THE EFFECTS OF ASYMMETRY AND UNCERTAINTY ON THE RESPONSE OF THE YIELD CURVE TO BRAZILIAN MONETARY POLICY

Área 4 - Macroeconomia, Economia Monetária e Finanças

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Resumo: Investigamos a influência das decisões e anúncios do Banco Central do Brasil na dinâmica do mercado de títulos em torno da reunião do Comitê de Política Monetária (COPOM). Consideramos quatro possíveis direcionadores distintos de movimento do mercado: (i) a surpresa efetiva do mercado na decisão do banco central; (ii) as respostas assimétricas do mercado a mudanças positivas ou negativas na taxa de juros oficial, (iii) a influência da incerteza econômica em torno das reuniões; e (iv) os efeitos dessas mudanças no comportamento do mercado ao longo do tempo. Descobrimos que os coeficientes de surpresa monetária têm um valor negativo para as taxas de longo prazo. Também, encontramos resposta assimétrica do componente surpresa para o sinal da mudança na política monetária. Há evidências de que mudanças positivas, em geral, são mais difíceis de prever pelo mercado. Os resultados indicam que uma maior incerteza aumenta o componente surpresa no curto prazo e reduz o efeito da política monetária nas taxas de juros de longo prazo. Além disso, há uma redução do componente surpresa sobre o comportamento do mercado de juros brasileiro ao longo do tempo.

Palavras-chaves: Surpresa, Política Monetária, Taxa de Juros, Banco Central.

Abstract: We investigate the influence of the Central Bank of Brazil's decisions and announcements on the bond yield market dynamics around the Monetary Policy Committee (COPOM) meetings. We consider four distinct possible drivers of market movement: (i) the effective market surprise on central bank decisions; (ii) the asymmetric market responses to positive or negative changes in the official policy rate; (iii) the influence of economic uncertainty around meetings; and (iv) the effects of these changes on market behavior over time. We find that the monetary surprise coefficients have a negative value for long-term rates. Moreover, we find an asymmetrical response of the sign of the surprise component of the change in the monetary policy. There is evidence that positive changes, in general, are more difficult to predict by the market. Higher uncertainty increases the effect of the monetary policy surprise component in the short-term and reduces the effect in the long-term yield rates. Moreover, there is a reduction in the impact of the surprise component on the Brazilian interest market over time.

Keywords: Surprise, Monetary Policy, Interest Rates, Central Bank.

Classificação JEL: E43, E52, E58

[1] Esse artigo foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior- CAPES (Código de Financiamento 001)

[2] Esse artigo foi realizado com o apoio do Conselho Nacional de Pesquisa Científica e Tecnológica - CNPq (Processo 311475/2018-3)

1 Introduction

Beginning in the 1990s, with the implementation of the inflation-targeting regime, we witnessed the development of monetary policy in its efforts to achieve its main objectives: price level control and economic growth (Blinder *et al.*, 2008). The primary goal of monetary policy is to affect macroeconomic variables such as output, employment, and inflation. However, the effect of monetary policy instruments on these variables is indirect. The primary monetary policy tool central banks use is the short-term interest rate, with communication playing a major role in setting expectations. This paper is an empirical study of the relationship between bond market dynamics and central bank communication.

Recent research suggests that communication is an essential and powerful part of the central bank's arsenal and may influence the financial markets, as strong as the short-term interest rates (Amato; Morris; Shin, 2002). Blinder *et al.* (2008) point out that communication increases the predictability of monetary policy decisions and helps achieve central banks' economic goals. From the point of view of policymakers and market agents, the reaction of financial markets to the communication of monetary policy decisions is of great interest, as it provides information such as the real and financial effects of monetary policy on the economy. León and Sebestyén (2012) claim that a monetary policy decision is much more than just changing an official interest rate. In addition, the management of monetary policy by central banks has also become an art of shaping market expectations, as expectations have the potential to impact the term structure of interest rates.

The possibility that the monetary authority may affect the economy depends on its ability to influence market expectations, especially concerning the future trajectory of interest rates and economic perspectives, since most structural decisions are focused on the medium and long term. The concept of "monetary surprise"emerges in the study of this influence. Ehrmann and Fratzscher (2003) point out that when monetary policy decision announcements are released to the public, part of the decision is already expected, and market prices have already changed before the announcement. The price movements that take place are the market's reaction to the surprise component in the news, that is, the monetary surprise. Goldberg and Leonard (2003) argue that, in efficient markets, interest rates should be influenced only by the surprise component of economic news. Therefore, it is essential to model the occurrence of unexpected information in evaluating the effect of monetary policy on the interest market.

The predominant approach to assessing a market reaction to monetary policy is based on the event study introduced by Cook and Hahn (1989). In this approach, the difference in interest rates between two days is regressed on the changes in the target rate. The estimated parameter can be understood as the "monetary surprise"effect, the part of the change in the target rate absorbed by the market on the day the information arrived. Thus, if the coefficient is not statistically different from zero, we assume that the monetary decision was fully anticipated.

Considering the occurrence of monetary policy surprises in small time windows increases the plausibility that the captured effect is due to exogenous changes in monetary policy, partly because few economic news is announced simultaneously. Cook and Hahn (1989), Kuttner (2001), and Cochrane and Piazzesi (2002) carry out empirical studies considering the effects on the fixed income market for the North American economy. Studies seem to confirm that changes in the target rate by the central bank affect short-, medium- and long-term market rates. In the Brazilian context, Tabak (2004) and Buchholz *et al.* (2012) are some of the works that assessed the impact of the Central Bank of Brazil's (BCB) monetary policy decisions on the Brazilian market.

Bernanke and Kuttner (2005), Chuliá, Martens and Dijk (2010), Altavilla *et al.* (2019) highlight two important findings about central bank communication. At first, it is necessary to consider market expectations and smooth information flows, as returns and volatilities respond only to the surprise component. Secondly, there is the possibility of asymmetric effects of target rate announcements in the bond market. For example, the response of yields and volatility could depend on the surprise being positive or negative or on the direction of the target rate change. For the Brazilian case, Oliveira and Ramos (2011) and Chague *et al.* (2015) analyze how the BCB's communication affects the term structure of interest rates.

More recently, Burjack, Qu and Timmermann (2019) and Tillmann (2020) discuss the importance of considering the economic uncertainty in the analyses of official target rate changes. The authors account for uncertainty by an inflation measure and point out that policy shocks affect not only expectations of future inflation but also term premia in proportions that can vary with the underlying state of the economy. Having direct evidence on the uncertainty channel in the transmission of monetary policy shocks is, therefore, essential. To the extent that an unanticipated tightening in monetary policy reduces investors' uncertainty about future inflation, it should also decrease nominal term premia. Tillmann (2020) finds that monetary policies aim to reduce long-term bond yields can become less effective if monetary policy uncertainty is high.

Shedding light on these discussions, we investigate the influence of central bank decisions and announcements on the bond yield market dynamics around the BCB's Monetary Policy Committee (COPOM). We consider four distinct possible drivers of market movement: (i) the effective market surprise; (ii) the asymmetric market responses to positive or negative changes in the official policy rate, (iii) the influence of economic uncertainty around meetings; and (iv) the effects of these changes on market behavior over time.

We use two different Brazilian data sets that allow us to directly measure the unanticipated component of yield dynamics to shocks in the official target rate. Our data feature daily survey expectations of the Brazilian official target rate reported by key institutional investors and money managers. The survey data are collected by the Brazilian Central Bank and Bloomberg L.P., which gives us a measure of the "pure" expectations component of changes to the target rate. Our results corroborate previous studies, finding a monetary surprise over short-term interest rates and long-term maturities. In addition, we find that the monetary surprise coefficients have a negative value for long-term rates, different results from the past international empirical evidence.

In addition, we find an asymmetrical response of the surprise component for the sign of the change in the monetary policy. There is evidence that positive changes, in general, are more difficult to predict by the market. We find a higher surprise component when Brazilian Central Bank is more hawkish. There is evidence that a higher uncertainty increases the surprise component on the short-term and reduces the effect of monetary policy on the long-term yield rates. Finally, there is a reduction in the impact of the press releases on the behavior of the Brazilian interest market over time, which is a strong indication of the improvement in the BCB's predictability by the agents participating in this market.

The remaining sections of this article are organized as follows: in section 2, the importance of communication in the process of implementing monetary policy and the concept of monetary surprise is discussed; section 3 presents the methodology and the database used; in section 4, an empirical analysis is carried out on how COPOM's decisions influence the market interest rate and; in the last section, the final considerations are presented.

2 Monetary Policy Surprises

2.1 The Unexpected Shocks of Monetary Policy

Analysis of the transmission mechanism for monetary policy shocks critically depends on having an accurate measure of policy shocks. One way to account for the surprise component is by following Cook and Hahn (1989). However, Bernanke and Kuttner (2005) show that the monetary policy decisions of the central bank are largely anticipated, with only the unanticipated component producing an impact on markets. Additionally, Burjack, Qu and Timmermann (2019) point out that bond yields can change either because of shifts in expected future short rates or because of shifts in risk premia, confounding the interpretation of market-based measures of monetary policy shocks.

Accounting for the points raised, we use a data set which features daily survey expectations of the Brazilian official target rate. We use both the BCB's Focus and the Bloomberg survey expectations. The Focus and Bloomberg surveys measure the pure expectations of future spot rates because they are not contaminated by risk premium (pricing) effects and other endogeneity issues. In this study, we also consider a major change implemented in August 2003 to the announcement of the target rate. Until that date, COPOM decisions were announced on the same afternoon as the decision date, with the market (partially) reacting to the announcement itself. Since August 2003, the announcement has been made after the markets close, with the complete market reaction reflected the day after the announcement. Thus, day-to-day changes in market rates are calculated between t = -1 and t = 0 (with t = 0 being the announcement date) until August 2003, and between t = 0 and t = 1 thereafter Buchholz *et al.* (2012).

Following Burjack, Qu and Timmermann (2019), let $r^e_{t+1|t}$ be the day-t survey forecast of the COPOM rate on day $t+1$. This forecast uses information obtained on day t, the last day of the COPOM meeting. Although the COPOM sets the rate on day t, the new rate only gets announced after markets have closed, so day $t+1$ is the "event date" for measuring the impact of the day-t announcement. We can decompose the actual post-meeting COPOM rate (r^{COPOM}_{t+1}) into its expected value, $r^e_{t+1|t}$ (observed from the surveys) and the (residual) unexpected component, $r^u_{t+1} : r^{COPOM}_{t+1} = r^e_{t+1|t} + r^u_{t+1}$. Subtracting the pre-announcement COPOM rate, from both sides and defining $\Delta r^{COPOM}_{t+1} = r^{COPOM}_{t+1} - r^{COPOM}_t$ and $\Delta r^e_{t+1|t} = r^e_{t+1|t} - r^{COPOM}_t$ we get the following relation between the actual one-day change in the COPOM rate, Δr^{COPOM}_{t+1}, and the expected change $\Delta r^e_{t+1|t}$. So:

$$\Delta r^{COPOM}_{t+1} = \Delta r^e_{t+1|t} + r^u_{t+1} \tag{1}$$

To check the validity of the Focus Survey, that is, if agents update forecasts on the days before and after the COPOM meetings, Burjack, Qu and Timmermann (2019) conduct Mincer-Zarnowitz efficiency tests. Their results find values we would expect for the forecasts to be unbiased. Moreover, the R^2 of their regression reflects how good survey participants were at forecasting COPOM rate changes, concluding that the surveys were very accurate in predicting changes in monetary policy over the sample and get updated quickly around the COPOM meeting.

2.2 Measuring the Surprise Element of Policy Actions

One approach to measuring the impact of the BCB's monetary policy decisions on the bond market is to calculate the market's reaction to official COPOM rate changes on the day of the change. Of course, the market may also react to the lack of change in the target rate if a change had been forecast. Because this approach involves looking at the response to specific events, it might be described as an "event–study" style of analysis (Bernanke; Kuttner, 2005). The relevant sample of events is the union of days before and after COPOM meetings.

We distinguish between expected and unexpected funds rate changes:

$$\Delta r^n_{t|t+1} = \beta_e \Delta r^e_{t|t+1} + \beta_u r^u_t + \varepsilon \tag{2}$$

where $\beta_e \Delta r^e_{t|t+1}$ and $\beta_u r^u_t$ are the anticipated and unanticipated changes in the official rate given by the survey measures, respectively. The error term ε represents factors other than then monetary policy that affect stock prices on event days. These factors are assumed to be orthogonal to the changes in the COPOM rate appearing on the right-hand side of the regression.

2.2.1 Asymmetric Effects

Bernanke and Kuttner (2005) and Chuliá, Martens and Dijk (2010) study the heterogeneity in the response of interest rates to monetary policy announcements across market prices. An asymmetric reaction to the monetary policy by the bond market can be defined as the chance that this reaction depends on the direction of the monetary authority's decision or the direction of the market surprise.

We investigate if there is an asymmetric effect considering the direction of the target rate changes:

$$\Delta r^n_{t|t+1} = \beta_1 \Delta r^e_{t|t+1} + \beta_2 P r^u_t + \beta_3 N r^u_t + \varepsilon_t, \tag{3}$$

where N is a dummy variable that takes one when $\Delta r^{COPOM}_{t|t-1} < 0$ and P is a dummy variable that takes one when $\Delta r^{COPOM}_{t|t-1} > 0$. A negative asymmetrical effect the interaction between the dummy N and the unexpected response. A positive asymmetrical effect is the interaction between the dummy P and the unexpected response. We seek to understand how the market responds to the sign of the change, if there is an increase in the surprise component when the Central Bank increases or decreases the interest rate.

2.2.2 The Influence of Uncertainty

The influence of economic uncertainty is captured by the interaction of the uncertainty measures and the monetary surprise. In our analyses, we use the difference between t and $t+1$ of the uncertainty index to account for the uncertainty coefficient:

$$\Delta r^n_{t|t+1} = \beta_e \Delta r^e_{t|t+1} + \beta_u r^u_t + \beta_{unc} \Delta unc \times r^u_t + \varepsilon_t \tag{4}$$

where the unc is one of three different economic uncertainty indexes: (i) the Brazilian Economy Uncertainty Index (IIE-Br), proposed by Ferreira *et al.* (2019); (ii) The Economic Policy Uncertainty Index (EPU) for Brazil, proposed by Baker, Bloom and Davis (2016); and (iii) the standard deviation of the Focus survey expectation.

The β_{unc} coefficient shows the interaction between changes in uncertainty indexes and monetary surprise. We expect the coefficient to be positive as an increase in uncertainty usually reflects a more challenging prediction environment.

2.2.3 Temporal Dynamics

The temporal dynamics are evaluated using a rolling window estimation using an initial sample with 50 observations. Thus, at each new period, we estimate the general equations (2), which account only for the expected and unexpected changes in the monetary policy rate, and equation (3), which accounts for the asymmetric response of a change in the target rate. This approach allows us to observe how the coefficients behave over time. As a result, it turns possible to infer whether there is a change in monetary surprise effect and whether the BCB's communication is more predictable and efficient.

3 Data

In this study, the COPOM target rate refers to the Selic-Meta. COPOM sets this rate in COPOM meetings that were held monthly until 2006. Since then, the meetings have happened in intervals of about 1.5 months. Concerning market interest rates, Pre x DI swap rates are used for maturities of 1, 3, 6, 12, 36, 60, and 84 months. We use swap contract rates instead of federal government bond rates because of the bonds' low liquidity in the Brazilian market (Oliveira; Ramos, 2011). The swap is between a fixed rate up until the maturity of the contract and the accumulated one-day DI interest rate, which follows almost exactly the monetary policy interest rate. We use daily rates from January 2002 to March 2022, accounting for the days before and after COPOM decisions (358 observations). Data are from the B3 stock exchange data service. Table 1 reports descriptive statistics for the target rate and the entire sample of market rates (4608 observations). The mean and volatility of market rates increase substantially with maturity.

Tabela 1 – Summary Statistics for Selected Interest Rates

	Mean	Standard Deviation	Maximum	Minimum
Selic	12.38	4.91	26.50	2.00
1 Month	12.24	4.95	26.95	1.90
3 Months	12.26	5.03	27.77	1.88
6 Months	12.34	5.15	28.99	1.87
1 Year	12.55	5.40	32.69	1.97
3 Years	13.47	6.15	43.38	3.31
5 Years	13.96	6.66	47.43	4.57
7 Years	14.22	6.96	50.35	5.04

Note: The table reports summary statistics for selected interest rates

Table 2 reports the total number of decision-making meetings and the monetary authority decision regarding the official target rate. The COPOM conducted 179 meetings, changing the official target rate most of the time in 117 meetings. The target rate was increased 51 times and decreased in 66 meetings.

Moreover, we use samples of survey forecasts and uncertainty indexes. The Focus survey are collected by the Brazilian Central Bank and measures the expectation of more than 100 institutions active in the Brazilian financial market. Bloomberg's survey captures the same information for a smaller number of selected institutions. The Brazilian Economy Uncertainty Index (IIE-Br), which measures the uncertainty of the Brazilian economy based on information collected from the country's main newspapers and financial market expectations about macroeconomic variable. The Economic

Tabela 2 – Summary Statistics for Monetary Policy Announcements and Decisions

Number of Meetings	Monetary Policy Decision	Number of Decisions
	Unchanged	62
179	Increase	51
	Decrease	66

Note: The table reports the number of COPOM meetings and their decisions regarding the target rate during the sample period. **Source:** BCB.

Policy Uncertainty Index (EPU) for Brazil, another uncertainty measure proposed by Baker, Bloom and Davis (2016).

4 Market Response to Shocks of Monetary Policy

Market agents largely anticipate shifts in central bank rates, and only unanticipated changes should impact markets. So, analyzing the transmission mechanism for monetary policy shocks depends on accurately measuring them. Because monetary policy shocks are typically not directly observable, it is necessary to use proxies in their place. The standard method uses changes in federal funds rate futures contracts on announcement days. However, bond yields can change either because of shifts in expected future short rates or because of shifts in risk premia, confounding the interpretation of market-based measures of monetary policy shocks (Burjack; Qu; Timmermann, 2019).

In Table 3, we report the results for Equation (2), which measures the effective market surprise, accounting for the expected and unexpected changes in the COPOM official rate given by the survey measures. In addition, results are reported for each maturity. As we found the regression's residuals to be autocorrelated and heteroscedastic, we use Heteroskedasticity- and autocorrelation-consistent (HAC) estimators of the variance-covariance matrix to circumvent this issue (Newey; West, 1987; Newey; West, 1994). Below each coefficient are the standard errors.

The results indicate that the anticipated component is not statistically significant, showing that bond yield prices incorporate all available information at the time. The unanticipated response to changes in the target rate, β_u, has three different results for our sample. For short-term rates, the surprise components are statistically significant and high, accounting for more than 90% of BCB's unanticipated movement on the 1-month, more than 80% for the 3-month rate, and almost 60% for the 6-month bond. The results are in line with empirical evidence for developed countries, as shown by Cochrane and Piazzesi (2002) and Bernanke and Kuttner (2005). The results are inconclusive for medium-term yield (one and three years). For the long-term maturities, we find the coefficient of unexpected changes to be negative for both Focus and Bloomberg surveys, which implies that a surprise interest rate hike would result in an unexpected reduction of long-term rates.

The findings support a strong bond yield response to monetary surprises, but far from uniform. In some cases, the reaction is muted, while it appears out of proportion to the surprise in others. One reason for the disparity is that the impact of a monetary policy surprise on expected future interest rates varies. Many surprises in the sample could have been interpreted as postponing or accelerating a policy change. Surprises that have a longer-lasting impact on policy expectations would naturally have a larger effect than those that merely altered the timing of policy actions.

Kurov and Stan (2018) point out that a negative coefficient in the long spectrum of the interest

Tabela 3 – The market response to SELIC rate changes

	1 Month	3 Months	6 Months	1 Year	3 Years	5Years	7 Years
				Focus			
β_e	-0.003	0.000	0.004	0.005	-0.015	-0.008	0.051
	(0.032)	(0.033)	(0.037)	(0.054)	(0.060)	(0.042)	(0.023)
β_u	0.918	0.809	0.577	0.293	0.206	-0.125	-0.506
	(0.109)	(0.076)	(0.139)	(0.170)	(0.162)	(0.131)	(0.160)
R^2	0.719	0.690	0.423	0.083	0.037	0.012	0.129
F	442.17	384.24	126.92	17.25	8.88	3.75	28.55
				Bloomberg			
β_e	0.018	0.019	0.015	0.001	-0.020	-0.022	-0.037
	(0.035)	(0.022)	(0.046)	(0.074)	(0.074)	(0.050)	(0.088)
β_u	0.982	0.865	0.624	0.347	0.251	-0.099	-0.306
	(0.135)	(0.072)	(0.052)	(0.103)	(0.088)	(0.125)	(0.091)
R^2	0.79	0.76	0.476	0.113	0.059	0.006	0.046
F	680.90	556.09	159.37	24.41	13.19	2.29	9.32

Note: The table reports the results for Equation (2), where β^e and β^u refer to the anticipated and unanticipated changes in the COPOM official rate, respectively. Newey–West standard errors are shown in parentheses.

rate term structure could be due to the informational character of a given notice of change in the target rate, that is, whether agents consider news as "good" or "bad." The idea is that if the market assesses the increase in interest rates as "good news," a healthier future economy will decrease long-term interest rates, as those rates will suffer a reduction due to the expectation of an improvement in the future economic scenario (Bernanke; Kuttner, 2005). Therefore, when monetary policy contraction (expansion) measures are announced, it is expected that in the future, interest rates will decrease (increase). With this in mind, the promotion of the "good" ("bad") announcement will have a negative (positive) indirect effect, in absolute value, which may outweigh the direct impact on the benchmark interest rate, allowing for the occurrence of a movement in the opposite direction.

4.1 Asymmetric Reaction to Monetary Policy Decisions

Another set of questions discusses asymmetries in the bond yield response to monetary policy due to the direction of the decision or the context in which it occurred. An asymmetric reaction will happen if it depends on the direction of the decision or the direction of the surprise. Here we will analyze the asymmetric market responses to positive or negative changes in the target policy rate.

In Table 4, we report the results for Equation (3) estimation results, which measures the unexpected market response of the Brazilian interest rate market to target rate changes considering Asymmetric Reaction to positive or negative movements in the target interest rate. A positive change asymmetrical effect is the interaction between the dummy P and the unexpected response. A negative change asymmetrical effect is the interaction between the dummy N and the unexpected response. We use HAC to correct for Heteroskedasticity and autocorrelation.

The results indicate that the including an asymmetric unanticipated component improves the results as the R^2 increases, showing significant coefficients and asymmetric response for the direction of the change of the monetary policy rate. For short- and medium-term rates, both coefficients, β_u^P and

Tabela 4 – The market response to SELIC rate changes considering Asymmetric Reaction to Monetary Policy Change

	1 Month	3 Months	6 Months	1 Year	3 Years	5Years	7 Years
				Focus			
β_e	-0.005	-0.011	-0.023	-0.029	-0.052	-0.044	0.049
	(0.032)	(0.037)	(0.054)	(0.070)	(0.073)	(0.052)	(0.025)
β_u^P	1.000	0.833	0.497	0.138	0.057	-0.293	-0.567
	(0.099)	(0.084)	(0.094)	(0.132)	(0.126)	(0.081)	(0.078)
β_u^N	0.681	0.779	0.888	0.823	0.794	0.539	-0.315
	(0.125)	(0.119)	(0.166)	(0.194)	(0.188)	(0.158)	(0.242)
R^2	0.730	0.669	0.392	0.114	0.099	0.147	0.131
F	234.32	174.35	56.37	12.50	11.35	16.65	15.03
				Bloomberg			
β_e	0.014	0.013	0.003	-0.012	-0.033	-0.035	-0.032
	(0.019)	(0.014)	(0.048)	(0.071)	(0.038)	(0.057)	(0.086)
β_u^P	1.105	0.929	0.583	0.239	0.139	-0.271	-0.332
	(0.078)	(0.040)	(0.033)	(0.045)	(0.014)	(0.050)	(0.051)
β_u^N	0.600	0.661	0.764	0.712	0.656	0.491	-0.315
	(0.063)	(0.045)	(0.117)	(0.127)	(0.093)	(0.166)	(0.445)
R^2	0.821	0.751	0.447	0.127	0.090	0.124	0.045
F	400.31	262.38	71.32	14.31	10.38	13.77	5.08

Note: The table reports the results for Equation (3), where β_u^P refers to the asymmetrical effect of an increase in interest rate and β_u^N refers to the asymmetrical effect of a decrease of interest rate. Newey–West standard errors are shown in parentheses.

β_u^N, have a positive sign, which implies that the surprises are in the same direction of the monetary policy decision. For example, if the COPOM decides to hike the interest rate, the bond market usually "jumps"in the same direction. However, the intensity is higher for positive changes for short-term rates. On the other hand, we find a stronger intensity for the negative change coefficient for medium maturities, showing an asymmetrical effect depending on the maturity and monetary decision. For the long-term maturities, both unexpected coefficients, β_u^P have a negative sign, and only for seven-year rate we find a negative coefficient for β_u^N.

The findings show an asymmetrical effect depending on maturities. Agents respond with greater adjustments in short-term bonds when the monetary authority decides to increase the target interest rate, which implies that the market usually believes the monetary authority to be more lenient with inflation. For the medium-term, a hypothesis is that agents believe the monetary authority has more predictability on future inflation, which results in a higher coefficient to negative moves. For the long-term, hikes in rates have more impact than interest rate reductions, which are in line with a central bank more hawkish than previously expected. This evidence could also result from longer decline cycles and a reduction in the level of rates in the sample (Tenreyro; Thwaites, 2016).

Our findings are consistent with previous literature. The results presented by Bernanke (2005) confirm the existence of a strong asymmetric reaction of the stock market to unanticipated changes in the federal funds rate. Papadamou (2013) shows that policy rate changes significantly affect US Treasury rates for all maturities. Also, the author shows evidence in favor of a nonlinear adjustment toward a long-run equilibrium, as the long-term rates adjust faster in such periods. Furthermore, Demiralp and Yılmaz (2012) examine the responsiveness of increases during tightening and decreases during easing in the US bond market. They show that the responsiveness of longer-term US Treasury securities to path revisions is significantly asymmetric.

4.2 Market response to Uncertainty

According to Tillmann (2020), the degree of uncertainty about monetary policy can be significant and fluctuating. This leads us to wonder if monetary policy is less effective in pushing bond yields if market participants have concerns about future monetary policy.

Although monetary policy is currently better articulated and predictable than in the past, policy anticipation is still a work in progress (Blinder *et al.*, 2008). In Table 5, we report Equation (4) estimation results using IIE-Br. The uncertainty effect is the interaction between a change of the index from time t to $t+1$ and the unexpected response. We use HAC to correct for Heteroskedasticity and autocorrelation.

Tabela 5 – The market response to SELIC rate changes considering IEE-BR as the Uncertainty Metric

	1 Month	3 Months	6 Months	1 Year	3 Years	5Years	7 Years
				Focus			
β_e	0.060	0.046	0.029	0.021	0.004	-0.019	0.083
	(0.020)	(0.014)	(0.023)	(0.041)	(0.038)	(0.040)	(0.053)
β_u	0.463	0.480	0.398	0.180	0.065	-0.049	-0.734
	(0.089)	(0.061)	(0.084)	(0.202)	(0.210)	(0.253)	(0.358)
β_{IEE}	0.060	0.044	0.024	0.015	0.019	-0.010	0.030
	(0.007)	(0.004)	(0.006)	(0.014)	(0.015)	(0.018)	(0.023)
R^2	0.899	0.806	0.461	0.092	0.056	0.015	0.154
F	773.48	359.09	74.85	10.06	6.76	2.62	17.84
				Bloomberg			
β_e	0.062	0.049	0.028	0.007	-0.009	-0.034	-0.031
	(0.015)	(0.018)	(0.032)	(0.052)	(0.052)	(0.048)	(0.048)
β_u	0.551	0.572	0.493	0.292	0.146	0.023	-0.365
	(0.067)	(0.076)	(0.128)	(0.227)	(0.201)	(0.213)	(0.158)
β_{IEE}	0.053	0.036	0.016	0.007	0.013	-0.015	0.007
	(0.005)	(0.006)	(0.010)	(0.017)	(0.015)	(0.016)	(0.010)
R^2	0.916	0.829	0.489	0.111	0.063	0.016	0.042
F	954.39	422.64	84.62	12.41	7.55	2.56	4.77

Note: The table reports the results for Equation (4), β^u refers to the unanticipated changes in the COPOM official rate, and β_{IEE} is the uncertainty coefficient. Newey–West standard errors are shown in parentheses.

The results indicate that the uncertainty component can impact the market agents' movements, especially for the short-term yield rates. For 1- 3- and 6-months maturities, we find statistically significant positive estimates for the uncertainty coefficient, β_{IEE}. In short-term yields, the reaction to a surprise move is higher in a more uncertain environment. However, this is not conclusive for medium- to long-term rates, possibly because of major changes in the economic environment in longer time horizons, which are more difficult to predict..

Tabela 6 – The market response to SELIC rate changes considering EPU as the Uncertainty Metric

	1 Month	3 Months	6 Months	1 Year	3 Years	5Years	7 Years
			Focus				
β_e	0.004	0.005	0.005	0.003	-0.017	-0.012	0.043
	(0.023)	(0.020)	(0.038)	(0.059)	(0.063)	(0.045)	(0.020)
β_u	0.892	0.793	0.572	0.302	0.212	-0.109	-0.474
	(0.136)	(0.162)	(0.109)	(0.153)	(0.145)	(0.126)	(0.099)
β_{EPU}	-0.004	-0.002	-0.001	0.001	0.001	0.002	0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
R^2	0.738	0.699	0.420	0.082	0.033	0.019	0.145
F	243.66	200.30	63.36	8.95	4.57	2.99	16.63
			Bloomberg				
β_e	0.022	0.021	0.013	-0.004	-0.023	-0.027	-0.050
	(0.030)	(0.030)	(0.047)	(0.071)	(0.076)	(0.052)	(0.088)
β_u	0.962	0.857	0.629	0.369	0.267	-0.075	-0.253
	(0.170)	(0.110)	(0.069)	(0.102)	(0.098)	(0.104)	(0.072)
β_{EPU}	-0.002	-0.001	0.000	0.002	0.002	0.002	0.005
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
R^2	0.800	0.761	0.474	0.117	0.058	0.013	0.066
F	350.27	278.14	79.42	13.16	7.04	2.28	7.17

Note: The table reports the results for Equation (4), β^u refers to the unanticipated changes in the COPOM official rate and β_{EPU} is the uncertainty coefficient. Newey–West standard errors are shown in parentheses.

These findings are in line with Kurov and Stan (2018), Burjack, Qu and Timmermann (2019), and Tillmann (2020), which show that uncertainty about monetary policy and inflation changes the way the term structure responds to monetary policy. Kurov and Stan (2018) point out that interest rates should react even more strongly to macroeconomic news in the presence of high uncertainty about monetary policy. This occurs because of the effect of the new information on market participants' expectations regarding future monetary policy, including the expected values of bond purchases and the occurrence of possible future changes in the target rate.

In Table 6, we report Equation (4) estimation results using the EPU index proposed by Baker, Bloom and Davis (2016). The uncertainty effect is the interaction between the change of the index from time t to $t + 1$ and the unexpected response. We use HAC to correct for Heteroskedasticity and autocorrelation. In contrast to results reported in Table 5, we find statistically significant positive estimates for the uncertainty coefficient, β_{EPU}, in long-term rates. The uncertainty coefficient has a positive sign for five- and seven-year maturities, implying that uncertainty may impact long-term and shorter rates. For the short-term rates, the results are in line with the ones we found in Table 5.

This result is interesting because it may relate to how each index is constructed. The EPU index uses text archives for the newspaper "Folha de São Paulo."In each month, the index counts the number of articles containing uncertainty terms and scales the raw EPU counts by the number of all articles in the same period. In contrast, the IIE-Br is a weighted average of two indexes. The first is the Indicator of Uncertainty in the Media (IIEBr-Mídia), which reflects the incidence of terms related to uncertainty in articles published in six of the most prominent newspapers in the country. The second is the Expectations Dispersion Indicator (IIEBr-Expectation), based on the dispersion of experts' forecasts for three macroeconomic variables (exchange rate, interest rate, and inflation in the next 12 months). Therefore, the IIE-Br index gets the impact of a broad set of economic variables directly related to the economy and the monetary policy, which may influence the BCB's decisions on monetary policy interest rate..

Tabela 7 – The market response to SELIC rate changes considering Focus Standard Deviation as the Uncertainty Metric

	1 Month	3 Months	6 Months	1 Year	3 Years	5Years	7 Years
				Focus			
β_e	-0.018	-0.011	-0.002	0.001	-0.018	-0.006	0.007
	(0.050)	(0.042)	(0.046)	(0.059)	(0.063)	(0.040)	(0.053)
β_u	0.978	0.857	0.601	0.311	0.219	-0.134	-0.323
	(0.184)	(0.137)	(0.107)	(0.158)	(0.156)	(0.129)	(0.161)
β_{SD}	0.827	0.654	0.328	0.255	0.171	-0.124	2.499
	(0.577)	(0.463)	(0.299)	(0.315)	(0.317)	(0.231)	(0.923)
R^2	0.736	0.703	0.424	0.080	0.033	0.007	0.233
F	240.94	204.13	64.22	8.80	4.52	1.93	28.70
				Bloomberg			
β_e	0.018	0.019	0.015	0.001	-0.020	-0.022	-0.038
	(0.035)	(0.032)	(0.048)	(0.068)	(0.074)	(0.049)	(0.075)
β_u	0.976	0.857	0.615	0.345	0.250	-0.098	-0.215
	(0.179)	(0.120)	(0.073)	(0.099)	(0.108)	(0.117)	(0.093)
β_{SD}	-0.204	-0.243	-0.285	-0.039	-0.050	0.036	2.923
	(0.297)	(0.240)	(0.172)	(0.275)	(0.365)	(0.256)	(0.680)
R^2	0.796	0.762	0.477	0.108	0.054	0.000	0.211
F	341.16	279.87	80.41	12.14	6.57	1.15	24.73

Note: The table reports the results for Equation (4), β^u refers to the unanticipated changes in the COPOM official rate and β_{SD} is the uncertainty coefficient. Newey–West standard errors are shown in parentheses.

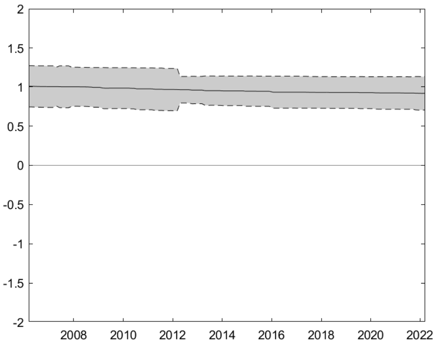
In Table 7, we report Equation (4) estimation results using the Focus standard deviation as the uncertainty measure. Again, we use HAC to correct for Heteroskedasticity and autocorrelation. Only the seven-year bond rate shows a positive and statistically significant coefficient. There is some degree of impact in short-term rates with lower significance levels.

Using different measures of uncertainty, we provide more evidence that in a more turbulent scenario, we see a reduction of monetary policy effect and a more volatile bond market behavior.

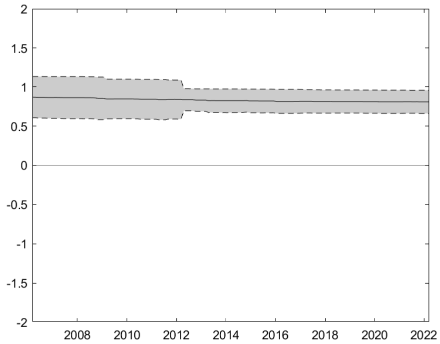
4.3 Inserting Temporal Dynamics

The ability of monetary policy to influence bond yields is well recognized. In reality, monetary policy's impact on longer-term yields is central to the monetary transmission mechanism. Researchers obtain this conclusion, however, using linear regression models for large time series samples, without accounting for the relationship between policy shocks and bond yields varies over time.

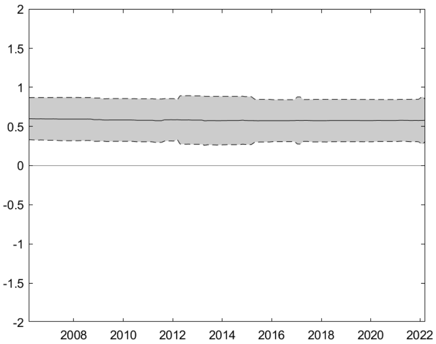
We seek to understand what has happened in the unexpected and asymmetric measures over time. The temporal dynamics are evaluated with a rolling window using an initial sample with 50



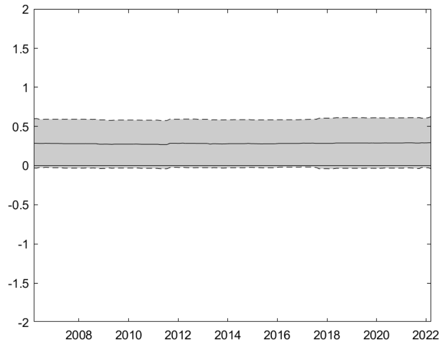
(a) 1 Month



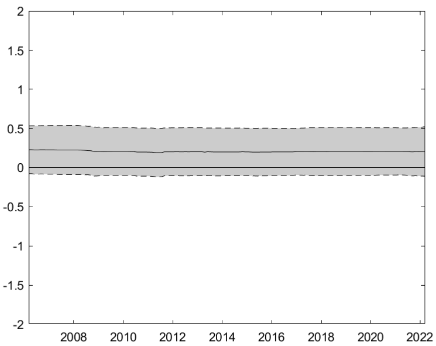
(b) 3 Months



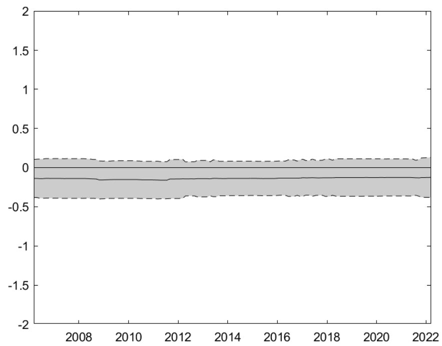
(c) 6 Months



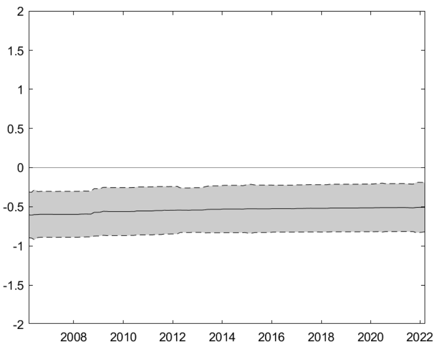
(d) 1 Year



(e) 3 Years



(f) 5 Years



(g) 7 Years

Figura 1 – Temporal dynamics for market response to SELIC rate changes

Source: Authors.

observations. At each new point, we estimate equations (2) and (3), and analyze the evolution of the coefficients.

In Figure 1, we report the results for the rolling window estimation of Equation (2). We use HAC to correct for Heteroskedasticity and autocorrelation. For each maturity, we show the means with 95% confidence bands. As shown in Table 3, we find statistically significant coefficients for 1-,3-, 6-month, and seven-year maturities. For the short-term rates, all coefficients are positive, with intensity reducing with the maturity increase. For the short-term rates, all coefficients are positive, with intensity reducing with the maturity increase. In contrast, the long-term rate shows a negative surprise coefficient and also a reduction of the surprise effect over time.

We can see reduction of 10

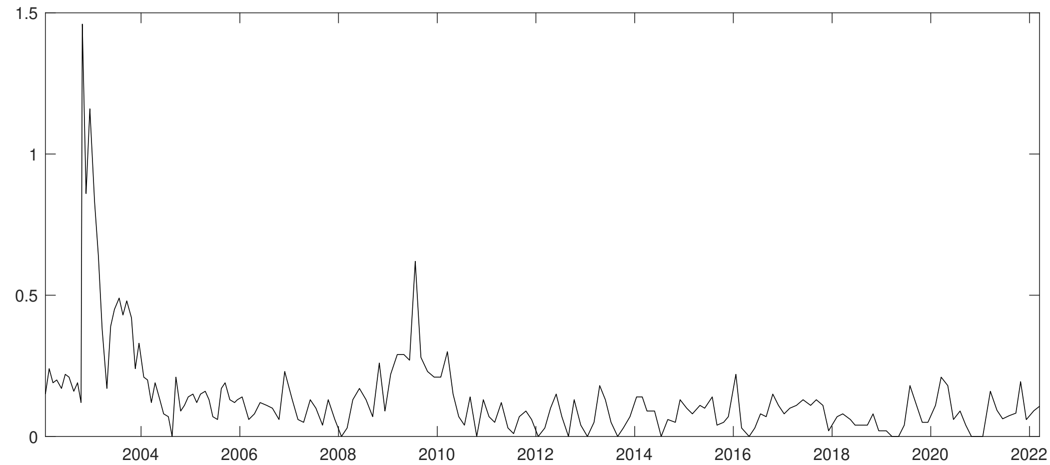
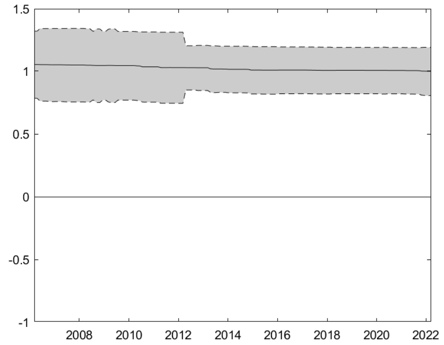


Figura 2 – Standard Deviation of Focus survey for monetary policy interest rate from 2002 to 2022
Source: BCB.

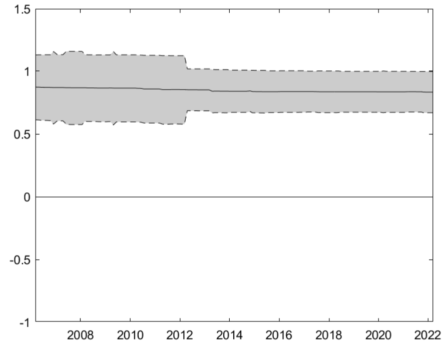
The main reasons for this volatility were the victory of the Worker's Party candidate in the 2002 election. . At that time, market agents believed that default on the public debt and other radical financial actions could be implemented. As a result, Brazil's presidential election in 2002 resulted in significant economic turmoil, with a speculative outflow of foreign capital and the necessity of a tight monetary policy. The interest rate peaked at 26.5% in early 2003 and begun to fall by June 2003 reducing to 16% at the April 2004 meeting (Barbosa-Filho, 2008). We also can observe this fact in Figure 2, where we show the Standard Deviation of Focus survey from 2002 to 2022.

Figures 3 and 4 report the results for rolling window estimation of Equation (3). We use HAC to correct for Heteroskedasticity and autocorrelation. For each maturity, we report the means with 95% confidence bands. In this case, we isolate each component of the asymmetrical analyses. In Figure 3 we show the results for the dynamic β_u^P. Short- and medium-term coefficients have a positive sign, implying that the surprise effects are in the same direction as the monetary policy decisions. For the long-term maturities, we find a negative coefficient. In Figure 4, we show the results for the dynamic β_u^N.

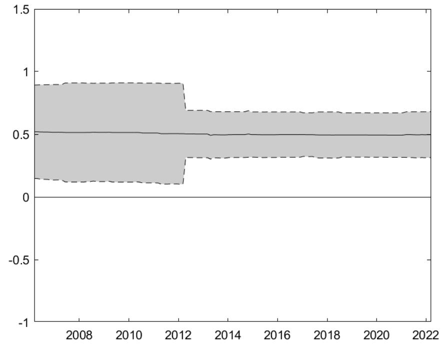
The results are similar to the ones reported in Table 4. For short- and medium-term rates, both coefficients, β_u^P and β_u^N, have a positive sign, which implies that the surprise effect is in the same direction as the monetary policy decision. For medium maturities, we find a stronger intensity for the negative change coefficient, showing an asymmetrical effect depending on the maturity and monetary



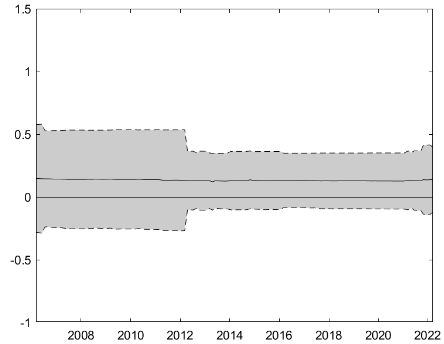
(a) 1 Month



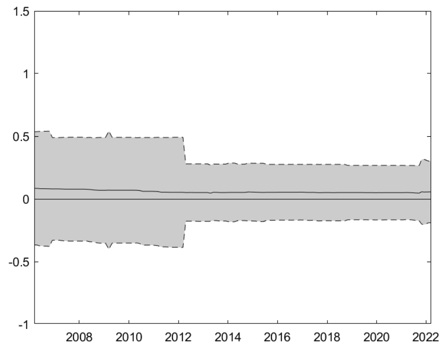
(b) 3 Months



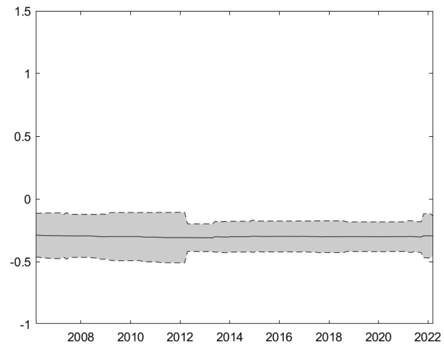
(c) 6 Months



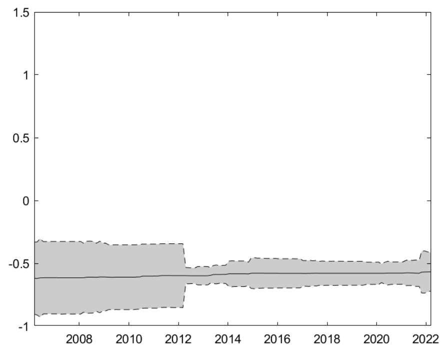
(d) 1 Year



(e) 3 Years

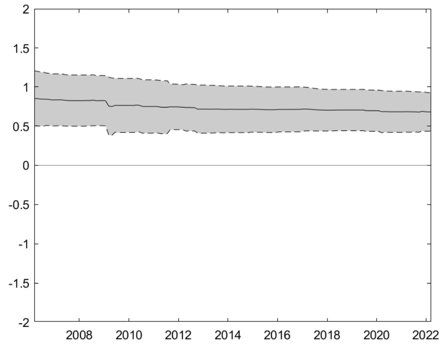


(f) 5 Years

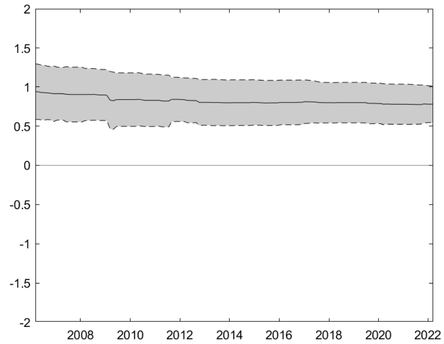


(g) 7 Years

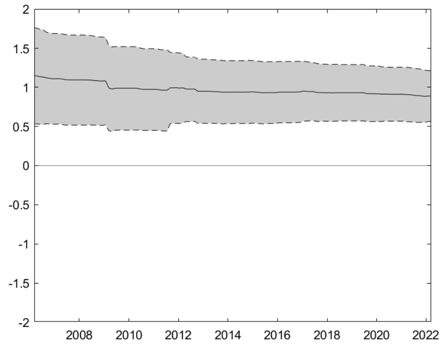
Figura 3 – Temporal dynamics for market response to SELIC rate changes and positive asymmetry
Source: Authors.



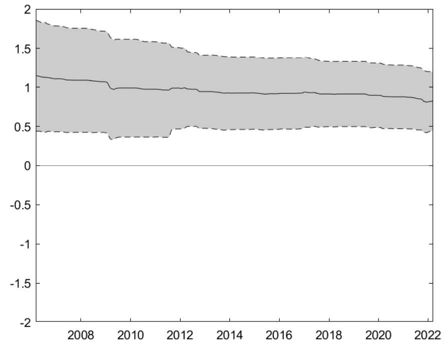
(a) 1 Month



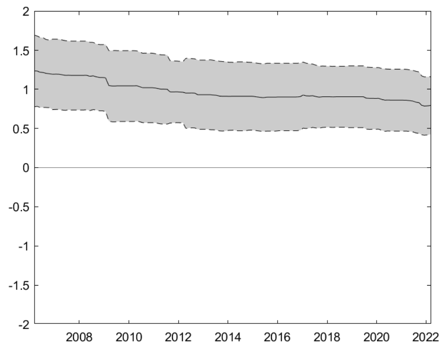
(b) 3 Months



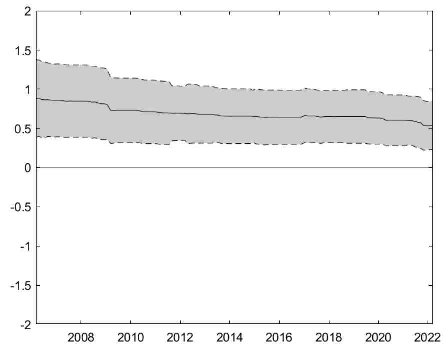
(c) 6 Months



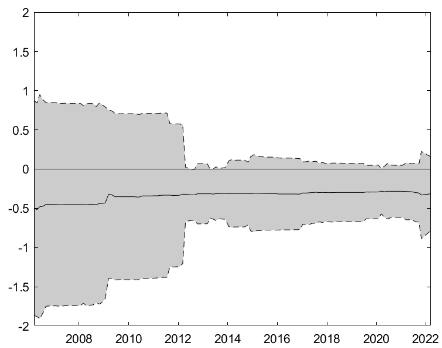
(d) 1 Year



(e) 3 Years



(f) 5 Years



(g) 7 Years

Figura 4 – Temporal dynamics for market response to SELIC rate changes and negative asymmetry
Source: Authors.

decision. For the long-term maturities, both unexpected coefficients, β_u^P have a negative sign, and only for the seven-year rate we find a negative coefficient for β_u^N. As we discovered in the results reported in Figure 1, there is a reduction of 10% of the intensity of each coefficient from 2006 to 2022, and there is also a reduction in the confidence bands, showing a decrease in volatility over time.

The results provide further evidence for the hypothesi proposed by Blinder *et al.* (2008) and Amato, Morris and Shin (2002), that there is a reduction in monetary surprise at moments of monetary policy decision announcements made by central banks. This is associated with the monetary authorities' efforts to increase their transparency, with a consequent improvement in their predictability by the market. As a consequence, monetary policy decisions, which have the potential to impact long-term interest rates, equity prices and exchange rates, may follow a smoother path.

The results also show that there is a difference in the market's behavior in relation to the directions of changes in the target rate, as already found for other financial assets. These results provide further evidence for monetary authorities to consider making and communicating their monetary policy decisions. Then, it is up to central banks to find ways to reduce agents' surprise in the face, mainly by increases in their monetary policy instruments, creating a more stable environment for investment and consumption in the economy.

5 Concluding Remarks

In this study, we investigate the influence of central bank decisions and announcements on the bond yield market dynamics around the BCB's COPOM meetings between January 2002 and March 2022. We use a unique data set containing daily survey forecasts of economic variables in Brazil to obtain direct measures of unanticipated changes in monetary policy and variation in economic uncertainty following central bank announcements. In addition, previous empirical work (Cook; Hahn, 1989; Cochrane; Piazzesi, 2002; Tabak, 2004; Bernanke; Kuttner, 2005; Buchholz *et al.*, 2012) is extended by considering four innovations to drivers of Brazilian bond market: (i) the effective market surprise on central bank decision; (ii) the asymmetric market responses to positive or negative changes in official policy rate; (iii) the influence of economic uncertainty around meetings; and (iv) the effects of these changes on market behavior over time.

The results indicate that changes in the target rate target between 2002 and 2022 caused strong movements in short- and long-term interest rates and moderate movements in medium-term rates. These results support the standard view among financial market participants that the BCB strongly influences market interest rates through its control of the target interest rate.

The evidence from this article corroborates previous evidence for the Brazilian market (Tabak, 2004; Oliveira; Ramos, 2011; Buchholz *et al.*, 2012; Chague *et al.*, 2015) and indicates that expectations of the future level of the target rate strongly influence other money market rates. Furthermore, this evidence is consistent with other studies on the effect of monetary policy announcements on government bond rates and other financial assets.

Moreover, our results underlined three new findings: (i) a strong asymmetry in the responsiveness of Brazilian Treasury yields; (ii) an effect of uncertainty on the responsiveness; and (iii) a reduction in monetary surprises over time. Our findings for the Brazilian economy suggest that central banks' control over long-term nominal yields is attenuated when uncertainty is high. Economic uncertainty is, thus, a critical variable to be accounted for both when analyzing the monetary policy transmission mechanism and when designing stabilization policies.

The results offer several implications for the design and the evaluation of monetary policy. The effects of monetary policies designed by central banks should consider potential asymmetric effects of monetary decisions, as well as the potential lower effectiveness in scenarios of high uncertainty is high. Also, support the hypothesis of Blinder *et al.* (2008) and Amato, Morris and Shin (2002), that central banks have become more transparent and predictable over time. The incorporation of temporal dynamics made it possible to evaluate the behavior of market agents at the moments of communication of monetary policy decisions over the years. We show that monetary surprises still occur. However, the effects of these shocks have become smaller.

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