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Deviating from Perfect Foresight but not from Theoretical Consistency: The Behavior of Inflation Expectations in Brazil

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WORKING PAPER SERIES Nº 2019-36

DEPARTMENT OF ECONOMICS, FEA-USP
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The aim of this paper is to investigate whether inflation expectations in Brazil have characteristics and statistical properties that can be correlated (possibly in a causal way) with observed variables of interest and expectations about them. We test the hypothesis of perfect foresight in the formation of inflation expectations by the respondents of the official survey conducted by the Central Bank of Brazil, examining the behavior of the possible forecast errors. As these errors are biased and can be predicted, we reject the hypothesis of perfect foresight. We also test models of noisy and sticky information, and we cannot conclude that the deviations from perfect foresight can be explained by information rigidity. Additionally, with a Vector Error Correction model, we find evidence that the expectations about the related macroeconomic variables respond to each other as predicted by a theoretically-grounded macroeconomic model. Therefore, inflation expectations in Brazil are to an important extent consistent with more general expectations about the future performance of the economy.

Keywords: Inflation expectations in Brazil; forecast errors in surveys; deviations from perfect foresight.

JEL Codes: D84; E10; E31.

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1 Introduction

Since May 1999, during the transition to an inflation targeting regime, the Central Bank of Brazil (BCB) conducts the Focus Survey, collecting market expectations for the most relevant macroeconomic variables, which are used as an input for monetary policy decisions by the BCB[1]. In fact, the BCB attaches great importance to the Survey results in the minutes of the meetings of the Monetary Policy Committee (Copom) and in inflation reports, which are an important part of the communication and transparency strategy adopted

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This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

[1]The Focus Survey compiles online-submitted forecasts of about 140 banks, asset managers and other institutions (real sector companies, brokers, consultancy firms, etc.). The provision of forecasts is not mandatory, but these institutions can submit forecasts as often as daily if they find it justified. The Survey daily monitors the market expectations for several inflation indices, the GDP and industrial production growth, the nominal exchange rate, the base interest rate, fiscal indicators and external sector variables. For more information about the Survey, see https://www.bcb.gov.br/en/monetarypolicy/marketexpectations.

by the Brazilian monetary authority. The expectations of private agents play a crucial role in the behavior of the economy, and they are important variables taken into account in economic policy decisions. Therefore, it is important (on both theoretical and empirical grounds) to understand the characteristics of such expectations, and how they are formed and revised.

Our aim in this paper is to investigate whether inflation expectations have characteristics that can be analytically associated with other observed variables and expectations about them. The assumption of perfect foresight, especially of inflation, has been assessed and challenged in the literature for quite a long time. Consequently, several models have been developed as an attempt to explain deviations from perfect foresight (often also referred to as full rationality). Mankiw, Reis, and Wolfers (2004) show that a sticky information model is good for explaining U.S. survey data on inflation expectations by both professionals and households, although it is not enough to fully explain deviations from full rationality. Coibion and Gorodnichenko (2015) conclude that a model of information rigidity is adequate to explain the formation of inflation expectations by professional forecasters in the U.S. and other 11 industrialized countries. Meanwhile, Berge (2018), following the methodology used by Coibion and Gorodnichenko (2015), concludes that sticky and noisy information models do not explain all the deviations from full rationality in surveys conducted with U.S. professional forecasters and households. As the Survey of Professional Forecasters in the U.S. began in 1968, this kind of investigation for the U.S. typically covers several decades.

Following Mankiw, Reis, and Wolfers (2004), Guillén (2008) finds that the inflation expectations included in the Focus Survey are neither rational, even in the weakest form of rationality, nor adaptive, for all forecast horizons between 2000 and 2007. Guillén's (2008) results suggest that there is a cost associated with the processing of new information, which can be an indication that sticky information can provide a reasonable explanation. Meanwhile, Araujo and Gaglianone (2010), using several forecast horizons between 2002 and 2008, and Kohlscheen (2012), using one month ahead expectations between 2002 and 2010, do not reject a weak form of rationality in the formation of the inflation expectations included in the Focus Survey, as both studies were not able to reject the hypothesis of non-existence of a forecast bias. Both studies, however, reject the strong form of rationality, since forecast errors could be predicted. By analyzing the response of individual professional forecasters to new information between 2006 and 2013, Correa and Picchetti (2016) find support for sticky information and staggered updating for the formation of inflation expectations referring to the current month in Brazil.

We test the hypothesis of perfect foresight of inflation by exploring the behavior of the forecast errors of the median of inflation expectations in the Focus Survey. As these errors are biased and can be predicted, we reject the hypothesis of perfect foresight. Furthermore, following Coibion and Gorodnichenko (2015) and Berge (2018), we test whether the process of inflation expectations formation of the respondents of the Focus Survey can be described by noisy and sticky information models. Although forecast revisions help to explain forecast errors, as expected by theory, the respective coefficient has an unexpected sign in the empirical analysis. Additionally, we are also able to use macroeconomic variables to predict forecast errors, even when we control for the revisions, which cannot occur in noisy and sticky information models. As a consequence, we cannot suggest that the deviations from perfect foresight of inflation in the Focus Survey can be explained by information rigidity.

We also investigate the consistency of expectations with the established macroeconomic theory. In order to do so, we verify whether the median of expectations behaves as expected by the relationship between

observed variables. To our knowledge, the theoretical consistency of expectations has been assessed only for individual series, and not for a representative set of related expectations, as we carry out in this paper. Using a Vector Error Correction (VEC) model, we look for evidence to confirm stylized facts emphasized in the established macroeconomic theory for the selected expectations. The confirmation of these stylized facts means that survey respondents inform expectations that are consistent with the operation of a macroeconomic model which is mostly theoretically grounded, although their inflation expectations cannot be described as perfect foresight.

The paper is organized as follows. After this introduction, Section 2 presents the theoretical framework regarding the expectations formation process and the relationship between the variables of interest. Data and the empirical setting for the analysis are presented in Section 3. The results are carefully discussed in Section 4, while Section 5 concludes.

2 Theoretical framework

In a setting of fully rational expectations (to which we alternatively refer as perfect foresight in this paper), the difference between the observed value of a variable at a given moment in time, represented by x_{t+h}, and its forecast, given by $F_t x_{t+h}$, should be explained only by a random error term, such that:

$$x_{t+h} - F_t x_{t+h} = \epsilon_t. \tag{1}$$

Therefore, forecast errors cannot be either biased or predicted. Alternative models use information rigidity or noisy information to explain deviations from perfect foresight, such as the models in equations (2) and (3), respectively, as represented in Coibion and Gorodnichenko (2015):

$$x_{t+h} - F_t x_{t+h} = \frac{\lambda}{1-\lambda}(F_t x_{t+h} - F_{t-1} x_{t+h}) + \nu_{t+h,t}, \tag{2}$$

$$x_{t+h} - F_t x_{t+h} = \frac{1-G}{G}(F_t x_{t+h} - F_{t-1} x_{t+h}) + \nu_{t+h,t}, \tag{3}$$

where λ is the probability that an agent does not update her or his information set at a given moment in time, G is the relative weight given to previous forecasts, and ν is the full-information rational expectations error. In a model of sticky information, as the model proposed by Mankiw and Reis (2002) represented by equation (2), there is a cost associated with information processing. As a result, agents do not update their information set every period, although their expectations are fully rational when updated. Meanwhile, in models of noisy information, like the model in Woodford (2003), represented in equation (3), agents not only update their information set periodically, but also know the true data generating process of the economy. Nonetheless, they do not perfectly observe the state of the economy, and rely on the signal received by them, which affects the parameter G.

The relationship between the variables of interest can be drawn from the established macroeconomic theory. As specified in the Phillips curve, the current inflation varies positively with the expected inflation and negatively (positively) with the unemployment rate (output gap). According to a standard Taylor rule, the interest rate should vary positively with the inflation rate and the output gap. As specified in the IS curve, an increase in the nominal interest rate has a negative effect on the aggregate demand and hence

aggregate output, as it decreases investment and consumption, while an increase in actual (or expected) inflation, by lowering the real interest rate, and in government expenditures have a positive effect on output. Additionally, aggregate output varies positively with the real exchange rate, as a real depreciation in the value of the local currency typically causes (even if with some lag) an increase in net exports.

In order to account for several idiosyncrasies of the Brazilian economy, Castro *et al.* (2015) develop and estimate the Stochastic Analytical Model with a Bayesian Approach (SAMBA), a dynamic stochastic general equilibrium model that yields theoretically consistent results and is used by the BCB for carrying out monetary policy. According to the results of SAMBA, an increase in the nominal interest rate leads to a decrease in the real GDP and in inflation, to a real appreciation of the domestic currency, and to a procyclical behavior of the fiscal policy, or, in other words, an increase in the primary surplus. Meanwhile, a real depreciation of the local currency leads to an increase in the inflation rate, which is followed by an increase in the interest rate by the monetary authority, which eventually causes a decrease in the real GDP and in the government expenditures. Lastly, a fiscal policy shock, represented by an increase in the government expenditures, leads to an increase in the level of economic activity, increasing the inflation rate as a consequence, with the monetary authority then raising the interest rate in the sequence. A fiscal policy shock eventually leads to a real depreciation of the domestic currency.

Therefore, these stylized facts and model predictions should be confirmed by the estimated behavior of the expectations about the respective variables, if these expectations are to be seen as following a theoretically consistent pattern.

3 Data and empirical setting

We analyze the median of the 12 months ahead expectations for inflation, the nominal exchange rate, the nominal interest rate, the level of economic activity, and the primary surplus, calculated by the Market Expectations System, where professional forecasters inform their expectations to the BCB. Although these series are daily, as these professionals can post their forecasts in the system everyday, the variables that are not market prices (inflation, economic activity, and primary surplus) are measured at least monthly. Therefore, it is necessary to choose a specific date in the month to be used. A reasonable choice would be the date of the public release of the Top 5 more accurate predictors[2]. However, the Top 5 ranking only takes into account predictions for inflation, the nominal exchange rate, and the nominal interest rate, with the additional difficulty that the dates of definition are different for different variables. To standardize the dates of the collected data, we use data for the first business day of the month. The first observation that is common to all series of interest is December 2001, which is a forecast for December 2002.

In the Market Expectations System, there are three alternatives for expectations about economic activity: monthly industrial production (12 months ahead), quarterly GDP growth rate (four quarters ahead), and annual GDP growth rate (one year ahead). We choose the annual GDP growth rate for this paper, since it is the longest series. Forecasts for the annual GDP and the primary surplus are made for the whole year, while we are working with 12 months ahead expectations. Thus, it is necessary to create some criterion

[2]The Focus Survey Top 5 is a monthly and annual ranking of institutions, based on the accuracy of their forecasts, in order to encourage the improvement of predictions.

for the selection of the date of reference. We use a weighted average[3], inspired in Minella *et al.* (2003). Additionally, the series for interest rate expectations covers the whole period, but there are no calculated expectations at some moments in time, which were approximated by linear interpolation.

The descriptive statistics of the expectations series are presented in Table 1. These statistics show the high variability in data, which is a characteristic of emerging economies. This is also a consequence of the instability in the Brazilian economy, which has gone through quite different moments within the analyzed period.

Table 1: Descriptive statistics of the expectations series, December 2001 to August 2018[1]

	INFLATION	INTEREST	EXCHANGE	GDP	SURPLUS
Mean	0.407	12.148	2.584	2.622	2.300
Median	0.400	12.000	2.460	3.154	2.800
Std. dev.	0.118	3.017	0.699	1.781	2.119
Min.	0.190	6.500	1.630	−0.200	−0.218
Max.	0.850	20.000	4.300	5.845	4.350
ARIMA(1,1,0)[2]	0.139 **	0.442 ***	0.640 ***	0.643 ***	0.494 ***
	(0.070)	(0.063)	(0.055)	(0.054)	(0.061)

[1] Values for the rates of inflation, nominal interest and GDP growth are in percentage, for the nominal exchange are the price of one unit of US dollar in units of the local currency, and for the primary surplus are as a proportion of GDP.

[2] Value of the autoregresive coefficient of an ARIMA(1,1,0) estimated for each variable. Standard errors are in parentheses. Significance levels: * 10%, ** 5%, *** 1%.

We explore the issue of whether there is perfect foresight of inflation, by testing for the presence of a forecast error bias and the predictability of such an error. Furthermore, we run two regressions, as in Coibion and Gorodnichenko (2015). The first one, a Mincer and Zarnowitz (1969) regression, regresses the forecast error on the forecast itself, while the second one, a Nordhaus (1987) regression, regresses the error on forecast revisions. Following Berge (2018), we include the unemployment rate and a long run interest rate in both regressions. Therefore, we estimate the following equations:

$$\pi_{t+12,t} - S_t\pi_{t+12,t} = \alpha + \varepsilon_t, \tag{4}$$

$$\pi_{t+12,t} - S_t\pi_{t+12,t} = \alpha + \beta_1 S_t\pi_{t+12,t} + \beta_2 u_{t-1} + \beta_3 i_{t-1} + \varepsilon_t, \tag{5}$$

$$\pi_{t+12,t} - S_t\pi_{t+12,t} = \alpha + \beta_1(S_t\pi_{t+12,t} - S_{t-1}\pi_{t+12,t}) + \beta_2 u_{t-1} + \beta_3 i_{t-1} + \varepsilon_t, \tag{6}$$

where $\pi_{t+12,t}$ is the observed inflation, $S_t\pi_{t+12,t}$ is the inflation expectation, $\pi_{t+12,t} - S_t\pi_{t+12,t}$ is the forecast error, u is the unemployment rate, and i is the interest rate. It should be noticed that the coefficient β_1 in equation (6) is equivalent to the coefficients $\frac{\lambda}{1-\lambda}$ and $\frac{1-G}{G}$ in equations (2) and (3), respectively. According to Coibion and Gorodnichenko (2015), these coefficients should be positive in models with information

[3]The series are given by $S_t^* x_{j,t} = \frac{(12-t+1)}{12} S_t x_{j,t} + \frac{(t-1)}{12} S_t x_{j+1,t}$, such that $S_t x_{j,t}$ is the expectation of the variable x, which can be the GDP or the primary surplus, for the year j in the month t. We modified the original weighted average in Minella et al. (2003), by adding one to $(12-t)$, and subtracting one to (t), since we use data for the first business day of the month.

rigidities. Additionally, when controlled for the forecast revision, as in equation (6), the forecast errors should not be predicted by related variables of interest.

Given that we use the forecast errors, we test the hypothesis of perfect foresight of inflation from December 2002, the first month for which we have a forecast, to August 2018. In 2016, the Brazilian Institute of Geography and Statistics (IBGE), the public institution responsible for producing statistical information, changed the methodology for the unemployment survey. Because none of the surveys cover the whole period, we do the test for three different periods. First, we test for the whole period and with the interest rate only. The second period covers from December 2002 to February 2016, with unemployment data from the Monthly Employment Survey (PME), and the third period covers from March 2012 to August 2018, with data from the Continuous National Household Sample Survey (PNAD). Data for PME and PNAD are, respectively, series 2179 and 6381, from the IBGE. For the observed inflation, we use the Extended National Consumer Price Index (IPCA). The IPCA is also produced by IBGE, but we obtained the respective data from the BCB (series 433). Lastly, the interest rate is the swap reference rate, with preset DI rate, 360-term day (series 7827 from the BCB, provided by B3).

In order to investigate whether expectations about variables of interest interact as predicted by a theoretically robust macroeconomic model, we conduct a multivariate analysis within the period that is common to all variables, which is December 2001 to August 2018. It is important to consider that the nominal exchange rate has a strong contemporaneous relationship with the risk perception of the Brazilian economy abroad, the so-called country risk. Therefore, it is interesting to verify the relationship between risk and nominal exchange rate expectations, which can also affect inflation. In order to do so, we include the monthly EMBI+Br, calculated by J.P. Morgan, in the analysis. We use the end-of-period value of the series 40490, from the Institute of Applied Economic Research (IPEA). Given that expectations were collected in the first business day of the month, we use the values of EMBI+Br at the end of the month $t-1$ for expectations with respect to the month t. Additionally, the inflation expectations series is seasonally adjusted by the X13-ARIMA-SEATS. From the review of theoretical and empirical results carried out in the preceding section, we expect that the relationships between these variables will have the signs presented in Table 2.

Table 2: Expected relationships between pairs of variables

	INFLATION	INTEREST	EXCHANGE	GDP	SURPLUS
RISK	+	+	+	?	?
INFLATION		+	?	?	?
INTEREST	-		-	-	+
EXCHANGE	+	+		+	?
GDP	+	+	-		?
SURPLUS	-	-	-	-	

This table shows the expected relationships between the variables, drawn from the review of theoretical and empirical results carried out in the preceding section. Positive relationships are represented by "+", and negative relationships by "-". When there is no defined prediction about the expected behavior of the variable, or the expected relation is ambiguous, it was used "?".

According the results of the Augmented Dickey-Fuller (ADF) test reported in Table 3, we fail to reject

the null hypothesis of unit root for all series. Meanwhile, the series are stationary in first difference. Because all series are I(1), it is necessary to test for the existence of cointegration relationships between them. We use the Johansen methodology and, as the results in Table 4 show, we reject the hypotheses of no cointegration relationship and of one cointegration relationship between the variables, and fail to reject the null hyphotesis of two cointegration relationships. Therefore, we estimate a VEC model, with two cointegration relationships, so that the expectations are treated as endogenous variables and the country risk is treated as an exogenous variable.

Table 3: ADF test results, December 2001 to August 2018

				Critical values		
Variable	Exogenous variables	Observations	Test statistic	1%	5%	10%
INFLATION	drift	201	-2.81	-3.46	-2.88	-2.57
DINFLATION	drift	200	-9.77	-3.46	-2.88	-2.57
INTEREST	drift and trend	201	-2.71	-3.99	-3.43	-3.13
DINTEREST	drift	200	-6.43	-3.46	-2.88	-2.57
EXCHANGE	drift	201	-1.24	-3.46	-2.88	-2.57
DEXCHANGE	drift	200	-5.79	-3.46	-2.88	-2.57
GDP	drift	201	-2.04	-3.46	-2.88	-2.57
DGDP	drift	200	-4.66	-3.46	-2.88	-2.57
SURPLUS	drift and trend	201	-2.03	-3.99	-3.43	-3.13
DSURPLUS	drift	200	-6.39	-3.46	-2.88	-2.57
RISK	drift	201	-2.14	-3.46	-2.88	-2.57
DRISK	drift	200	-8.45	-3.46	-2.88	-2.57

This table shows the results of the Augmented Dickey-Fuller test, so that *DINFLATION*, *DINTEREST*, *DEXCHANGE*, *DGDP*, *DSURPLUS*, and *DRISK* are the first difference of *INFLATION*, *INTEREST*, *EXCHANGE*, *GDP*, *SURPLUS*, and *RISK*, respectively.

Table 4: Johansen cointegration test results, December 2001 to August 2018

	Trace statistic				Eigenvalue statistic			
		Critical values				Critical values		
	Test statistic	1%	5%	10%	Test statistic	1%	5%	10%
$r <= 4$	1.54	11.65	8.18	6.50	1.54	11.65	8.18	6.50
$r <= 3$	8.39	23.52	17.95	15.66	6.84	19.19	14.90	12.91
$r <= 2$	19.75	37.22	31.52	28.71	11.36	25.75	21.07	18.90
$r <= 1$	49.80	55.43	48.28	45.23	30.05	32.14	27.14	24.78
$r = 0$	93.77	78.87	70.60	66.49	43.97	38.78	33.32	30.84

This table shows the results of the Johansen cointegration test, for both the trace and the eigenvalue statistics, so that r is the number of cointegration relationships being tested.

4 Results

The results for the forecast errors associated with the formation of inflation expectations are presented in Table 5, with ex-post forecast errors being given by $e_t = \pi_{t+12,t} - S_t\pi_{t+12,t}$. As it is possible to realize in the first panel of Table 5, the mean forecast errors are relatively low. These errors are even lower between March 2012 and August 2018. When the errors are regressed on a constant, as in equation (4), we reject the non-existence of a forecast bias and, therefore, the perfect foresight of inflation in its weakest form, except for the period between March 2012 and August 2018. Similarly, the persistence of forecast errors, which are shown in the second panel of Table 5, is lower for the second period, both for the coefficient of a first order autoregressive process and for the sum of the autoregressive coefficients of an autoregressive process with optimal lag chosen by the AIC criterion. Given that such forecast errors are persistent, they can be predicted and, therefore, inflation expectations cannot be seen as perfectly foresighted in a stronger form as well, a result which is also obtained in Guillén (2008), Araujo and Gaglianone (2010), and Kohlscheen (2012).

Furthermore, the results for the Mincer-Zarnowitz and Nordhaus regressions, presented in the third and fourth panels of Table 5, show that the related macroeconomic variables of interest also help to predict forecast errors. These macroeconomic variables continue to be significant even when we control for the forecast revision, which suggests that models of information rigidities do not explain deviations from perfect foresight. Another argument against such models as a good explanation of the inflation expectations contained in the Focus Survey is the coefficient sign for the forecast revision, which is negative. This result differs from that obtained in Guillén (2008) and Correa and Picchetti (2016).

The results for the VEC estimation are presented in Table 6. The country risk has a positive significant relationship with the expectations about inflation and nominal exchange rate, as expected, as well as with the expectations about the primary surplus. For the response of expectations about the relevant macroeconomic variables, one of the statistically significant results does not show the expected sign: the response of the expected economic activity to a change in the expected level of the nominal exchange rate. The other significant results are the response of the expected inflation to a change in the expected nominal exchange rate; the response of the expected nominal interest rate to a change in the expected nominal interest and exchange rates; the response of the expected nominal exchange rate to a change in the expected nominal interest rate and level of economic activity; the response of the expected level of economic activity to a change in the expected inflation and level of economic activity; and the response of the expected primary surplus to a change in the expected inflation, nominal interest rate, and primary surplus.

Figures 1 to 5 in the appendix present the response of the several expectations to an impulse to each expectations series, which is calculated with the coefficient matrix of the moving average representation of the VAR form of the estimated VEC model. According to Figure 1, an expected increase in inflation leads to an expected increase in the level of economic activity and to an expected decrease in the primary surplus. Figure 2 shows that an expected increase in the nominal interest rate leads to an expected increase in the primary surplus, as in Castro *et al.* (2015). As can be seen in Figure 3, an increase in the expected nominal exchange rate, that is, an expected nominal depreciation of the local currency leads to an expected decrease in the level of economic activity. This latter result differs from what would typically be expected from the established macroeconomic theory, although it should be kept in mind that it does not refer to the expectation of a real depreciation of the local currency. However, an increase in the real exchange rate in

Table 5: Behavior of forecast errors in the formation of inflation expectations

	Complete sample (12/2002 – 08/2018)	PME period (12/2002 – 02/2016)	PNAD period (03/2012 – 08/2018)
Mean and absolute forecast errors			
Mean error	0.082 **	0.113 ***	0.059
	(0.038)	(0.038)	(0.057)
Mean absolute error	0.231	0.228	0.227
Persistence of forecast errors			
AR(1)	0.642	0.667	0.511
SARC [order]	0.595 [2]	0.605 [2]	0.511 [1]
Mincer-Zarnowitz regressions			
α	−0.085	0.126	0.300
	(0.162)	(0.167)	(0.338)
$S_t\pi_{t+12,t}$	−0.372	−0.090	−0.201
	(0.313)	(0.262)	(0.418)
i_{t-1}	0.024***	0.040***	0.026
	(0.009)	(0.010)	(0.016)
u_{t-1}	—	−0.118***	−0.045**
		(0.031)	(0.019)
R^2	0.124	0.168	0.205
R^2 adj.	0.115	0.152	0.172
Nordhaus regressions			
α	−0.238**	0.090	0.243
	(0.102)	(0.096)	(0.220)
$S_t\pi_{t+12,t} - S_{t-1}\pi_{t+12,t}$	−0.633**	−0.681**	−0.759
	(0.293)	(0.284)	(0.498)
i_{t-1}	0.024***	0.041***	0.024
	(0.008)	(0.010)	(0.018)
u_{t-1}	—	−0.120***	−0.046**
		(0.031)	(0.019)
R^2	0.131	0.208	0.239
R^2 adj.	0.122	0.192	0.208
Observations	189	159	78

The first panel of this table shows the results for the mean and absolute forecast errors. For the mean error, it is presented the result for the following regression: $e_t = \alpha + \varepsilon_t$. The second panel shows the results for the coefficient of an AR(1) model and for the sum of the coefficients of an autoregressive model (SARC) with optimal lag chosen by the AIC criterion, which is indicated between brackets. The third panel shows the results for $e_t = \alpha + \beta_1 S_t\pi_{t+12,t} + \beta_2 i_{t-1} + \beta_3 u_{t-1} + \varepsilon_t$, and the fourth panel shows the results for $e_t = \alpha + \beta_1(S_t\pi_{t+12,t} - S_{t-1}\pi_{t+12,t}) + \beta_2 i_{t-1} + \beta_3 u_{t-1} + \varepsilon_t$. Newey-West standard errors are in parentheses. Significance levels: * 10%, ** 5%, *** 1%.

Table 6: VEC estimation results, December 2001 to August 2018

	INFLATION	INTEREST	EXCHANGE	GDP	SURPLUS
ECT_1	-0.058 ***	-0.255	-0.131 ***	-0.153 **	0.154 **
	(0.016)	(0.304)	(0.041)	(0.126)	(0.068)
ECT_2	-0.001 *	0.003	-0.001	-0.007	0.009 ***
	(0.000)	(0.008)	(0.001)	(0.003)	(0.002)
α	0.051 **	0.150	0.110 ***	0.164	-0.211 ***
	(0.016)	(0.308)	(0.041)	(0.127)	(0.069)
$RISK_{t-1}$	0.279 ***	1.876	0.789 ***	0.042	0.690 **
	(0.069)	(1.340)	(0.178)	(0.553)	(0.298)
$\Delta INFLATION_{t-1}$	-0.029	-0.172	-0.282	1.323 **	-0.770 **
	(0.075)	(1.462)	(0.194)	(0.604)	(0.325)
$\Delta INTEREST_{t-1}$	0.003	0.392 ***	0.005	-0.001	0.042 ***
	(0.004)	(0.072)	(0.010)	(0.030)	(0.016)
$\Delta EXCHANGE_{t-1}$	0.045 *	1.105 **	0.539 ***	-0.703 ***	-0.112
	(0.025)	(0.496)	(0.066)	(0.205)	(0.110)
ΔGDP_{t-1}	-0.005	0.195	-0.042 **	0.562 ***	0.003
	(0.008)	(0.149)	(0.020)	(0.062)	(0.033)
$\Delta SURPLUS_{t-1}$	0.005	-0.431	-0.008	-0.050	0.237 ***
	(0.016)	(0.306)	(0.041)	(0.126)	(0.068)
R^2	0.154	0.248	0.482	0.471	0.411
R^2 adj.	0.114	0.213	0.458	0.446	0.383

This table shows the results for the VEC model estimated for the expectations, so that ECT_1 ECT_2 are the error correction terms. Standard errors are in parentheses. Significance levels: * 10%, ** 5%, *** 1%.

one period leads to a decrease in the real GDP in later periods in Castro *et al.* (2015). Moreover, there are several studies about the contractionary effects of a real depreciation in the value of the local currency in emerging economies, e.g. Edwards (2003). Lastly, we can note in Figure 5 that an increase in the expected primary surplus leads to a decrease in the expected nominal interest rate, which is a result in line with the estimates in Castro *et al.* (2015). In the SAMBA model, an increase in the government expenditures, which can be interpreted as a decrease in the primary surplus, leads to an increase in the nominal interest rate. The impulse response functions are not statistically significant in the other cases.

5 Conclusion

Our empirical exploration found that the median inflation expectations formed by the respondents of the Focus Survey conducted by the BCB cannot be considered as informationally efficient. The reason is that the associated forecast errors can be predicted by the behavior of other related macroeconomic variables of interest, which violates the perfect foresight hypothesis. Moreover, our results suggest that models with information rigidity do not satisfactorily explain such deviations from perfect foresight. As regards the pairwise relationship between the several expectations series of interest, the results for the VEC estimation suggest that to a great extent these expectations (especially inflation expectations) are formed in a way mostly consistent with a theoretically-grounded macroeconomic model. In fact, this theoretical consistency is likely to be a major reason why the forecast errors associated with the formation of inflation expectations are relatively low. This suggests, in turn, that the Brazilian monetary authority has been successful in the

management of inflation expectations, which is essential in its pursuit of a low and stable inflation rate.

As future research it will be worth investigating whether expectations about other measures of economic activity or forecast horizons also yield consistent results. Other issues for future research include how the relationship between inflation expectations and observed inflation impacts on the credibility of monetary policy; the potential asymmetry in the response of inflation expectations to increases and decreases in the observed inflation; and the relationship between inflation expectations compiled through the Focus Survey and those formed by the BCB itself, which are published in the minutes of the Copom meetings and in inflation reports.

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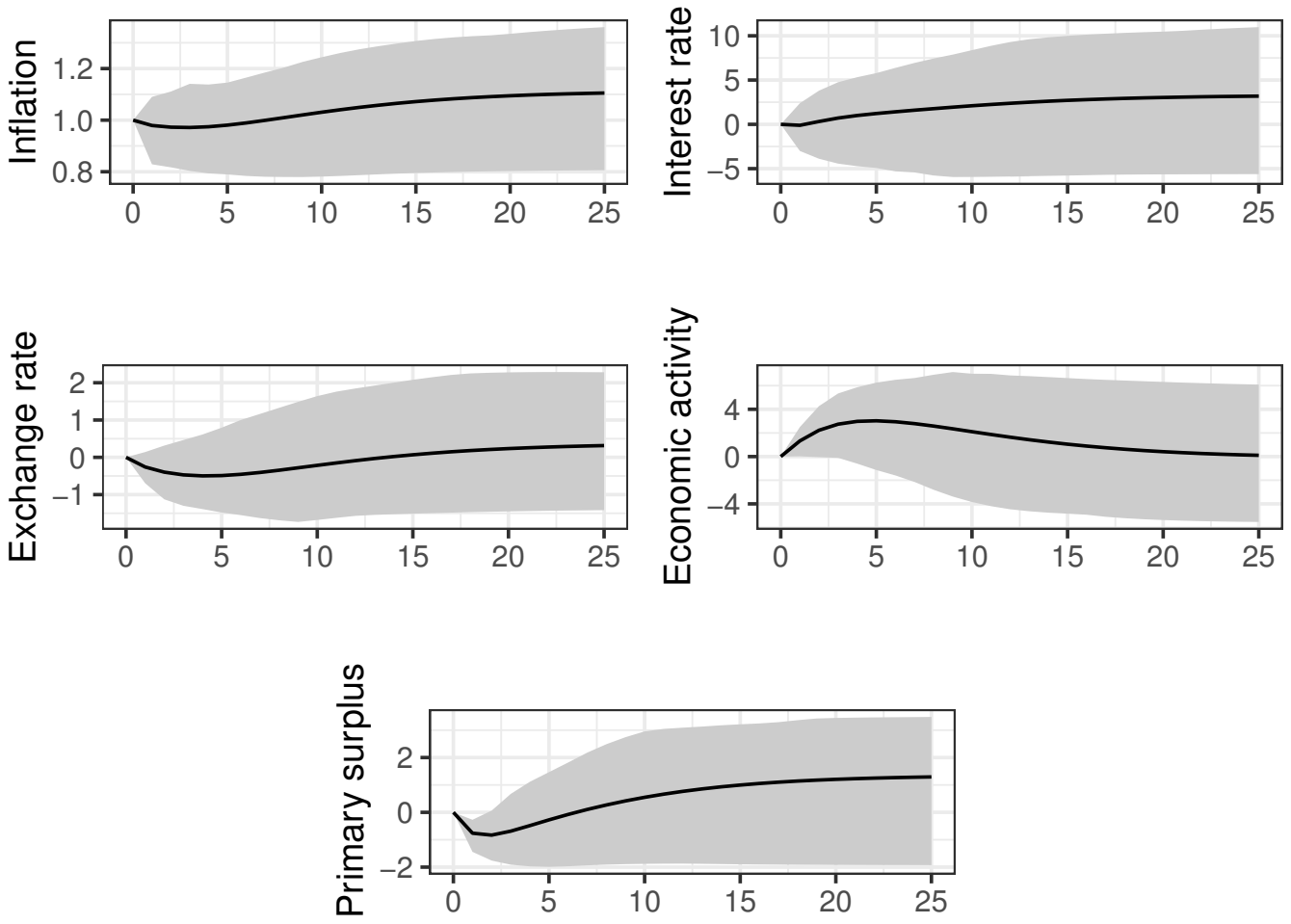
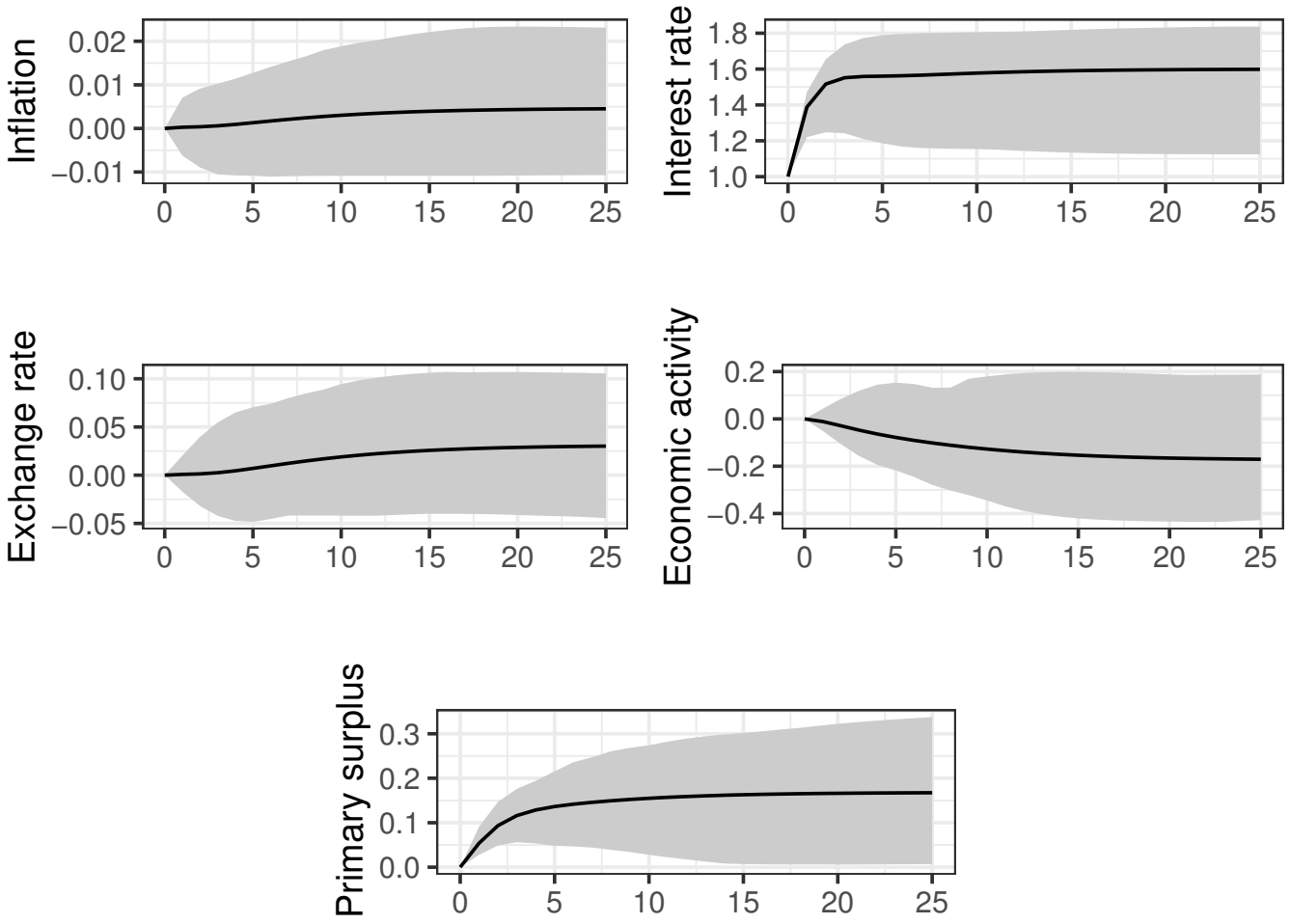
Appendix

Figure 1: Response of selected expectations to an impulse to inflation expectations



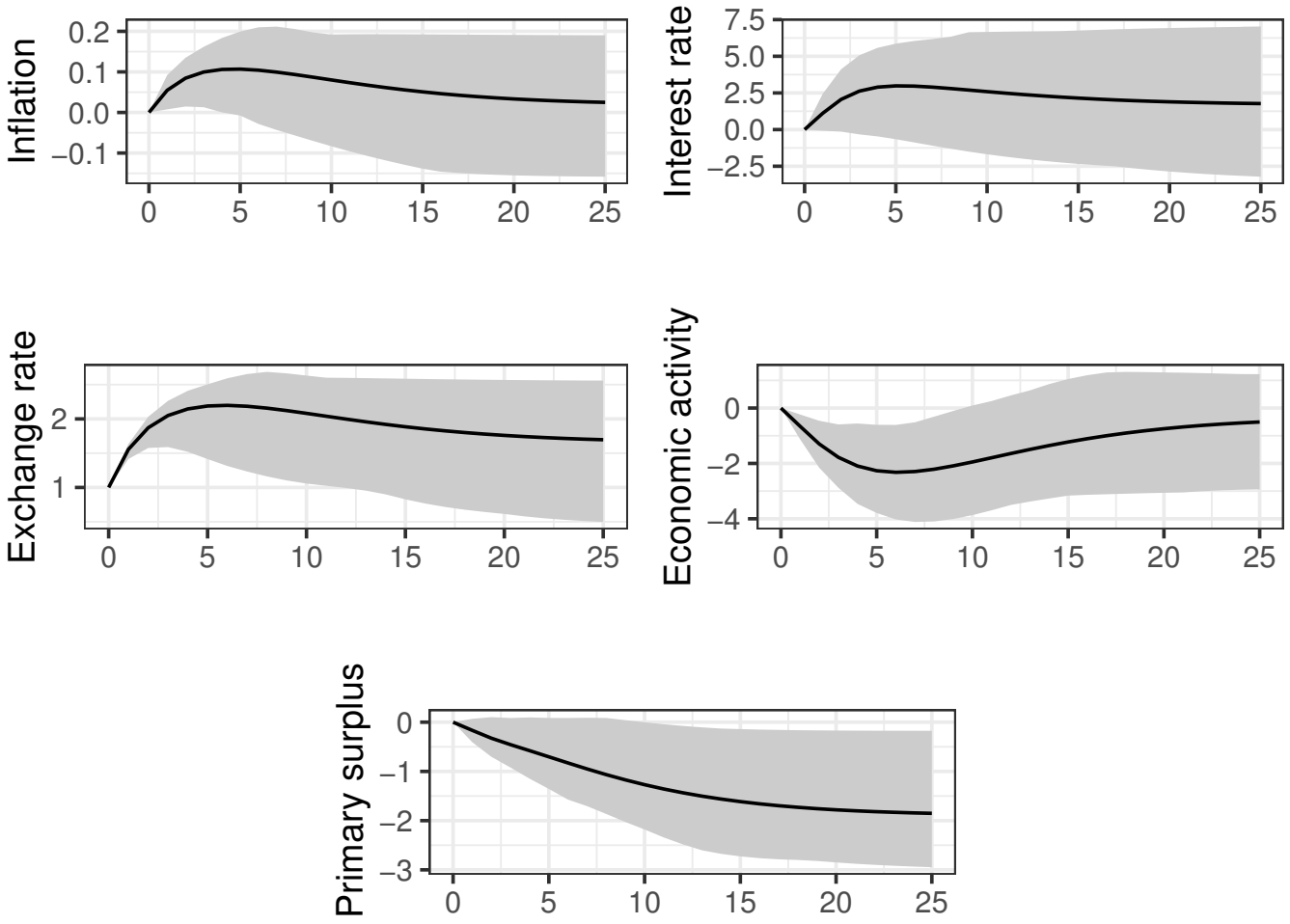
This figure shows the response of the selected expectations, up to 25 periods ahead, to an impulse to inflation expectations, with the 95% confidence bands, estimated using bootstrap methods, represented by the gray area.

Figure 2: Response of selected expectations to an impulse to nominal interest rate expectations



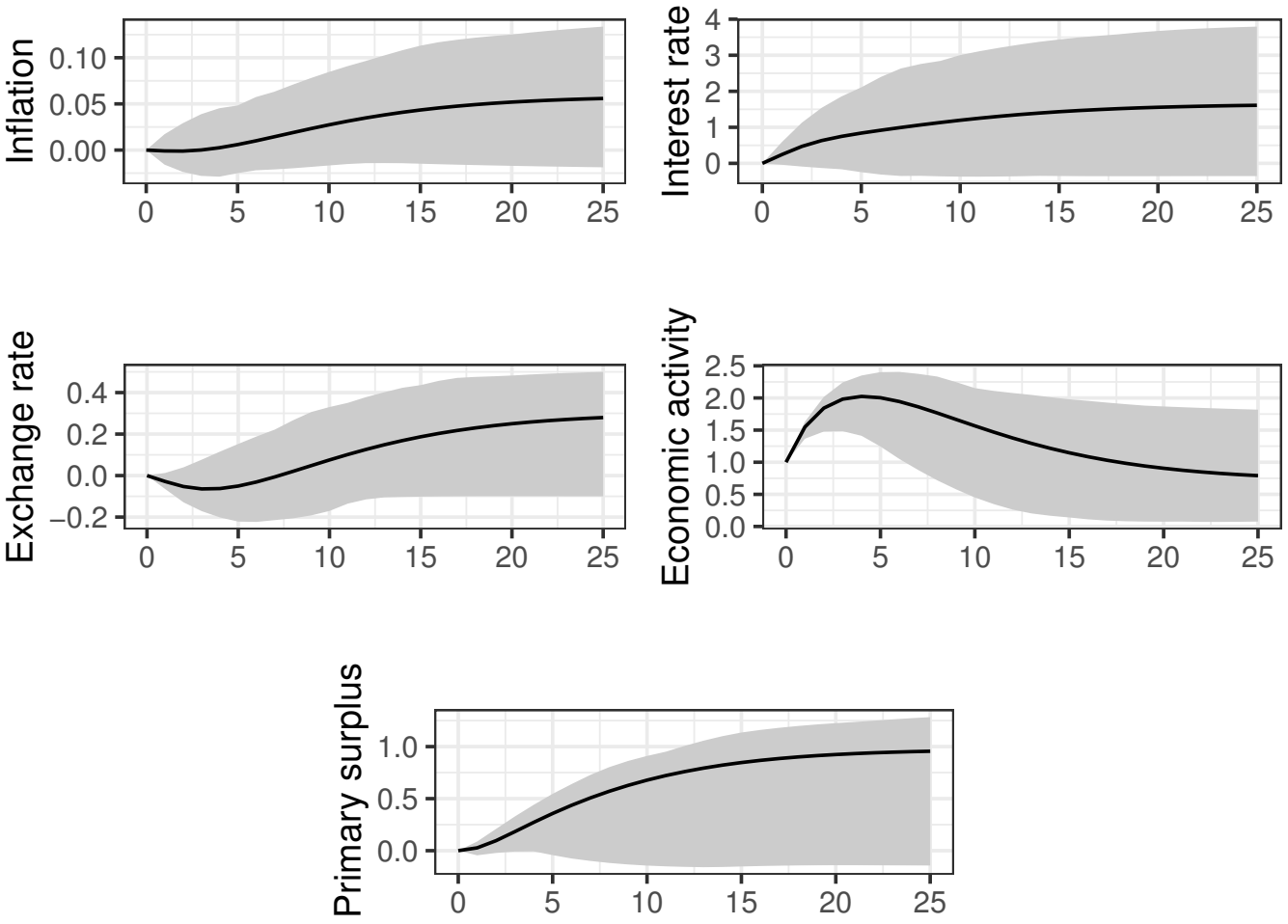
This figure shows the response of the selected expectations, up to 25 periods ahead, to an impulse to nominal interest rate expectations, with the 95% confidence bands, estimated using bootstrap methods, represented by the gray area.

Figure 3: Response of selected expectations to an impulse to nominal exchange rate expectations



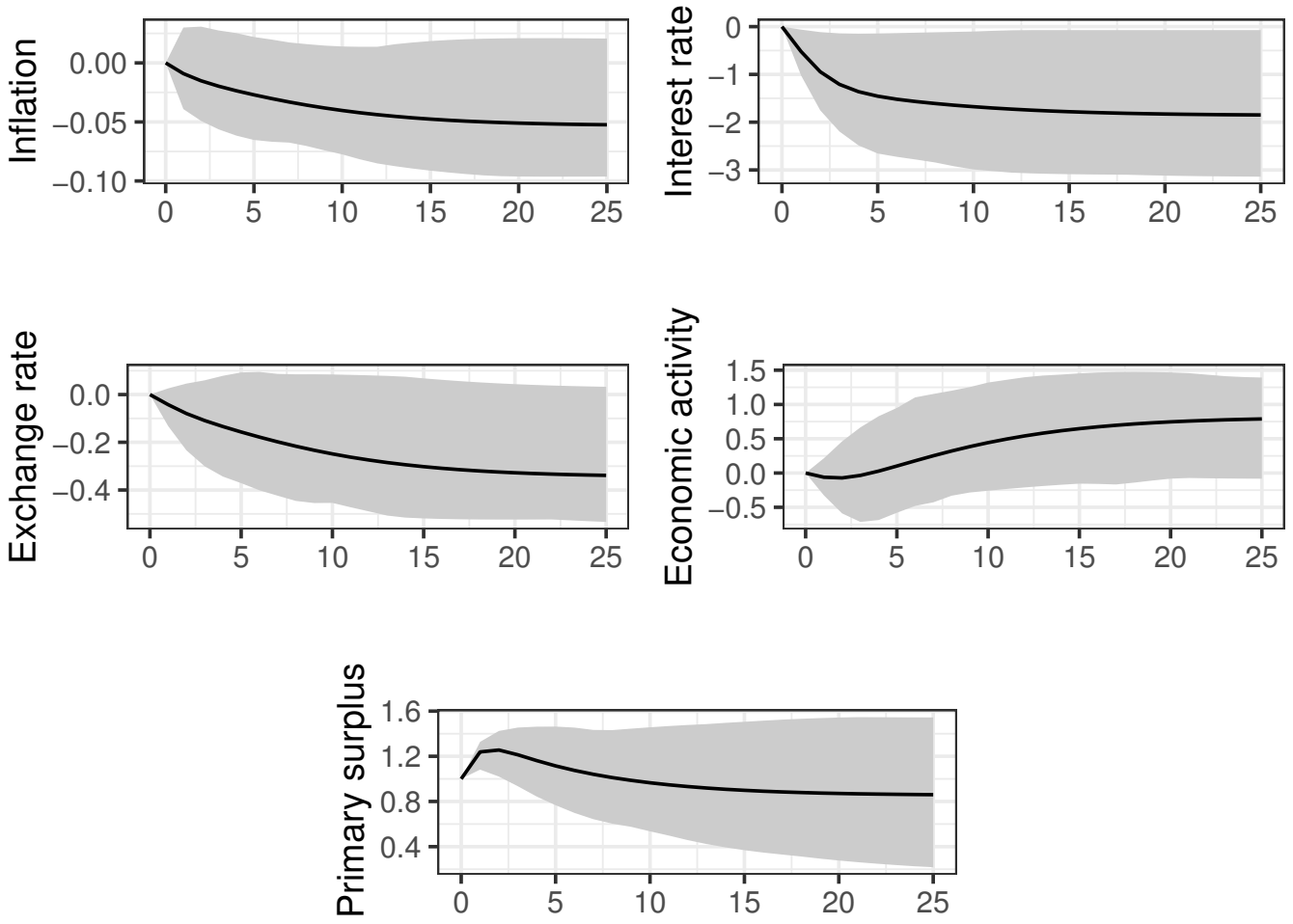
This figure shows the response of the selected expectations, up to 25 periods ahead, to an impulse to nominal exchange rate expectations, with the 95% confidence bands, estimated using bootstrap methods, represented by the gray area.

Figure 4: Response of selected expectations to an impulse to economic activity expectations



This figure shows the response of the selected expectations, up to 25 periods ahead, to an impulse to economic activity expectations, with the 95% confidence bands, estimated using bootstrap methods, represented by the gray area.

Figure 5: Response of selected expectations to an impulse to primary surplus expectations



This figure shows the response of the selected expectations, up to 25 periods ahead, to an impulse to primary surplus expectations, with the 95% confidence bands, estimated using bootstrap methods, represented by the gray area.