary Policy and the Yield Curve

The most well-known theory about the formulation of the term structure of interest rates combines three assumptions thoroughly used by economists: rational expectations, arbitrage and preference for liquidity. Assume that i_t^1 and i_t^m are the interest rates charged in period t for loans with respective maturities of 1 period (shortest possible term) and of m periods. The relation between i_t^1 and i_t^m can be approximated as follows:

$$i_t^m = i_t^1 + \sum_{s=t+1}^{m} E_t\left[i_s^1\right] + \rho_t^m \tag{1}$$

where ρ_t^m is the term premium that compensates investors for committing their resources for m periods of time. When the monetary authority has direct control over i_t^1, it may affect i_t^m

to the extent that it is capable of influencing the market expectations about the future path of short-term rates up to the maturity date of the loan.

As discussed in the Introduction, clear and credible BCB communication may cause longer-term interest rates to move not only due to unanticipated changes in the short-term interest rate, but also due to changes regarding inflation expectations:

$$\Delta i_t^m \neq 0 \text{ if } \begin{cases} i_t^1 \neq E_{t-1}\left[i_t^1\right] \\ E_t\left[\pi_s\right] \neq E_{t-1}\left[\pi_s\right], \text{ for } s > t \end{cases} \tag{2}$$

Unfortunately, equation (2) is not testable. In order to make this equation useful from an econometric perspective, it is necessary to understand first how inflation expectations are formed. If expectations are rational, it is reasonable to rely on the importance of the macroeconomic variables suggested by the Phillips Curve. Bevilaqua, Mesquita and Minella (2006) perform this exercise. Using the median for the 12-month ahead IPCA[7] inflation rate forecast as the dependent variable, the authors show that the following variables are statistically significant in at least one of the several specifications tested: the 12-month ahead inflation target, past inflation, the output gap computed from the industrial production, nominal and real exchange rates and the Brazilian sovereign risk premium measured by the EMBI+.

Since interest rates for different maturities are continuously negotiated throughout a trading session, new information is instantly incorporated into the yield curve, thus, making it difficult to identify the exact moment in which the market's information set is being updated. The solution is to rely on variables for which movements only occur in discrete and previously defined intervals and for which unanticipated surprises can be measured. Under these conditions, it is possible to know the exact moment in which a new piece of information is being incorporated by the market and, consequently, when projections are being revised. This is the case for both the IPCA and the industrial production, with the latter being identified as y_t in

[7] The IPCA, which stands for Extended Consumer Price Index, is the price index that was adopted for the purposes of the Inflation Targeting regime. The data collection period of the IPCA goes from the 1st day until 30th day of the month of reference. The target population of the IPCA includes families dwelling in the urban areas, with monthly income (from any source) ranging from one to 40 minimum salaries.

the equation (3) below:

$$E_t\left[\pi_s\right] \neq E_{t-1}\left[\pi_s\right] \text{ , for } s > t, \text{ if } \begin{cases} \pi_t \neq E_{t-1}\left[\pi_t\right] \\ y_t \neq E_{t-1}\left[y_t\right] \end{cases} \tag{3}$$

With respect to the other variables that affect expectations, the inflation target is also announced in discrete intervals. Nonetheless, its updating occurs with very low frequency (once a year) and with a considerable lead (two years in advance), making it less useful for an econometric exercise. Finally, the exchange rate and the sovereign risk premium cannot help us test the hypothesis in equation (2) since they are also financial instruments that are continuously traded and, therefore, it is not possible to know which movements in those two variables were already expected and which were unexpected surprises.

By combining equations (2) and (3), it is possible to rewrite our hypothesis into the following format:

$$\Delta i_t^m \neq 0, \text{ if } \begin{cases} i_t^1 \neq E_{t-1}\left[i_t^1\right] \\ \pi_t \neq E_{t-1}\left[\pi_t\right] \\ y_t \neq E_{t-1}\left[y_t\right] \end{cases} \tag{4}$$

3 Data and Empirical Strategy

We test the hypothesis described by equation (4) using daily data from the Brazilian economy. The sample spans the period from January 2$^{\text{nd}}$, 2004 to December 30$^{\text{th}}$, 2008, totaling 1,239 trading days. We compute fixed interest rates of 21, 63, 126, 252 and 504 working days (or equivalently, 1, 3, 6, 12 and 24 months) which are used as dependent variables. These rates are constructed using the most liquid One-day Interbank Deposit Futures Contract traded at the Brazilian Mercantile & Futures Exchange (BM&F), expressed as annual rates (with daily compounding based on a 252-day year[8]).

We use three sets of explanatory variables. The first group includes the macroeconomic variables that directly map into equation (4): decisions from Copom's meetings for the Selic

[8] Details about this contract are available at http://www.bmf.com.br/portal/pages/frame_home.asp?idioma=2&link=/portal/pages/contratos2/pdf/IDfutures.pdf

rate, the monthly IPCA consumer inflation rate, and the industrial production YoY growth rate.[9] The second set includes other inflation and activity level indicators that were not used in Bevilaqua, Mesquita and Minella (2006), but for which market analysts also have relative precise forecasts: the IPCA-15[10], IGP-10 , IGP-M and IGP-DI[11] monthly inflation rates, and the retail sales YoY growth rate. For each of the explanatory variables from the first two groups, we collect not only the value that was actually announced, but also the market's consensus expectation proxied by the median of the forecasts of the market analysts that are surveyed by Bloomberg News Service. The third group includes the daily BRL exchange rate and the Brazilian sovereign risk premium measured by the 5-year CDS. Even though these two variables do not help us test hypothesis (4) for the reasons already discussed in the previous section, we cannot ommit them from the regression since we know that they are related to the interest rates.

The variables from the first two groups are announced in intervals that are lower than the frequency of our regressions (daily). For this reason, we allocate their values (or their surprises) to the first trading session in which the information is available and zero to all other working days. Every variable announced after the closing of the market from day $t-1$ and before the closing of the market from day t will be dated as of t. This remark is only relevant for Copom's decisions, which are always made public after the closing of the trading session (therefore, the decision from Copom's meeting of January 21$^{\text{st}}$, 2004 enters in the regression dated as January 22$^{\text{nd}}$, 2004). All other macroeconomic data used as explanatory variables are announced in the morning. The IGPs are announced by Getúlio Vargas Foundation (FGV) at 8am and the rest of our data is announced by the Brazilian Institute of Geography and

[9] It is important to mention that market analysts are able to construct short term forecasts for both variables with a considerable degree of accuracy. Almost all participants in the Bloomberg's survey have access to some sort of daily consumer price data collection that is aimed at reproducing the IPCA methodology. Furthermore, they also have access to leading indicator models based on public data such as vehicle production, corrugated board sector sales, vehicle flow in roadways, etc...

[10] The IPCA-15 is a price index that follows the same methodology of the IPCA with one single difference: its data collection period goes approximately from the 16$^{\text{th}}$ day of the previous month to the 15$^{\text{th}}$ day of the month of reference.

[11] The IGPs are General Price Indexes that combine a CPI, a PPI and also a price index for the civil contruction sector. All three IGPs share the same methodology with a difference on their data collection periods: the IGP-10 is collected from the 11$^{\text{th}}$ day of the previous month to the 10$^{\text{th}}$ day of the month of reference, the IGP-M is collected from the 16$^{\text{th}}$ day of the previous month to the 15$^{\text{th}}$ day of the month of reference, and the IGP-DI is collected from the 1$^{\text{st}}$ to the 30$^{\text{th}}$ day of the month of reference.

Statistics (IBGE) at 9am (the same time that the BM&F trading session starts).

Let $\overrightarrow{y_t}$ be the vector with all fixed interest rates i_t^m of maturity m:

$$\overrightarrow{y_t} = \left[i_t^{21}, i_t^{63}, i_t^{126}, i_t^{252}, i_t^{504}\right]' \tag{5}$$

Also let $\overrightarrow{x}_t$ be the set of macroeconomic surprises and $\overrightarrow{z_t}$ be the vector of controls (the exchange rate and the sovereign risk premium). Our empirical strategy will consist of estimating Vector Autoregressive models (VARs) with the following structure:

$$\Delta\overrightarrow{y}_t = A_0 + \sum_{p=1}^{P} A_p \Delta\overrightarrow{y}_{t-p} + B\overrightarrow{x}_t + C\Delta\overrightarrow{z}_t + \overrightarrow{\varepsilon}_t \tag{6}$$

4 Empirical Evidence

4.1 Baseline Model

Our baseline regression is given by equation (6) with the following variables included in $\overrightarrow{x}_t$: Copom's decision surprises and IPCA and industrial production standardized surprises. Copom's decision surprises are measured by the difference between the actual change in the Selic rate that is announced after a Copom meeting and the market expected change (an effective raise of 75 bps against a consensus of 50 bps is equivalent to a positive surprise of 25 bps; in the case of an expected decision the surprise is zero). IPCA and industrial production standardized surprises are simply the difference between the actual and the expected value, divided by the time-series standard deviation of the forecast error series. With this normalization, the coefficients associated with the IPCA and the industrial production can be interpreted as the impact on the yield curve of a one standard deviation expectation mistake. Based on the Bayesian Information Criterion (Schwarz), we chose $P = 2$ for our VAR. Table 1 presents the results.

First, the standardized surprises associated with both the IPCA and the industrial production do raise the slope of the yield curve: the impact is stronger the longer the maturity. It is also interesting to note that the impacts of both macroeconomic variables are indistinguish-

able (see figure 1): a forecast error of 2 standard deviations (statistically relevant) in any of the two variables increases the 24-month maturity interest rate by more than 10 bps. These effects can be interpreted as empirical evidence that the Brazilian Inflation Targeting regime possesses a significant degree of credibility. Macroeconomic surprises that prompt the agents to revise their inflation forecasts indeed cause them to expect future movements in the Selic rate in a manner that is consistent with the Inflation Targeting regime.

Second, we can see that surprises in Copom's decisions have a statistically significant effect on all five maturities with an "inverted U" shape (see figure 2). Moreover, this effect is quite strong: a 10 bps surprise has an impact on the yield curve that ranges from 6 bps (on the 24-month rate) to 9 bps (on the 6-month rate). This result is particularly relevant because it implies that if the BCB reduces the Selic rate by less than what the market expects (and thus causing a positive surprise), the interest rates that most matter for spending decisions could instead increase. That could perfectly be the Copom's intentions if the committee believes that the market has overreacted to certain macroeconomic news and is currently pricing too agressive future rate cuts. However, it is important for the monetary authority to bear in mind that in a limiting case a cut in the basic interest rate could actually have a contractionist effect on the aggregate demand.

Another interesting feature of this result comes from the "inverted U" shape, that is, the impact of the corrective surprise is larger on the middle range of the term structure. If we think about this shape in the context of a monetary easing cycle, then it is consistent with a steepening of the longer end of the yield curve after a more aggressive than expected interest rate cut: long-term rates do fall but by a lesser amount than medium-term rates.

Third, exchange rate and sovereign risk premium movements also have an impact on the yield curve with effects that are larger the longer the maturity. However, these two variables might be correlated to the term structure not only because of their influence on the expected inflation, but also through their correlation with the term premium.[12] For example, a global liquidity crisis would be associated with a reduction of foreign holdings of Brazilian bonds that would simultaneously depreciate the BRL and increase Brazilian interest rates for all

[12] Denoted by ρ_t^m in equation (1).

maturities.

If this is the case, then we would expect the controls (exchange rate and sovereign risk) to better explain the longer end of the yield curve (where the term premium is more important). In order to examine this hypothesis, we estimate two variations of our baseline model. The first variation only includes macroeconomic surprises (Copom's decisions, IPCA and industrial production). In the second variation, we only include the controls (the exchange rate and the sovereign risk).[13] The estimation outputs from both models are presented in tables 2 and 3, respectively. As presumed, in the model that only includes the exchange rate and the sovereign risk, the R^2 monotonically increases from 15.4% for the 1-month maturity to 28.8% for the 24-month maturity. The opposite pattern is observed for the model that only includes macroeconomic surprises. The R^2 monotonically decreases from 35.7% for the 1-month maturity to 4.3% for the 24-month maturity, suggesting that surprises have larger explanatory power the shorter the maturity. Figure 3 illustrates the opposite pattern of the R^2 obtained from both models.

The finding of international capital flows as the most important drivers of the longer term rates helps explain the Brazilian version of the interest rate "conundrum." At the end of 2004, the significant increase in the foreign holdings of Brazilian assets generated downward pressure on long-term rates while the Copom was beginning a new monetary tightening cycle. As a result, the usual steepening of the yield curve as a response to the increases in the Selic rate was not observed.

4.2 Expected versus Unexpected Copom's Decisions

We observed that surprises in Copom's decisions have a substantial effect on the term structure of interest rates. However, out of the 48 Copom's meetings held between 2004 and 2008 there were only nine occasions in which the outcome was different than those expected by the market's consensus (less than one out of five). Does this mean that the other 39 Copom's meetings had no noticeable effect on the yield curve?

Not necessarily. We should remember that the distribution of market analysts expectations

[13] Lags of the dependent variable were still included in both variations.

concerning Copom's decision has a very peculiar shape. In the majority of the meetings, this distribution is binomial with at least a 25 bps distance between the two expected outcomes. In more uncertain times, there may even be three expected outcomes, which nevertheless have a minimum distance of 25 bps between them. Nonetheless, there are also times in which uncertainty is so low that every analyst is expecting the exact same outcome. Hence, even when Copom's decisions are expected (the outcome is equal to the median of the analysts expectations) there will still be cases where a share of the analysts will be surprised by at least 25 bps. And even though these analysts do not represent a major part of the whole group, their reaction to their surprise could cause statistically significant changes in the yield curve.

In order to test for this potential effect, we collected all expected outcomes that were inputted by the market analysts surveyed by Bloomberg for each Copom meeting. Out of 48 Copom's meetings, there were only 12 occasions in which all analysts expected the exact same outcome, 25 in which there were two expected outcomes and 11 in which there were three. For each Copom meeting, we ranked all expected outcomes according to the share of analysts that were behind them. Then, we associated the most expected outcome with the series "Copom's decision 1^{st} surprise,"[14] the second most expected outcome to the series "Copom's decision 2^{nd} surprise," and finally the least popular expected outcome with "Copom's decision 3^{rd} surprise."

Table 4 presents the estimation output of equation (4) with the inclusion of these new series in the $\overrightarrow{x}_t$ vector. The results show that "Copom's decision 2^{nd} surprises" have a statistically significant effect on the first three maturities (1-, 3- and 6-months) and that "Copom's decision 3^{rd} surprises" have a statistically significant impact on the 1-month maturity. In table 5, we check whether the additional (2^{nd} and 3^{rd}) forecast errors' impacts on the term structure are the same in both cases when decisions are expected and unexpected (Copom's decisions are considered "expected" when the majority of the analysts are correct, i.e., Copom's decision 1^{st} surprise equals zero).

[14] The series "Copom's decision 1^{st} surprise" is identical to the series "Copom's decision surprise" in the baseline model.

The estimated coefficients shows that the 2nd and 3rd most common expectation mistakes are only relevant when Copom's decisions are expected. If the BCB changes the Selic rate by the exact amount that the majority of the analysts had expected, then the mistake made by the minority of the analysts will have a significant impact on the first four maturities of the yield curve (up to 12-months). The magnitude of this effect is not negligible: 2 bps on average for every 10 bps of surprise (see figure 4). This result allows for potentially strange dynamics after Copom's meetings that the BCB should be aware of. Imagine a Copom meeting in which 70% of the market analysts expect a Selic cut of 50 bps and the other 30% expect a 75 bps cut. If the Copom decides to cut the Selic rate by 50 bps "as expected by the market consensus," interest rates up to 12-months maturity would increase on average by 5 bps because of the 25 bps surprise from 30% of the market analysts.

4.3 Other Inflation and Activity Level Indicators

As previously discussed, Bevilaqua, Mesquita and Minella (2006) show that both the IPCA and the industrial production determine the 12-month expected inflation. Consequently, in an Inflation Targeting Regime, where the Central Bank has credibility, both variables should affect the yield curve. The estimation results from our baseline regression have shown that this is indeed the case. But how about other measures of inflation and activity level?

As a robustness check, we try to answer this question by testing the effect on the yield curve of other price indexes and another activity level indicator for which the market also has relatively reliable forecasts: the IPCA-15, IGP-10, IGP-M, IGP-DI and retail sales. For each of these variables we calculate its standardized surprise, which is the difference between the actual and the expected value, normalized by the standard deviation of the error series.

Table 6 shows that all but one of the estimated coefficients associated with the IGPs forecast errors are not statistically significant. Only the impact of the IGP-10 on the 1-month maturity is significant at 5%. We can also see that retail sales do not have any systematic impact on the yield curve. Only the IPCA-15 presents more robust effects, with significant impacts on the 3-, 6- and 12-month maturities of the term structure.

If we compare the IPCA and the IPCA-15 impacts on the yield curve (figure 5), we can see that they are almost identical for the first three maturities, but for the longer end of the term structure (12- and 24-month maturities) the IPCA has a stronger effect. This implies that even though both price indexes share the exact same methodology (except for a difference on the data collection period) the fact that the IPCA is the official Inflation Targeting price index makes it more important than the IPCA-15.

In table 7, we merge all price indexes that share the same methodology into a single series. More specifically, we merge the IPCA and IPCA-15 into a series called IPCAs and the IGP-10, IGP-M and IGP-DI into a series named IGPs. This grouping only makes sense if the market does not make a distinction between price indexes of the same "family," and allows for more surprises in one single series, therefore, increasing the precision of the estimation of the coefficients' standard errors. Nonetheless, the results show that surprises in the IGPs still do not exhibit any robust effect on the curve. With respect to the IPCAs, there is marginal improvement on the precision of the estimates since the impact of IPCAs standardized surprises becomes statistically significant for all five maturities of the term structure, and not just for the last four.

5 Conclusion

This paper provides empirical evidence that the Brazilian Inflation Targeting regime possesses a significant degree of credibility. Our regression results suggest that macroeconomic announcements that lead market participants to believe that higher inflation or overheating of the economy is more likely to occur will also prompt them to expected future changes in the Selic rate in a manner that is compatible with a monetary authority committed to price stability. As a consequence, the yield curve will instantaneously move accordingly. More specifically, we find that the announcements of an IPCA or an industrial production significantly above that of the market consensus will steepen the yield curve. We also find that the IGPs and the retail sale index (other very important price and activity level indexes in Brazil) do not cause any systematic effect on the yield curve. With respect to the IPCA-15, its impact on

the yield curve is almost identical to that of the IPCA for the first three maturities, but for the longer end of the term structure the IPCA has stronger effects. This implies that even though both price indexes share the exact same methodology (except for a difference on the data collection period) the fact that the IPCA is the official Inflation Targeting regime price index makes it more important than the IPCA-15.

However, if the Copom believes that the market has either over or under reacted to a particular piece of information, it can send a signal to market participants by surprising them with changes in the Selic rate. The difference between Copom's decisions actual and expected outcomes have quite a strong effect on the yield curve. These corrective surprises have a strong "inverted U" shape effect on the yield curve, which is consistent with a steepening of the longer end of the yield curve after a more aggressive than expected interest rate cut. This result is also interesting because it implies that if the BCB reduces the Selic rate by less than what the market expects, interest rates for all maturities of the term structure could actually widen. That could perfectly be the Copom's intentions if the committee believes that the market is currently pricing too aggressive future rate cuts. However, it is important for the monetary authority to bear in mind that in a limiting case a cut in the basic interest rate could instead have a contractionary effect on aggregate demand.

We also find that even when Copom's decisions are expected (in the sense that the outcome is equal to the analysts' median expectations) there will still be cases where a share of the analysts will be surprised. And even though these analysts do not represent a major part of the whole group, their reaction to their surprise could cause statistically significant changes in the yield curve. This additional effect is due to the peculiar shape of the distribution of market analysts' expectations concerning Copom's decision. In the majority of the meetings, this distribution is binomial with at least a 25 bps distance between the two expected outcomes.

Finally, we show that while macroeconomic surprises (IPCA, industrial production and Copom's decisions) have better explanatory power for shorter maturities of the term structure, the exchange rate and the sovereign risk have better explanatory power on the opposite end of the yield curve. The latter two variables are related to the term structure not only because of

their influence on the expected inflation, but also through their correlation with term premium (which is more important the longer the maturity). This feature can help explain the Brazilian version of interest rate "conundrum." The significant increase in foreign holdings of Brazilian assets during the beginning of the 2004 monetary tightening cycle reduced the sensitivity of the term structure with respect to the Selic rate.

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Table 1: Impact of Macroeconomic Surprises and Other Controls on Different Maturities of the Term Structure of Interest Rates (in Basis Points)

Regressor \ Maturity	*1-mo.*	*3-mo.*	*6-mo.*	*12-mo.*	*24-mo.*
Copom´s decision surprise $_t$	0.667**	0.861**	0.899**	0.826**	0.603**
	(0.031)	(0.052)	(0.113)	(0.134)	(0.177)
IPCA standardized surprise $_t$	0.523	1.773**	3.850**	4.440**	4.741*
	(0.346)	(0.580)	(1.267)	(1.499)	(1.973)
Ind. Prod. stand. surprise $_t$	0.760*	1.688**	3.166*	3.260*	4.419*
	(0.352)	(0.591)	(1.291)	(1.528)	(2.010)
Δ(*Exchange rate*)$_t$	0.003**	0.009**	0.025**	0.033**	0.050**
	(0.001)	(0.001)	(0.003)	(0.004)	(0.005)
Δ(*Brazilian CDS*)$_t$	0.029**	0.079**	0.250**	0.316**	0.419**
	(0.007)	(0.011)	(0.025)	(0.029)	(0.039)
$\mathbf{R^2}$	38.97%	32.28%	27.97%	29.12%	30.06%
SBIC			27.034		

Note 1: each coefficient represents the basis-point impact on different maturities of the term structure of interest rates (columns) of a one-unit change of the regressor (rows). Copom's decision surprises, Δ(Exchange rate) and Δ(Brazilian CDS) are measured in basis-points. IPCA and Industrial Production standardized surprises are measured in standard-deviation forecast errors.
Note 2: estimation output based on a VAR(2) with 1, 3, 6, 12 and 24 months interest rates as endogenous variables. Coefficients associated with the constant and lags of the endogenous variables were omitted from the table. Standard errors in parenthesis. The symbols ** and * denote that the individual coefficient is significant at the 1% and 5%, significance level respectively.

Table 2: Impact of Macroeconomic Surprises Only on Different Maturities of the Term Structure of Interest Rates (in Basis Points)

Regressor \ Maturity	*1-mo.*	*3-mo.*	*6-mo.*	*12-mo.*	*24-mo.*
Copom´s decision surprise $_t$	0.663**	0.851**	0.869**	0.788**	0.547**
	(0.032)	(0.055)	(0.128)	(0.154)	(0.206)
IPCA standardized surprise $_t$	0.548	1.843**	4.040**	4.693**	5.150*
	(0.355)	(0.619)	(1.428)	(1.720)	(2.305)
Ind. Prod. stand. surprise $_t$	0.812*	1.831**	3.606*	3.822*	5.193*
	(0.361)	(0.631)	(1.455)	(1.753)	(2.349)
$\mathbf{R^2}$	35.67%	22.63%	8.36%	6.45%	4.25%
SBIC			27.305		

Note 1: each coefficient represents the basis-point impact on different maturities of the term structure of interest rates (columns) of a one-unit change of the regressor (rows). Copom's decision surprises are measured in basis-points. IPCA and Industrial Production standardized surprises are measured in standard-deviation forecast errors.
Note 2: estimation output based on a VAR(2) with 1, 3, 6, 12 and 24 months interest rates as endogenous variables. Coefficients associated with the constant and lags of the endogenous variables were omitted from the table. Standard errors in parenthesis. The symbols ** and * denote that the individual coefficient is significant at the 1% and 5%, significance level respectively.

Table 3: Impact of Macroeconomic Controls Only on Different Maturities of the Term Structure of Interest Rates (in Basis Points)

Regressor \ Maturidade	*1-mo.*	*3-mo.*	*6-mo.*	*12-mo.*	*24-mo.*
$\Delta(Exchange\ rate)_t$	0.003**	0.009**	0.025**	0.033**	0.051**
	(0.001)	(0.002)	(0.003)	(0.004)	(0.005)
$\Delta(Brazilian\ CDS)_t$	0.029**	0.078**	0.249**	0.315**	0.419**
	(0.008)	(0.013)	(0.026)	(0.030)	(0.039)
$\mathbf{R^2}$	15.44%	16.09%	23.38%	26.16%	28.79%
SBIC			27.056		

Note 1: each coefficient represents the basis-point impact on different maturities of the term structure of interest rates (columns) of a one-unit change of the regressor (rows). Δ(Exchange rate) and Δ(Brazilian CDS) are measured in basis-points.
Note 2: estimation output based on a VAR(2) with 1, 3, 6, 12 and 24 months interest rates as endogenous variables. Coefficients associated with the constant and lags of the endogenous variables were omitted from the table. Standard errors in parenthesis. The symbols ** and * denote that the individual coefficient is significant at the 1% and 5%, significance level respectively.

Table 4: Impact of Macroeconomic Surprises and Other Controls on Different Maturities of the Term Structure of Interest Rates (in Basis Points), Taking Into Account the Full Distribution of Copom's Decision Expectation Errors

Regressor \ Maturity	*1-mo.*	*3-mo.*	*6-mo.*	*12-mo.*	*24-mo.*
Copom´s decision 1st surprise $_t$	0.530**	0.745**	0.846**	0.781**	0.600**
	(0.032)	(0.056)	(0.125)	(0.149)	(0.196)
Copom´s decision 2nd surprise $_t$	0.202**	0.203**	0.168*	0.127	0.009
	(0.018)	(0.031)	(0.069)	(0.081)	(0.107)
Copom´s decision 3rd surprise $_t$	0.048**	0.018	-0.043	-0.024	-0.003
	(0.018)	(0.032)	(0.070)	(0.083)	(0.110)
IPCA standardized surprise $_t$	0.523	1.773**	3.850**	4.440**	4.741*
	(0.324)	(0.569)	(1.265)	(1.499)	(1.974)
Ind. Prod. stand. surprise $_t$	0.915**	1.846**	3.299*	3.360*	4.426*
	(0.331)	(0.580)	(1.290)	(1.529)	(2.013)
Δ(*Exchange rate*)$_t$	0.004**	0.009**	0.025**	0.033**	0.050**
	(0.001)	(0.001)	(0.003)	(0.004)	(0.005)
Δ(*Brazilian CDS*)$_t$	0.025**	0.075**	0.247**	0.314**	0.419**
	(0.006)	(0.011)	(0.025)	(0.029)	(0.039)
R^2	46.45%	34.93%	28.32%	29.27%	30.06%
SBIC			26.931		

Note 1: each coefficient represents the basis-point impact on different maturities of the term structure of interest rates (columns) of a one-unit change of the regressor (rows). Copom's decision 1st, 2nd and 3rd surprises, Δ(Exchange rate) and Δ(Brazilian CDS) are measured in basis-points. IPCA and Industrial Production standardized surprises are measured in standard-deviation forecast errors.
Note 2: Copom's decision 1st, 2nd and 3rd surprises refer respectively to the 1st, 2nd and 3rd most common forecast error after each Copom meeting.
Note 3: estimation output based on a VAR(2) with 1, 3, 6, 12 and 24 months interest rates as endogenous variables. Coefficients associated with the constant and lags of the endogenous variables were omitted from the table. Standard errors in parenthesis. The symbols ** and * denote that the individual coefficient is significant at the 1% and 5%, significance level respectively.

Table 5: Impact of Macroeconomic Surprises and Other Controls on Different Maturities of the Term Structure of Interest Rates (in Basis Points), Taking Into Account the Full Distribution of Copom's Decision Expectation Errors and Whether the Decision Was Expected or Not

Regressor \ Maturity	*1-mo.*	*3-mo.*	*6-mo.*	*12-mo.*	*24-mo.*
Copom´s decision 1st surprise $_t$	0.577**	0.806**	0.992**	0.965**	0.759**
	(0.036)	(0.063)	(0.140)	(0.166)	(0.219)
Copom´s decision 2nd surprise $_t$	0.218**	0.220**	0.213**	0.180*	0.049
(when expected)	(0.019)	(0.033)	(0.072)	(0.086)	(0.113)
Copom´s decision 2nd surprise $_t$	0.091	0.146	(0.022)	(0.053)	(0.001)
(when unexpected)	(0.070)	(0.123)	(0.273)	(0.323)	(0.426)
Copom´s decision 3rd surprise $_t$	0.079**	0.068	0.071	0.126	0.142
(when expected)	(0.023)	(0.040)	(0.089)	(0.105)	(0.138)
Copom´s decision 3rd surprise $_t$	0.060	(0.025)	(0.109)	(0.149)	(0.207)
(when unexpected)	(0.045)	(0.080)	(0.177)	(0.210)	(0.277)
IPCA standardized surprise $_t$	0.525	1.776**	3.856**	4.448**	4.749*
	(0.323)	(0.568)	(1.264)	(1.497)	(1.973)
Ind. Prod. stand. surprise $_t$	0.933**	1.867**	3.351**	3.424*	4.478*
	(0.330)	(0.580)	(1.289)	(1.526)	(2.013)
Δ(*Exchange rate*)$_t$	0.004**	0.009**	0.026**	0.034**	0.051**
	(0.001)	(0.001)	(0.003)	(0.004)	(0.005)
Δ(*Brazilian CDS*)$_t$	0.024**	0.074**	0.245**	0.311**	0.417**
	(0.006)	(0.011)	(0.025)	(0.029)	(0.039)
$\mathbf{R^2}$	46.82%	35.18%	28.63%	29.62%	30.23%
SBIC			26.972		

Note 1: each coefficient represents the basis-point impact on different maturities of the term structure of interest rates (columns) of a one-unit change of the regressor (rows). Copom's decision 1st, 2nd and 3rd surprises, Δ(Exchange rate) and Δ(Brazilian CDS) are measured in basis-points. IPCA and Industrial Production standardized surprises are measured in standard-deviation forecast errors.
Note 2: Copom's decision 1st, 2nd and 3rd surprises refer respectively to the 1st, 2nd and 3rd most common forecast error after each Copom meeting.
Note 3: Copom's decisions are considered "expected" when the majority of the analysts are correct (i.e., Copom's decision 1st surprise is zero).
Note 4: estimation output based on a VAR(2) with 1, 3, 6, 12 and 24 months interest rates as endogenous variables. Coefficients associated with the constant and lags of the endogenous variables were omitted from the table. Standard errors in parenthesis. The symbols ** and * denote that the individual coefficient is significant at the 1% and 5%, significance level respectively.

Table 6: Impact of Macroeconomic Surprises and Other Controls on Different Maturities of the Term Structure of Interest Rates (in Basis Points), Considering Alternative Measures of Inflation and Activity Level

Regressor \ Maturity	*1-mo.*	*3-mo.*	*6-mo.*	*12-mo.*	*24-mo.*
Copom´s decision surprise $_t$	0.668**	0.863**	0.903**	0.830**	0.606**
	(0.031)	(0.052)	(0.113)	(0.134)	(0.177)
IPCA standardized surprise $_t$	0.533	1.792**	3.893**	4.487**	4.796*
	(0.345)	(0.578)	(1.264)	(1.498)	(1.974)
IPCA-15 standardized surprise $_t$	0.671	1.920**	3.800**	3.773*	3.219
	(0.348)	(0.582)	(1.273)	(1.508)	(1.988)
IGP-10 standardized surprise $_t$	0.779*	1.185	1.640	1.337	0.309
	(0.386)	(0.646)	(1.413)	(1.674)	(2.206)
IGP-M standardized surprise $_t$	-0.036	0.117	0.383	0.681	0.379
	(0.349)	(0.583)	(1.276)	(1.512)	(1.993)
IGP-DI standardized surprise $_t$	0.339	0.698	1.661	1.855	2.351
	(0.371)	(0.621)	(1.359)	(1.610)	(2.123)
Ind. Prod. stand. surprise $_t$	0.764*	1.694**	3.182*	3.280*	4.448*
	(0.352)	(0.589)	(1.288)	(1.526)	(2.011)
Retail sales stand. surprise $_t$	0.107	-0.007	0.496	0.395	0.597
	(0.346)	(0.579)	(1.266)	(1.500)	(1.978)
Δ(*Exchange rate*)$_t$	0.003**	0.009**	0.025**	0.033**	0.051**
	(0.001)	(0.001)	(0.003)	(0.004)	(0.005)
Δ(*Brazilian CDS*)$_t$	0.030**	0.080**	0.252**	0.317**	0.420**
	(0.007)	(0.011)	(0.025)	(0.029)	(0.039)
$\mathbf{R^2}$	39.41%	33.13%	28.68%	29.61%	30.29%
SBIC			27.154		

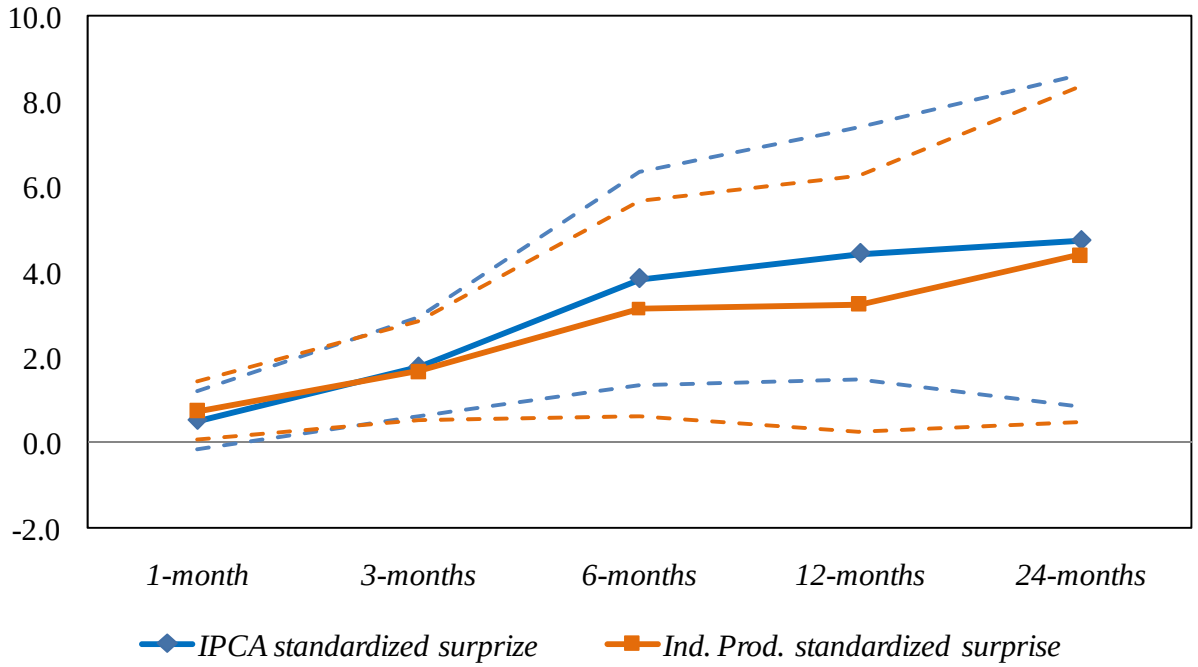
Note 1: each coefficient represents the basis-point impact on different maturities of the term structure of interest rates (columns) of a one-unit change of the regressor (rows). Copom's decision surprises, Δ(Exchange rate) and Δ(Brazilian CDS) are measured in basis-points. IPCA, IPCA-15, IGP-10, IGP-M, IGP-DI, Industrial Production and Retail Sales standardized surprises are measured in standard-deviation forecast errors.
Note 2: estimation output based on a VAR(2) with 1, 3, 6, 12 and 24 months interest rates as endogenous variables. Coefficients associated with the constant and lags of the endogenous variables were omitted from the table. Standard errors in parenthesis. The symbols ** and * denote that the individual coefficient is significant at the 1% and 5%, significance level respectively.

Table 7: Impact of Macroeconomic Surprises and Other Controls on Different Maturities of the Term Structure of Interest Rates (in Basis Points), Considering Alternative Measures of Inflation and Activity Level and Merging Price Indexes with Same Methodology on Single Series

Regressor \ Maturity	*1-mo.*	*3-mo.*	*6-mo.*	*12-mo.*	*24-mo.*
Copom´s decision surprise $_t$	0.668**	0.863**	0.903**	0.831**	0.608**
	(0.031)	(0.052)	(0.113)	(0.134)	(0.177)
IPCAs standardized surprise $_t$	0.604*	1.841**	3.789**	4.029**	3.848**
	(0.244)	(0.408)	(0.892)	(1.057)	(1.393)
IGPs standardized surprise $_t$	0.398	0.709*	1.265	1.290	0.970
	(0.214)	(0.358)	(0.783)	(0.928)	(1.223)
Prod. Ind. padronizado $_t$	0.764*	1.692**	3.170*	3.262*	4.413*
	(0.352)	(0.588)	(1.286)	(1.524)	(2.009)
Retail sales stand. surprise $_t$	0.126	0.013	0.499	0.375	0.534
	(0.345)	(0.577)	(1.263)	(1.497)	(1.973)
Δ(*Exchange rate*)$_t$	0.003**	0.009**	0.025**	0.033**	0.051**
	(0.001)	(0.001)	(0.003)	(0.004)	(0.005)
Δ(*Brazilian CDS*)$_t$	0.030**	0.080**	0.252**	0.317**	0.420**
	(0.007)	(0.011)	(0.025)	(0.029)	(0.039)
$\mathbf{R^2}$	39.33%	33.08%	28.64%	29.56%	30.20%
SBIC			27.074		

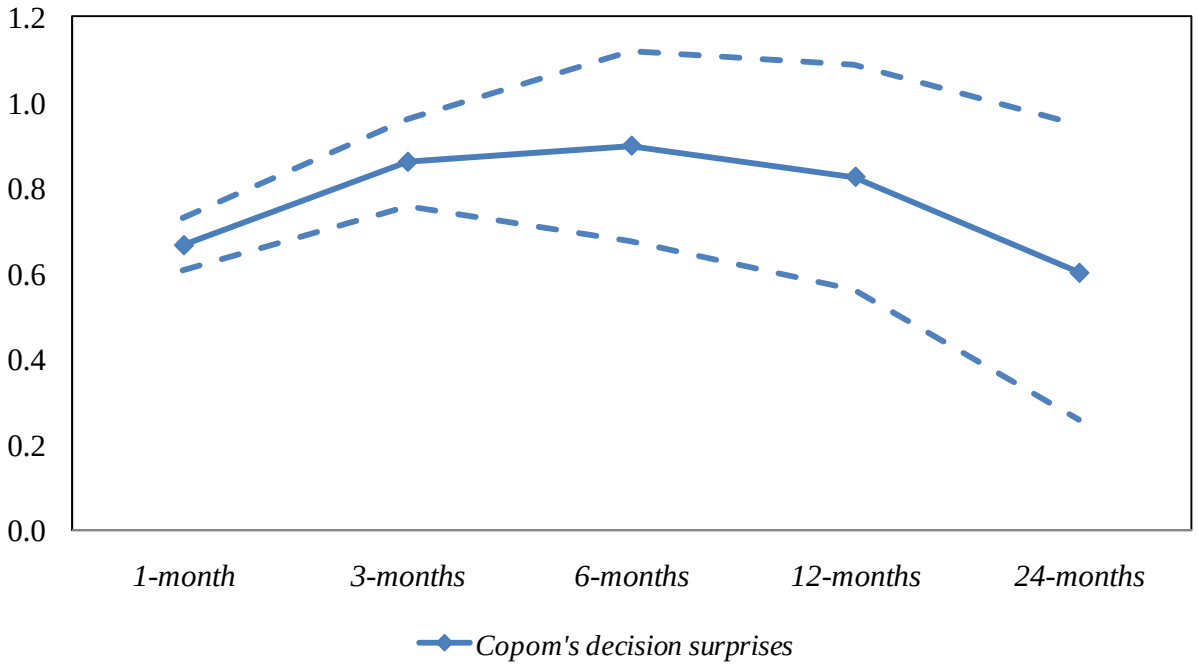
Note 1: each coefficient represents the basis-point impact on different maturities of the term structure of interest rates (columns) of a one-unit change of the regressor (rows). Copom's decision surprises, Δ(Exchange rate) and Δ(Brazilian CDS) are measured in basis-points. IPCAs, IGPs, Industrial Production and Retail Sales standardized surprises are measured in standard-deviation forecast errors.
Note 2: estimation output based on a VAR(2) with 1, 3, 6, 12 and 24 months interest rates as endogenous variables. Coefficients associated with the constant and lags of the endogenous variables were omitted from the table. Standard errors in parenthesis. The symbols ** and * denote that the individual coefficient is significant at the 1% and 5%, significance level respectively.

Figure 1: Impact of a 1 Standard Deviation Surprise on IPCA and Industrial Production on Different Maturities of the Term Structure of Interest Rates (in Basis Points)



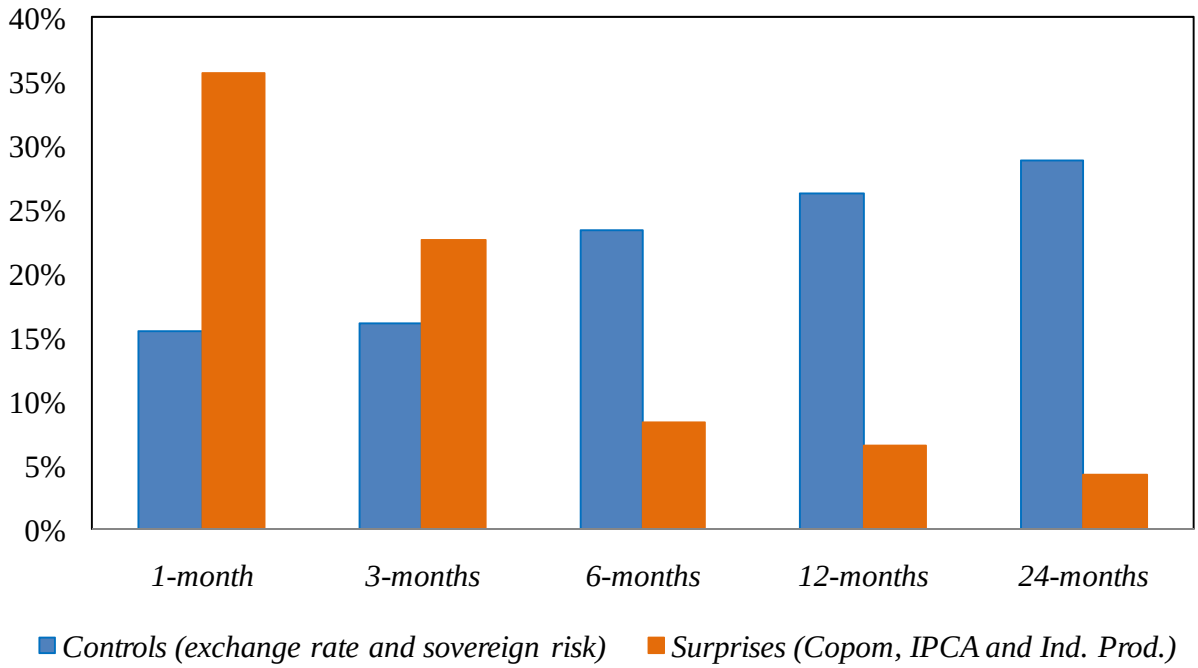
Note: graph based on the estimated coefficients of table 1. The dashed lines represent the 95% confidence interval.

Figure 2: Impact of a 1 Basis Point Surprise in Copom's Decisions on Different Maturities of the Term Structure of Interest Rates (also in Basis Points)



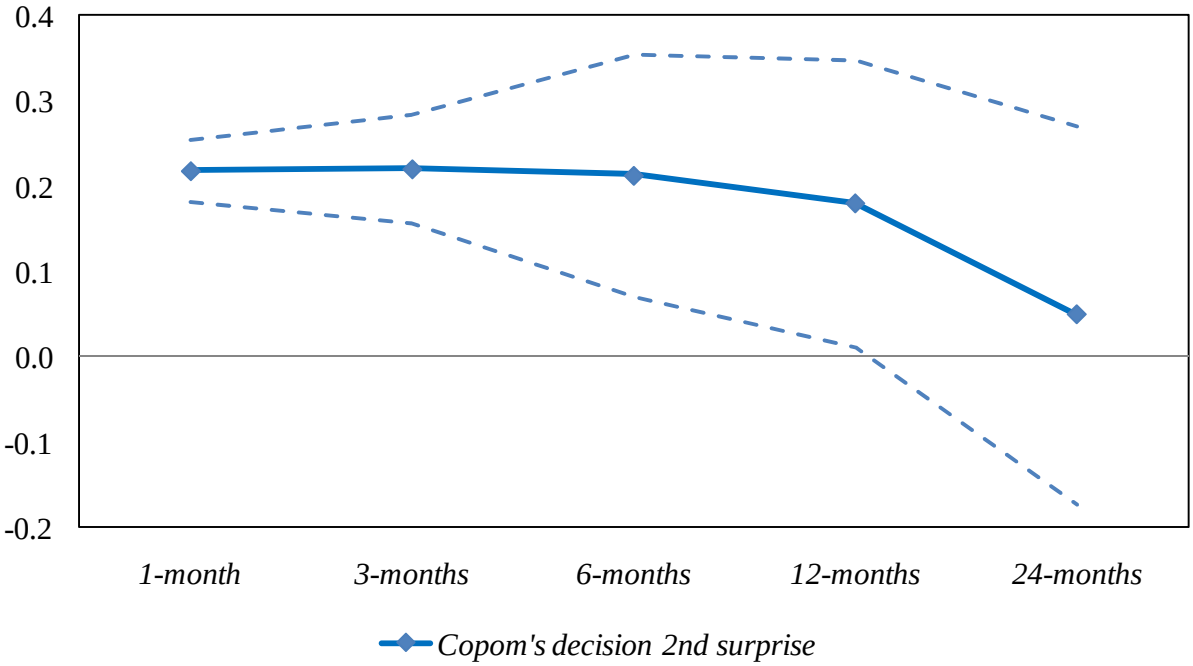
Note: graph based on the estimated coefficients of table 1. The dashed lines represent the 95% confidence interval.

Figure 3: R^2 Obtained from Different Models (Controls Only versus Surprises Only) for Different Maturities of the Term Structure of Interest Rates



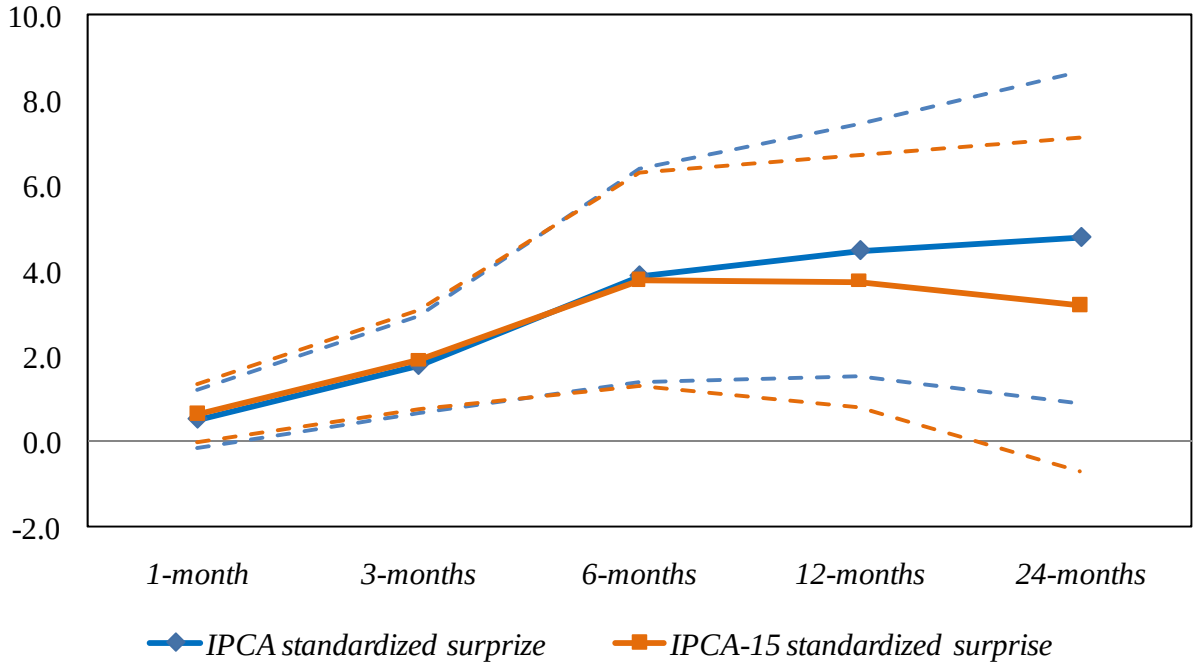
Note: graph based on the estimation outputs of tables 2 and 3. Each column represents the estimated R^2 of the VAR for each of the different maturities of the term structure of interest rate.

Figure 4: Impact of a 1 Basis Point in Copom's Decisions 2nd Most Common Surprise on Different Maturities of the Term Structure of Interest Rates (also in Basis Points)



Note 1: Copom's decision 2nd surprise refers to the 2nd most common forecast error after each Copom meeting.
Note 2: graph based on the estimated coefficients of table 4. The dashed lines represent the 95% confidence interval.

Figure 5: Impact of a 1 Standard Deviation Surprise on IPCA and IPCA-15 on Different Maturities of the Term Structure of Interest Rates (in Basis Points)



Note: graph based on the estimated coefficients of table 6. The dashed lines represent the 95% confidence interval.