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Market Forecasts in Brazil: performance and determinants*

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Abstract

This paper assesses a wide set of aspects of market forecasts in Brazil: rationality, predictive power, joint performance, epidemiology and determinants. Using the survey conducted by the Central Bank of Brazil (CBB) among professional forecasters during the inflation targeting period, the main results are as follows: i) credibility in Brazilian monetary policy has increased over time, since inflation targets are important to explain inflation expectations, and private agents perceive the CBB as following a Taylor-type rule that is consistent with the inflation targeting framework; ii) market inflation forecasts had similar or better forecast performance than ARMA-, VAR- and BVAR-based forecasts with standard information sets; iii) the joint performance of market forecasts has improved over the past years; iv) in the decomposition of forecast errors for inflation, interest rate and exchange rate, the common forecast error component prevails over the idiosyncratic component across survey respondents; v) top-five forecasters published by the CBB are influential in other respondents' forecasts; vi) inflation forecasts are unbiased but not fully efficient; and vii) inflation forecast uncertainty is positively related to increasing inflation and to country-risk premium.

Keywords: market forecasts; inflation expectations; inflation targeting; credibility; Brazil

JEL Classification: E47; E49; E58

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1. Introduction

The inflation targeting regime in Brazil led to a remarkable shift in the importance that both the Central Bank of Brazil (CBB) and market participants assign to inflation forecasts. The CBB has systematically used market forecasts as an instrument to assess the conduct of monetary policy and the performance of the policy regime. Market forecasts have also been used as an important input in the monetary policy decision process as it is acknowledged that inflation forecasts are part of firms' price setting decisions, affecting actual inflation. This requires monetary policy to set its instruments so as to ensure that inflation expectations are anchored to the target.

The prominent role played by expectations has enacted increased interest in the empirical analysis of Brazilian inflation forecasts. Bevilaqua, Mesquita, and Minella (2008), Carvalho and Bugarin (2006), Cerisola and Gelos (2005), Minella, Freitas, Goldfajn and Muinhos (2003), and Guillén (2008) have all attempted to dissect the inner workings of market inflation forecasts in Brazil.

This paper goes further. It expands the set of analyzed economic forecasts to include variables other than inflation forecasts, also adding multivariate methods to the set of techniques that have been employed for Brazilian data. Furthermore, analysis of market forecasts in Brazil is enhanced by the use of the entire panel of professional forecasts for chosen economic variables.

Initially, the paper evaluates the rationality of inflation forecasts, by applying the usual bias and efficiency tests. Then it compares market forecasts' predictive power to ARMA-, VAR- and BVAR-based forecasts. The paper then goes on to test the joint performance of survey participants' forecasts for inflation, interest rate and exchange rate using the methodology developed in Bauer, Eisenbeis, Waggoner, and Zha (2003, 2006) and Eisenbeis, Waggoner, and Zha (2002). We then proceed to assess whether published top-five forecasts contaminate the remainder of professional forecasts in a systematic way. Next, we investigate the factors behind the behavior of inflation forecasts and their robustness over time. We go on to assess the formation of Selic (policy) interest rate forecasts, and finally provide some evidence on the likely determinants of inflation forecast dispersion.

The main results found in the paper can be summarized as follows: i) inflation forecasts are unbiased but not fully efficient; ii) market forecasts had similar or better forecast performance than ARMA-, VAR- and BVAR-based inflation forecasts with standard information sets; iii) in the decomposition of forecast errors for inflation, interest rate and exchange rate, the common forecast error component prevails over the idiosyncratic component across survey respondents; iv) the joint performance of market forecasts has improved over the past years, albeit not monotonically; v) top-five forecasts published by the CBB are influential in the survey of inflation, interest rate and exchange rate forecasts; vi) inflation uncertainty is positively related to increasing inflation and to country-risk premium; vii) credibility in inflation targets is strong, as they play an important role in explaining inflation expectations; viii) the importance of inflation targets in the formation of inflation expectations increased after the country overcame the 2002-2003 confidence crisis; and ix) private agents perceive the CBB as following a Taylor-type rule that is consistent with the inflation targeting framework, with Selic interest rate expectations depending mostly on deviations of inflation expectations from the target. These last results provide evidence that the CBB has built up credibility during the inflation targeting regime.

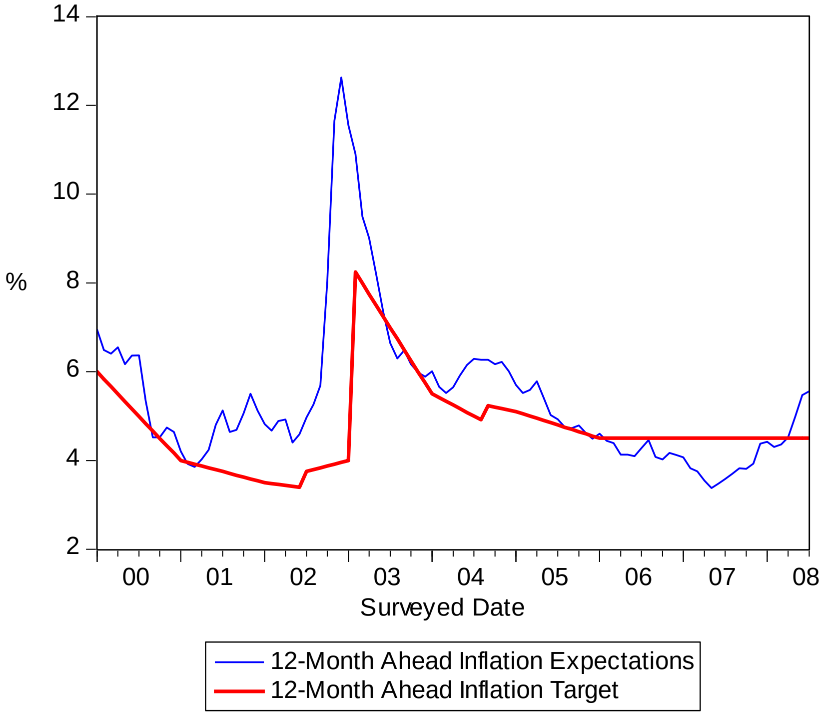
The paper is organized as follows. Section 2 provides some details on the database used and gives an overview of the behavior of market forecasts for inflation, the Selic rate, and the exchange rate. The section that follows tests the unbiasedness and efficiency of inflation forecasts. Section 4 compares the predictive power of market inflation forecasts to model-based forecasts. Section 5, in turn, assesses the joint performance of market forecasts. Section 6 investigates the dissemination of published top-five forecasts to the sample of professional forecasts. The last section estimates the determinants of inflation and Selic interest rate forecasts, and provides some evidence on the determinants of inflation forecast dispersion.

2. Market forecasts: overview and database

CBB's Investor Relations Office (Gerin) surveys market expectations of macroeconomic variables amongst around 100 professional forecasters. The survey has been compiled since the early years of the inflation targeting regime, and aggregated measures have been published on a weekly basis. Although the survey includes a number of variables, this paper focuses on inflation[1], exchange rate and Selic interest rate expectations.

Figure 2.1 shows market inflation forecasts and inflation targets in Brazil. Inflation forecasts refer to the Broad National Consumer Price Index (IPCA), which is used for the official inflation target. The forecast value shown refers to the median of the 12-month ahead inflation forecasts (cumulative inflation from *t* through *t+11*),[2] surveyed on the eve of the release of the IPCA-15 index, a date to which we refer as "critical date"[3]. The inflation target series also refers to the 12-month ahead target. Since the targets are set for calendar years, we use interpolated data. The series takes into account the fact the CBB pursued an adjusted target for 2003 and 2004[4] and an off-center objective within the original target range for 2005[5], which constituted the main reference for agents. We refer to this series as "adjusted target series".

Figure 2.1. Inflation Expectations and Inflation Target (12-month ahead) – 2000:1-2008:7



[1] Relatively low liquidity at time horizons that are policy relevant has so far limited the reliability of inflation expectations indicators derived from government bonds. In order to strengthen incentives for accurate reporting of forecasts, the CBB regularly publishes rankings of the best forecasters of several variables.

[2] For the period from 2000:1 through 2001:10, however, the survey does not provide direct information on 12-month-ahead inflation expectations, but contains information on expectations for the current and following calendar years. In this case, we combine the values for the current and following year. We subtract the actual inflation up to the current month from the expectations for the current year, and use expectations for next year proportional to the number of remaining months. For the tests of bias and consistence, however, we do not include this interpolated data period to avoid the use of approximated series.

[3] Since IPCA-15 is calculated including information of the prices of the first half of the current month, using a posterior date would mean the use of expectations formed with some information about inflation in *t*. Using the monthly average would also add the problem that the first days of the month include expectations for *t-1*.

[4] The adjusted targets were announced by the CBB in January 2003 in the official letter sent to the Ministry of Finance. In June 2003, the CMN confirmed the adjusted target for 2004 as the official target.

The dynamics of inflation expectations in Brazil has not been stable, and that calls for a fragmentation of the sample into three periods. The first covers the implementation and first years of the inflation targeting regime. Inflation targeting in Brazil was implemented rapidly and in a moment of great uncertainty. Yet inflation expectations became relatively well anchored, tracking the declining targets of that period. The second period, starting in mid-2001, was marked initially by a deviation of expectations from the target, triggered by the rationing of electric energy and exchange rate depreciation. The most important event, however, was the confidence crisis at the end of 2002 and beginning of 2003, when the probability of a change in the policy regime and the large exchange rate depreciation made inflation expectations soar to reach 12% p.a., while the target was set at 4%. However, with a strong reaction of the CBB and increasing confidence that the policy regime would be maintained, inflation forecasts receded to around 7% in the middle of 2003 and to less than 6.0% at the end of the year. The third period is characterized by the end of the confidence crisis and its effects, the return of expectations to values around the target, and the consolidation of the inflation targeting regime.

Inflation forecast errors also portrait those movements (Figure 2.2)[6]. The unexpected inflationary shocks of 2001 and mainly of 2002 generated forecast errors as high as 12 percentage points. On the other hand, the forecasts made at the very end of 2002 and first half of 2003 overestimated future inflation, probably because they were based on the assumption that there was a relevant probability of a change in the policy regime, which did not materialize. In the following years, forecast errors were relatively lower, reflecting the construction of a more stable economic environment in the country. With the inflation rise in 2008, however, forecasts that had been made one year earlier ended up underestimating future inflation. Note that, since forecasts refer to a 12-month horizon, forecast errors tend to present high correlation. For instance, if monthly inflation in December 2000 is higher than expected, all forecasts made from January to December 2000 will exhibit errors.

Figures 2.3 and 2.4 show forecasted values for the Selic interest rate and for the change in the exchange rate.[7] Selic rate forecasts tend to closely track inflation forecasts, a relationship we further elaborate on in Section 7. As to the exchange rate, expectations of

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[5] In the minutes of the September 2004 Monetary Policy Committee (Copom) meeting, the CBB announced that would pursue a 5.1% goal instead of the 4.5% target for 2005.

[6] Forecast errors are defined as actual minus forecasted inflation.

[7] Both are surveyed on the critical dates. The values for the Selic, starting in 2002:1, are calculated as the arithmetic average, from month *t+1* through *t+12*, of the forecasts for the Selic interest rate target at the end of each month. The values for the exchange rate change, in turn, are calculated as the average exchange rate forecasted from *t* to *t+1* divided by its average value in the previous month.

depreciations prevailed in most of the sample, except for the confidence crisis period and the second half of 2007.

Figure 2.2. Inflation Forecast Errors
(12-month actual inflation minus forecasted inflation) – 2000:1-2007:8

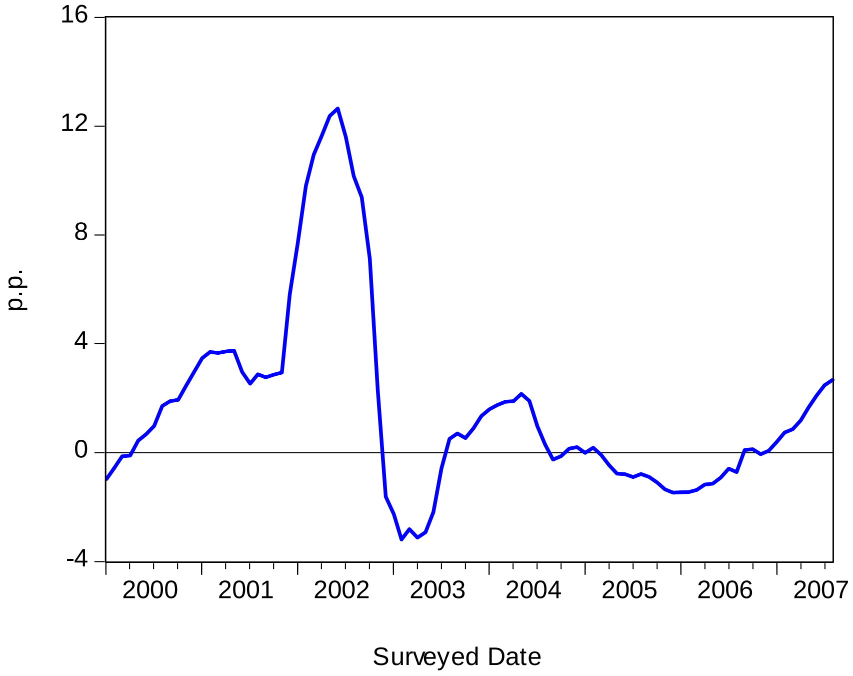


Figure 2.3. Selic Interest Rate Expectations
(forecast of the average Selic target over a 12-month horizon) – 2002:1-2008:7

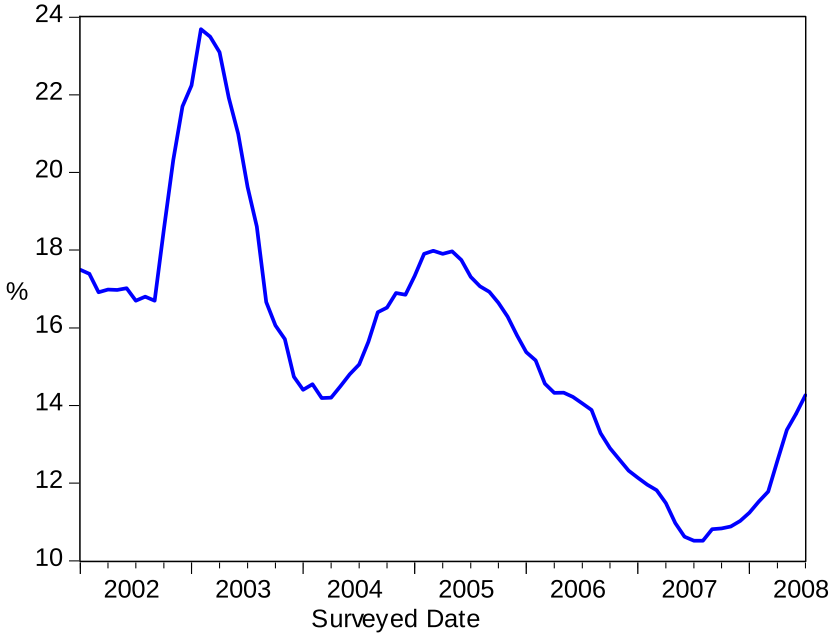
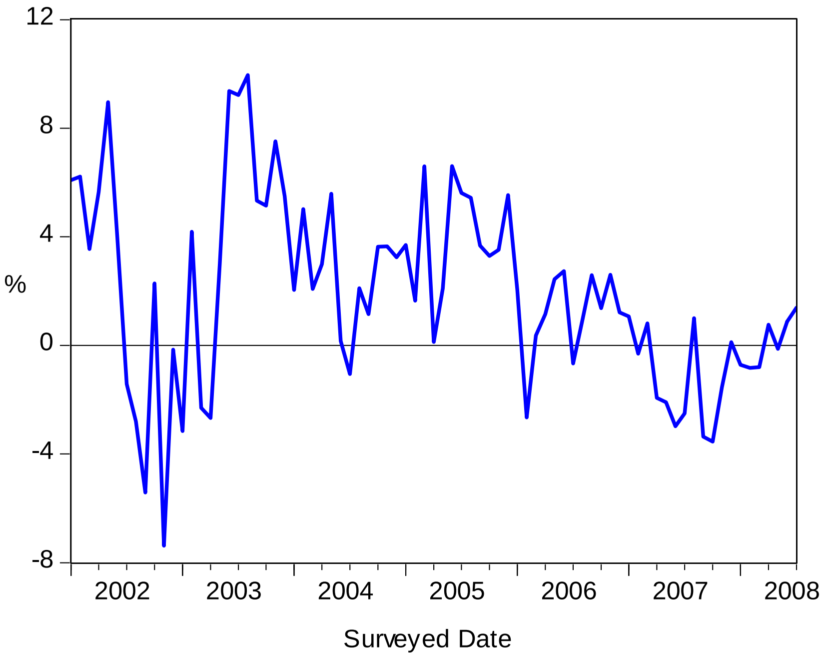


Figure 2.4. Exchange Rate Change Expectations
(forecast of the average exchange rate change over a 12-month horizon) – 2002:1-2008:7



3. Rationality of market inflation forecasts

The economic literature abounds in theories of how expectations are formed. Yet, monetary policy prescriptions are strongly conditioned on the assumed expectations formation rule.

In Cagan, Friedman and Nerlove's adaptive expectations theory, agents are assumed to look essentially to past levels and past forecasts of economic variables to form their predictions (Evans and Honkapohja, 2001). Such a myopic behavior was not compatible with the rising perception that economic agents are optimizers. That, in addition to the acknowledgment that "adaptive expectations, or any other fixed-weight distributed lag formula, provide poor forecasts in certain contexts and that better forecast rules may be readily available"[8] laid the ground for the rationality theory, firstly formulated explicitly by Muth (1961). Rationality implies that economic agents fully understand the underlying forces that drive the economy, with complete knowledge of the economic model and its parameters. For decades, the rationality assumption has been at the heart of mainstream economics.

[8] Evans and Honkapohja (2001, p. 11).

More recent expectations theories have attempted to incorporate more plausible psychological traits of human decision-making, relaxing strict rationality in a number of ways. Some examples are econometric learning (Evans and Honkapohja, 2001, 2003, 2008; Sargent and Marcet, 1989a, 1989b, 1992; Sargent, 1993), which has been widely applied to macroeconomic models for monetary policy analysis (Cogley and Sargent, 2005; Gaspar, Smets and Vestin, 2006; Millani 2005; Svensson, 2003; Preston, 2003), constant gain and perpetual learning (Orphanides and Williams, 2005, 2007), neural learning (Yang, 2000), bounded rationality with capacity constraints to process information (Sims 2005), sticky information (Mankiw and Reis 2002), and rules of thumb (Galí and Gertler, 1999). Each of these assumptions brings about distinct prescriptions for optimal monetary policy decisions, yet many of them still advocate for rationality in the long-run equilibrium.

Previous studies for Brazil show that market inflation forecasts do not conform to the strict rationality hypothesis. Carvalho and Bugarin (2006), sampling up to January 2004, found that, although market forecasts did not show systematic biases, they were not efficient in the use of information available with respect to a number of economic variables. Also, Guillén (2008) tested a set of expectations theories and found that the median forecast is more likely to conform to the sticky-information theory.

In this section we test the rationality of market forecasts for inflation in Brazil, measured by the IPCA change over a 12-month horizon, properly accounting for the maximum theoretical order of serial correlation in estimated residuals. To this end, the regressions are carried out with a Newey-West covariance matrix that allows for an MA(*k*) structure of residuals, where *k* is the maximum forecast horizon.

Rational forecasts are unbiased and fully efficient in the use of any information available to the forecaster. Standard unbiasedness assumptions are tested with the null joint hypothesis $H_0 : \alpha = 0,\ \beta = 1$ in the model

$$\pi_{t,t+k} = \alpha + \beta E_t \pi_{t,t+k} + \mu_{t+k} \ , \qquad (3.1)$$

or, more restrictively[9], they fulfill the null $H_0 : \varphi = 0$ in the model

[9] Fildes and Stekler (2002) report that not rejecting H_0 in equations (3.1) and (3.3) is a sufficient, but not necessary, condition for rationality. They argue, however, that the rationality tests in (3.2) and (3.5) are “a more

$$\varepsilon_{t,t+k} = \varphi + \eta_{t+k} \ , \qquad (3.2)$$

where (α, β, φ) are parameters to be estimated, π_{t+k} is inflation realized at time *t*+*k*, $E_t \pi_{t,t+k}$ are expectations produced at time *t* for a *k*-month ahead horizon, and (μ, η) are MA(*k*) residuals.

Under the null, if *k*-month ahead inflation were not impacted by unpredictable shocks that occurred from the moment the forecast is made to the moment inflation realizes, inflation would vary one to one with unbiased expectations. This assumption implies that forecast errors are made only inasmuch as they result from unpredictable shocks.

Table 3.1 shows unbiasedness test results for the median inflation forecast surveyed by the CBB accumulated over a 12-month forecast horizon (from *t* to *t*+11, and from *t*+1 to *t*+12). The p-values mostly favor the unbiasedness assumption, although the limited sample size, covering a period in which the economy was hit by a number of large shocks, suggests caution upon interpreting the results. In fact, the estimated constant is high, so the p-values favor the null mostly because of the magnitude of estimated standard deviations.[10]

Table 3.1. Unbiasedness Tests for the Median Inflation Forecasts
Ho: Unbiasedness

Model tested (equation #)	Forecast horizon	Surveyed period	# of obs	Regressors (standard error)			P-value of the joint F test
				α	β	φ	
3.1	*t to t+11*	Jan 2002 to Aug 2007	68	4.05 *(2.78)*	0.54 *(0.30)*		0.3009
3.1	*t+1 to t+12*	Jan 2002 to Jul 2007	67	5.35 *(3.50)*	0.30 *(0.40)*		0.1483
3.2	*t to t+11*	Jan 2002 to Jul 2007	67			1.40 *(1.26)*	0.2700
3.2	*t+1 to t+12*	Jan 2002 to Jul 2007	67			1.46 *(1.29)*	0.2640

restrictive condition", and that "the rejection of these rationality tests suggests that forecasts might have been improved".

[10] The evidence on other countries is mixed (Keane and Runkle, 1990). For Chile and Mexico, Carvalho and Bugarin (2006) found that expectations passed the unbiasedness tests.

Following Ang, Bekaert and Wei (2005), we test for the possibility of an asymmetry in the bias, augmenting equation (3.1) with a dummy variable, D_t, which equals one if inflation at time *t* exceeds its past twelve-month moving average, $\pi_t - \frac{1}{12}\sum_{j=0}^{11}\pi_{t-j} > 0$. Otherwise D_t is set to zero. In other words, we verify whether forecasts are biased when inflation is increasing. Non-linear biases are reflected in statistically significant α_2 and β_2 coefficients in the following regression:

$$\pi_{t,t+k} = \alpha_1 + \alpha_2 D_t + \beta_1 E_t \pi_{t,t+k} + \beta_2 D_t E_t \pi_{t,t+k} + \mu_{t+k}\,. \tag{3.3}$$

The estimated p-values do not provide evidence of asymmetry (Table 3.2). However, since the estimated coefficient present large standard deviations, one should be cautious about this result.

Table 3.2. Asymmetric Unbiasedness Tests for the Median Inflation Forecasts

Model tested (equation #)	Forecast horizon	Surveyed period	# of obs	Regressors (p-value for H0: α1=0, β1=1, α2=0, β2=0)			
				α1	β1	α2	β2
3.2	*t* a *t*+11	Jan 2002 to Aug 2007	68	6.54 *(0.184)*	0.00 *(0.126)*	-2.87 *(0.378)*	0.70 *(0.174)*

Efficiency in the use of information available at the moment forecasts are made implies the null $H_0 : \alpha = 0,\ \beta = 1,\ \Gamma = 0$ in the model

$$\pi_{t,t+k} = \alpha + \beta E_t \pi_{t,t+k} + \Gamma'\Theta_t + \mu_{t+k} \tag{3.4}$$

or, in tandem with (3.2), the null $H_0 : \varphi = 0,\ \Phi = 0$ in the model

$$\varepsilon_{t,t+k} = \varphi + \Phi'\Theta_t + \eta_{t+k}\ , \tag{3.5}$$

where the parameter vectors Γ in (3.4) and Φ in (3.5) are associated with a matrix of macroeconomic series Θ_t available to the forecaster at time *t*.

Table 3.3 shows the efficiency test results for the same inflation forecasts, using also Newey-West covariance matrix with MA(k) residuals[11]. For the entire sample, market forecasts attain efficiency in the use of data on inflation and the output gap. However, forecasts are not efficient in the use of information on the interest rate and the exchange rate. Taken literally, these results imply that forecasters could not properly anticipate the pass-through of the exchange rate to consumer prices. The 2002-2003 confidence shock may be held responsible for this result, as the exchange rate and the policy rate were importantly and unpredictably impacted during this period. In fact, forecasts produced after January 2004 attained efficiency in the use of the exchange rate too, but still not for the interest rate. According to the estimated coefficients (not shown), higher interest rates would have reduced forecast errors, which could reflect misperceptions about the actual monetary policy transmission mechanism, especially in what regards the transmission of interest rates to inflation at short horizons.[12]

Table 3.3. Efficiency Tests for Inflation Forecasts
H0: Efficient median forecasts; Forecast horizon: *t+1* to *t+12*

Regressors	*P-value* of the joint F test	
	Sample periods	
	2002:1-2007:7	2004:1-2007:7
3 lags of the monthly consumer price (IPCA) inflation	0.5542	0.9795
1 lag of the IPCA acumulated in the last 12 months	0.4728	0.4888
3 lags of the recursive industrial output gap	0.2749	0.4816
3 lags of the exchange rate on the last day of the month	0.0049	0.5529
3 lags of the Selic interest rate target on the last day of the month	0.1000	0.0000
1 lag of the average target of the Selic rate over the past 12 months	0.4781	0.6278

Note: All regressions include a constant term.

[11] The results are qualitatively equivalent for the forecast horizon *t* to *t*+11.
[12] For Chile and Mexico, Carvalho and Bugarin (2006) found that expectations usually passed the test for efficiency, but also with some exceptions, mainly for Mexico in the case of the interest rate.

4. The predictive power of market inflation forecasts

In this section, we compare the predictive power of the mean market inflation forecast over a 12-month ahead horizon with that of inflation forecasts obtained from alternative forecasting methods. The purpose is not to find the best forecasting method, but to assess the relative performance of market forecasts, which use a large information set, in comparison to autoregressive models with standard data sets, which are usually considered good forecasting tools.

Table 4.1 shows the root mean squared errors of market forecasts and forecasts arising from an univariate ARMA and different VAR and Bayesian VAR (BVAR) specifications, all of them estimated recursively[13]. The VARs and BVARs were estimated using the standard set of Brazilian monthly data on the inflation rate, the Selic interest rate, the exchange rate, and industrial production[14], either in logs or in first log-differences. The sample begins in August 1999, and the first forecast exercise starts in 2001:12. We tested the out-of-sample predictive power of specifications with fixed six lags and with optimal lag choices using both AIC and SBC criteria. Since estimations with SBC optimal lags underperformed those with AIC, we report only the latter.

Due to the magnified effect of the 2002-2003 confidence crisis on the path of macroeconomic variables, we split the data sample into two periods to assess the forecast performance. In the full surveyed sample (January 2002 to June 2007), professional forecasters produced root mean squared forecast errors very close to ARMA and VARs and BVARS using first log-differenced data. In the subsample that excludes most of the shocks that stemmed from the confidence crisis, i.e., January 2004 to June 2007, the root mean squared error of the mean market forecast was substantially lower than the best econometric forecast obtained using only autoregressive models. This result might imply that professional forecasters were able to use information other than that obtained from autoregressive models. In fact, economic agents might have combined forecasts from autoregressive model with those from other models and from judgment, relying on an information set significantly larger

[13] Recursive estimations better approximate the possible inference from the information set that was available to forecasters at the moment they produced their forecasts. It is advisable to use real-time data in these comparisons, but those were not available for this study.

[14] We also tested a specification that excludes industrial production, but its forecast underperformed the best forecast with the broader dataset. We also tested alternative VAR and BVAR specifications that included fiscal and other real sector variables in the set of endogenous variables or that took the sovereign spread (EMBI+ Brazil) as an exogenous variable, but the out-of-sample predictive power of these alternatives was also outperformed by the specifications presented in Table 4.1.

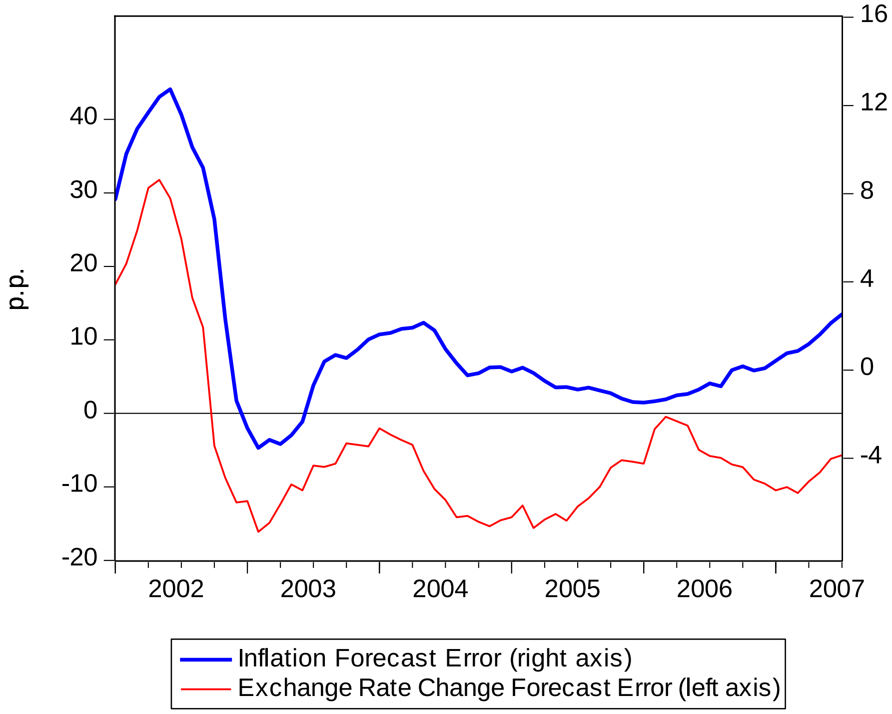
than that used in the autoregressive models. Furthermore, during the confidence crisis, agents assigned a relevant probability of change in the policy regime, which did not materialize, but resulted in an overshooting of inflation forecasts.

Table 4.1. Root Mean Squared Errors of Inflation Forecasts

	Dates when forecasts were produced	
	2002:1 to 2007:6	2004:1 to 2007:6
Mean Market Forecast	4.43	1.22
Dependent variables in log-levels		
Univariate forecasting		
ARMA(6,6)	4.44	2.69
Multivariate forecasting		
Optimal lag choice (AIC)		
Standard VAR	6.86	3.59
Bayesian VAR - Minnesota prior	5.51	3.59
Bayesian VAR - Harmonic decay	5.54	3.76
Bayesian VAR - Geometric decay	5.76	3.97
Fixed 6 lags		
Standard VAR	9.89	2.83
Bayesian VAR - Minnesota prior	5.59	2.75
Bayesian VAR - Harmonic decay	5.32	2.88
Bayesian VAR - Geometric decay	5.66	3.72
Dependent variables in first log-differences		
Multivariate forecasting		
Optimal lag choice (AIC)		
Standard VAR	4.17	2.47
Bayesian VAR - Minnesota prior	4.09	2.47
Bayesian VAR - Harmonic decay	4.13	2.47
Bayesian VAR - Geometric decay	4.13	2.47
Fixed 6 lags		
Standard VAR	5.10	3.22
Bayesian VAR - Minnesota prior	4.31	2.81
Bayesian VAR - Harmonic decay	4.12	2.73
Bayesian VAR - Geometric decay	4.05	2.54

Inflation forecast errors seem to be partially related to exchange rate forecast errors. Figure 4.1 shows the forecast errors (defined as actual minus forecasted values) for 12-month ahead inflation and exchange rate change expectations (defined as in Figure 2.4). The correlation coefficient is 0.90. For the first half of the sample, this relationship is very strong, i.e., errors in the forecast of the exchange rate change can explain a large part of inflation forecast errors. However, over the last three years of the sample, inflation forecast errors have reduced significantly, and exchange rate forecast errors does not seem to have played an important role.[15] Note that initially exchange rate forecasts largely underpredicted the exchange rate change due to the confidence crisis. The peak was in 2002:5, when agents forecasted a 9.0% average increase in the exchange rate from t to t+11, but the actual value was 40.7% (the inflation forecast error peaked at 12.7 p.p. in the following month). From 2002:10 through the end of the sample (2007:7), however, forecast errors were negative. Agents overpredicted the exchange rate depreciation (forecasts made at the end of 2002 and in 2003), expected some depreciation while the exchange rate appreciated (2004-2006) or even forecasted some appreciation, but the exchange rate decreased at a faster pace (2007).

Figure 4.1. Forecast Errors of Inflation and Exchange Rate Change over a 12-Month Horizon Period



[15] Estimation exercises (not shown) point to the same direction.

5. The joint performance of market forecasts in Brazil

The literature that empirically analyzes market forecasts in Brazil has mainly focused on forecasts for inflation. However, the Central Bank of Brazil surveys market expectations on a number of other macro variables, reporting rankings of top-five forecasters for the consumer price inflation, wholesale price inflation (IGP-DI and IGP-M) and the exchange rate. The rankings are produced for each macroeconomic series individually, disregarding the possible economic relation they bear to each other.

In this section, we employ the method developed in Bauer, Eisenbeis, Waggoner, and Zha (2003, 2006) and Eisenbeis, Waggoner, and Zha (2002) to assess the joint accuracy of multivariate market forecasts. The method is based on statistical theory and weighs forecast errors for distinct macro variables according to their predictability. Forecast errors of easier-to-forecast variables are more penalized in the calculations; in addition, the correlations amongst the variables being forecast are properly taken into account. By normalizing forecast errors we obtain a univariate measure of multivariate forecasting capacity. This measure allows for both intertemporal and cross-sectional analysis of forecast accuracy.

The method assumes that forecast errors made by institution *j* for a vector Y_t of economic variables are normally distributed with a zero mean and covariance Ω_t:

$$Y_t - Y_t^e(j) \sim \aleph(0, \Omega_t), \tag{5.1}$$

where Y_t and $Y_t^e(j)$ are *m* x 1 vectors, *m* is the number of economic variables being forecast, and $Y_t^e(j)$ is the vector of economic forecasts made by institution *j* for vector Y_t.

The Gaussian assumption for forecast errors implies that the normalized variable $(Y_t - Y_t^e(j))' \, \Omega_t^{-1} \, (Y_t - Y_t^e(j))$ has a $\chi^2(m)$ distribution. The p-value that is associated with this measure, calculated as $1 - \chi^2_{cdf}(m)$, can thus be interpreted as the probability of observing a worse forecast error. The p-value, referred to as "accuracy score" in Bauer et al (2006), is used as an indicator of joint forecast accuracy. These scores allow for the ordering of forecasts according to their overall performance within the cross section of forecasts and also for the assessment of the time evolution of forecast performance.

The dynamic covariance matrix Ω_t is obtained from a decomposition of forecast errors into common and idiosyncratic components:

$$
\begin{aligned}
\Omega_t &\equiv E\{(Y_t - Y_t^e(j))'(Y_t - Y_t^e(j))\} \\
&= E\{(Y_t - \overline{Y}_t + \overline{Y}_t - Y_t^e(j))'(Y_t - \overline{Y}_t + \overline{Y}_t - Y_t^e(j))\} \\
&= E\{(Y_t - \overline{Y}_t)'(Y_t - \overline{Y}_t)\} + E\{(\overline{Y}_t - Y_t^e(j))'(\overline{Y}_t - Y_t^e(j))\} \\
&\equiv \Omega_t^{\ c} + \Omega_t^{\ i},
\end{aligned}
\tag{5.2}
$$

where Ω^c is the common component, Ω^i is the idiosyncratic component, and the vector $\overline{Y}_t$ is assumed to differ from Y_t only when unpredictable shocks occur. The theoretical vector $\overline{Y}_t$ is a latent variable, and the method attempts to approximate it with BVAR projections or with the mean market forecast. This decomposition segregates the variance of the errors that are attributed to unpredicted events (Ω^c) from the variance of forecast errors that are due to the use of an underperforming forecast model (Ω^i) by individual forecasters.

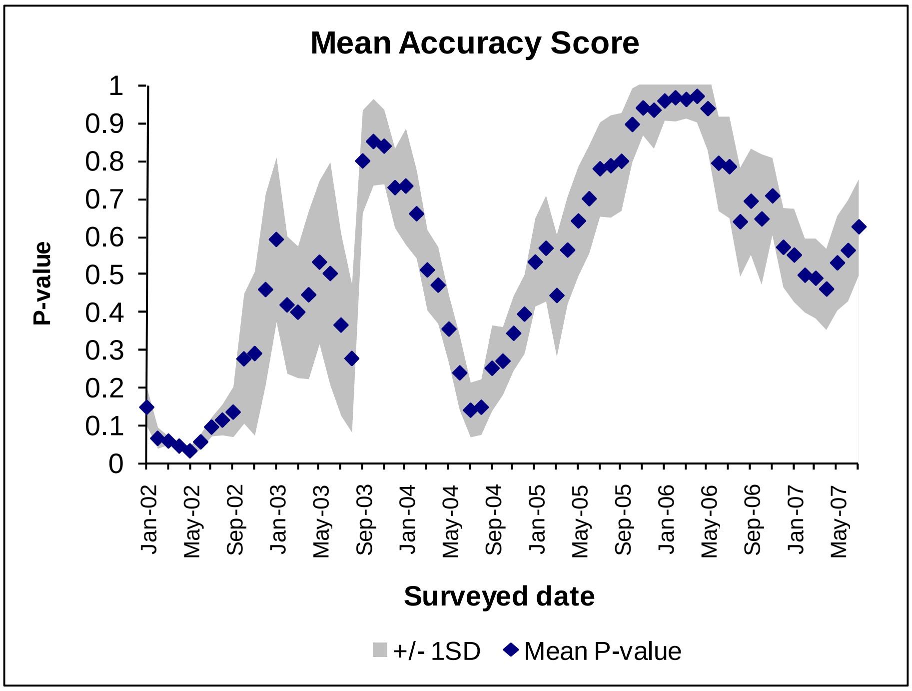
The estimation of the common component covariance can be performed in a number of ways, and the results might be sensitive to the selected choice. Bauer et al (2006) report the performance of different choices of common covariance matrices. They consider a model-based covariance matrix, estimated from a Bayesian VAR, and a survey-based covariance matrix, estimated as the forecast error covariance of the mean forecaster in the survey. In the case of the US data, they show that the mean forecast approximates the true model of the economy better than a VAR forecast does. The results of the test using a survey-based common covariance are also more in line with expected statistical properties of the score distribution. They also report that a time-varying common covariance matrix does not outperform a constant covariance estimated with the full sample, implying that common forecast errors in the US are covariance-stationary.

We also estimate the common component covariance matrix using both methods, i.e., based on VAR and BVAR estimations and on the survey. We use time-varying common covariance matrices to calculate accuracy scores. To better approximate the information set available to forecasters at each moment, in the case of the model-based common covariance, we estimate VARs and BVARs recursively to build the covariance matrices from the forecast errors obtained with this recursive estimation for the horizon in question.

The idiosyncratic covariance component ($\Omega_t^{\ i}$), in turn, is estimated as the sample covariance matrix of forecast errors across individual forecasters in CBB's survey, as proposed in Eisenbeis, Waggoner and Zha (2002). The average vector $\overline{Y}_t$ used in the calculations is the same vector employed to calculate the common covariance matrix Ω^c.

We chose forecasts of three key macroeconomic variables to conduct the multivariate assessment: consumer price inflation, the exchange rate, and Selic interest rate. Figure 5.1 shows the evolution of the mean accuracy score over time using the survey to estimate the common covariance matrix Ω^c, proxied by the covariance of the mean forecast errors.

Figure 5.1. Mean Accuracy Score Using Gerin's Mean Forecast as a Proxy for the Best Forecasting Model



The overall performance of forecasts was highly volatile throughout the analyzed sample. At the beginning of the series the mean accuracy score was very low. 2002 coincides with the period of the confidence crisis in the monetary policy regime. By envisaging a possibility of a structural break in the conduct of monetary policy, and thus in inflation dynamics, forecasters could have been attributing a higher probability to a change in the underlying model of the economy. Over most of 2003, with a new government in office and a tight monetary policy stance, the accuracy of market forecasts improved slightly. However, the improvement was accompanied by a great dispersion of scores within the cross section of market participants.

Over 2004, the market was persistently bearish on their exchange rate forecasts with high bets on a looser monetary policy. As this scenario did not materialize over the forecast period (year 2005), and also because of firstly unexpected and then longer lasting commodity and oil price shocks that fed mostly into inflation alone, forecast accuracy significantly worsened over this period.

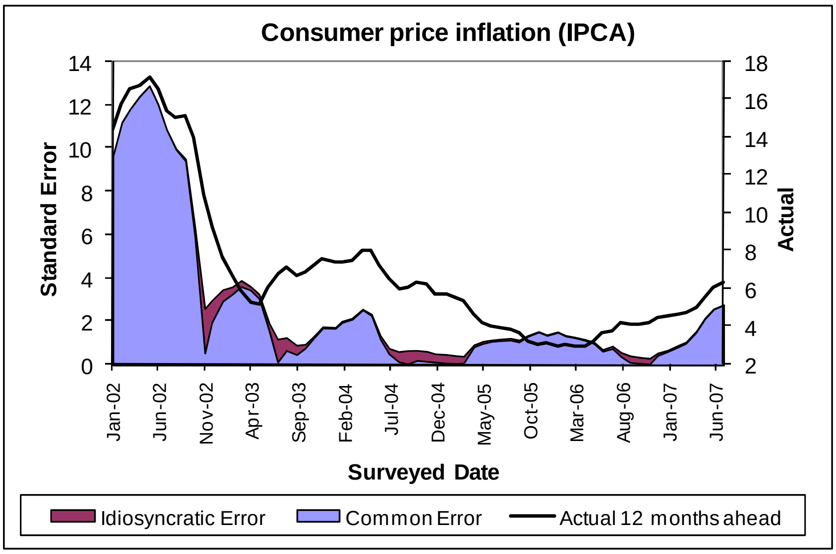
Afterwards, after monetary policy entered into a tightening cycle in the end-2004, and economic growth slowed towards a pace that was more consistent with non-inflationary supply conditions, forecast accuracy steadily improved, in spite of important uncertainties regarding oil prices and the contagion of external shocks to the exchange rate throughout most of 2005.

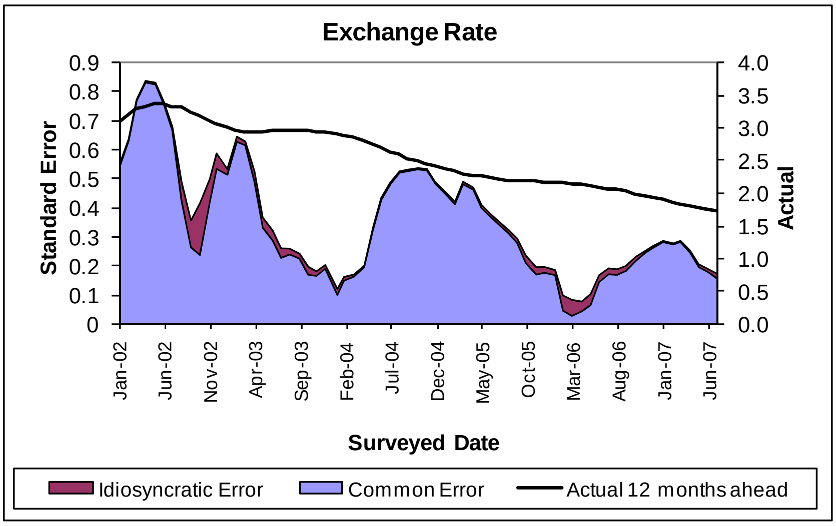
In September 2005, the central bank resumed interest rate cuts. As demand gained momentum, amid uncertainties regarding the time lag of the monetary transmission channel in Brazil, forecast accuracy worsened after mid-2006. Important uncertainties prevailed during this period regarding oil prices, the contagion of asset price volatility to the Brazilian exchange rate, and the monetary transmission.

The idiosyncratic component played a smaller role in total forecast errors, as shown in the forecast error decomposition of each macroeconomic series, using the survey mean prediction error as a proxy for the true unpredictable value (Figure 5.2). In other words, a large part of each agent's forecast errors was common to all respondents. In the case of inflation, the idiosyncratic component prevailed only in times of large forecast dispersion across respondents, such as at the end of 2002, or when the average forecast error was low, such as in the second half of 2004. During most of the period, however, the common forecast error component prevailed, indicating the important role of aggregate shocks to the economy. This result may also be rationalized as a respondents' attempt to align their forecast to those of their peers so as to avoid making large desynchronized forecast errors.

The trough in accuracy performance over 2004 was not so intense in model-based calculations of accuracy scores (Figure 5.3). Model-based calculations confirm the low accuracy performance at the beginning of the series, but do not support the depth of the second most important trough observed in Figure 5.1.

Figure 5.2. Decomposition into Common and Idiosyncratic Errors of Individual Variables Using the Forecast Error of Gerin's Mean Forecast as the Common Error





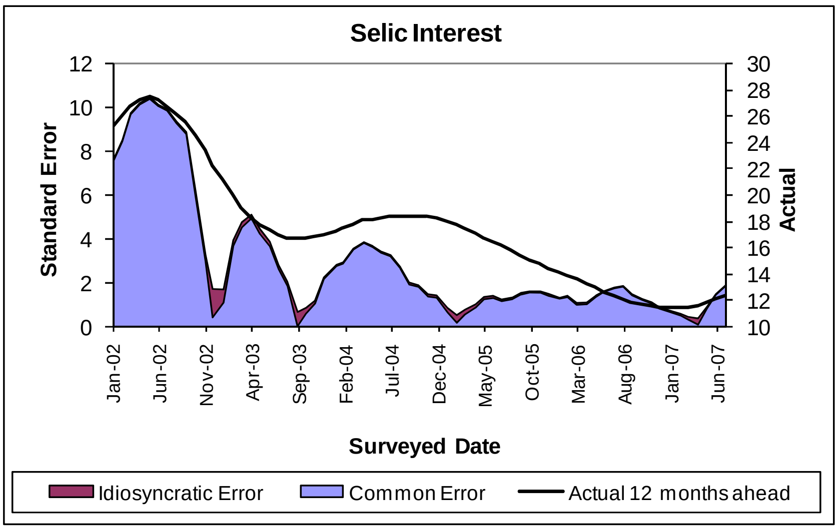
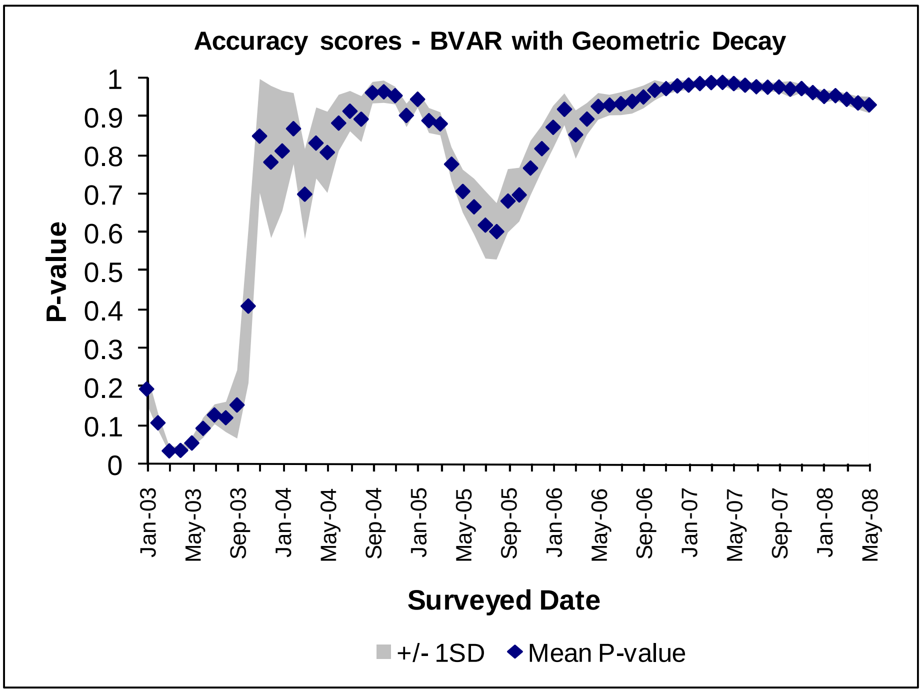


Figure 5.3. Model-Based Accuracy Scores Using a Time-Varying Common Covariance



6. Epidemiology of market forecasts

This section tests whether a selected group of top forecasters in CBB's survey is influential to the remaining survey participants. Should top forecasters be a focal point to professional forecasters, monetary authority should weigh the option of making use of this group to help transmit its policy intentions and economic assessment to a wider audience. As Blinder et al. (2008) note, on a comprehensive survey on central bank communication, "central bank communication is (…) a two-way street: it must have both a transmitter and a receiver, and either could be the source of uncertainty or confusion." To help mitigate doubts that remain after policy decisions or publication of monetary policy reports, some central banks choose to hold press conferences or meetings with professional forecasters. However, the empirical evidence presented in Blinder et al does not confirm that more (or less) concentrated communication practices improve the predictability of monetary policy to positively assist in the formation of expectations.

The tests in this section are inspired on Carroll's (2003) epidemiology model, with the distinction that the epidemiology tests are applied to each participant in the survey, not only to the mean forecast. By using disaggregated data, we are better able to analyze the micro behavior of forecasts in a more direct stance[16].

The CBB has been announcing top-five forecasters since July 2001. Professional forecasters are ranked according to their performance under three different forecast horizon periods. Short-, medium- and long-term top-five forecasters are those with the best performance considering one-, one- to six- and 12-month horizons, respectively[17], and their forecasts are published on a weekly basis. Since we focus on 12-month ahead forecasts, we use the long-term best forecasters in our tests.

We test the epidemiology of top-five forecasts of three variables: inflation, average Selic interest rate, and average exchange rate. For each forecasted variable x_t, the first specification we test is the following:

$$x_{t,12m}^{e,j} = \alpha + \beta_1 x_{t-1,12m}^{e,top5} + \beta_2 x_{t-1,12m}^{e,j} + \beta_3 \left(x_{t-1,12m}^{e,j} - x_{t-1,12m} \right), \qquad (6.1)$$

where the subindices *t* or *t*-1 refer to the date when the projection was made, *12m* stands for the fact that we are testing forecasts over a 12-month period, the superscript *e* refers to predicted values, *j* stands for each survey respondent, and *top5* indicates that the variable refers to the forecast of long-term top-five forecasters. In particular, we are interested in testing whether respondents' forecasts respond to top-five forecasts (β_1 different from zero), controlling for their own past forecasts and forecast errors.

To control for other forecasting sources, we test a second specification in which the set of regressors is extended to include current forecasts from BVARs of standard stationary variables. The BVARs would work as a proxy of the statistical model that subsidizes professional forecasters upon their forecast production. In the case of inflation forecasts, we also include inflation targets in the set of controls, capturing relevant information that is not included in the information set of the used vector autoregressive models. The regressions are the following:

[16] Guillén (2007) uses aggregate measures of the Brazilian survey to test for a distinct type of epidemiology, based on information costs.
[17] The horizon used has changed slightly over time.

$$x^{e,j}_{t,12m} = \alpha + \beta_1\, x^{e,top5}_{t-1,12m} + \beta_2\, x^{e,VAR}_{t,12m} + \beta_3\, x^{e,j}_{t-1,12m} + \beta_4 \left(x^{e,j}_{t-1,12m} - x_{t-1,12m}\right) \qquad (6.2a)$$

and, for inflation:

$$\pi^{e,j}_{t,12m} = \alpha + \beta_1\, \pi^{e,top5}_{t-1,12m} + \beta_2\, \pi^{e,VAR}_{t,12m} + \beta_3\, \pi^{e,j}_{t-1,12m} + \beta_4 \left(\pi^{e,j}_{t-1,12m} - \pi_{t-1,12m}\right) + \beta_5\, \pi^{target}_{t,12m}\,, \qquad (6.2b)$$

where VAR indicates that the variable refers to the mean BVAR forecast.

A third controlling specification replaces the BVAR projections by the current median survey response, which, as shown in Section 4, has similar or better forecasting performance than those from standard econometric specifications in Brazil. The regressions are as follows[18]:

$$x^{e,j}_{t,12m} = \alpha + \beta_1\, x^{e,top5}_{t-1,12m} + \beta_2\, x^{e,median}_{t,12m} + \beta_3\, x^{e,j}_{t-1,12m} + \beta_4 \left(x^{e,j}_{t-1,12m} - x_{t-1,12m}\right) \qquad (6.3a)$$

and, for inflation:

$$\pi^{e,j}_{t,12m} = \alpha + \beta_1\, \pi^{e,top5}_{t-1,12m} + \beta_2\, \pi^{e,median}_{t,12m} + \beta_3\, \pi^{e,j}_{t-1,12m} + \beta_4 \left(\pi^{e,j}_{t-1,12m} - \pi_{t-1,12m}\right) + \beta_5\, \pi^{target}_{t,12m}\,. \qquad (6.3b)$$

For each specification, we restrict the sample to disaggregated series outnumbering 20 observations. This leaves us with 64 institutions for inflation forecasts, 68 for the interest rate, and 66 for exchange rate forecasts.

In every specification, some regressions exhibit serially correlated residuals, possibly implying the need for a better specification of their epidemiology. Table 6.1 shows the results for the subsamples that do not present serial correlation, recording the share of statistically significant regressors in this sample.

[18] However, there are drawbacks to each of these controlling variables. The BVAR might not be the statistical model used by every forecaster to produce their forecasts. The current median forecast, in turn, may already incorporate the influence of variables external to standard macroeconomic data, such as top-five forecasts. In this sense it might not be fully orthogonal to this regressor.

Table 6.1. Epidemiology Tests

	# of regressions with non-autocorrelated residuals	% share of significant coefficients associated with the regressors				
		$x^{e,top5}_{t-1,12m}$	$x^{e,j}_{t-1,12m}$	$\left(x^{e,j}_{t-1,12m} - x_{t-1,12m}\right)$	$x^{e,top5}_{t-1,12m}$ but not $x^{e,j}_{t-1,12m}$	$x^{e,top5}_{t-1,12m}$ but not $\left(x^{e,j}_{t-1,12m} - x_{t-1,12m}\right)$
Inflation forecasts						
Equation #						
6.1	43	39.5	83.7	46.5	9.3	18.6
6.2b	44	52.3	63.6	31.8	25.0	31.8
6.3b	38	52.6	57.9	44.7	21.1	26.3
Interest rate (Selic) forecasts						
Equation #						
6.1	47	42.6	66.0	63.8	25.5	14.9
6.2a	61	42.6	73.8	73.8	13.1	6.6
6.3a	55	36.4	52.7	25.5	3.6	25.5
Exchange rate forecasts						
Equation #						
6.1	63	49.2	77.8	33.3	14.3	34.9
6.2a	61	49.2	59.0	8.2	24.6	42.6
6.3a	57	19.3	52.6	22.8	5.3	15.8

Note: Each cell from the third column on refers to the percent share of regressions that show statistically significant coefficients at the 10% confidence level associated with each regressor indicated in the headline column. The two columns to the right refer to the share of regressions that have significant coefficients associated with the top-five forecasts but not with their own lagged forecast term (sixth column) or forecast error (seventh column).

The results provide evidence of an important influence of top-five forecasts on survey responses for the three variables. The coefficient on the top-five forecasts is statistically significant in large part of the regressions. Most of the specifications show a significant coefficient in more than 40% of the regressions. In the case of inflation, top-five forecasts look more influential in the regressions with controls. In these specifications (6.2b and 6.3b), a little more than a half of survey participants fine-tune their forecasts with published top-five forecasts. The sixth column shows the share of regressions where the own lagged forecast term is not significant whereas the top-five forecast term is. For inflation, there is an important fraction of respondents (25%) who adjust their projections relying more on top-five forecasts than on their own past forecast. In the last column, which records the share of regressions where the own forecast error is not significant but the top-five forecast term is, we can also see that part of respondents adjust their projections relying more on top-five forecasts than on their own forecast errors.

For interest rate forecasts, about two-fifths of the respondents fine-tune their projections to take top-five forecasts into account. For the exchange rate, the importance to which top-five forecasts contaminate the other forecasts is sensitive to the control. With BVARs, about half of respondents are affected by the top-five, half of which rely on the top-five but not on their own lagged forecasts. With median forecasts in the controlling set, the influence of the top-five forecasts drops to one-fifth of total participants. The results in the sixth and seventh column for the Selic and exchange rates are not robust either.

To draw conclusions on whether these results should be of concern to the central bank, we refer to Cornand and Heinemman (2008)[19]. In their theory, "information with low precision should be partially withheld from the public; (*whilst*) information of high precision should always be released with full publicity"[20]. Even at the risk that the market put too much emphasis on public information, Cornand and Heinemman argue that "the higher the precision of public signals, the lower is the probability that an exaggerated weight reduces welfare".

We have shown that CBB's survey forecasts perform as well as or even better than standard forecasting procedures (see Section 4). By itself, publicity of survey forecasts would thus be welfare enhancing. One step further, CBB's publicity of top forecasters can thus be interpreted as even more welfare improving, given that these forecasts are even more accurate and thus help reduce the costs that the market and firms bears upon attempting to form higher order expectations.

Learning is also another important component of expectations formation in the Brazilian sample. There is an important share of respondents exhibiting significant coefficients attached to lagged forecast levels and past forecast errors. Several studies have shown that learning can have important implications for monetary policy, and generally best practices should be tailored according to the learning rule that is followed by the agents in the economy[21]. The constraints imposed to optimal monetary policy by the interaction of learning and higher order expectations is, to our best knowledge, an open issue that merits investigation.

[19] The economic literature has been recently debating on the optimal degree of publicity and precision of public information (e.g. Cornand and Heinemman, 2008, Morris and Shin, 2002 and 2007).
[20] Cornand and Heinemman, 2008, "Can central banks talk too much?", 27 May 2008, at www.voxeu.org.
[21] It is beyond our purpose in this paper to identify which learning rule best fits the survey data. Theoretical surveys on this issue can be found in Evans and Honkapohja (2003a, 2008) and Bullard (2006).

7. The determinants of inflation and interest rate market forecasts and forecast dispersion

This section estimates the determinants of inflation and interest rate market forecasts in Brazil. In the case of inflation forecasts, we are particularly interested in the role played by the targets. Regarding interest rate expectations, our objective is to check whether agents perceive the CBB as following some rule. The section also outlines some insights about the behavior of inflation expectations dispersion across survey respondents, a measure that can be considered as a proxy for inflation uncertainty.

7.1. Determinants of inflation forecasts

We estimate the determinants of inflation forecasts following the approach in Bevilaqua, Mesquita and Minella (2008). The variables included in the regression are chosen based on a basic Phillips curve analysis. In other words, variables that are usually found—empirically or theoretically—to be determinants of inflation could also explain the behavior of inflation expectations. In particular, we include the output gap, past inflation, exchange rate change and commodity price change in the set of regressors. The inflation target also enters as a regressor because it is expected to work as an anchor for inflation expectations.

The dependent variable is 12-month ahead market inflation forecasts. For the inflation target, we use the 12-month adjusted target series (defined in Section 2). The output gap is estimated recursively using an HP filter applied to the industrial production series[22], and enters the equation with a two-month lag because of the presence of lags in the release date. The past inflation regressor refers to the 12-month change since we want to capture less noisy movements. The same applies to the exchange rate and commodity prices, for which we use six-month changes.

Table 7.1 shows the estimation results, which are in general in line with those found in Bevilaqua et al (2008). We also present a second specification, which includes a dummy variable for the peak of the confidence crisis (2002M11–2003M1). The objective is to verify the results when we control for an abnormal period, marked by expectations of a change in policy regime. We would not expect inflation targets to play an important role when agents believe that there is a relevant probability that the policy regime will be changed—either by

[22] In other words, output gap at time t is estimated with the series up to time t. However, it is not equivalent to real time data because we are using revised data.

replacing inflation targeting by another framework or by following a less committed policy regime.

Table 7.1. Determinants of Inflation Expectations
Dependent Variable: 12-Month Ahead Inflation Expectations (2000:1–2008:6)

Regressors	Specifications	
	I	II
Constant	0.87	0.52
	(0.65)	(0.63)
Inflation Target (12-month ahead)	0.51**	0.72***
	0.20	(0.17)
Output Gap (-2)	0.06	0.01
	(0.08)	(0.05)
12-Month Inflation (-1)	0.26***	0.17***
	(0.07)	(0.05)
Six-Month Nominal Exchange Rate Change (-1)	0.07***	0.04***
	(0.02)	(0.01)
Six-Month Commodity Price Change (-1)	0.02*	0.01*
	(0.01)	(0.01)
Dummy for 2002:11-2003:1		4.86***
		(0.45)
R-squared	0.7465	0.8877
Adjusted R-squared	0.7333	0.8806

Notes: Standard errors—shown in parentheses—were corrected by Newey-West heteroskedasticity and autocorrelation consistent covariance matrix estimator since estimation residuals present autocorrelation and heteroskedasticity. *, ** and *** indicate the coefficient is significant at the 10%, 5%, and 1% levels, respectively.

Both specifications illustrate the important role played by inflation targets for the formation of inflation expectations in Brazil. The coefficient is statistically significant. Adding the dummy variable increases the importance of inflation targets in the estimation as it generates higher point estimates. We reject, however, the null hypothesis that the coefficient is equal to one at the 10% level.

Past inflation, exchange rate change and commodity price change also enter significantly, whereas the output gap is not significant[23]. A novelty in the results, compared to previous papers, was to find a significant coefficient on commodity prices, although with a low magnitude. When the dummy variable for the confidence crisis is included, all point estimates diminish. This result may reflect the fact that expectations were marked by a factor not included in the regression—the probability of a policy regime change—and that, during that period, inflation and the exchange rate were increasing.

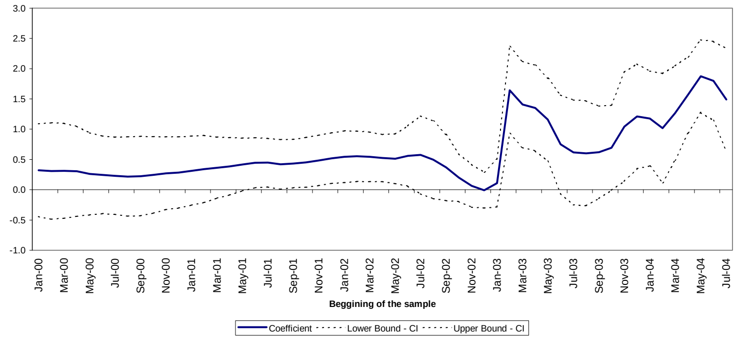
In the inflation targeting regime, inflation expectations should converge to the target in a medium-run horizon. Note, however, that the dependent variable refers to the cumulative inflation from t through $t+11$ and not to the inflation prevailing 12 months (or further) ahead. Therefore, because of the presence of lags in the transmission mechanism of monetary policy, we would expect that other variables in addition to the inflation target would affect inflation over the next 12 months. Furthermore, the presence of a tolerance interval allows the central bank to accommodate some shocks or neutralize only part of their effects. Fully neutralizing all shocks would generate unnecessary volatility. Actually, in the case of temporary shocks, a full reaction could produce stop-and-go movements because of the lags in the transmission mechanisms.

In order to capture possible changes over time we also estimate 48-month rolling window regressions with the specification without the dummy, whose results are presented in Figure 7.1. The results confirm the increasing importance of inflation targets and the effect of the 2002-2003 confidence crisis. For the subsample that includes the confidence crisis, the inflation target is less significant. In fact, at the end of 2002 and in January 2003, expectations were far away from the target, which pushed down coefficient estimates as far as around zero. With the adoption of the adjusted targets and the increasing confidence that, in fact, the policy regime would not be changed, targets recovered their role. For the sample starting in 2004, when distrust about the maintenance of the policy regime had largely faded away, estimates of the coefficient on the inflation target are around one or even greater than that.

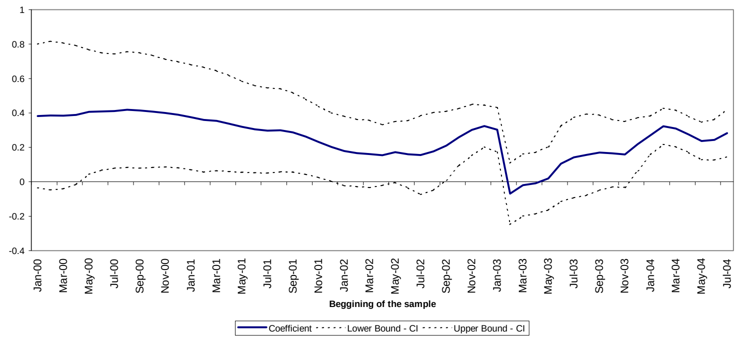
[23] Similar results were obtained using an output gap filtered from the rate of industrial capacity utilization, estimated by Getulio Vargas Foundation (FGV).

Figure 7.1. Coefficients of the Regressors of 12-Month Ahead Inflation Forecasts in a 48-Month Rolling Window Estimation

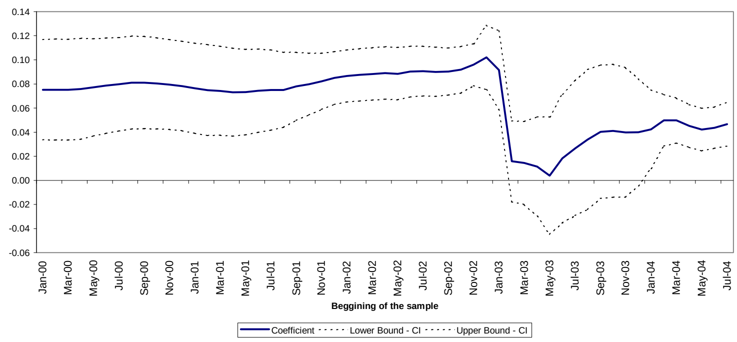
Panel A
Coefficient on the Inflation Target



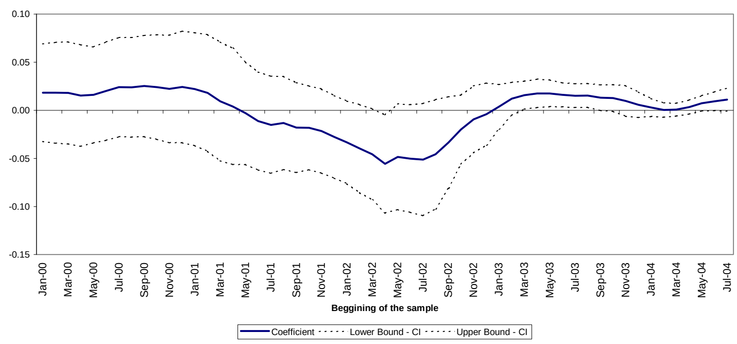
Panel B
Coefficient on Past Inflation



Panel C
Coefficient on the Exchange Rate Change



Panel D
Coefficient on Commodity Price Change



The coefficient on past inflation falls abruptly in 2003 because of the introduction of the adjusted target that year. It increases over the rest of the sample, but it is still lower than that in the initial subsamples. Considering full sample estimation and the rolling window exercise, their point estimates are around 0.15-0.30. Considering the arguments listed above concerning lags in the transmission mechanism of monetary policy and the room for shock accommodation, those estimates seem consistent with an inflation targeting framework.

The same reasoning applies to the exchange rate. Their estimates, however, clearly indicate a reduction in the pass-through to inflation expectations, with a tighter interval. This result, however, should be analyzed with caution because the greater magnitude of the estimates is affected by the confidence crisis period. The estimates of the coefficient on commodity price changes are statistically significant only in the last subsamples, which indicates the role played by those prices in domestic inflation in the more recent period. Concerning the results for the other two coefficients (not shown), the output gap is significant only in some subsamples, and the coefficient on the constant is high when we include the confidence crisis period.

7.2. Determinants of Selic interest rate forecasts

We also estimate the determinants of policy interest rate forecasts. In particular, we are interested in verifying whether expectations of the Selic interest rate are consistent with the inflation targeting framework. Estimations for the actual Selic rate present evidence that the CBB sets it responding to deviations of expected inflation from the target and allows for some interest-rate smoothing[24]. The issue here is whether the market has also incorporated this evidence into their forecasts. In some sense, it is a way of checking the credibility of the CBB. In other words, we are assessing whether agents believe that the CBB fulfills its commitment to the inflation targeting regime.

According to a basic Taylor rule that incorporates only inflation and lagged interest rate, the nominal policy rate evolves according to:

$$i_t = \alpha i_{t-1} + (1-\alpha)\left[\gamma\left(E_t \pi_{t+h} - \bar{\pi}_{t+h}\right) + \bar{\pi}_{t+h} + r\right], \tag{7.2.1}$$

where i_t is the policy interest rate, E_t is the expectations operator, π_{t+h} is inflation over a horizon h, $\bar{\pi}_{t+h}$ is the inflation target, and r is the equilibrium real interest rate. The coefficient γ measures the response of the interest rate to deviations of inflation expectations from the target. According to the "Taylor principle", it should be greater than one: positive deviations of inflation from the target should be responded with a higher real interest rate. The coefficient α measures the degree of interest-rate smoothing. Note that, in the steady-state, where $E_t\pi_{t+h} - \overline{\pi}_{t+h} = 0$, the nominal interest rate should be equal to the target plus the equilibrium real rate.

In our estimations, the dependent variable is the 12-month ahead market forecast of the average Selic rate target (which was calculated using the forecasts for the end of each month). Therefore, according to equation (7.2.1), those expectations will depend on the deviation of inflation rate expectations from the target. The horizon span will depend on the value of *h*, but because of data availability and for simplicity, we use 12-month ahead market inflation forecasts. We estimate, using two-stage least squares (2SLS), the following equation:

$$E_t i_{t+h} = \alpha i_{t-1} + (1-\alpha)\left[\gamma\left(E_t\pi_{t+h} - \overline{\pi}_{t+h}\right) + \overline{\pi}_{t+h} + c\right], \qquad (7.2.2)$$

where $E_t i_{t+h}$ is the 12-month ahead market forecasts of the average Selic rate target, i_{t-1} is past Selic target, $E_t\pi_{t+h}$ is the 12-month ahead market inflation forecasts (including month *t*), $\overline{\pi}_{t+h}$ is the 12-month ahead target (calculated using interpolation)[25], and c is a constant.

The results are shown in Table 7.2, which includes two specifications: with and without the interest-rate smoothing component. The estimate of γ (the coefficient of the term corresponding to deviations of inflation expectations from the target) is larger than one. Using a Wald test, we can reject the null that this coefficient is equal to one in both specifications. The interest-rate smoothing component significantly improves the fit of the regression. The value of 0.56 tends to be lower than that in Taylor rule estimates because the dependent variable here refers to expectations of the Selic rate over a 12-month horizon. The constant would indicate an equilibrium real interest rate of 7.7% per year.

Figure 7.2 shows the forecast errors of inflation and interest rate, confirming the role played by inflations expectations. The correlation coefficient of the two errors is 0.95, which implies that interest-rate forecast errors are in large part related to inflation forecast errors.

[24] For example, Fraga, Goldfajn, and Minella (2003), and Minella and Sousa-Sobrinho (2009).
[25] For this estimation, we are using the CMN targets without any adjustment. Using the adjusted target series, the results are similar, although we do not reject the null of γ=1 (the p-value is 0.12 in specification II). The point estimates are 1.22 and 1.32 for specifications I and II.

Therefore, there is strong evidence that private agents perceive the CBB as following a behavior that is consistent with the inflation targeting regime. When agents expect a higher inflation rate in the future, they also expect that the nominal Selic rate will rise and in magnitude greater than that of inflation forecast, implying, therefore, an increase in the real interest rate.

This result confirms the credibility built up by the CBB. In fact, one way of measuring credibility is verifying whether agents believe that the monetary authority will behave in line with the committed, which seems to be indicated by this estimation.

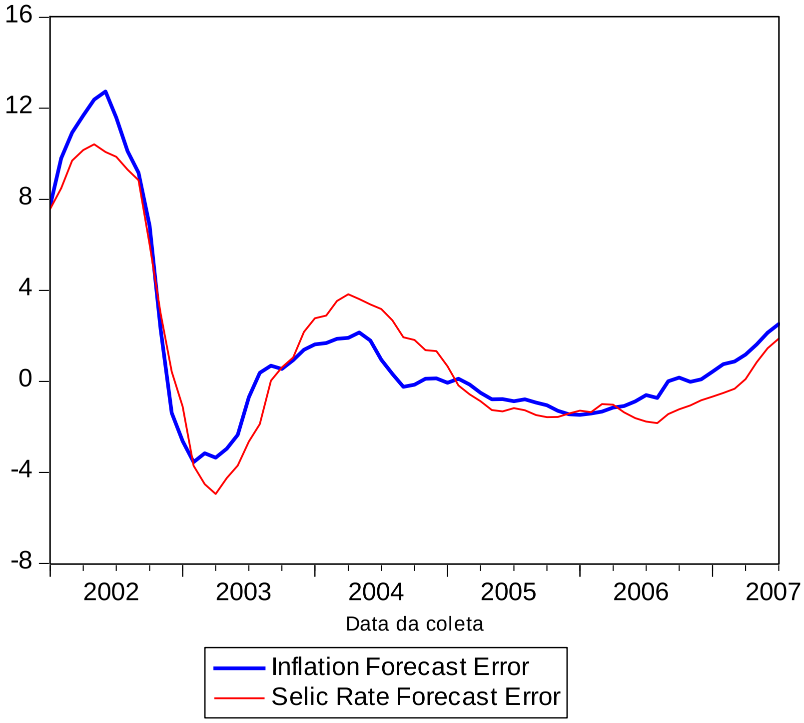
Table 7.2. Determinants of Selic Rate Expectations
Dependent Variable: 12-Month Ahead Average Selic Interest Rate Expectations (2002:1–2008:7)

Regressors	Specifications	
	I	II
Constant	9.57***	7.74***
	(0.43)	(0.55)
12-Month Ahead Inflation Expectations minus Target	1.42***	1.23***
	(0.23)	(0.11)
Selic Interest Rate Target (-1)		0.56***
		(0.06)
R-squared	0.6956	0.9359
Adjusted R-squared	0.6915	0.9342
Wald Test: Coefficient on Inflation Expectations = 1 (p-value shown)	0.07	0.03

Notes: Standard errors—shown in parentheses—were corrected by Newey-West heteroskedasticity and autocorrelation consistent covariance matrix estimator since estimation residuals present autocorrelation and heteroskedasticity. *, ** and *** indicate the coefficient is significant at the 10%, 5%, and 1% levels, respectively.

Intrument variables: constant, inflation target, selic interest rate target(-1), 12-month ahead inflation expectations(-1 and -2), 12-month actual inflation(-1), 6-month exchange rate change(-1).

Figure 7.2. Errors of Inflation and Selic Rate 12-Month Ahead Forecasts



7.3. Expectations dispersion

The CBB's survey also brings information on forecast dispersion across respondents. Dispersion of forecasts for inflation, the exchange rate and the Selic rate are highly correlated, as Figure 7.3 shows. The correlation is around 0.6-0.8, reflecting a strong relationship among those variables.

Inflation forecast dispersion can be regarded to as a proxy for inflation uncertainty.[26] Table 7.3 shows the results of an OLS estimation where the dependent variable is the coefficient of variation of inflation forecasts.[27] Inflation forecast dispersion depends positively on the sovereign spread (dubbed EMBI Brazil) and on inflation rate change. Periods when the country-risk premium is high or inflation rate is increasing tend to be characterized by higher forecast dispersion. This result seems consistent with the historical evidence. Moments of higher country-risk premium in Brazil were characterized by great general uncertainty.

[26] Using the Survey of Professional Forecasters in the US, Giordani and Soderlind (2003) compute the aggregate inflation uncertainty as the combination of individual uncertainty (average standard deviation of individual histograms) and disagreement on the point forecast. In the case of the Brazilian survey, however, the respondents provide only point forecasts instead of probabilities for different intervals; thus the available measure of uncertainty is the disagreement among participants. In spite of this limitation, disagreement seems to capture to a large extent the degree of inflation uncertainty, as it is known to move together with individual uncertainty in the US survey (correlation of 0.6).

[27] Coefficient of variation is defined as (standard deviation/average of inflation expectations)*100. To be coherent with previous estimations, we use the values on the critical dates.

Similarly, at moments when inflation was increasing, such as in 2001-2003, there was significant uncertainty about future inflation values.

Figure 7.3. Dispersion of Expectations (coefficient of variation)

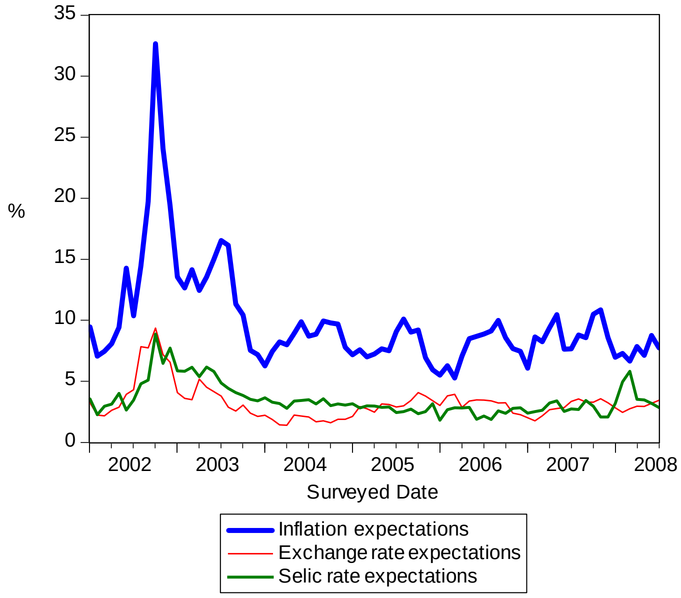


Table 7.3. Inflation Expectations Dispersion

Dependent Variable: Coefficient of Variation* of the 12-Month Ahead Inflation Expectations (2002:1–2008:7)

Regressors	Coefficients
Constant	6.44*** (0.57)
12-Month Inflation(-1) minus 12-Month Inflation(-7)	0.18** (0.08)
Embi(-1)	0.56*** (0.10)
Dummy for 2002:10	15.25*** (1.47)
R-squared	0.7784
Adjusted R-squared	0.7696

* Defined as (standard deviation/average)*100.

Notes: Standard errors—shown in parentheses—were corrected by Newey-West heteroskedasticity and autocorrelation consistent covariance matrix estimator since estimation residuals present autocorrelation and heteroskedasticity. *, ** and *** indicate the coefficient is significant at the 10%, 5%, and 1% levels, respectively.

8. Conclusion

2008 is the tenth year of inflation targeting in Brazil. Expectations behavior, especially inflation expectations, is one of the cornerstones of the regime. This paper takes a broad perspective. It assesses inflation expectations in different aspects—rationality, predictive power, epidemiology and determinants—investigates the determinants of Selic interest rate forecasts, and conducts multivariate performance analysis of inflation, interest rate and exchange rate forecasts.

The usual bias and efficiency tests suggest that market inflation forecasts are unbiased, but they point to the rejection of the efficient use of information. The assessment of the joint forecast performance of inflation, interest rate, and exchange rate shows that forecasts are usually made with high alignment amongst respondents as the common error component across survey participants prevails over the idiosyncratic component in the decomposition of forecast errors. The forecast performance, however, has improved over the past years, although not monotonically. In the case of inflation forecasts, they had similar or better forecast performance than those from autoregressive models.

The dispersion of inflation expectations seems to be related to the country-risk premium, which gives some indication of the state of confidence in the economy, and to inflation rate changes. Moments when inflation rises are usually associated with more uncertainty about its future values.

The estimation concerning the determinants of inflation expectations confirms the results of previous studies in regard to the prominent role played by the inflation targets, which increased after the effects of the confidence crisis faded away. Expectations of the Selic rate, in turn, are in line with the expected in an inflation targeting framework, that is, they depend basically on deviations of inflation expectations from the target. In a nutshell, market expectations of the policy interest rate depend on market inflation expectations, which, in turn, depend on the inflation target. This result confirms the credibility built up by the Central Bank of Brazil.

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