Inflation Targeting Regime and Fiscal Credibility in Brazil: A Quantile Regression Probabilistic Analysis

Michel Cândido de Souza * Elder Tiago da Costa de Souza †

Área Temática: Macroeconomia, Economia Monetária e Finanças

Resumo

O principal objetivo deste artigo é investigar a interação entre a credibilidade fiscal e a trajetória da inflação acumulada Brasileira, considerando o regime de metas. Utilizando regressões quantilicas e estimando as densidades condicionais, encontramos que uma melhora na credibilidade fiscal pode reduzir em até 35% a probabilidade de que a inflação não feche o mês dentro dos limites do regime de metas. Além disso, existem situações nas quais, apos um longo período de estabilidade, a melhora na credibilidade fiscal pode levar a um aumento na probabilidade de que a inflação acumulada viole os limites estipulados. Logo, ressaltamos a necessidade de parcimônia na execução de politicas econômicas baseadas somente em estimativas médias.

Abstract

The main objective of this paper is to investigate the interaction between fiscal credibility and the trajectory of Brazilian accumulated inflation, considering the target regime. Using quantile regressions and estimating conditional densities, we find that an improvement in fiscal credibility can reduce the probability that inflation does not close the month within the limits of the target regime by up to 35%. In addition, there are situations where, after a long period of stability, improved fiscal credibility may lead to an increase in the likelihood that accumulated inflation will violate the stipulated limits. Therefore, we emphasize the need for parsimony in the execution of economic policies based on average estimates.

Key-words: Fiscal Credibility; Quantile Regression; Inflation Target.
JEL Classification: C22; E31; E62.

*Federal University of Jequitinhonha and Mucuri Valleys- UFVJM. e-mail: michel.souza@ufvjm.edu.br
†Federal University of Juiz de Fora- UFJF. e-mail: eldertcsouza@gmail.com. The authors would like to thank CNPq, CAPES and FAPEMIG for their financial support.

1 Introduction

The inflation targeting regime is adopted by the central bank of several nations, including those in development. Historically, New Zealand, in 1990, was the first to adopt the inflation target regime, shortly after, the adoption by Canada, in 1991, followed by the United Kingdom in 1992, Sweden and Finland in 1993, and Israel, Australia and Chile in 1994. In Brazil, the adoption was later, precisely in the year 1999. The adoption of this regime aims to stabilize the prices, making the agent's expectations to converge to the inflation target.

According to Johnson (2002) and Johnson (2003) the adoption of inflation targets by industrialized countries has reduced the expected inflation level of these countries. Similar results were found in Bernanke et al. (1999), Vega e Winkelried (2005), Mishkin e Schmidt-Hebbel (2007) and Gonçalves e Salles (2008).

Due to the fundamental role that public expectations play in this regime, reputation and credibility have become indispensable instruments for the success (Mendonca (2007)). These monetary policy instrument seeks to keep inflation low, as well as to act as an anchor in the expectation formation process (Levin et al. (2004)). Therefore, the way in which monetary policy is to be implemented depends directly on the credibility of the monetary authority.

Thus, the greater the credibility of the central bank, the lower the movements required in the interest rate to control the price level and, indirectly, the lower the reaction movements of the real aggregates (Neuenkirch e Tillmann (2014)).

However, even if monetary credibility is a necessary condition for controlling prices, it is preceded by fiscal stability and sustainability of public debt. Nonetheless, until then, the emphasis of the expectation approach was being given only to monetary policy. According to Cespedes e Gali (2013), developments in fiscal policy around the global financial crisis of 2007-2009 (subprime crisis) are undoubtedly an important fact for Fiscal policy to enter again in the literature of policies Economic.

From the subprime crisis, developing and developed countries, with the aim of exiting the crisis, begin to use fiscal and monetary expansionist policy. However, as an inheritance of this policy arrangement, countries such as Greece, Italy, Ireland, Portugal and Spain began to see their public debt/GDP ratio rise and began to worry about fiscal policy and the risk of debt default.

The effects of the fiscal policy on inflation and the GDP gap began to be studied by several authors. Benigno e Woodford (2003), Kirsanova et al. (2007), Gali (2008), Çebi (2012) are examples of some studies that investigated the interaction of fiscal and monetary policies. The results show that fiscal policy and its interaction with monetary policy are decisive in the trajectory of inflation, GDP gap and the relationship of GDP debt. According to Nunes e Portugal (2009), the lack of coordination between monetary and fiscal policies should be considered a factor that can trigger or intensify a conjuncture of economic instability. Besides, in the limit, monetary policy may not have any effect on inflation if there is no sustainable fiscal policy. That is because, an undisciplined tax policy can exert pressure on the monetary authority sooner or later, monetize the debt, incurring an increase in future inflation (Sargent e Wallace (1981)).

Dealing with domestic price dynamics, the Brazilian economy experienced periods of hyperinflation in recent history, often reaching three digits in the 1980s. But since the 1990s, after the implementation of *Plano Real* in 1994, the price index returned to stability with an average value of 6.45 % p.p., from 1996 to 2014. However, with the external crisis, instability of public accounts, pressure on the exchange rate and growth of uncertainty, the deviation of the price level has returned to attention in recent quarters. The Extended Consumer Price Index (IPCA), for example, reached double digits in 2015, an unusual event since 2002.

Thus, in the brazilian economy recent period, high inflation, high interest rate and explosive trajectory of public debt resulted in loss of monetary and fiscal credibility. These facts justifies the study of the effects of fiscal credibility on brazilian's inflation rates considering an inflation target regime. The aims of this paper is to assess the implication of fiscal credibility and answer the following question: *How does an increase in fiscal credibility affect the probability of accumulated inflation remaining within the target?*. For this, we use an instrumental quantile regression model and estimate the conditional density functions to obtain the probabilities.

Our results indicate that the main source of asymmetry is the fiscal credibility index, which presents positive coefficients in the lower quantile of inflation and negative in the upper ones. Furthermore, we find evidence that an improvement in the fiscal credibility index can, in most cases, induce a reduction of up to 35% in the probability that cumulative inflation is out of target. This is corroborated by the robustness tests performed.

However, estimations indicate that after long periods of stability improvements in fiscal credibility could increase the likelihood that cumulative inflation will close outside the inflation target. We believe that this distortion occurs through the channel of expectations, since agents can associate this behavior with a future discretionary monetary policy. Finally, we reinforce the relevance of parsimony in the execution of economic policies that don't consider heterogeneity cycles in monetary variables.

2 Literature review

There is a reasonable number of studies in the literature dealing with optimal fiscal policies, such as Monacelli e Perotti (2008), Gali et al. (2007), among others. However, this literature has been considered in isolation, subtracting the effects of monetary policy. Nevertheless, as pointed out in the previous sections, the modern macroeconomics says that both fiscal and monetary policies are not independent and put a relevant burden on fiscal policy, which influences and can even undermine monetary policy, through the risk of monetization of debt by increasing future inflation and interest rate.

Therefore, it is necessary to have good public debt management, in order to avoid the default, and a good credibility in fiscal policy, since the market expectation influences the demand for bonds, and therefore in the capacity of of the government to deal with the debt. In other words, fiscal credibility is directly related to the sustainability of public debt (Mendonca e Machado (2013)). The fiscal entity is regarded as credible if economic agents have confidence in government plans to avoid the risk of public debt default. According to Kopits (2000), fiscal credibility is developed through well-defined rules and structural reforms, which guarantee the sustainability of public debt.

In order to measure the fiscal credibility of the government, and following the line adopted in by Mendonca (2007) related to monetary policy credibility, Mendonca e Machado (2013) introduces the fiscal credibility index. This index is based on market expectations regarding the public debt with respect to GDP and is described by the equation below.

$$ICF = \begin{cases} 1 \quad if \quad E_t(Debt_{t+12}) \leq Debt^{Min} \\ 1 - \frac{1}{Debt^{Max} - Debt^{Min}}[E_t(Debt_{t+12}) - Debt^{Min}] \quad if \quad E_t(Debt_{t+12}) < Debt^{Max} \\ 0 \quad if \quad E_t(Debt_{t+12}) \geq Debt^{Max} \end{cases} \tag{1}$$

Equation 1 shows that the fiscal credibility index ICF is equals 1 if the expectations of the debt-to-GDP ratio, 12 months ahead, is less than or equal to the minimum limit, $Debt^{Min}$ defined by the Maastricht Treaty (regarded as a reference point by the IMF – International Monetary Fund). However, if these expectations are greater than or equal to the maximum limit $Debt^{Max}$, also defined by the above mentioned Treaty, the fiscal credibility index is null. It is noteworthy that the fluctuation band is defined by the difference between $Debt^{Max}$ and $Debt^{Min}$. If the expectations of the debt-to-GDP ratio are within this range, the Mendonca e Machado (2013) presents values between zero and 1.

The authors present empirical evidence for Brazil on the structure Debt and the effects of this structure on the ratio of debt to GDP. As a result, Mendonca e Machado (2013) finds that the commitment to public debt increases fiscal credibility, which is crucial for debt management. Another result says that an increase in the average maturity of the participation of bonds linked to inflation increases the risk of default (increase in the debt ratio with respect to GDP), a result that goes against what is verified by the standard literature. And an increase in the share of securities linked to the exchange rate decreases the debt-to-GDP ratio. Leaving as a main message that an efficient management of public debt, able to ensure the sustainability of public debt, demands that the government seeks to control inflation, stabilize the exchange rate and implement the policy of fiscal credibility.

King (1995) stresses that low fiscal credibility implies a higher interest rate. A way proposed by Dominguez (2005) to reduce the interest rate arising from the low credibility of the Government would be the adoption of an optical strategy to reduce the maturity of the public debt.

With regard to inflation, there is a channel of interaction between fiscal and monetary policy, since, according to Mishkin e Savastano (2001) the monetization risk of public debt is relevant in environments of inflation targets because it can initiate an inflationary process . Moreover, this interaction can be extended to fiscal and monetary credibility, since, as mentioned by Mendonca e Hauel (2016), an improvement in monetary credibility means that the expectations of the agents are well anchored and the consequence of this is a reduction in the interest rate, which in turn contributes to stabilizing or reducing public debt. This reduction in debt can be interpreted as a process of gaining tax credibility.

Demirel (2012) works on the effects of monetary credibility on imperfect fiscal credibility, through a New-Keynesian model of a closed economy with government. The author found that an improvement in the capacity of fiscal commitment, that is, improvement in fiscal credibility, induces more soft monetary policy responses, after a mark-up shock. In addition, when analyzing the response of an improvement in the capacity of fiscal commitment with a monetary policy under commitment, he finds that the response is very similar, compared to monetary policy under discretion, giving the understanding that the gains in the stabilization of monetary policy under commitment disappear as fiscal commitment increases.

Mendonca e Hauel (2016) investigate the effects of fiscal and monetary credibility on public debt, considering emerging economies under the inflation targets regime. The empirical work is is built considering the Brazilian economy, an economy that is still in the process of creating monetary and fiscal credibility. Using a GMM model, the authors finds that credibility contributes to improving the management of public debt under a regime of inflation targets, as well as reducing costs related to the increase in the average maturity of debt and the increase in the share of inflation-indexed securities.

Lemoine e Linde (2016) examine the effects of budgetary consolidation based on expenditure when the credibility with respect to cuts in spending are long-lasting is imperfect. Through a DSGE model, for an open economy and calibrated for European countries, the authors find two main results: First, under an independent monetary policy, the adverse impact of limited credibility is small, and consolidation is expected to reduce public debt to a relatively low production cost, since monetary policy offers more accommodation under perfect credibility. Second, the lack of monetary accommodation under membership in monetary union implies that the cost of production can be significantly higher, and that progress to reduce government debt in the short and medium term may be limited under credibility imperfections.

Hu e Zaragaza (2018) use a DSGE model to analyze the impact of fiscal credibility on the real variables of the economy in two scenarios, one of high credibility and the other of low credibility.

The authors find that different degrees of credibility have a significant quantitative impact on the macroeconomic variables. In particular, according to the model, fully reliable spending cuts can reduce 0.7% compared to production growth, while unreliable cuts induce a more limited production response.

3 Methodology and Data

We can define a quantile τ as the value q, such that $100\tau\%$ of the sample values are less than q, with $0 < \tau < 1$. This definition can be stated using the cumulative distribution of a random variable X:

$$F(x) = P(X \leq x) \tag{2}$$

If we use the inverse function of the cumulative distribution above, at point τ, we have that the quantil τ of the random variable X is:

$$F^{-1}(\tau) = inf\{x : F(x) \geq \tau\} \tag{3}$$

Then, the inverse function gives us the quantile value for the probability chosen from the *infimum* of those with a probabilistic sum greater than or equal to the quantile.

The Quantile Regressions (QR) method was introduced by Koenker e Bassett (1978). From this analysis, the researcher can estimate the relationship between a set of explanatory variables x and the τ quantile of the dependent variable y. Unlike the OLS models that are estimated on the mean of the response variable distribution, this approach is a useful technique because it allows us to study the effect of an explanatory variable at various quantiles of the dependent y_t. In other words, the QR models are able to incorporate heteroscedasticity, since they allow us to verify if the coefficients of the explanatory variables change significantly (statistically) at different points of the dependent variable distribution.

Considering a vector of continuous response variables $y = (y_1, y_2, ...y_t)$ and another vector of explanatory $x = (x_{1i}, x_{2i}, ..., x_{ki})$, with subscript i representing the series within the same variable, $i = (1, 2, ...t)$. A standard linear regression model can be written as $E(y|x) = x^{'}\beta$, such that β is a vector of k parameters.

Now a quantile regression model can be understood as $Q_y(\tau|x) = x^{'}\beta(\tau)$, such that $\beta(\tau)$ is a matrix with dimensions of k parameters by τ quantiles, representing the effects of explanatory variables at various points of y. The regression parameters $\beta(\tau)$ are conditionated to the τ-quantile and estimates can be obtained by the solution below:

$$\min_{\forall\beta\in R} \sum_{i=1}^{t} \rho_\tau(y - x^{'}\beta(\tau)) \tag{4}$$

Given ρ_τ as a linear loss function:

$$\rho_\tau(u) = \begin{cases} \tau u, u \geq 0 \\ (\tau - 1)u, u < 0 \end{cases} \tag{5}$$

Replacing:

$$Q(\beta(\tau)) = min\left[\tau \sum_{i:y\geq x'\beta(\tau)}^{t} |y - x'\beta(\tau)| + (1-\tau) \sum_{i:y<x'\beta(\tau)}^{t} |y - x'\beta(\tau)|\right] \tag{6}$$

This non-differentiable function requires linear programming methods for their minimization. This problem can be summarized in:

$$\min_{\beta(\tau)\in R} \tau U + (1-\tau)V \tag{7}$$

$$\boldsymbol{s.a.}\ Y = \beta(\tau)X + U - V \tag{8}$$

The error vector u is composed of U and V. These terms represent the positive and negative parts of the regression residuals, respectively. Two approaches are commonly used in the solution of this problem: the *Simplex* method for moderate-size samples or the *Interior Point* method for larger databases, both guarantee a solution with finite number of iterations.

Finally, the construction of the confidence intervals is performed by the moving blocks bootstrap standard errors, which are more commonly used than the standard analytical errors [1]. The moving blocks bootstrap methodology is preferable since it makes no assumption about the distribution of the response variable, being able to generalize the (QR) results and estimate the intervals in any case of residual distribution and provides heteroscedasticity and autocorrelation robust standard errors.

In order to investigate the possible asymmetry in response variable distributions, we estimate the conditional quantile density function $f(F^{-1}(\tau))$ according to Koenker e Xiao (2004):

$$f_n(F_n^{-1}(t)) = \frac{2h_n}{F_n^{-1}(t+h_n) - F_n^{-1}(t-h_n)} \tag{9}$$

where the function $F_n^{-1}(s)$ is an estimate of $F^{-1}(s)$ and h_n is a bandwidth. Here, we obtain $F^{-1}(s)$ using the empirical quantile function for the linear model:

$$\hat{Q}(\tau|\overline{x}) = \overline{x}^T\hat{\alpha}(\tau) \tag{10}$$

Taking this into account, we can estimate $f(F^{-1}(t))$:

$$f_n(F_n^{-1}(t)) = \frac{2h_n}{x^T(\hat{\alpha}(t+h_n) - \hat{\alpha}(t-h_n))} \tag{11}$$

[1] Even when the residual errors are asymptotically distributed according to a normal.

To better understand how a variation in the fiscal credibility index may affect the probability of the Brazilian economy closing the year outside the inflation target, we follow the specification proposed by Mendonca e Silva (2016).

Furthermore, we estimate a Hybrid New Keynesian Phillips Curve:

$$\pi_t = \beta_1 \pi_{t-1} + \beta_2 E_t[\pi_{t+1}] - \beta_3 x_t + \beta_5 ICF_t + \varepsilon_t \tag{12}$$

But these version of the Phillips curve present an endogeneity problem. Consequently, the simple Quantile Regression estimation is inconsistent and must be replaced by the Two Stage Quantile Regression (TSQR) method. Moreover, to deal with heteroskedasticity and autocorrelation we use the *Moving Block Bootstrap* (MBB) method by Fitzenberger (1998).

Table 1 – HNKPC - Variables

Name	**Time**	**Source**
Fiscal Credibility Index	2003:01-2016:02	Mendonca e Machado (2013)
Accumulated 12-Month Inflation	2003:01-2016:02	IBGE
Lagged Inflation	2003:01-2016:02	IBGE
Inflation Exp. Acc. Over the Next 12 Months	2002:01-2016:02	BACEN
Output Gap	2003:01-2016:02	IBGE
Wage Mass	2003:01-2016:02	IBGE
Real Exchange Rate	2003:01-2016:02	BACEN

Note: Data sources descriptions and time interval.

All the data are analyzed in monthly frequency. The accumulated 12-month inflation is measured by the IPCA and seasonally adjusted. For inflation expectations we use the Central Bank reports based on the FOCUS estimates over the next 12 months. For the gap variable, which is often treated as the marginal cost of the economy, we chose two proxies based on the works of Gali e Gertler (1999) and Sims (2008): 1) The Brazilian industrial output and 2) The share of total wages in output. We calculate (1) as the difference between the industrial production index, seasonally adjusted using the X13- ARIMA, and its potential value obtained through the Hodrick-Prescott filter. Finally, 2) is constructed as the ratio between the effective wage mass of the economically active population and the nominal GDP, seasonally adjusted using the X13-ARIMA method.

For changes in the prices of the non-produced input, (Δv_t), we follow Mazali e Divino (2010) and calculate the percentage change in the nominal exchange rate between real and dollar for a three-period interval, according to the following formula $\Delta v_t = 100ln\left(\frac{v_t}{v_{t-3}}\right)$.[2]

The following variables are endogenous: Output Gap, Wage Mass, Inflation Expectations, Unemployment and Exchange Rate. In this context, following Blanchard e Galí (2007), Mazali e Divino (2010), Chorteas et al. (2012) and Boz (2013), all these variables were instrumentalized using two inflation lags and two lags of the variable itself, except in the case of inflation expectations that the literature suggests the use of only one lag.[3]

[2] All variables, after treatments, are stationary. The tests used were ADF, ADF-GLS, PP and KPSS.

[3] From the Cragg-Donald and Kleibergen-Paap tests, we reject the null hypothesis that the chosen instruments are weak for endogenous variables.

4 Results

4.1 Instrumental Baseline Quantile Regression

The estimated coefficients follow in the table below. As we can see, the estimates indicate stable behavior (between quantiles) for the coefficients of: lag component, expectations and product gap. In other words, there is no evidence of asymmetry in these variables. However, when we observe the variable fiscal credibility, we can note that (especially at the extremes) the coefficients differ from the 2SLS estimates, represented by the horizontal orange lines. The QR and 2SLS confidence intervals are not intercepted, which reinforces the asymmetric marginal effect of fiscal credibility on inflation accumulated in the last 12-months.

Table 2 – Results HNKPC

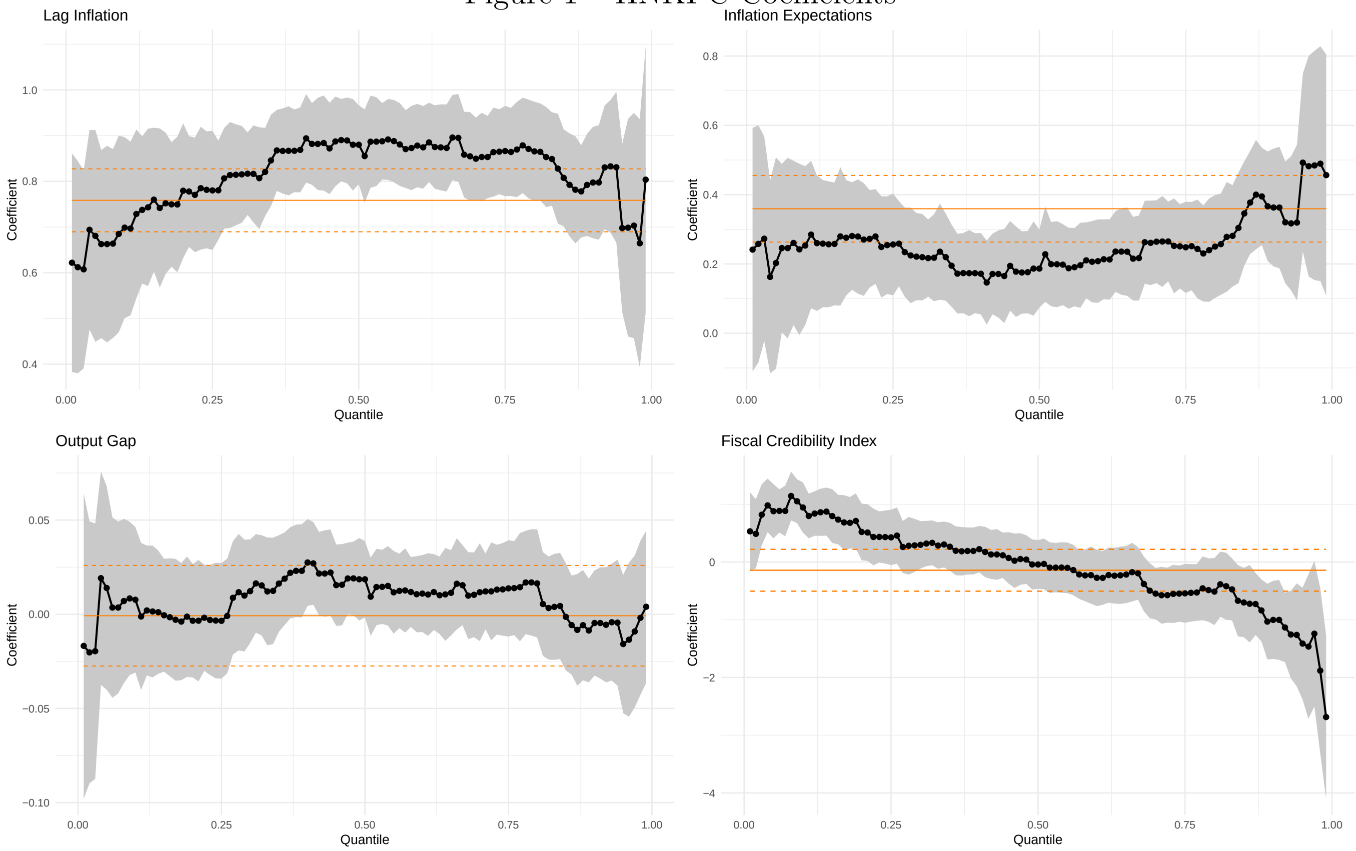
Estimation	**Quantile**	β_1	β_2	β_3	β_4
GMM		0.801^*	0.296^*	0.014	-0.407^*
2SLS		0.758^*	0.359^*	0.001	-0.143
	0.05	0.680^*	0.202	0.013	0.879^*
	0.10	0.698^*	0.253^{**}	0.007	0.944^*
	0.15	0.759^*	0.257^{**}	-0.005	0.795^*
	0.20	0.779^*	0.270^*	-0.003	0.520^{***}
	0.25	0.780^*	0.256^*	-0.003	0.426
	0.30	0.815^*	0.219^*	0.012	0.297
	0.35	0.845^*	0.194^*	0.016	0.264
	0.40	0.868^*	0.171^{**}	0.027^{***}	0.222
	0.45	0.871^*	0.194^*	0.015	0.070
QR	**0.50**	0.879^*	0.186^{**}	0.018	-0.042
	0.55	0.891^*	0.187^{**}	0.011	-0.101
	0.60	0.878^*	0.208^*	0.010	-0.273
	0.65	0.872^*	0.235^*	0.011	-0.216
	0.70	0.849^*	0.264^*	0.011	-0.547^{**}
	0.75	0.866^*	0.248^*	0.013	-0.543^{**}
	0.80	0.865^*	0.250^*	0.016	-0.512^*
	0.85	0.807^*	0.345^*	-0.001	-0.700^*
	0.90	0.797^*	0.362^*	-0.004	-1.002^*
	0.95	0.697^*	0.492^*	-0.015	-1.413^*

Note: All standard error estimates and the cov. matrix of the regressions were based on the MBB method.

($*$) is relative to 1%, ($**$) 5% and ($***$) 10%.

Below, we present the figure with estimates for all percentiles. For this figure, the black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. In addition, the horizontal lines represent the 2SLS (orange) values with their respective confidence intervals (dashed orange lines):

Figure 1 – HNKPC Coefficients



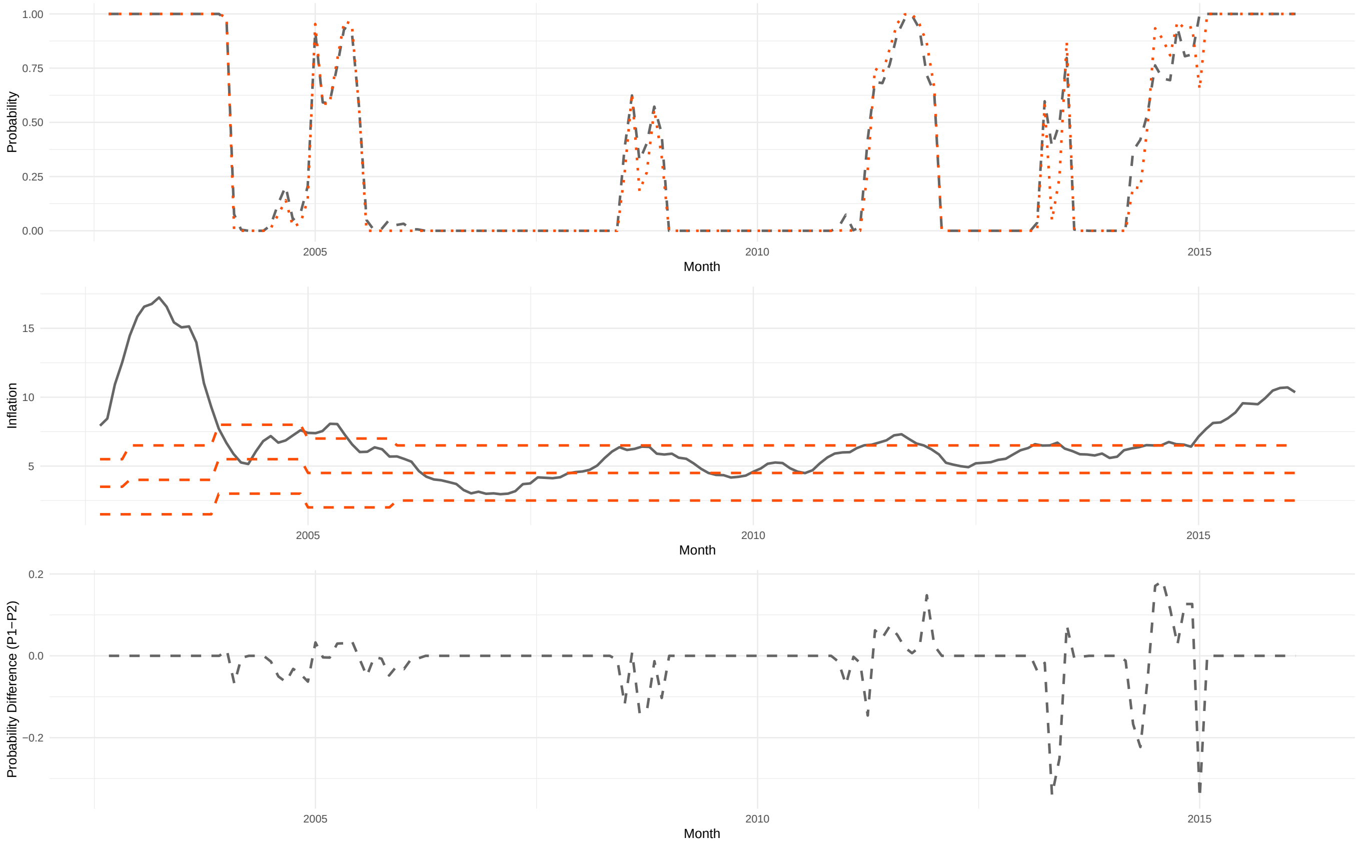
Note: The y-axis indicates the value of the coefficient and x-axis the quantile analyzed.

The estimated results, for all percentiles, reinforce what was found in the previous table (based on 95% confidence level). The coefficients associated to fiscal credibility present asymmetric behavior in extreme quantiles. Moreover, the magnitude and sign of marginal effects change: positive at low levels of accumulated inflation and negative in periods of price acceleration. This result illustrates a behavior not yet documented by the Brazilian literature. Indicating that, for low levels of accumulated inflation, fiscal credibility can exert a perverse effect, boosting the index of aggregate prices in the economy.

Following, to capture this asymmetry, that the fiscal credibility index can induce in the accumulated inflation trajectory, we estimate the conditional density functions at each point in time. We perform the following exercise: First, we calculate the probability curve that: in each month, accumulated inflation does not fall within the annual target. We then compare these estimates with a new probability curve for the same data but with the fiscal credibility index plus 1 standard deviation each month.

In some cases, the improvement in the fiscal credibility index (+1 standard deviation) can reduce the probability that accumulated inflation does not remain within the limits established by the Central Bank by up to 35%. However, the most interesting results are those that confirm the phenomenon found in the previous table: In specific periods, the improvement in the fiscal credibility index may hinder the fulfillment of the inflation target. This phenomenon contradicts the conventional literature estimates (focused on the mean parameters).

Figure 2 – Probability Curves and Inflation Target Coefficients



Note: First, the monthly conditional calculated probability curves, second the behavior of the 12-month accumulated inflation with the respective inflation targets and last, differential probability between the two conditional states: 1 - Density is estimated monthly based on the observed values of the variables and 2: Density is estimated based on the same data, but with a plus of +1 standard deviation in fiscal credibility index each month.

This result, using intuitively what was proposed by Lucas (1972), indicates that the effectiveness of some policy strategies may vary according to the agents perceptions. Therefore, an average effect, some times, can lead us to a sub-effectiveness of the desired economic policy.

4.2 Robusteness

To validate the findings, we performed some robustness tests in the model. In other words, we submit the new Keynesian Phillips curve to some changes in the proxies for economic activity and inclusion of the exchange component, seeking to understand the level of sensitivity of the results found previously[4]:

1. *Use of Wage Mass as measure of economic activity;*

2. *Use of IBC-Br Gap as measure of economic activity;*

3. *Inclusion of exchange pass-through in Industrial Production Gap model;*

[4] The graphs and probability curves (for all tests) can be found in the Appendix.

4. *Inclusion of exchange pass-through in Wage Mass Gap model;*

5. *Inclusion of exchange pass-through in IBC-Br Gap model.*

6. *Inclusion of exchange pass-through and use of Unemployment.*

When we replace the gap measure (Industrial Production) by Wage Mass and IBC-Br, we observe results similar to the previous ones. First, the backward-looking component oscillates between 0.65 and 0.80, within the 2SLS confidence interval. The inflation expectations (forward-looking component) show stable behaviour over the quantiles and the real economic activity variable presents no statistical significance, mostly. However, the fiscal credibility index shows a decreasing behavior along the quantiles and significant in the extremes, changing the sign but oscillating less in magnitude. Following, when we replace the industrial product gap with the IBC-Br gap, the results remain. But with a small improvement in the significance of the real variable (IBC-Br) in the quantiles near the median.

Basically, from these two initial robustness tests, we can conclude that changes in the variable that measures the real activity do not change the results of the estimated coefficients. So that the asymmetry verified in the variable index of fiscal credibility is maintained throughout the quantiles. This result allows us to re-estimate the probability curves, in order to verify if the improvement in fiscal credibility can affect the probability that accumulated inflation will close the month within the target.

Again, there are indications that an improvement in fiscal credibility can reduce the probability that accumulated inflation does not remain within the target regime bands. However, in the case of wage mass, the reduction in probability reaches a maximum value of 20%. What is interesting to note, again, is when an improvement in credibility leads to an increase in the likelihood that cumulative inflation will close the month off the target. Moreover, it occurs mostly when inflation has been kept within the target for a prolonged period. Consequently, this reinforces the previous results of the positive coefficients at the lower quantiles of the conditional distribution of the accumulated inflation.

We can observe the same behavior when the industrial production variable is replaced by the IBC-Br, so that the reduction reaches the maximum value of 25 %. Moreover, we note the return of the previously verified patter (in the same periods): a possible increase in the probability of cumulative inflation being out of target after improvements in fiscal credibility.

Now, moving to the final robustness tests (relative to the addition of the pass through component), we can observe that the results for the backward and forward looking components are stable, as well as the non-significance of the real variable remains. Following, the wage mass proxy presents a slight gain of significance in the lower quantiles, while the IBC-Br is concentrated mainly in the quantiles near the median. But the inclusion of the new variable seems to allow an even better visualization of the asymmetry present in the coefficients of the fiscal credibility index (for all economic activity proxies), since the differences (to the estimated value in the mean (2SLS)) are more expressive in extreme quantiles.

Finally, after verifying similar results (in the estimated quantile coefficients) with the addition of the exchange component, we proceeded to re-estimate the conditional probability curves, in order to verify how an improvement in fiscal credibility can affect the accumulated inflation dynamics and the fulfillment of the inflation target, considering a generalized increase of one standard deviation in every month of the fiscal credibility index. Once again, the results already observed are verified.

5 Conclusions

The main objective of this paper is to advance in the investigation of fiscal credibility index effects on inflation dynamics. Specifically, we calculate the probability that the price level remains within the inflation target. First, we investigate changes in the slope coefficients of dependent variables in one hundred quantiles. We found a stable behavior (between quantiles) for the coefficients of lag component, expectations and product gap.

Moreover, the most interesting results are based on the asymmetry of the fiscal credibility index, which has a positive effect at the 05% - 20% quantiles and negative at 70% - 99% quantiles of the accumulated inflation. This unexpected behavior is reinforced by the estimation of the conditional density functions, even after performing robustness tests in the model. An improvement of +1 standard deviation in the fiscal credibility index can, mostly in periods of high / moderate inflation, reduce the likelihood by up to 35 % of accumulated monthly inflation to close the month outside the target range.

However, there are exceptions. Apparently, after long periods of monetary stability, shocks to fiscal credibility may induce an increase in the price level through the channel of expectations. That is, we believe that agents may understand the attempt to improve fiscal stability as an indicative of a possible future discretionary behavior, then they adjust prices upwards and the effect expected by the government would not be verified. Finally, we believe that future studies, which seek to verify the persistence and dynamics of accumulated inflation shocks, as well as to delimit the periods, may expand the results found in this paper.

Bibliography

BENIGNO, P.; WOODFORD, M. Optimal monetary and fiscal policy: A linear quadratic approach. *NBER Macroeconomics Annual*, n. 18, p. 271–333, 2003.

BERNANKE, B. et al. *Inflation targeting: lessons from the international experience.* [S.l.]: Princeton University Press, 1999.

BLANCHARD, O.; GALí, J. Real wage rigidities and the new keynesian model. *Journal of Money, Credit and Banking*, v. 39, n. s1, p. 35–65, 2007.

BOZ, C. Estimating the new keynesian phillips curve by quantile regression method for turkey. *Modern Economy*, v. 4, p. 627–632, 2013.

CESPEDES, L.; GALI, J. Fiscal policy and macroeconomic performance: An overview. *Serie Banco Central de Chile*, v. 17, p. 1–25, 2013.

CHORTEAS, G.; MAGONIS, G.; PANAGIOTIDIS, T. The asymmetry of the new keynesian phillips curve in the euroarea. *Economic Letters*, v. 114, n. 2, p. 161–163, 2012.

DEMIREL, D. The value of monetary policy commitment under imperfect fiscal credibility. *Journal of Economic Dynamics and Control*, n. 36, p. 813–829, 2012.

DOMINGUEZ, B. Reputation in a model with a limited debt structure. *Review of Economic Dynamics*, v. 8, p. 600–622, 2005.

FITZENBERGER, B. The moving blocks bootstrap and robust inference for linear least squares and quantile regressions. *Journal of Econometrics*, v. 82, n. 2, p. 235 – 287, 1998.

GALI, J. *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework.* [S.l.]: Princeton University Press, 2008.

GALI, J.; GERTLER, M. Inflation dynamics: A structural econometric analysis. *Journal of Monetary Economics*, v. 44, n. 2, p. 195–222, October 1999.

GALI, J.; LOPEZ-SALIDO, D.; VALLES, J. Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, v. 5, p. 227–270, 2007.

GONçALVES, C.; SALLES, J. Inflation targeting in emerging economies: what do the data say? *Journal of Development Economics*, n. 85, p. 312–318, 2008.

HU, R.; ZARAGAZA, C. Fiscal stabilization and the credibility of the u.s. budget sequestration spending austerity. *Journal of Economic Dynamics and Control*, v. 93, p. 54–66, 2018.

JOHNSON, D. R. The effect of inflation targeting on the behavior of expected inflation: Evidence from an 11 country panel. *Journal of Monetary Economics*, v. 49, p. 1493–1519, 2002.

JOHNSON, D. R. The effect of inflation targets on the level of expected inflation in five countries. *Review of Economics and Statistics*, n. 4, 2003.

KING, M. A. "monetary policy implications of greater fiscal discipline (commentary). *Proceedings - Economic Policy Symposium - Jackson Hole, Federal Reserve Bank of Kansas City*, 1995.

KIRSANOVA, T. et al. Optimal fiscal policy rules in a monetary union. *Journal of Money, Credit and Banking*, v. 3, n. 7, p. 1759–1784, 2007.

KOENKER, R.; BASSETT, G. Regression quantiles. *Econometrica*, v. 46, n. 1, p. 33–50, 1978.

KOENKER, R.; XIAO, Z. Unit root quantile autoregression inference. *Journal of the American Statistical Association*, v. 99, n. 467, p. 775–787, 2004.

KOPITS, G. How can fiscal policy help avert currency crises? *IMF Working Paper*, n. 00/185, 2000.

LEMOINE, M.; LINDE, J. Fiscal consolidation under imperfect credibility. *European Economic Review*, n. 88, p. 108–141, 2016.

LEVIN, A. T.; NATALUCCI, F.; PIGER, J. The macroeconomic effects of inflation targeting. *Federal Reserve Bank of St. Louis Review*, v. 86, n. 4, p. 51–80, 2004.

LUCAS, R. Expectations and the neutrality of money. *Journal of Economic Theory*, v. 4, n. 2, p. 103 – 124, 1972.

MAZALI, A. A.; DIVINO, J. A. Real wage rigidity and the new phillips curve: the brazilian case. *Revista Brasileira de Economia*, v. 64, p. 291 – 306, 09 2010.

MENDONCA, H. Towards credibility from inflation targeting: the brazilian experience. *Applied Economics*, v. 39, n. 20, p. 2599–2615, 2007.

MENDONCA, H.; HAUEL, G. The effect of monetary and fiscal credibility on public debt: empirical evidence from the Brazilian economy. *Applied Economics Letters*, v. 23, n. 11, p. 816–821, 2016.

MENDONCA, H. F.; MACHADO, R. M. Public debt management and credibility: Evidence from an emerging economy. *Economic Modelling*, v. 30, p. 10 – 21, 2013.

MENDONCA, H. F.; SILVA, R. Observing the influence of fiscal credibility on inflation: Evidence from an emerging economy. *Economics Bulletin*, v. 36, n. 4, p. 2333–2349, 2016.

MISHKIN, F. S.; SAVASTANO, M. Monetary policy strategies for latin america. *Journal of Development Economics*, v. 66, 2001.

MISHKIN, F. S.; SCHMIDT-HEBBEL, K. Does inflation targeting make a difference? *NBER Working Papers*, n. 12876, 2007.

MONACELLI, T.; PEROTTI, R. Fiscal policy, wealth effects and markups. *National Bureau of Economic Research Working Paper*, n. 14584, 2008.

NEUENKIRCH, M.; TILLMANN, P. Inflation targeting, credibility, and non-linear taylor rules. *Journal of International Money and Finance*, v. 41, p. 30–45, 2014.

NUNES, A. F.; PORTUGAL, M. S. Políticas fiscal e monetária ativas e passivas: uma análise para o brasil pós-metas de inflação. In: *37 ENCONTRO NACIONAL DE ECONOMIA - ANPEC*. [S.l.: s.n.], 2009.

SARGENT, T.; WALLACE, N. Some unpleasant monetarist arithmetic. *Federal reserve bank of Minneapolis quarterly review*, v. 5, n. 3, p. 1–17, 1981.

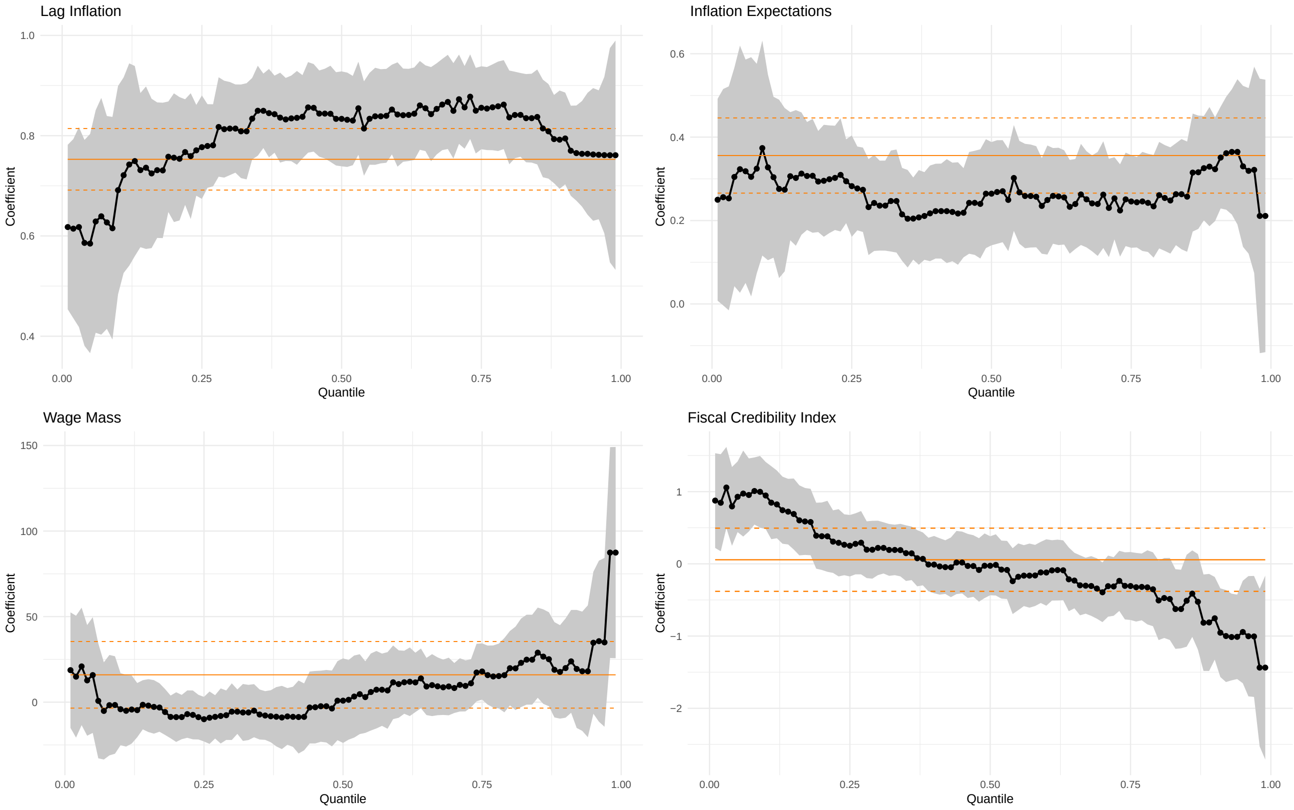
SIMS, C. Inflation expectations, uncertainty, the phillips curve, and monetary policy. In: *Federal Reserve Bank of Boston Conference*. [S.l.: s.n.], 2008.

VEGA, M.; WINKELRIED, D. Inflation targeting and inflation behavior: A successful story? *International Journal of Central Banking*, v. 3, n. 1, p. 153–175, 2005.

ÇEBI, C. The interaction between monetary and fiscal policies in Turkey: An estimated new keynesian DSGE model. *Economic Modelling*, v. 9, n. 4, p. 1258 – 1267, 2012.

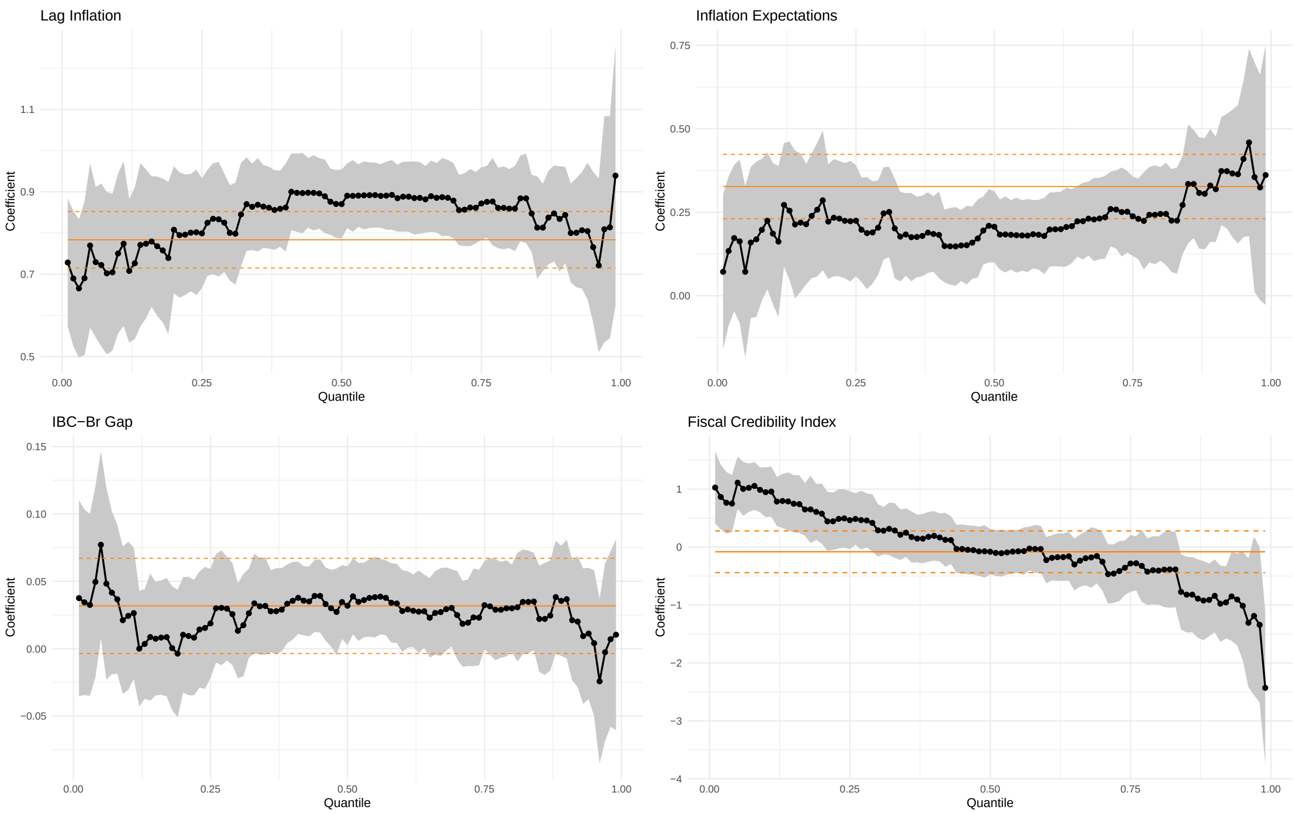
1 Appendix

Figure 3 – Robusteness (1): Coefficients



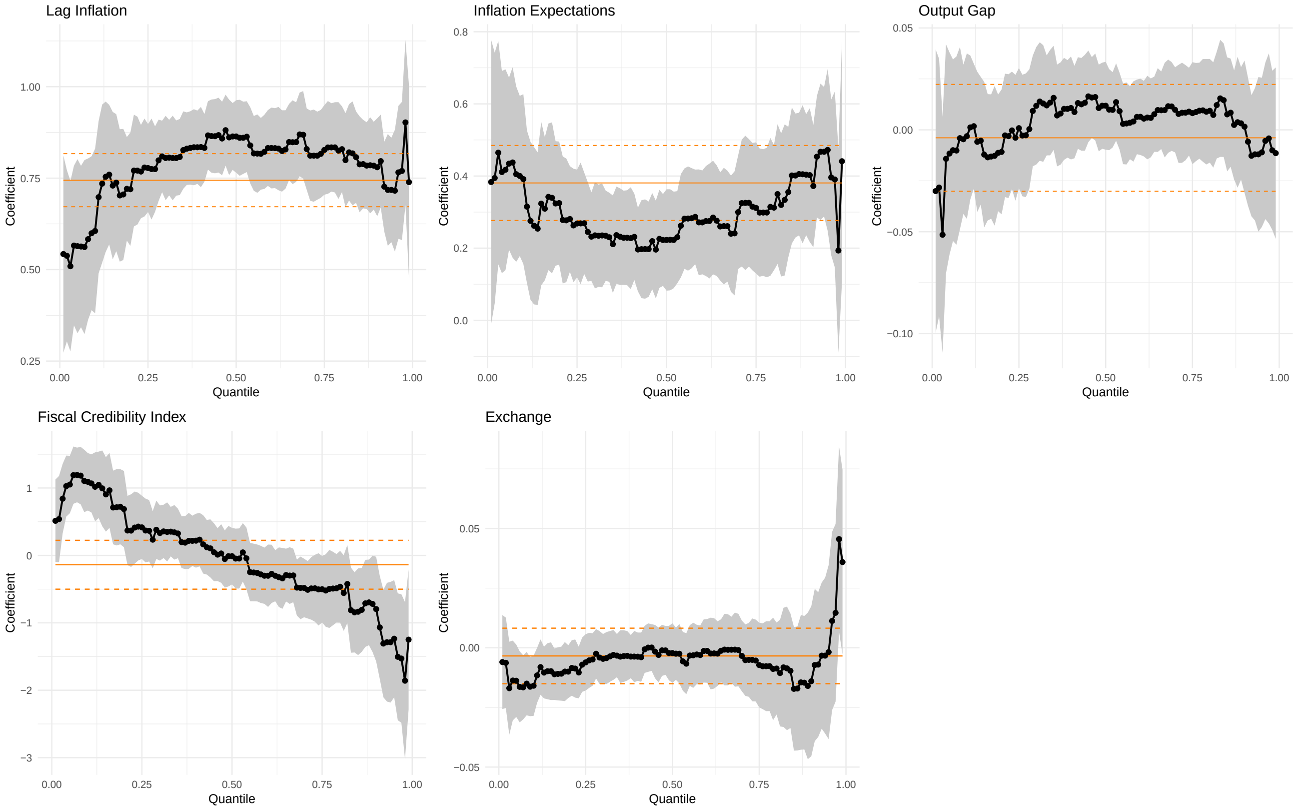
Note: The y-axis indicates the value of the coefficient and x-axis the quantile analyzed.

Figure 4 – Robusteness (2): Coefficients



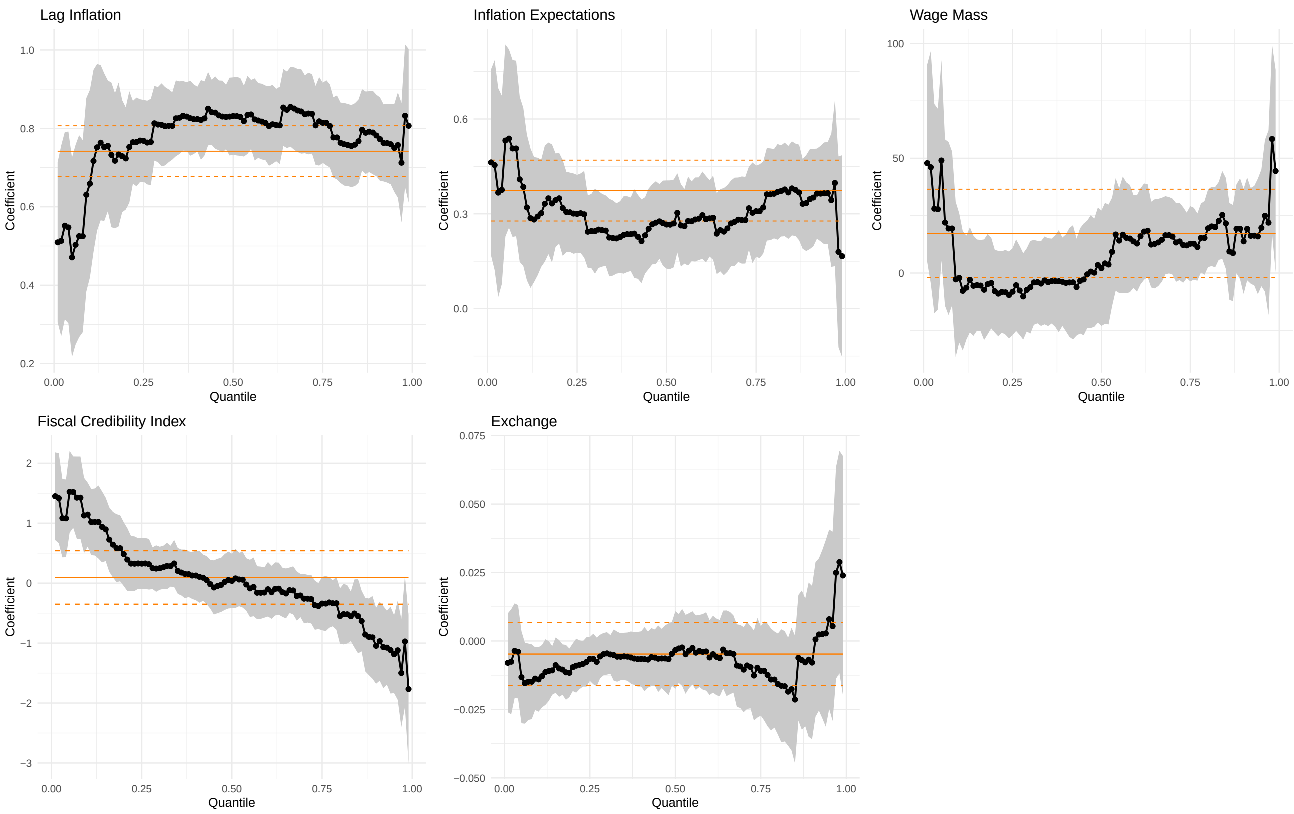
Note: The y-axis indicates the value of the coefficient and x-axis the quantile analyzed.

Figure 5 – Robusteness (3): Coefficients



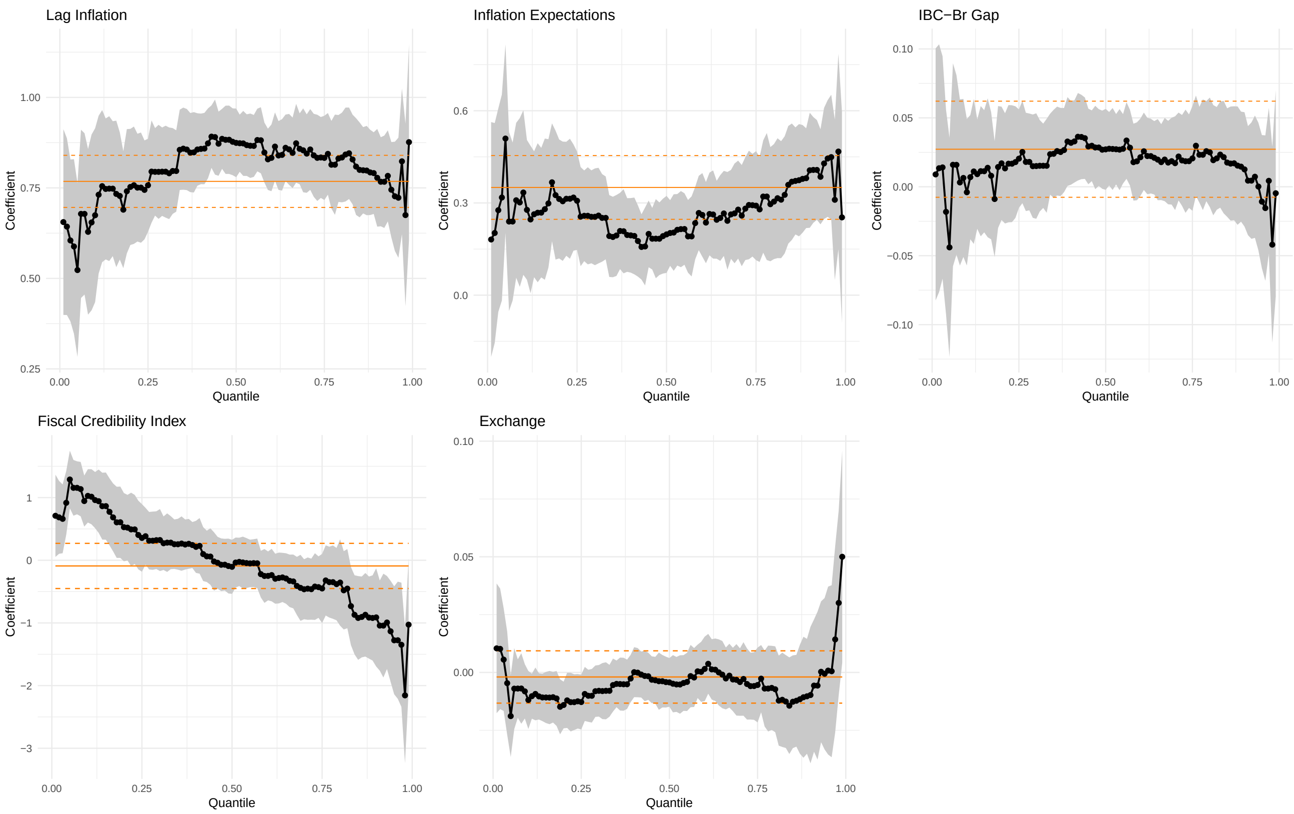
Note: The y-axis indicates the value of the coefficient and x-axis the quantile analyzed.

Figure 6 – Robusteness (4): Coefficients



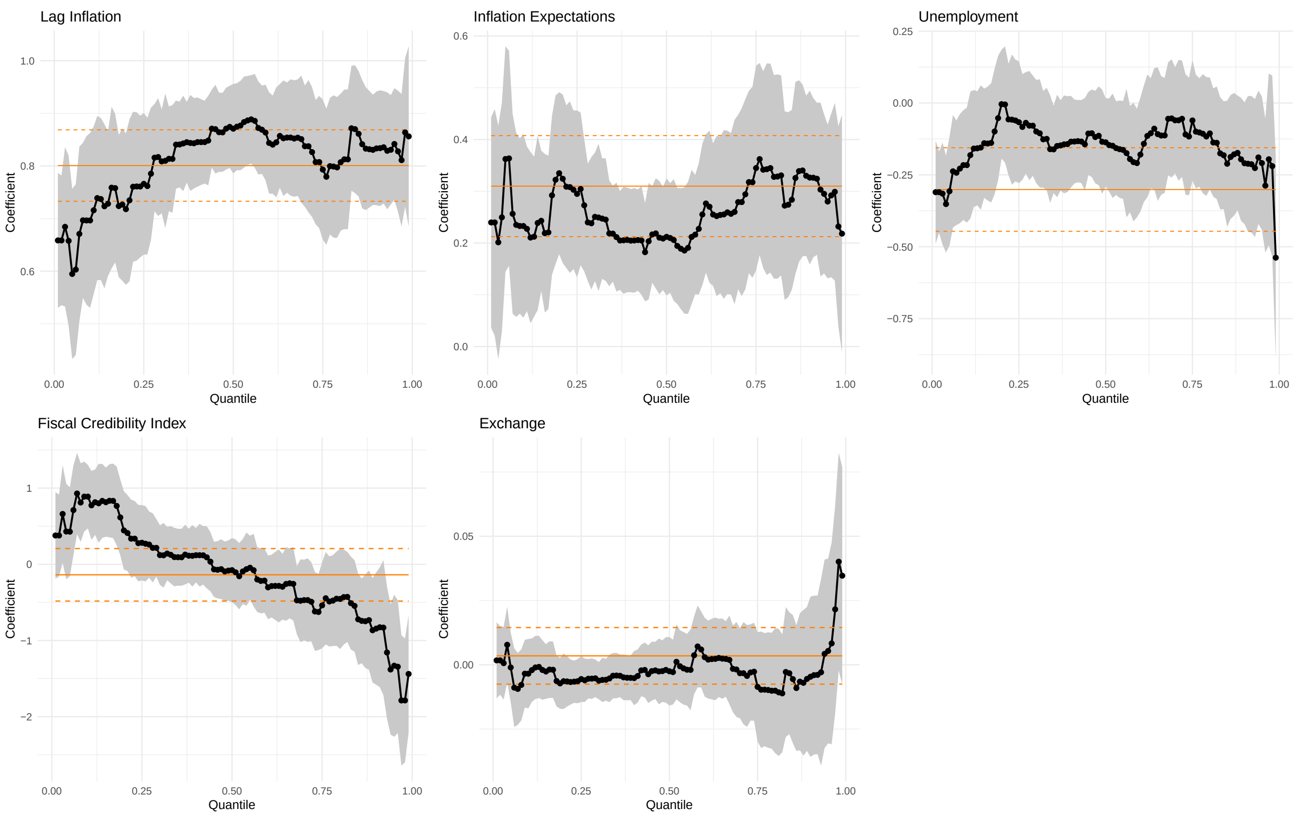
Note: The y-axis indicates the value of the coefficient and x-axis the quantile analyzed.

Figure 7 – Robusteness (5): Coefficients



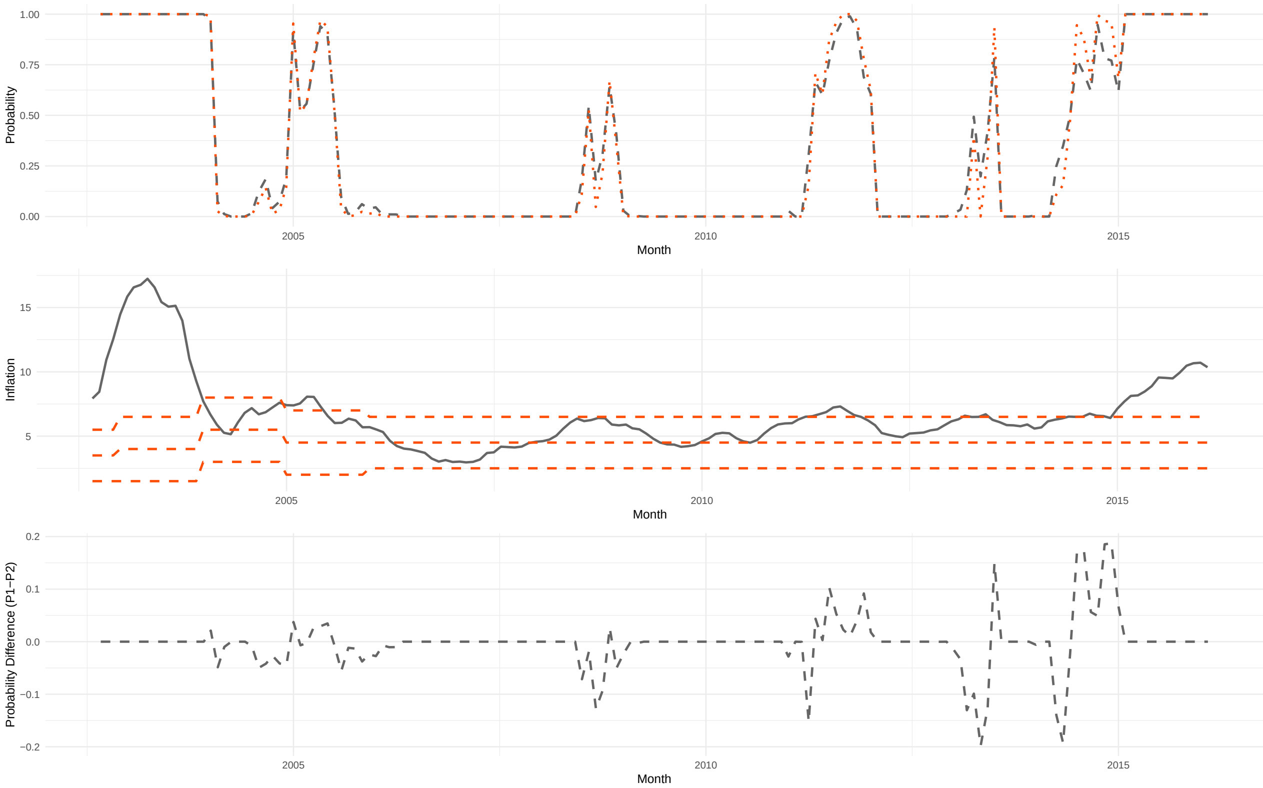
Note: The y-axis indicates the value of the coefficient and x-axis the quantile analyzed.

Figure 8 – Robusteness (6): Coefficients



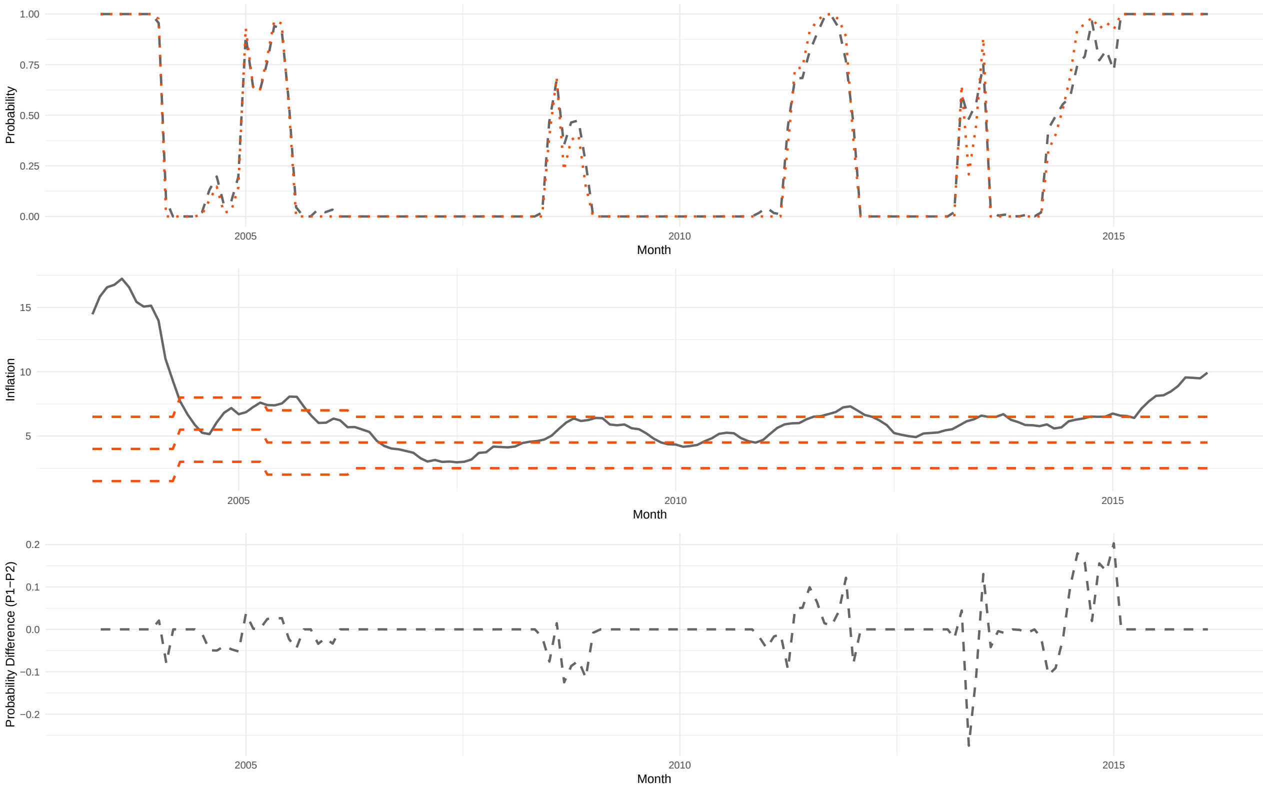
Note: The y-axis indicates the value of the coefficient and x-axis the quantile analyzed.

Figure 9 – Probability Curves and Inflation Target Coefficients: Robustness (1)



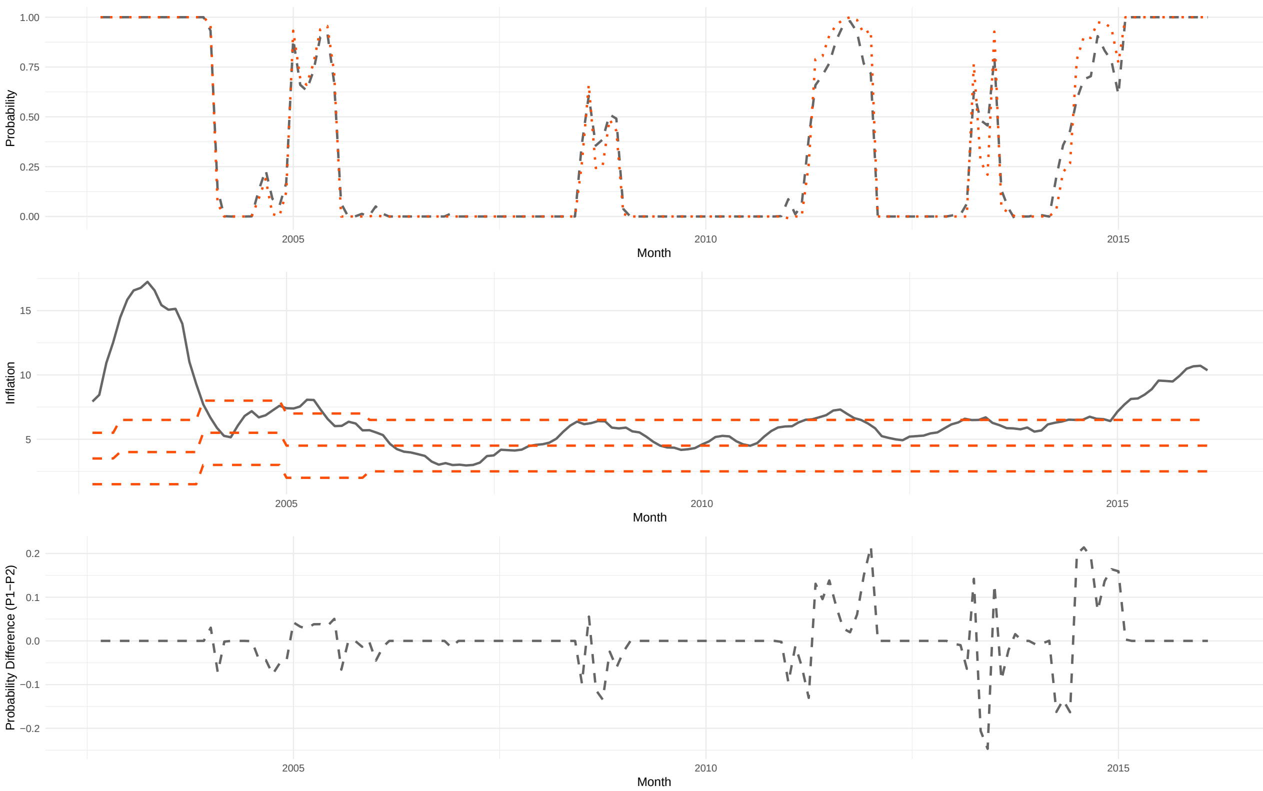
Note: First, the monthly conditional calculated probability curves, second the behavior of the 12-month accumulated inflation with the respective inflation targets and last, differential probability between the two conditional states.

Figure 10 – Probability Curves and Inflation Target Coefficients: Robustness (2)



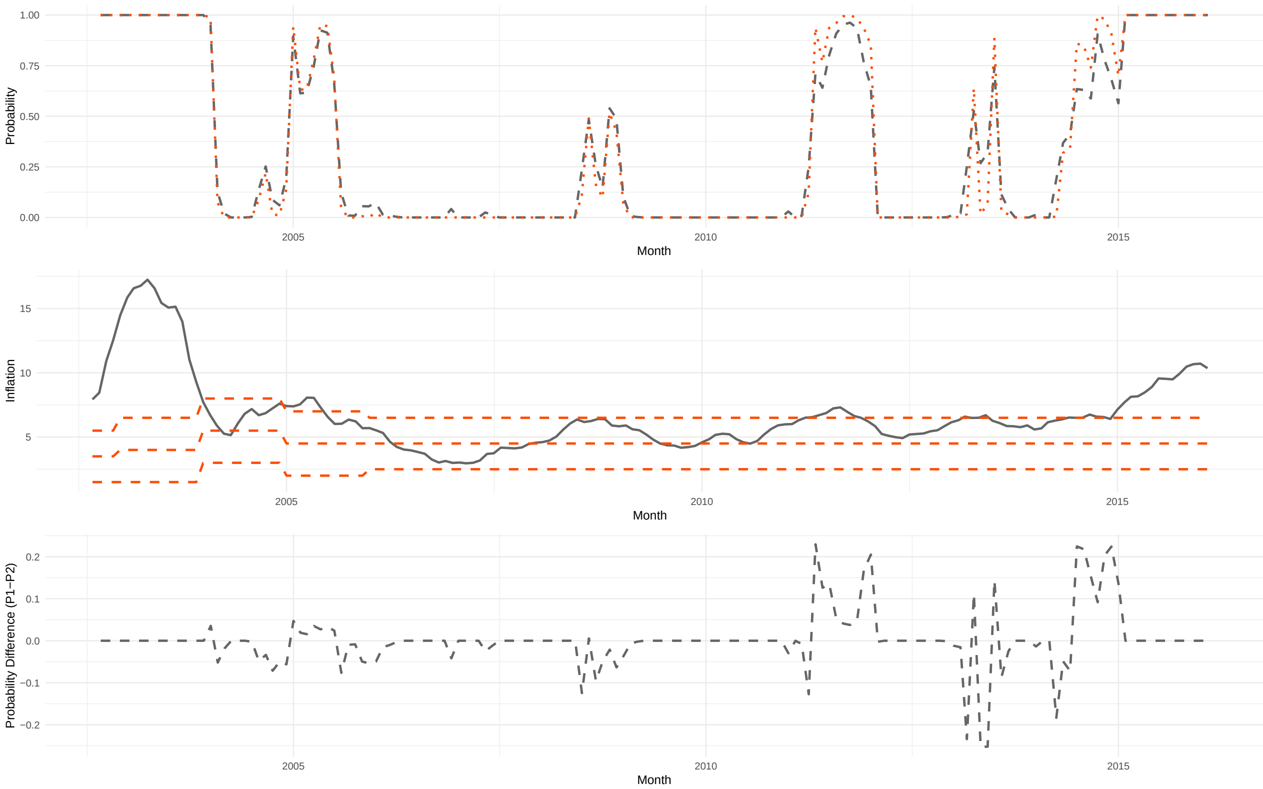
Note: First, the monthly conditional calculated probability curves, second the behavior of the 12-month accumulated inflation with the respective inflation targets and last, differential probability between the two conditional states.Since the IBC-Br data are available from 2003, the results of the probability curve are computed for a slightly lower time interval.

Figure 11 – Probability Curves and Inflation Target Coefficients: Robustness (3)



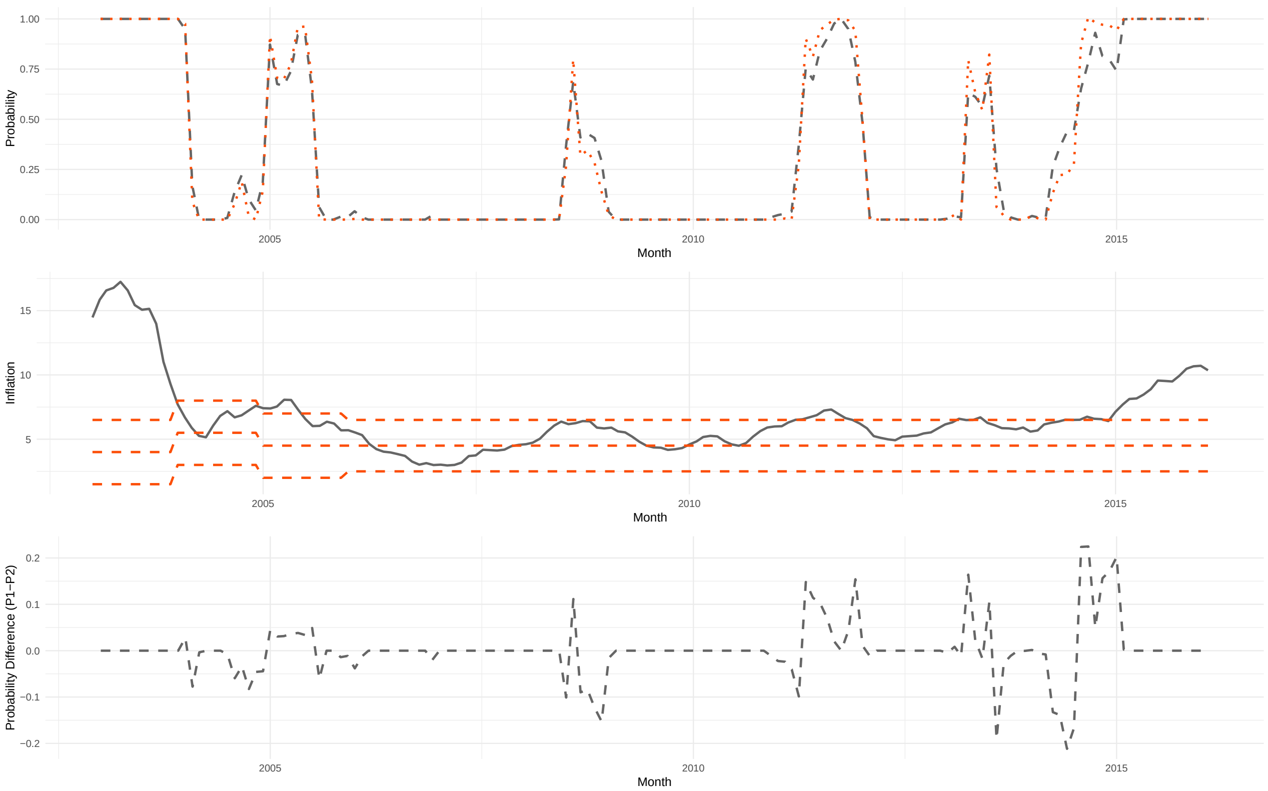
Note: First, the monthly conditional calculated probability curves, second the behavior of the 12-month accumulated inflation with the respective inflation targets and last, differential probability between the two conditional states.

Figure 12 – Probability Curves and Inflation Target Coefficients: Robustness (4)



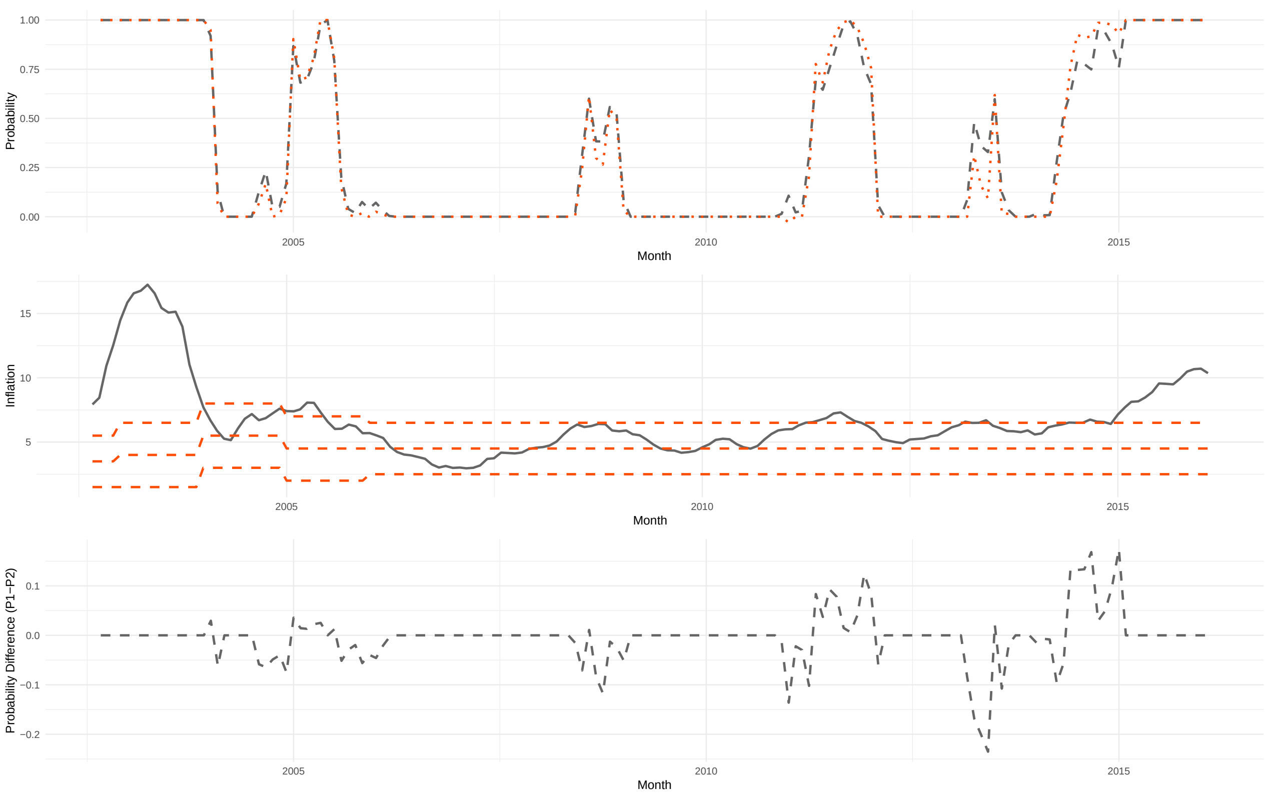
Note: First, the monthly conditional calculated probability curves, second the behavior of the 12-month accumulated inflation with the respective inflation targets and last, differential probability between the two conditional states.

Figure 13 – Probability Curves and Inflation Target Coefficients: Robustness (5)



Note: First, the monthly conditional calculated probability curves, second the behavior of the 12-month accumulated inflation with the respective inflation targets and last, differential probability between the two conditional states.

Figure 14 – Probability Curves and Inflation Target Coefficients: Robustness (6)



Note: First, the monthly conditional calculated probability curves, second the behavior of the 12-month accumulated inflation with the respective inflation targets and last, differential probability between the two conditional states.