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Central bank's forecasts and lack of transparency: An assessment of the effect on private expectations in a large emerging economy☆

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ABSTRACT

We analyze whether the Central Bank of Brazil's Inflation Reports projections influences the private's inflation expectations. Specifically, we investigate how the central bank's inflation forecasts affect the private sector's inflation expectations through a qualitative and quantitative examination of the disagreement measure between them. Furthermore, we appraise if the lack of transparency resulting from the difference between the central bank's inflation forecasts and the realized inflation affects the private's inflation expectations. Although the findings confirm the previous studies that point out that the central bank transparency can affect the readjustment of market expectations, the results do not rule out the possibility of the central bank's forecast and private's inflation expectations being affected reciprocally.

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1. Introduction

One cornerstone for the modern monetary policy is the central bank's ability to guide private's inflation expectations. Central banks' inflation forecasts and private's inflation expectations use different sets of information and reflect differences concerning their future economic views (Siklos, 2013). Hence, transparency represents a mechanism that can improve the expectation channel of monetary policy by reducing the asymmetric information between the central bank and the private sector (Blinder et al., 2008; de Mendonça and Simão Filho, 2008; Ehrmann et al., 2012).

This paper revisits the analysis of the central bank transparency in Brazil, looking into the effect of disclosing the central bank's forecasts on the formation of private's inflation expectations. In specific, we analyze how the central bank's inflation forecasts affect the private sector's inflation expectations taking into account a qualitative and quantitative investigation of the disagreement

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measure between them. We also evaluate if the lack of transparency resulting from the difference between the central bank's inflation forecasts and the realized inflation affects private inflation expectations.

Although it is predominant the vision that the central bank's forecast has the power to affect the formation of inflation expectations of private agents, some authors such as Romer and Romer (2000) and Bernanke and Woodford (1997) point out that we cannot rule out the possibility that the private sector has information that the central bank would like to infer.[4] We check this possibility for the Brazilian case through a qualitative and quantitative analysis similar to that developed by Fujiwara (2005) based on the Bank of Japan. Furthermore, to analyze the influence of the lack of central bank transparency on the private sector's inflation expectations, we use a measure for the lack of transparency close to that proposed by de Mendonça and Galveas, 2013 as a proxy.[5]

Our analysis uses data on both the Central Bank of Brazil's (CBB) inflation projections gathered from the Inflation Reports and the private sector's inflation expectations through the Focus-market readout provided by the CBB from 2001 to 2017. The dataset covers the largest part of the period under inflation targeting in Brazil and ends before the market's turbulence due to extremist candidates' strength in the presidential election of 2018. It is noteworthy that Brazil is one of the first emerging economies to adopt inflation targeting, and thus the relevance of the expectations channel of monetary policy is not secondary.[6] Moreover, the CBB has international recognition for its ability to manage data picked up from the market.[7] In short, the Brazilian experience can bring new insights for emerging economies that search for improving the inflation expectations channel.

Based on disagreement measures for several time horizons (from the current quarter to four quarters ahead), we analyze whether CBB's inflation projections' disclosure affects the private sector to update its expectations. In addition, we evaluate whether the CBB's inflation projections have higher predictive capacity than the inflation forecasts of private agents and whether these forecasts contain useful information for the process of forming inflation expectations by private agents. Furthermore, we provide empirical evidence from econometric models concerning the impact of an increase in the lack of the central bank transparency and the central bank's forecasts on private inflation expectations. In general, the findings indicate that CBB's inflation projections and transparency have some power to affect private expectations. However, we verify that the effect is not immediate, it is more effective for horizons higher than two quarters, and there is a possibility of a reverse channel of influence.

Although the analysis regarding the effect of the central bank's inflation forecast on the private sector's expectations has been investigated by several scholars and the dominant result is that the latter is affected by the former in developed countries (see, e.g., Fujiwara, 2005; and Hubert, 2015), the results are not consensual for the analysis of emerging economies. Pedersen (2015) provides evidence that the Central Bank of Chile's inflation forecasts affect private forecasters' short-term inflation expectations. In the same vein, de Mendonça and de Deus (2019) investigate whether inflation forecasts provided by central banks in three inflation targeting emerging economies (Brazil, Mexico, and Poland) affect the change (update) in the inflation expectations of private forecasters and do not find statistical significance for this relationship. Hence, at least for the case of emerging economies, further investigation concerning this subject is needed.

The paper is organized as follows. Section 2 introduces a simple theoretical model, which shows the impact of both the central bank's forecasts and the lack of central bank transparency on private inflation expectations. Section 3 provides quantitative and qualitative evidence regarding central bank projections' influence in the Inflation Report on private expectations and robustness analysis. Section 4 concludes.

2. Impact of the central bank's forecast and lack of transparency on predictions of inflation

Based on theoretical models that analyze the effect of central bank transparency on the conduct of monetary policy (see, for example, Walsh, 2003; and de Mendonça and Simão Filho, 2007), we introduce a simple model that shows the impact of central bank's forecast and lack of transparency on private sector's inflation expectations. To consider how the monetary policy affects the private sector's decisions, we consider a new Keynesian Phillips curve that combines the choice of prices in a staggered manner by firms under imperfect competition, that is:

$$\pi_t = \beta E_t(\pi_{t+1}) + \delta x_t + e_t \quad ,(1)$$

where π_t is the inflation rate; $E_t(\pi_{t+1})$ is the expected future inflation; β is the utility discount factor; x_t is the output gap; $\delta > 0$ is the elasticity of inflation to the output gap; and e_t is the inflation shock.

We assume that the intertemporal allocation of consumption is a result of two effects. The first effect considers that an increase in the expected output gap ($E_t(x_{t+1})$) would increase the current output gap, while the second takes into account the impact of the real interest rate on the level of consumption (i_t - $E_t(\pi_{t+1})$). Hence, the dynamic *IS* is:

$$x_t = E_t(x_{t+1}) - \frac{1}{\sigma}[i_t - E_t(\pi_{t+1})] + \xi_t \quad ,(2)$$

[4] For a discussion regarding the central bank's forecast based on inside information that the private sector does not have, see El-Shagi, Giesen, and Jung (2016).

[5] As highlighted by de Mendonça and Galveas, 2013, a large part of the literature takes into account measures based on an approach that considers several questions related to practice and disclosure of central bank information. Hence, these measures are subject to the researcher's bias. Moreover, institutional features of the central banks do not change in short periods. Therefore, the standard transparency measures are not adequate for analysis with time-series data.

[6] For an analysis concerning inflation target as anchors the private sector's inflation expectations, see Pierdzioch and Rülke (2013).

[7] CBB was awarded in the Central Banking FinTech RegTech Global Awards 2018 for Best Data Management Initiative.

where i_t is the nominal interest rate, σ is the coefficient of risk aversion, and ξ is the exogenous shock on demand.

Regarding the central bank's role in the model, we consider an environment under inflation targeting. Hence, the situation where the central bank is not committed to the target represents a loss. Moreover, the central bank's loss depends on an incentive contract (a punishment mechanism). In other words, as greater is the punishment (τ) for the deviations of the inflation to the target (π-$\pi^{target} \neq 0$), greater is the central bank's loss. Therefore, the central bank loss function (L^{CB}) corresponds to.[8].

$$L_t^{CB} = \frac{1}{2}E_t^{CB}\sum_{n=0}^{\infty}\beta^n[\quad \lambda(x_{t+n})^2 + \pi_{t+n}^2 + \tau(\pi_{t+n} - \pi_{t+n}^{target})^2] \quad ,(3)$$

where β is an intertemporal discount rate ($0 < \beta < 1$) and n is the number of time periods.

Because central banks need some discretionary power for managing the monetary policy, we consider that the central bank's forecasts do not reveal full information relative to supply shocks to the private sector (see, Blinder, 2000). Hence, the inflation caused by supply shocks (e_t^{π}) is a result of the sum of the predictions of inflation shocks that the central bank reveals to the private sector ($E_t^{CB}(e_t^{\pi}) = e_t^{CB}$) and an error, which corresponds to a lack of central bank transparency (w). Thus,

$$e_t^{\pi} = e_t^{CB} + w_t. \quad (4)$$

The private sector knows that the central bank does not have perfect control over inflation. Moreover, to simplify the model, we assume a socially optimal inflation target as zero. Therefore, the central bank loses its reputation when the inflation deviates from that relative to the central banks' forecasts revealed to the private sector. Hence, replacing π^{target} by e^{π} into the central bank's loss function implies that the policymaker's problem is:

$$\min_x \frac{1}{2}E_t^{CB}\sum_{n=0}^{\infty}\beta^n[\quad \lambda(x_{t+n})^2 + \pi_{t+n}^2 + \tau(\pi_{t+n} - e_{t+n}^{\pi})^2]. \quad (5)$$

The first-order condition is:

$$\lambda x_t + \frac{\delta\pi_t}{\delta x_t}(1+\tau)\pi_t - \delta\tau e_t^{\pi} = 0. \quad (6)$$

Solving Eq. (6) for π_t, considering this result one period ahead, and applying the expectation operator, we obtain.[9].

$$E_t\pi_{t+1} = \frac{1}{\frac{\lambda+\delta^2(1+\tau)}{(\delta^2\tau+\lambda)\rho_e e_t^{CB}} - \beta} + \frac{1}{\frac{\lambda+\delta^2(1+\tau)}{\delta^2\tau\rho_w w_t} - \beta\lambda}. \quad (7)$$

Therefore, the forecasts regarding the inflation shock that the central bank reveals to the private sector and the lack of central bank transparency directly impact the inflation expectations. Intuitively, private expectations on inflation increase when the central bank publishes projections that indicate an increase in the inflation shocks.[10] Moreover, the greater the lack of central bank transparency, the greater the increase in private inflation expectations.

3. Empirical analysis

The theoretical model's main prediction is that the private sector's inflation expectations are sensitive to the central bank's inflation forecasts and the lack of central bank transparency. In this section, we confront this prediction based on the Brazilian quarterly data from 2001 to 2017 in the following way. In the first part, we provide evidence of the influence of the central bank's projections in the Inflation Report on private expectations using a battery of tests available from the inflation forecasting analysis literature. In the second part, we show evidence, through Ordinary Least Squares (OLS) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models, regarding the effect of both central forecast and lack of transparency on private's inflation expectations.

3.1. Analyzing the influence of CBB's inflation forecasts on private expectations

In order to analyze whether CBB's inflation forecasts affect private expectations, we use projections for the inflation from the CBB and the market for the period from the fourth quarter of 2001 to the third quarter of 2017. The CBB's inflation forecasts correspond to the 12-month cumulative inflation projections published at the end of each quarter in the Inflation Reports. Besides the central inflation projection, the Inflation Report includes probability intervals of 10 %, 30 %, and 50 % using horizons from the current quarter (nowcast) to four quarters ahead.[11]

[8] Although we do not explicitly consider the pressure from political shocks in the loss function, they are included in the model by the random fluctuations of the output (see, for example, Walsh, 2003).

[9] The derivation of Eq. (7) is in appendix A.1.

[10] For empirical evidence that supports the view that central bank's forecasts influence private expectations, see Fujiwara (2005), Hubert (2011), Pedersen (2015), and de Mendonça and de Deus (2019).

[11] The CBB's inflation forecasts are conditional projections for inflation based on a benchmark scenario that considers unchanged interest and exchange rates throughout the projection horizon.

The private sector's inflation expectations are available from the Focus-market readout provided by the CBB. CBB collects daily market expectations with close to 140 institutions (mostly banks, asset managers, dealers, and brokers) that participate in the Market Expectations System. Considering the median of the monthly inflation projections (accumulated in 12 months) in each quarter and the same horizons regarding the CBB's inflation forecasts, we used four measures of expectations gathered from the Inflation Report date. The first measure corresponds to inflation expectations regarding the day immediately before the publication of the Inflation Reports. The second refers to inflation expectations on the day immediately following the publication of the Reports. The third and fourth measures correspond to inflation expectations five days before and five days after the publication of Inflation Reports. It is important to note that the choice of one day apart from the publication of the Inflation Reports is an attempt to prevent the use of any information distinct from CBB's inflation forecasts and that may influence the private agents' expectations. We use five days before and after the Reports' publication to increase the private agents' chance of updating their inflation expectations.

To consider the influence of the CBB's inflation forecasts on private expectations, we use a disagreement measure (*DIS*), which is a result of the absolute value of the distance between the private inflation expectations (*PIE*) and the CBB's inflation forecasts (*CBBIF*), that is.[12].

$$DIS_{P,K}^{I,h} = |PIE_{h,\ P}^{K} - CBBIF_{h}^{I}|, \tag{8}$$

where: $PIE_{h,P}^{K}$ is the private sector's inflation expectation (accumulated in 12 months) at quarter t regarding the time horizon h (0 - current quarter (*nowcast*), 1, 2, 3, and 4 quarters ahead) available from the Time Series Management System/CBB (TSMS/CBB). K is the number of days before or after the publication of the Inflation Reports (five days before (-5), one day before (-1), one day after ($+1$), and five days after ($+5$)). P is the period regarding the private expectations, that is, if before or after the CBB's projections. $CBBIF_{h}^{I}$ is the CBB's inflation projections published with probability intervals (I = 10 %, 30 %, 50 %, and central) and time horizon h. Fig. 1 shows the path of the disagreement between the private sector's expectations and CBB's inflation forecasts considering the different time horizons (0, 1, 2, 3, and 4 quarters ahead) for one and five days before and after the publication of the Inflation Reports.

Based on the results of the absolute value of the distance between the private sector's inflation expectations and the CBB's inflation forecasts, we make a qualitative evaluation taking into account five groups:

(G1) the difference before the CBB's publication of inflation forecasts (*CBBPIF*) is non-zero and is not larger than the difference after the *CBBPIF*;.

(G2) the difference before the *CBBPIF* is non-zero and is larger than the difference after the *CBBPIF*;.

(G3) differences both before and after the *CBBPIF* are zero;.

(G4) the difference before the *CBBPIF* is zero, but that after the *CBBPIF* is larger than zero; and.

(G5) the differences before and after the *CBBPIF* are equal and larger than zero.

Table 1, based on the classification of the five groups mentioned above, shows the behavior of private's inflation expectations taking into account the CBB's publication of inflation forecasts. Considering all projection horizons h and probability intervals I, as well as $PIE_{h,J}^{K=[-1,+1]}$and $PIE_{h,J}^{K=[-5,+5]}$, we observe that the sum of shares of the categories G1, G4, and G5 gives (cases of disagreement between the CBB and private sector) more than 60%. Therefore, we can conjecture that the CBB's transparency, through the publication of projections for inflation, is not working as a tool to guide the private sector's inflation expectations. In other words, the results indicate that the private sector seems does not follow CBB's forecasts of price developments.

We provide a quantitative examination to evaluate the possible influence of the CBB on private's inflation forecasts using OLS regressions. Specifically, the disagreement between the private's inflation expectations and the CBB's inflation forecasts after the publication of the Inflation Reports is regressed on the disagreement before the publications. In this vein, we consider two specifications to capture the average (common) effect and the individual fixed effect, respectively:

$$DIS_{after,K}^{I,h} = \alpha_1 + \beta_1 DIS_{before,K}^{I,h} + \varepsilon_1; \tag{9}$$

and

$$DIS_{after,K}^{I,h} = \alpha_2 + \beta_2 DIS_{before,K}^{I,h} + \sum_{j=1}^{J} z_j G23_j + \varepsilon_2, \tag{10}$$

where z_j are dummy variables with a value equal to one, which corresponds to occasions when the influence of the CBB's inflation forecasts on the private sector's inflation expectations belongs to the group G2 or G3, and value equal to zero otherwise.

The interpretation of the results regarding the coefficients is straightforward. We expected that when there exists a disagreement between the CBB and the private sector's inflation forecasts before the publication of the Inflation Reports, the disagreement is not eliminated after the publication. Therefore, we expect that the coefficients on $DIS_{before,K}^{I,h}$, that is, β_1 and β_2, being positive. In contrast, for the cases where the CBB has an influential role in anchoring inflation expectations (groups 2 and 3), we expect a fall in the disagreement of inflation expectations after the publication of the Inflation Reports. In other words, we expect that the coefficient on *G23* (z_j) is negative.

Table 2 shows the results of the regressions for both Eqs. (9) and (10).[13] The findings indicate that independent of time horizon, probability interval, and the number of days before or after the Inflation Reports publication, the coefficients β_1 are positive and have

[12] It is noteworthy that different, for example, from Hubert (2014) and Fujiwara (2005), instead of considering the disagreement among forecasters belonging to the same group (private forecaster's expectations), our measure takes into account the disagreement between different agents.

[13] To verify the presence of unit roots in the series, we performed Phillips-Perron and Dickey-Fuller-GLS unit root tests. The results (available from the authors on request) indicate that all series are I(0).

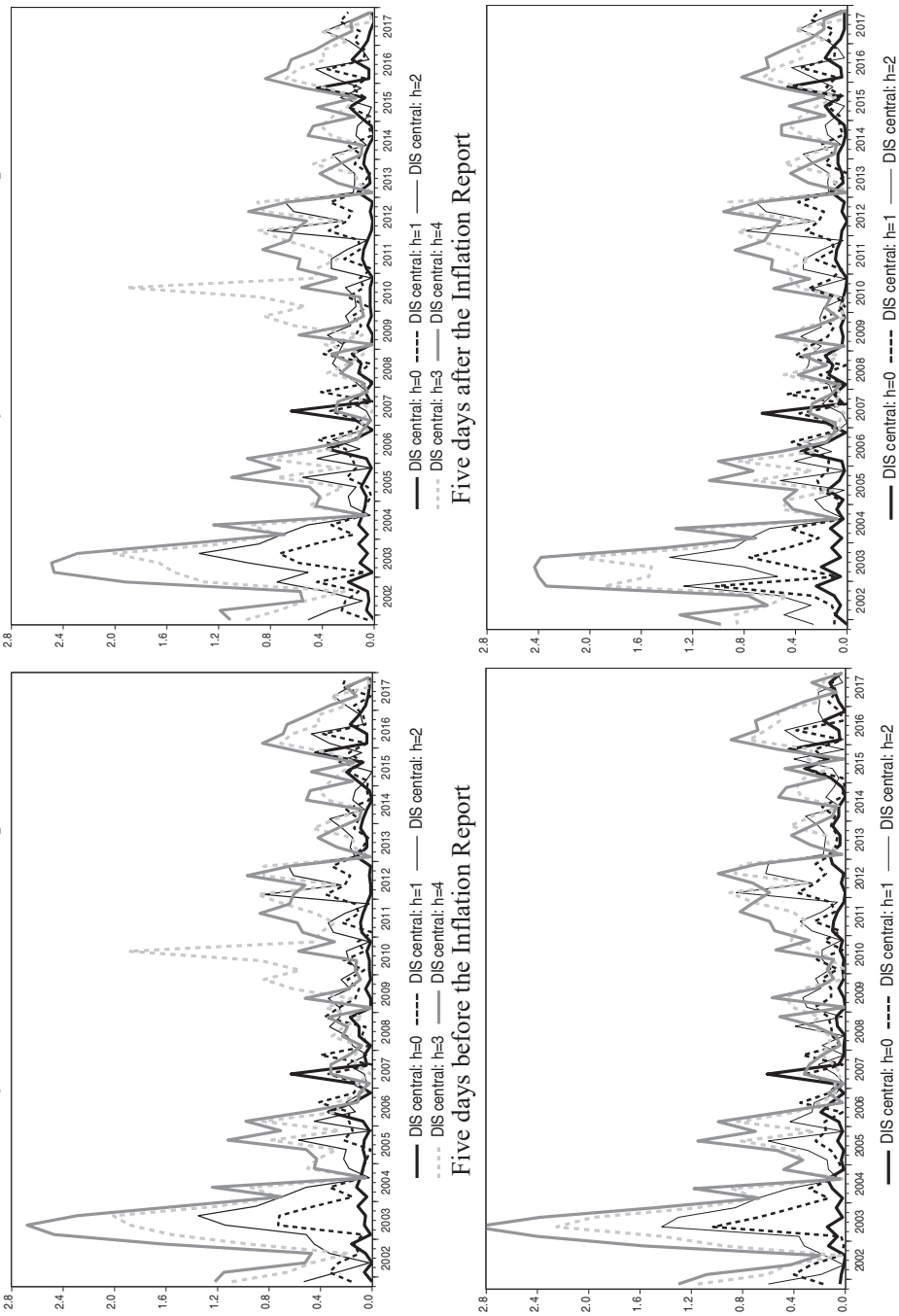

Fig. 1. *The disagreement between the private's inflation expectations and CBB's inflation forecasts*, Notes: The disagreement measure (*DIS*) results from the absolute value of the distance between the private inflation expectations (gathered from www3.bcb.gov.br/sgspub/localizarseries/localizarSeries.do?method=prepararTelaLocalizarSeries) and the CBB's inflation forecasts (gathered from www.bcb.gov.br/en/publications/inflationreport - central projection – see Eq. 8). *h* is the time horizon: 0 - current quarter (nowcast), 1, 2, 3, and 4 quarters ahead.

Table 1
Qualitative evaluation for Central Bank of Brazil's influence on private inflation expectations.

	Probability interval = 10%						Probability interval = 30%					Probability interval = 50%						Central projection					
	G1	*G2*	*G3*	*G4*	*G5*	*Tot.*	*G2*	*G3*	*G4*	*G5*	*Tot.*	*G1*	*G2*	*G3*	*G4*	*G5*	*Tot.*	*G1*	*G2*	*G3*	*G4*	*G5*	*Tot.*
h= 0																							
N. cases: K= [− 1, + 1]	17	11	0	0	37	65	14	1	0	34	65	13	15	0	1	36	65	20	8	2	1	34	65
% total: K= [− 1, + 1]	26.2	16.9	0	0	56.9	100	21.6	1.5	0	52.3	100	2	23.1	0	1.5	55.4	100	30.8	12.3	3.1	1.5	52.3	100
N. cases: K= [− 5, + 5]	23	22	0	5	15	65	26	0	3	14	65	21	29	0	0	15	65	26	18	0	6	15	65
% total: K= [− 5, + 5]	35.4	33.8	0	7.7	23.1	100	40	0	4.6	21.6	100	32.3	44.6	0	0	23.1	100	40	27.7	0	9.2	23.1	100
h= 1																							
N. cases: K= [− 1, + 1]	20	21	2	0	22	65	23	1	0	22	65	20	22	0	0	23	65	24	17	1	1	22	65
% total: K= [− 1, + 1]	30.8	32.3	3.1	0	33.8	100	35.4	1.5	0	33.9	100	30.8	33.8	0	0	35.4	100	36.9	26.2	1.5	1.5	33.9	100
N. cases: K= [− 5, + 5]	33	27	0	0	5	65	32	0	0	5	65	26	34	0	0	5	65	37	20	0	1	7	65
% total: K= [− 5, + 5]	50.8	41.5	0	0	7.7	100	49.2	0	0	7.7	100	40	52.3	0	0	7.7	100	56.9	30.8	0	1.5	10.8	100
h= 2																							
N. cases: K= [− 1, + 1]	21	25	0	1	18	65	25	0	0	19	65	24	23	0	0	18	65	23	22	0	2	18	65
% total: K= [− 1, + 1]	32.3	38.5	0	1.5	27.7	100	38.5	0	0	29.2	100	36.9	35.4	0	0	27.7	100	35.4	33.8	0	3.1	27.7	100
N. cases: K= [− 5, + 5]	28	34	0	0	3	65	36	0	2	1	65	27	37	0	0	1	65	33	30	0	0	2	65
% total: K= [− 5, + 5]	43.1	52.3	0	0	4.6	100	55.4	0	3.1	1.5	100	41.5	56.9	0	0	1.5	100	50.8	46.1	0	0	3.1	100
h= 3																							
N. cases: K= [− 1, + 1]	23	28	0	0	14	65	25	0	1	14	65	26	25	0	0	14	65	24	26	0	0	15	65
% total: K= [− 1, + 1]	35.4	43.1	0	0	21.5	100	38.5	0	1.5	21.5	100	40	38.5	0	0	21.5	100	36.9	40	0	0	23.1	100

(*continued on next page*)

Table 1 (*continued*)

	Probability interval = 10%						Probability interval = 30%					Probability interval = 50%						Central projection					
	G1	*G2*	*G3*	*G4*	*G5*	*Tot.*	*G2*	*G3*	*G4*	*G5*	*Tot.*	*G1*	*G2*	*G3*	*G4*	*G5*	*Tot.*	*G1*	*G2*	*G3*	*G4*	*G5*	*Tot.*
N. cases: K= [− 5, + 5]	35	26	0	1	3	65	31	0	0	3	65	30	32	0	0	3	65	33	28	0	1	3	65
% total: K= [− 5, + 5]	53.9	40	0	1.5	4.6	100	47.7	0	0	4.6	100	46.2	49.2	0	0	4.6	100	50.8	43.1	0	1.5	4.6	100
h= 4																							
N. cases: K= [− 1, + 1]	18	28	0	1	18	65	24	0	0	18	65	22	25	0	0	18	65	20	26	1	0	18	65
% total: K= [− 1, + 1]	27.7	43.1	0	1.5	27.7	100	36.9	0	0	27.7	100	33.8	38.5	0	0	27.7	100	30.8	40	1.5	0	27.7	100
N. cases: K= [− 5, + 5]	32	29	0	0	4	65	35	0	0	4	65	39	32	0	0	4	65	32	28	0	1	4	65
% total: K= [− 5, + 5]	49.2	44.6	0	0	6.2	100	53.8	0	0	6.2	100	44.6	49.2	0	0	6.2	100	49.2	43.1	0	1.5	6.2	100

Note: Qualitative movements are categorized into five groups. (G1) the difference before the CBB's publication of inflation forecasts (CBBPIF) is non-zero and is not larger than the difference after the CBBPIF; (G2) the difference before the CBBPIF is non-zero and is larger than the difference after the CBBPIF; (G3) differences both before and after the CBBPIF are zero; (G4) the difference before the CBBPIF is zero, but that after the CBBPIF is larger than zero; and (G5) the differences before and after the CBBPIF are equal and larger than zero. h = time horizon (0 – nowcast, 1, 2, 3, 4 quarters ahead). K is the number of days before or after the publication of Inflation Reports (one day before (−1) and one day after (+1), that is, $[-1, +1]$; and five days before (−5) and five days after (+5), that is, $[-5, +5]$).

Table 2
Central Bank of Brazil's influence on private inflation expectations.

I, h:	$K = [-1, +1]$			$K = [-5, +5]$		
	Eq. (2)	Eq. (3)		Eq. (2)	Eq. (3)	
	β_1	β_2	z_j[a]	β_1	β_2	z_j[a]
$I=10$ %, $h=0$	1.022 (0.010)	1.019 (0.011)	-0.019 (0.001)	0.919 (0.109)	1.023 (0.077)	-0.090 (0.012)
$I=30$%, $h=0$	1.033 (0.016)	1.024 (0.015)	-0.017 (0.001)	0.938 (0.093)	1.059 (0.104)	-0.100 (0.017)
$I=50$ %, $h=0$	1.021 (0.011)	1.018 (0.011)	-0.019 (0.001)	1.038 (0.078)	1.148 (0.126)	-0.100 (0.019)
$I=$central, $h=0$	1.011 (0.015)	1.008 (0.009)	-0.016 (0.001)	0.923 (0.096)	1.013 (0.053)	-0.086 (0.008)
$I=10$ %, $h=1$	0.904 (0.061)	0.962 (0.069)	-0.039 (0.012)	0.436 (0.152)	0.885 (0.138)	-0.187 (0.032)
$I=30$ %, $h=1$	0.993 (0.031)	1.015 (0.015)	-0.042 (0.005)	0.723 (0.114)	0.857 (0.160)	-0.173 (0.025)
$I=50$ %, $h=1$	0.978 (0.022)	1.014 (0.014)	-0.050 (0.006)	0.784 (0.114)	0.949 (0.192)	-0.194 (0.048)
$I=$central, $h=1$	0.912 (0.039)	0.982 (0.019)	-0.048 (0.008)	0.500 (0.159)	0.839 (0.206)	-0.183 (0.038)
$I=10$ %, $h=2$	0.958 (0.034)	1.017 (0.041)	-0.053 (0.013)	0.711 (0.118)	0.919 (0.107)	-0.186 (0.050)
$I=30$ %, $h=2$	1.032 (0.028)	1.045 (0.036)	-0.044 (0.006)	0.738 (0.117)	1.071 (0.100)	-0.224 (0.039)
$I=50$ %, $h=2$	1.010 (0.025)	1.023 (0.029)	-0.058 (0.009)	0.836 (0.098)	1.003 (0.157)	-0.218 (0.057)
$I=$central, $h=2$	0.966 (0.021)	1.019 (0.036)	-0.054 (0.014)	0.784 (0.083)	0.944 (0.066)	-0.204 (0.061)
$I=10$ %, $h=3$	0.986 (0.023)	1.011 (0.021)	-0.061 (0.014)	0.868 (0.069)	1.070 (0.090)	-0.231 (0.044)
$I=30$ %, $h=3$	0.980 (0.025)	0.993 (0.023)	-0.065 (0.012)	0.757 (0.132)	0.976 (0.091)	-0.208 (0.042)
$I=50$ %, $h=3$	1.009 (0.015)	1.005 (0.011)	-0.074 (0.006)	0.924 (0.074)	0.996 (0.045)	-0.208 (0.027)
$I=$central, $h=3$	0.987 (0.019)	1.020 (0.028)	-0.058 (0.015)	0.925 (0.062)	1.064 (0.073)	-0.232 (0.052)
$I=10$ %, $h=4$	0.984 (0.018)	1.022 (0.026)	-0.054 (0.014)	0.946 (0.042)	1.049 (0.064)	-0.156 (0.044)
$I=30$ %, $h=4$	0.963 (0.016)	1.000 (0.011)	-0.057 (0.010)	0.907 (0.054)	0.990 (0.051)	-0.171 (0.041)
$I=50$ %, $h=4$	0.989 (0.011)	0.998 (0.006)	-0.049 (0.004)	0.903 (0.073)	0.976 (0.041)	-0.151 (0.021)
$I=$central, $h=4$	0.992 (0.017)	1.021 (0.024)	-0.053 (0.013)	0.946 (0.036)	1.030 (0.056)	-0.179 (0.052)

Note: Coefficients (β_1, β_2, and z_j - with statistical significance at the 1% confidence level) are a result of OLS regressions based on Eqs. (9) and (10). Robust (Newey-West) standard errors are in parentheses. I = probability intervals (10%, 30%, 50%, and central) and h = time horizon (0 – nowcast, 1, 2, 3, 4 quarters ahead). K is the number of days before or after the publication of Inflation Reports (one day before (−1) and one day after (+1), that is, $[-1, +1]$; and five days before (−5) and five days after (+5), that is, $[-5, +5]$). a = average of the coefficients on *G23* (see Eq. 3). The result of regressions with all z_js are in the appendix (see tables A.1, A.2, A.3, and A.4).

Table 3
Predictive accuracy test and RMSE.

Test:	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$
DM-HLN (K=[−1])	-1.661	-1.766	-1.804	-1.390	-1.398
DM-HLN (K=[+1])	-1.790	-2.149	-1.859	-1.443	-1.419
DM-HLN (K=[−5])	-0.383	0.742	-1.143	-1.206	-1.342
DM-HLN (K=[+5])	-2.082	-1.815	-1.770	-1.545	-1.423
t-critical value (0.10)[a]	-1.671	-1.671	-1.671	-1.671	-1.671
RMSE:					
$PIE_{h,before}^{K=-1}$	0.132	0.978	1.845	2.565	3.116
$PIE_{h,after}^{K=+1}$	0.128	0.957	1.829	2.551	3.110
$PIE_{h,before}^{K=-5}$	0.167	1.020	1.879	2.591	3.140
$PIE_{h,after}^{K=+5}$	0.116	0.912	1.793	2.518	3.096
$CBBIF_h^{I=central}$	0.176	1.003	1.916	2.693	3.343

Note: *DM-HLN* is the Diebold and Mariano (1995) test with a correction factor for small samples, as proposed by Harvey et al. (1997). I = probability interval - central projection. h = time horizon (0, 1, 2, 3, 4 quarters ahead). K is the number of days before or after the publication of Inflation Reports (one day before (−1), one day after (+1), five days before (−5), and five days after (+5)).

[a] We use the critical value at the 0.10 level of significance because the findings permit us to interpret the results. If we consider the critical value at the 0.05 level, we have a mix of results that do not give us a reasonable interpretation.

statistical significance at the 1% confidence level. In other words, an increase (or decrease) in the disagreement between CBB and private's inflation forecasts leads to an increase (or decrease) in the disagreement after the publication of the Inflation Report. Moreover, the coefficients around one suggest an "inertial effect" and that the CBB's inflation forecasts have no power to affect the private sector's inflation expectations. This result agrees with the significant share of category G5 concerning the effects of the CBB on private expectations (see Table 1), which, in turn, indicates that the private sector is indifferent to the CBB's forecasts in the Inflation Reports.

Regarding the results of the regressions of Eq. (3), the coefficients β_2 follow the same behavior presented for β_1. In other words, the evidence confirms that the disagreements before the publication of the Inflation Reports remain after the publication. One

Table 4
Encompassing test CBB's inflation forecasts and private sector's inflation expectations.

	$h=0$	$h=1$	$h=2$	$h=3$	$h=4$
HLN (K = [+1])	-1.383	-1.764	-1.753	-1.892	-1.957
HLN (K = [+5])	-1.544	-1.705	-1.711	-1.892	-2.043
N. observ.	65	64	63	62	61
t-critical value (0.10)	-1.671	-1.671	-1.671	-1.671	-1.671

Note: *HLN* is the Harvey et al. (1997) test. h = time horizon (0, 1, 2, 3, 4 quarters ahead). K is the number of days after the publication of Inflation Reports (one day after (+1) and five days after (+5)).

important result is that the coefficients regarding the occasions when the publication of the projections in the Inflation Reports does not increase the disagreement between the CBB's forecasts and the private sector's inflation expectations (G2 and G3) are negative and significant.[14] This result is crucial because it indicates the possibility of the CBB's inflation forecasts to affect private expectations reducing or maintaining null the disagreement. Although the coefficients are negative and significant for any specification, we observe that the models with $K=[-5,+5]$ have coefficients on γ_j, in absolute values, higher than those with $K=[-1,+1]$. Hence, we can conjecture that the effect of the publication of the CBB's forecasts in the Inflation Report is not immediate, and it takes some days to be effective.

Besides the investigation regarding the CBB's inflation forecasts affect private expectations, we evaluate whether CBB's forecasts have higher power predictions than those from the private agents. Moreover, we investigate whether CBB's inflation forecasts are useful for the formation of private expectations.

To evaluate the predictive power, we tested the null hypothesis of the CBB's inflation forecasts are more accurate than the private sector by the comparison of the mean squared errors as proposed by Diebold and Mariano (1995) with Harvey, Leybourne, and Newbold (1997) correction factor for small samples. Based on the CBB's inflation forecasts ($CBBIF_h^{I=central}$) and private inflation expectations ($PIE_{h,P}^K$), the means squared errors are $e_h^{CBB2}$and $e_{h,P}^{priv2}$, respectively. Hence, $\{(e_h^{CBB2}, e_{h,P}^{priv2})\}$ is the bivariate vector regarding the means squared errors of CBB and private forecasts. Assuming a loss function ($g(.)$) that is directly associated with the forecast errors, then $g(e_h^{CBB2}) = e_h^{CBB2}$ and $g(e_{h,P}^{priv2}) = e_{h,P}^{priv2}$, which corresponds to a loss differential $d_t \equiv [g(e_h^{CBB2}) - g(e_{h,P}^{priv2})]$. The null hypothesis is the "equal accuracy" for CBB and private sector forecasts regarding inflation, $[g(e_h^{CBB2})] = E[g(e_{h,P}^{priv2})]$, that is:

$$H_0: E[d_t] = 0 \tag{11}$$

If we reject the null hypothesis, the forecast with the lower mean squared error is more accurate. The result of the predictive accuracy test in Table 3 shows that, in general, in the shorter time horizons ($h=0$, 1, and 2), there is a difference between the CBB and

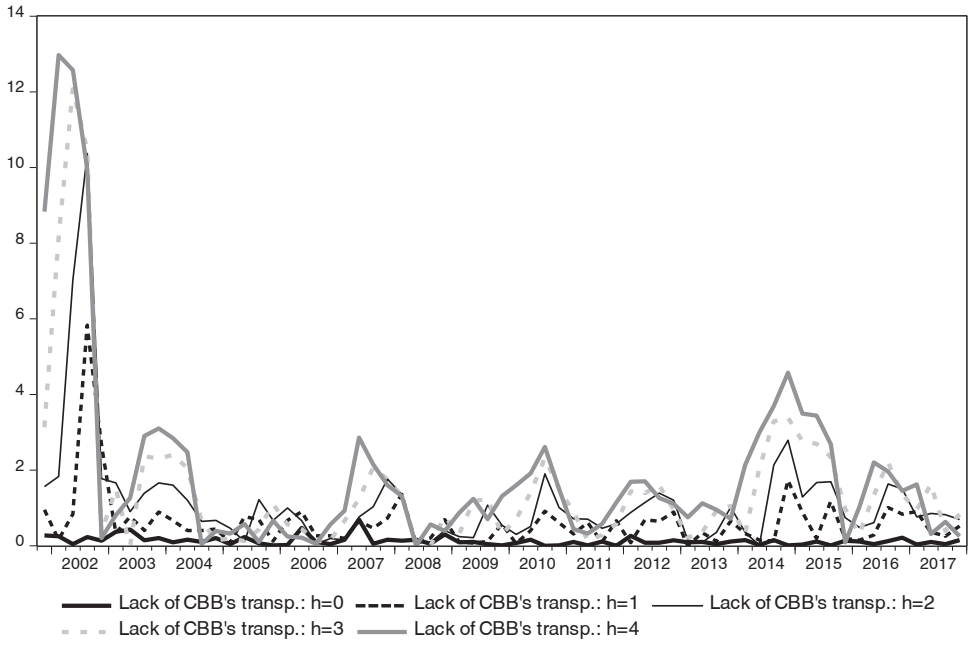

Fig. 2. *Lack of CBB's transparency*. Notes: Lack of CBB's transparency results from the absolute value of the difference between the CBB's inflation forecasts and the realized inflation (see Eq. 13). h is the time horizon: 0 - current quarter (nowcast), 1, 2, 3, and 4 quarters ahead.

Table 5
Effect of CBB's inflation forecasts and lack of transparency on private inflation expectations - OLS and GARCH (1,1).

	h= 0		*h= 1*		*h= 2*		*h= 3*		*h= 4*	
Regressors:	OLS	GARCH (1,1)	OLS	GARCH (1,1)	OLS	GARCH (1,1)	OLS	GARCH (1,1)	OLS	GARCH (1,1)
Constant	0.044	-0.045 (0.029)	-0.123 (0.085)	-0.095	-0.096	-0.069 (0.120)	-0.291	-0.523	-0.871	-0.826
	(0.053)			(0.071)	(0.094)		(0.215)	(0.182)* **	(0.554)	(0.203)* **
$PIE_{T-1}^{K=+1}$	-0.009	-0.013 (0.007)*	0.052 (0.026)* *	0.043	0.103	0.104 (0.024)* **	0.168	0.258	0.418	0.426
	(0.016)			(0.018)* *	(0.027)* **		(0.050)* **	(0.016)* **	(0.073)* **	(0.024)* **
w_{T-1}	0.128	0.196	0.058	0.027	0.089	0.090 (0.029)* **	0.059	0.077	0.063	0.062
	(0.104)	(0.133)	(0.053)	(0.043)	(0.029)* **		(0.037)	(0.020)* **	(0.020)* **	(0.016)* **
$CBBIF_T^{I=central}$	1.000 (0.016)* **	1.018	0.969	0.977	0.927	0.926 (0.030)* **	0.931	0.870	0.799	0.779
		(0.006)* **	(0.027)* **	(0.022)* **	(0.037)* **		(0.088)* **	(0.039)* **	(0.176)* **	(0.041)* **
Constant		0.002		0.001		0.002		0.068		0.125
		(0.001)		(0.002)		(0.005)		(0.022)* **		(0.026)* **
$Resid_{t-1}^2$		1.731 (0.502)* **		-0.144		-0.128 (0.091)		0.825		-0.036
				(0.134)				(0.352)* *		(0.185)
$GARCH(-1)$		0.102		1.088		1.125 (0.136)* **		-0.025		
		(0.105)		(0.129)* **				(0.092)		
R^2	0.998	0.997	0.994	0.994	0.988	0.987	0.943	0.938	0.903	0.903
Prob. White	0.484		0.721		0.084		0.639		0.000	
Prob. ARCH-LM		0.708		0.974		0.829		0.796		0.995

Note: * indicates the significance level of 10 %, ** the significance level of 5 %, and *** the significance level of 1 %. Regressions based on Eq. (14): $PIE_T^{K=+1} = \beta_0 + \beta_1 PIE_{T-1}^{K=+1} + \beta_2 w_{T-1} + \beta_3 CBBIF_T^{I=central} + \varepsilon_T$, where: $\varepsilon_T \sim N(0,\sigma^2)$, and $T = t + h$, *after*. OLS robust (Newey-West) standard errors are in parentheses. GARCH robust (Bollerslev-Wooldridge) standard errors are in parentheses. The sample is from 2002q1 to 2017q4.

the private inflation forecasts and thus rejects the null hypothesis. Moreover, the comparison from the root mean square errors (RMSE) show that the accuracy of inflation forecasts from the private sector is higher than the CBB (RMSE is lower for the private sector than for the CBB). The results from the horizons $h = 3$ and 4 show that there is no difference concerning the prediction power between the CBB and the private sector. The findings agree with the literature that shows that central banks' inflation forecasts are not superior to private inflation forecasts.[15] A possible reason for this result in the Brazilian case is because the CBB makes its inflation projections in scenarios and are conditional on assumptions for some economic variables (constant exchange rate and monetary policy interest rate).

It is important to note that although our results show that the private forecasts are more accurate than CBB's inflation forecasts, the CBB's forecasts matter for the private expectations because CBB has an informational advantage in comparison to the private sector. The CBB is the monetary policymaker and thus knows how it will use the monetary policy instruments to lead with inflation or respond, for example, to an economic downturn. Hence, when CBB publicizes its forecasts, this information represents a sign regarding its future actions and can add new information to the private sector to make its forecasts. Therefore, to investigate whether the CBB's forecasts can be useful for the formation of private inflation expectations, we use the Harvey et al. (1997) encompassing test where the null hypothesis is:

$$\text{H0:} \quad e^{priv}_{h,after} \times (e^{priv}_{h,after} - e^{CBB}_{h}) = 0, \tag{12}$$

where $e^{priv}_{h,after}$ is the difference between the private sector's inflation expectations at the quarter t for the horizon h after the publication of the projections in the Inflation Report and the inflation accumulated in 12 months at $t + h$. $e^{CBB}_{h}$is the difference between the CBB's central projection at quarter t for the horizon h and the inflation accumulated in 12 months at $t + h$.

The null hypothesis considers that all relevant information from the CBB's inflation forecasts is contained in private agents' inflation expectations. Hence, if the null hypothesis is rejected, it means that private agents can improve their predictions with the knowledge of CBB's inflation forecasts. The result of the encompassing test in Table 4 shows that both forecasts one day and five days after the publication of the Inflation Reports reject the null hypothesis for the horizons from one to four quarters ahead ($h = 1,2,3,4$). In other words, there exists evidence that the forecasts available from the CBB are useful for the formation of private's inflation expectations.

3.2. Robustness analysis

Considering the theoretical model results that CBB's inflation projections and the lack of central bank transparency can affect the private sector's inflation expectations, we provide additional empirical evidence. Such as in the previous section, we use CBB's inflation forecasts available from the Inflation Reports ($CBBIF^{I=central}_{h}$) and private sector's expectations (one day after the publication of the Inflation Report) from the TSMS/CBB ($PIE^{K=+1}_{h,after}$), for the time horizons from 0 (nowcast) to 4 quarters ahead. Our proxy for the measure of the lack of central bank transparency (w) is a result of the absolute value of the difference between the CBB's inflation forecasts and the realized inflation (INF, accumulated in four quarters) at the quarter t, that is:

$$w_t = |CBBIF^{I=central}_{h} - INF_t|. \tag{13}$$

In general, Fig. 2 shows that the lack of CBB's transparency increases as the time horizon also increases.

Our general specification is as follows:

$$PIE^{K=+1}_{T} = \beta_0 + \beta_1 PIE^{K=+1}_{T-1} + \beta_2 w_{T-1} + \beta_3 CBBIF^{I=central}_{T} + \varepsilon_T \tag{14}$$

where: $\varepsilon_T \sim N(0,\sigma^2)$, and T = t + h, after.

We provide empirical evidence based on two approaches: OLS and GARCH (1,1) models.[16] Garch estimates consider the possible presence of non-constant conditional variance on private inflation expectations. OLS regressions use the Newey-West estimator, and GARCH regressions use the robust method of Bollerslev-Wooldridge to provide robust standard errors.

The results in Table 5 show that the private sector takes into account the CBB's forecasts and its own lagged expectations for its formation of inflation expectations. The coefficients on CBB's inflation forecasts are positive and significant for all horizons. However, the maximum effect is close to 1 p.p. related to the nowcasting horizon and decreases to close to 0.79 p.p. when we consider four quarters ahead. Concerning the coefficients on the lagged private inflation expectations, we observe that they are positive and significant except for the horizon $h = 0$. Moreover, we observe that contrary to the CBB's forecasts, the effect on private expectations increases while the horizon increases.

The results reported in Table 5 agree with Hubert (2015) that argues that the private sector attributes higher weight to the most recent information in forming its expectations. Besides, because the CBB's inflation projections use a benchmark scenario with unchanged interest and exchange rates throughout the projection horizon reduces the weight that the private sector attribute to these

[14] The result of regressions with all z_j is available from the appendix (see tables A.1, A.2, A.3, and A.4).

[15] Boero, Smith, and Wallis (2008), and Casillas-Olvera and Bessler (2006) show that the expectations of private agents contained in the UK Survey of External Forecasters are better than BOE's forecasts over long horizons, while D'Agostino and Whelan (2008), and Gamber and Smith (2009) find little evidence of the predictive superiority of the Greenbook in the United States. Hubert (2015) shows that the inflation forecasts of central banks in the United Kingdom, Canada, Japan, and Sweden are less accurate than the private agent's inflation expectations.

[16] Autocorrelation and partial autocorrelation functions, Q-statistics, and unit root tests are available from the authors on request.

projections for longer horizons. The coefficients on the lack of central bank transparency show that private's inflation expectations are positive and significant from a time horizon of two quarters ahead. In summary, the findings are in line with those presented in the theoretical model that both CBB's inflation projections and lack of central bank transparency affect private inflation expectations.

4. Concluding remarks

We analyzed whether the publication of inflation forecasts in the Inflation Reports affects the formation of private expectations in Brazil based on data provided by the CBB from the Inflation Reports and Market Expectations System for CBB's forecasts and private expectations, respectively. In particular, taking into account time horizons from the current quarter to four quarters ahead from 2001 to 2017, we investigated qualitatively and quantitatively the relationship between the central bank and the private forecasts.

The main result is that the publication of the CBB's forecasts in the Inflation Report and the lack of central bank transparency can affect the formation of private expectations.[17] Our findings suggest that the effect of CBB's inflation projections on private expectations is not immediate. One possible reason for this result is that central bank credibility is not high in Brazil (see de Mendonça, 2018), and thus the private sector takes some days to evaluate the central bank's news. Moreover, we found that the CBB's forecasts are less accurate than the private sector's inflation expectations. Notwithstanding this result, the findings from the tests proposed by Diebold and Mariano (1995) with Harvey et al. (1997) correction factor for small samples show that the informational content into CBB's inflation projections is relevant for the formation of private inflation forecasts. One possible interpretation from this result is that although the private sector's expectations can be more accurate than the CBB, the private sector must not ignore CBB's projections because they represent a complementary source of information on future inflation.

In brief, albeit the findings confirm the previous studies regarding the Brazilian economy that central bank transparency can affect the readjustment of market expectations (see, e.g., de Mendonça and Simão Filho, 2008; and Montes and Nicolay, 2015), there is an indication that a new framework is needed. The empirical results do not rule out whether the central bank's forecast and private's inflation expectations can be affected reciprocally. Hence, one fact that cannot be neglected in the expectations channel of monetary policy is how the CBB's forecasts can add information to the private sector to improve inflation expectations.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ecosys.2022.101035.

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[17] A possible explanation for the difference of the results found by, for example, de Mendonça and de Deus, 2019 is that while in this paper we consider the effect of the central bank's inflation forecast on the level of private sector's expectations, the analysis from the mentioned authors considers the central bank's inflation forecast on changes in the private sector's expectations.