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

Regime de Metas e Credibilidade Fiscal no Brasil: Uma Análise Probabilística Utilizando Regressões Quantílicas

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Abstract: We investigate the interaction between fiscal credibility and the dynamic of Brazilian inflation, considering the target regime. Using instrumental quantile regressions, we find that the coefficients associated with fiscal credibility present asymmetric behavior in extreme quantiles. Moreover, the magnitude and sign of marginal effects change: positive at low levels of cumulative inflation and negative at periods of price acceleration. Sequentially, using conditional densities, we estimate that an improvement in fiscal credibility (+1 standard deviation) may reduce the probability that inflation will not close the month within the limits of the target regime by up to 25%. However, there is additional evidence that contradicts the intuition, indicating that after long periods of monetary stability, singular moments of recession and uncertainty may allow that a positive shock in fiscal credibility to increase the probability that inflation will violate bounds, since agents may interpret the change as a possible future discretionary behavior.

Keywords: Fiscal credibility. Quantile regression. Inflation target.

Resumo: Investigamos a interação entre a credibilidade fiscal e a trajetória da inflação acumulada Brasileira, considerando o regime de metas. Utilizando regressões quantílicas instrumentais, encontramos que os coeficientes associados à credibilidade fiscal apresentam comportamento assimétrico em quantis extremos. Além disso, a magnitude e o sinal dos efeitos marginais mudam: positivo em níveis baixos de inflação acumulada e negativo em períodos de aceleração de preços. Em sequência, usando densidades condicionais, estimamos que uma melhora na credibilidade fiscal (+1 desvio padrão) pode reduzir a probabilidade de que a inflação não feche o mês dentro dos limites do regime de metas em até 25%. Contudo, existem evidências adicionais que contradizem a intuição, indicando que após longos períodos de estabilidade monetária, momentos pontuais de recessão e incerteza podem possibilitar que um choque positivo na credibilidade fiscal aumente a probabilidade de que a inflação acumulada viole os limites, uma vez que os agentes podem interpretar a mudança repentina como um indicativo de comportamento discricionário futuro.

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Palavras-Chave: Credibilidade fiscal. Regressão quantílica. Metas de inflação.

JEL Code: E31; E52; E62.

1 Introduction

The inflation target regime has been adopted by central banks, including those in developing countries. Historically, New Zealand, in 1990, was the first to adopt the inflation target regime, shortly after, the adoption with Canada, in 1991, followed by the United Kingdom in 1992, Sweden and Finland in 1993, and Israel, Australia, and Chile in 1994. Brazil adopted the regime several years later, in 1999. This regime aims to stabilize prices, making the agent's expectations 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 can be found in papers by Bernanke *et al.* (1999), Vega and Winkelried (2005), Mishkin and Schmidt-Hebbel (2007), and Gonçalves and Salles (2008).

Through expectations, reputation and credibility have become indispensable instruments for success (MENDONÇA, 2007). In few words, they could keep inflation low by anchoring the expectations formation process, but their effectiveness (in the short run) depends on the agents' beliefs about the monetary authority (LEVIN *et al.*, 2004). 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 aggregates (NEUENKIRCH; TILLMANN, 2014).

However, for better price control, monetary credibility is a necessary but not sufficient condition and must be preceded by the fiscal stability and sustainability of public debt. According to Cespedes and Galí (2013), the global financial crisis of 2007– 2009 (the subprime crisis) was an inflection point for fiscal health to return to the debate. In practice, several nations explored fiscal instruments to overcome this crisis. However, as an inheritance of this arrangement, countries such as Greece, Italy, Ireland, Portugal, and Spain observed an accelerated increase in their public debt-to-GDP ratio and began to worry about the risk of debt default.

The interaction between fiscal policy and inflation has been the subject of an extensive research agenda. Benigno and Woodford (2003), Kirsanova *et al.* (2007), Galí (2008), and Çebi (2012) are examples of some studies that investigated the interaction of fiscal and monetary policies. The empirical evidence often indicates that fiscal-monetary interaction can be decisive both in the path of prices and in output. According to Nunes and Portugal (2009), weak coordination between monetary and fiscal policies should be considered a factor that can trigger or intensify a conjuncture of economic instability. At the threshold, the absence of sustainable fiscal rules can invalidate/reverse the direct effects of monetary policy on inflation (through debt monetization pressures, see SARGENT; WALLACE, 1981).

In terms of analyzing Brazilian price dynamics, the economy specifically experienced periods of hyperinflation in recent history, often reaching three digits in the 1980s. Only after Plano Real, in 1994, did the price index return 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 uncertainty, the deviation of the price level has returned to attention. For example, the Extended Consumer Price Index (IPCA) reached double digits in 2015 and, recently, in August 2021, which were unusual events.

The recent combination of growing inflation, high interest rate, and explosive path of public debt can deteriorate monetary and fiscal credibility. These facts together motivate the study about the effects of fiscal credibility on Brazil's inflation rates, considering the prevalence of the inflation target regime. Our paper aims to understand: *How does an increase in fiscal credibility affect the probability of accumulated inflation remaining within the target?*

To answer, we use instrumental quantile regressions and estimate the conditional density functions to obtain probabilities, without distribution assumptions. Our main contribution is to assess, probabilistically, how much fiscal credibility affects the maintenance of the price index within the limits of the inflation target regime. Why is the asymmetric effect of fiscal credibility important? Because it can make price movements smoother at different levels of inflation.

The results indicate that much of the asymmetry on price variation comes from the fiscal credibility index, which presents positive coefficients at the lower quantile of inflation and negative ones at the upper. Furthermore, we find evidence that an improvement in the fiscal credibility index can, in most cases, induce a reduction of up to 25% in the probability that cumulative inflation is out of target.

Additionally, after long periods of stability, singular moments of recession and uncertainty may allow a positive shock in fiscal credibility to increase the probability that cumulative inflation will close outside the inflation target. We believe that these exceptions occur through the channel of expectations since agents can associate a fiscal credibility shock with a future discretionary monetary policy. Finally, we reinforce the relevance of parsimony to conduce economic policies that do not consider heterogeneity phases in monetary and fiscal variables.

The rest of the paper is structured as follows: Section 2 briefly presents the theoretical/empirical discussion about fiscal credibility, section 3 explains the methodology/data, and section 4 analyses the results. Finally, section 5 summarizes the main conclusions.

2 FISCAL CREDIBILITY, WHAT DO WE KNOW?

Scholars such as Monacelli and Perotti (2008) and Galí *et al.* (2007) investigate aspects related to optimal fiscal policies. However, most of the literature overlooks the cross effects of fiscal commitment on monetary variables. Fiscal credibility is necessary to avoid default risk and smooth market expectations. King (1995) stresses that low fiscal credibility can lead to a higher interest rate. Similarly, Dominguez (2005) indicates that, as a consequence of low fiscal credibility, it may be necessary for the government to reduce the maturity of public debt. In other words, fiscal credibility is strongly related to the dynamic of public debt (MENDONÇA; MACHADO, 2013) and, consequently, to the agents' beliefs about government plans to avoid debt defaults. These expectations can be affected by well-defined rules and structural reforms (see KOPITS, 2000).

Specifically, regarding prices, according to Mishkin and Savastano (2001), the monetization risk of public debt can trigger inflationary pressures through expectations. Moreover, as mentioned by Mendonça and Hauel (2016), by solidifying the agents' beliefs, the monetary authority can reduce the interest rate and contribute to debt control. Demirel (2012) investigates the effects of the central bank on fiscal credibility through a baseline New Keynesian model for a closed economy with the government. The results indicate that if the policymaker can commit, monetary leadership is more desirable. However, if it is strongly discretionary, the fiscal planner is preferable. Fiscal responsibility plays a central role in the model, so gains in monetary stabilization (under central bank commitment) gradually decrease as fiscal credibility increases.

Lemoine and Linde (2016) examine the effects of fiscal consolidation under imperfect credibility. Through a *Dynamic Stochastic General Equilibrium* (DSGE) open economy model, calibrated for Europe, the authors find two main results: i) Under an independent monetary policy, the impact of limited credibility (about spending cuts) is small, and consolidation could reduce public debt for a low production cost. ii) The absence of monetary accommodation (under currency union) implies that the cost can be superior. Consequently, efforts to reduce government debt may be limited.

Hu and Zaragaza (2018) simulate a model to analyze the impact of fiscal credibility on economic cycles. The authors find that different degrees of credibility have a significant quantitative impact on the macroeconomic variables. According to the model, credible promises about future spending cuts can affect production more (compared to low-reliability announcements).

For the Brazilian economy, Mendonça and Machado (2013) present an empirical application for fiscal credibility[3] based on market expectations of the Debt-GDP ratio:

[3] Following the principles present by Mendonça (2007).

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

The fiscal credibility equals one if the expectations of the debt-to-GDP ratio, 12 months ahead, are less than or equal to the minimum limit. However, if these expectations are greater than or equal to the maximum limit, the fiscal credibility index is null. Finally, if the expected debt ratio is inside the $[Debt^{Max}, Debt^{Min}]$ interval, the credibility index is defined by the difference from the minimum. For debt limit bands, the authors use the *Maastricht Treaty*[4], a convention adopted by the *International Monetary Fund*. Results indicate that commitment to public debt increases fiscal credibility and, consequently, facilitates debt management. Furthermore, an increase in the average maturity of inflation-linked bonds increases the default risk (against what is verified by the standard literature). Additionally, an increase in the share of exchange-linked bonds decreases the debt-to-GDP ratio. The main message is that efficient management of debt demands credibility.

Mendonça and Hauei (2016) investigate the effects of fiscal and monetary credibility on Brazilian public debt, considering emerging economies under the inflation targets regime. Through a GMM estimator, Mendonça and Hauei (2016) find that credibility contributes to improving the management of public debt under 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.

Mendonça and Silva (2016) present a critique of the fiscal index presented by Mendonça and Machado (2013). The authors argue that the traditional index can overestimate the performance of fiscal credibility since it does not consider the primary surplus. To solve the problem, they propose an alternative index based on primary surplus expectations:

[4] Directly, $Debt^{Max}$ = 70% and $Debt^{Min}$ = 50%.

$$FCRED_t = \begin{cases} 1 \quad if \quad FPS_{Min}^{ideal} \leq E_t(FPS_{t+12}) \leq FPS_{Max}^{ideal} \\ 1 - \left[\frac{\left[E_t(FPS_{t+12}) - FPS_{Max}^{ideal}\right]}{FPS_{Max}^{tolerance} - FPS_{Max}^{ideal}}\right] \; if \; FPS_{Max}^{ideal} < E_t(FPS_{t+12}) \leq FPS_{Max}^{tolerance} \\ 1 - \left[\frac{\left[E_t(FPS_{t+12}) - FPS_{Min}^{ideal}\right]}{FPS_{Min}^{tolerance} - FPS_{Min}^{ideal}}\right] \; if \; FPS_{Min}^{ideal} < E_t(FPS_{t+12}) \leq FPS_{Min}^{tolerance} \\ 0 \quad if \quad E_t(FPS_{t+12}) < FPS_{Min}^{tolerance} \; or \; E_t(FPS_{t+12}) > FPS_{Max}^{tolerance} \end{cases} \tag{2}$$

Where $\left[FPS_{Min}^{ideal}, FPS_{Max}^{ideal}\right] = [FPS^* - 0{,}05, FPS^* + 0{,}10]$ and $\left[FPS_{Min}^{tolerance}, FPS_{Max}^{tolerance}\right] = [FPS^* - 0{,}15, FPS^* + 0{,}30]$. Using *Ordinary Least Squares* (OLS), *Generalized Method of Moments* (GMM), and *Vector Autoregression* (VAR) analysis, the results suggest that the primary surplus is relevant to reduce inflation and anchor expectations.

Recently, Montes and Acar (2018) indicate that since 2009, there have been several revisions to the primary surplus target. These changes indicate that this variable may respond to political pressures in Brazil. Therefore, conveniently, policymakers may use surplus targets to anchor market expectations (in the short term), which does not reflect improvements in credibility. The authors provide an attempt to unify the debt and surplus dimensions into one fiscal credibility indicator and analyze the impacts on the disagreement in expectations about inflation:

$$ICF_t = \begin{cases} 1 & if \quad E_t(ps_{t+12}) \geq ps^{ideal} \\ 1 - \left[\frac{\left[E_t(ps_{t+12}) - ps^{ideal}\right]}{ps^{toler} - ps^{ideal}}\right] & if \quad ps^{ideal} > E_t(ps_{t+12}) > ps^{toler} \\ 0 & if \quad E_t(ps_{t+12}) \leq ps^{toler} \end{cases} \tag{3}$$

Results indicate that when fiscal credibility is low, the uncertainty related to the future behavior of inflation is higher. The ps^{ideal} term represent the required primary surplus throughout the year for gross public debt in relation to GDP reach 50% in 12 months, and ps^{toler} is the required primary surplus for gross public debt in relation to GDP reach 70% the maximum tolerable amount for the public debt so that it does not become unsustainable (Maastricht Treaty). Both depends on debt-to-GDP, expected real interest rate and expected output growth rate (12 months ahead).

$$ps^{ideal} = (Debt_t - 50\%) + Debt_t\left[\frac{E_t(r_{t+12}) - E_t(g_{t+12})}{1+E_t(g_{t+12})}\right] \quad (4)$$

$$ps^{toler} = (Debt_t - 70\%) + Debt_t\left[\frac{E_t(r_{t+12}) - E_t(g_{t+12})}{1+E_t(g_{t+12})}\right] \quad (5)$$

As mentioned above, the advantage of this approach is the union of the debt-GDP ratio and the primary surplus in the same indicator, considering the expectations related to the fiscal effort required to keep gross public debt at a sustainable level. Therefore, we adopted the Montes and Acar index (2018) as a reference, but in the robustness section, we tested the two other approaches: Mendonça and Machado (2013) and Mendonça and Silva (2016).

Based on the above contributions, our objective is to investigate whether the relationship between fiscal credibility and inflation remains at the extreme quantiles of current inflation distribution and, especially, if this relationship may affect the probability of accumulated inflation remaining within the target. There are advantages to using quantile regressions in this problem, which offer responses conditional to the different moments of inflation. In the following section, we develop the methodological strategy adopted through quantile regression models.

3 METHODOLOGY

The quantile regressions (QR) were introduced by Koenker and Bassett (1978). Unlike the OLS models (based on the mean), the QR approach studies the asymmetric effect of an independent variable at various quantiles of the dependent y_t. In other words, the QR models can incorporate heteroscedasticity since they allow us to verify if the coefficients of the explanatory variables change significantly (statistically) at different points of the explained variable distribution.

Considering a vector of response $y = (y_1, y_2, \dots y_t)$ and another vector of explanatory variables $x = (x_{1i}, x_{2i}, \dots, x_{ki})$, with subscript i representing the series within the same variable, a standard linear regression model can be written as $E(y \mid x) = x' \beta$, such that β is a vector of k parameters. Similarly, 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 conditioned to the $\tau - quantile$ and estimates can be obtained by the solution below:

$$\min_{\forall\beta \in R} \sum_{i=1}^{t} \rho_\tau\big(y - x'\beta(\tau)\big) \tag{6}$$

Given ρ_τ as a linear loss function:

$$\rho_\tau(u) = \begin{cases} \tau u, & u \geq 0 \\ (\tau - 1)u, & u < 0 \end{cases} \tag{7}$$

Replacing:

$$Q\big(\beta(\tau)\big) = min\left[\tau \sum_{i:y \geq x'\beta(\tau)}^{t} |y - x'\beta(\tau)| + (1-\tau) \sum_{i:y < x'\beta(\tau)}^{t} |y - x'\beta(\tau)|\right] \tag{8}$$

The non-differentiable function of Equation (8) requires linear programming methods for its minimization and can be presented by:

$$\min_{\beta(\tau) \in R} \quad \tau U + (1-\tau)V \tag{9}$$
$$s.a. Y = \beta(\tau)X + U - V$$

Where the error vector u is divided into vectors U and V, with elements containing respectively the positive and negative parts of the residuals.

Commonly, two approaches stand out for the solution: The Simplex method for moderate-size samples or the Interior Point method for large databases. Both guarantee a solution with a finite number of iterations. Finally, the construction of the confidence intervals is performed by the moving blocks bootstrap standard errors, which are frequently employed, even when the residual errors follow a normal.

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

$$f_n\left(F_n^{-1}(t)\right) = \frac{2h_n}{F_n^{-1}(t+h_n) - F_n^{-1}(t-h_n)} \tag{10}$$

we obtain $F^{-1}(s)$ using the empirical quantile function for the linear model. 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 Mendonça and Silva (2016). Furthermore, we estimate a Hybrid New Keynesian Phillips Curve:

$$\pi_t = \beta_1\, \pi_{t-1} + \beta_2\, E_t\left[\pi_{t+1}\right] - \beta_3\, x_t + \beta_4\, ICF_t + \varepsilon_t \tag{11}$$

But this version of the Phillips Curve presents 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) by Fitzenberger (1998). This 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 for any residual distribution and provides heteroscedasticity and autocorrelation robust standard errors.

We use monthly data[5], between 2003 and 2020, to improve quantile and conditional density estimations (Table 01). The explained variable is the accumulated 12- month IPCA seasonally adjusted (X13-ARIMA). In the explanatory block, we have inflation expectations and fiscal credibility[6], using the Central Bank reports based on the monthly median of the FOCUS estimates over the next 12 months.

For the gap variable (the marginal cost of the economy), we chose two proxies based on the contributions by Galí and Gertler (1999) and Sims (2008): *i* - The Brazilian industrial output, and *ii* - The share of wages mass in production. We calculate *i* as the difference between the industrial production index, seasonally adjusted, and its potential value (obtained through the Hodrick-

[5] We chose to keep the benchmark model until March 2020, before social distancing began in Brazil. However, we use pandemic data as a robustness test in the results section.

[6] Using month ahead expectations for public debt (limits 0.5 and 0.7), primary surplus, Selic rate and GDP growth.

Prescott filter) and *ii* as the ratio between effective wage mass[7] and the nominal GDP, seasonally adjusted.

Finally, for changes in the prices of the non-produced inputs, (Δv_t), we follow Mazali and Divino (2010) and calculate the percentage change in the nominal exchange rate (monthly mean) between real and dollar for a three-period interval[8].

Table 1 – HNKPC - Variables

Name	Time	Source
Fiscal Credibility Index	2003:01 – 2020:02	Montes and Acar (2018)
Accumulated 12-Month Inflation	2003:01 – 2020:02	IBGE
Lagged Acc. 12-Month Inflation	2003:01 – 2020:02	IBGE
Inflation Exp. Acc. Next 12 Months	2003:01 – 2020:02	BACEN
Output Gap	2003:01 – 2020:02	IBGE
Wage Mass	2003:01 – 2020:02	IBGE
Nominal Exchange Rate	2003:01 – 2020:02	BACEN

Note: Elaborated by the authors. Data sources descriptions and time interval.

Fiscal Credibility Index, Output Gap, Wage Mass, Inflation Expectations, Unemployment, and Exchange Rate are endogenous[9]. Then, following Blanchard and Galí (2007), Mazali and 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 where the literature suggests the use of only one lag[10].

[7] Total of employed population multiplied by the average monthly income, from Monthly Employment Survey – PME.

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

[9] The expectation formation phase responds to the current dynamics of macroeconomic variables and, indirectly, to the agent's perceptions and fears. In other words, *forward-looking* endogeneity comes from output gap, prices, and movements beyond the traditional formulation of the Phillips curve, such as uncertainty, fiscal responsibility, international trade, governance, and even institutional/political changes.

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

4 RESULTS

The estimates indicate stable behavior (across 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 *Two-Stage Least Squares* (2SLS) estimates. The QR and 2SLS confidence intervals do not intersect, reinforcing the asymmetric marginal effect of fiscal credibility on inflation accumulated in the last 12 months.

Table 2 – Results HNKPC

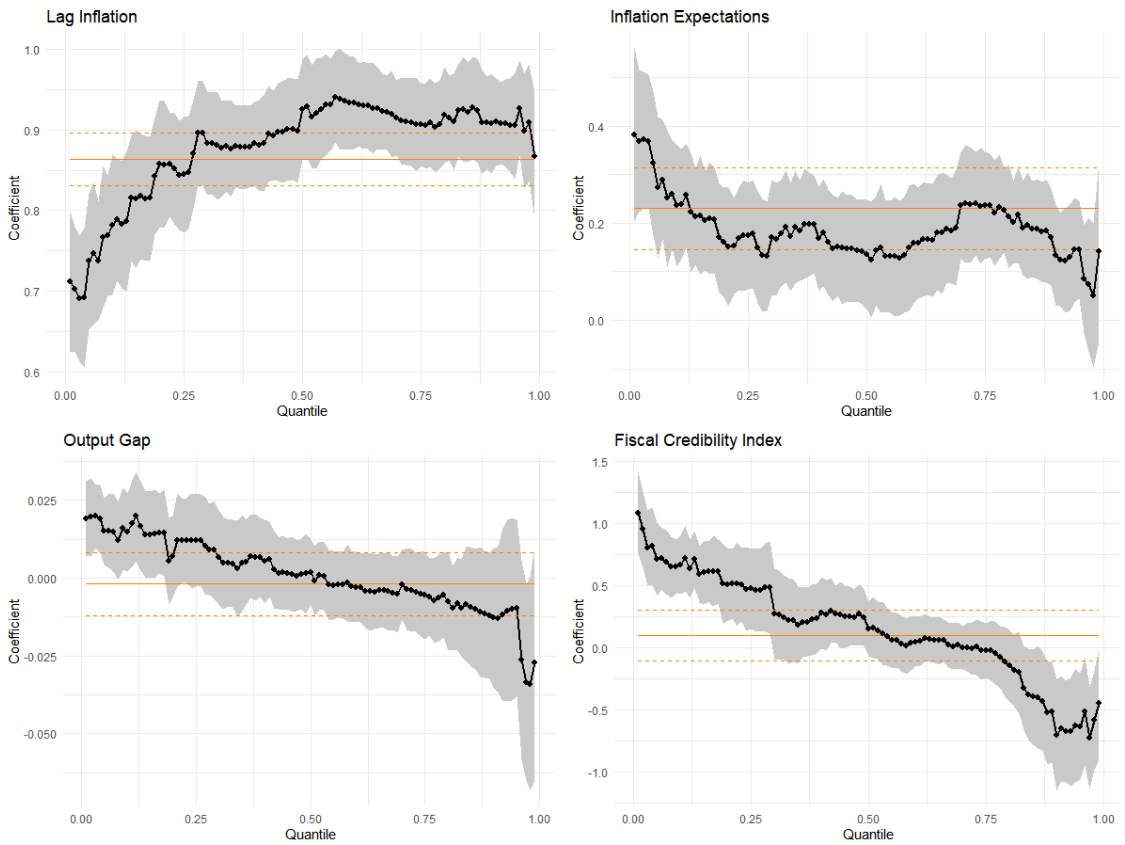
Estimator	Quantile	β_1	β_2	β_3	β_4
GMM		0.858*	0.283*	0.004	-0.127*
2SLS		0.863*	0.230*	0.001	-0.100
	0.05	0.737*	0.323*	0.014**	0.715*
	0.10	0.782*	0.236*	0.014***	0.670*
	0.15	0.814*	0.216*	0.013	0.607*
	0.20	0.857*	0.160*	0.006	0.508*
	0.25	0.844*	0.173*	0.012	0.476**
	0.30	0.883*	0.170*	0.006	0.273**
	0.35	0.876*	0.191*	0.004	0.185***
	0.40	0.883*	0.168**	0.005	0.284**
	0.45	0.897*	0.149*	0.001	0.254***
QR	0.50	0.925*	0.135**	0.001	0.155
	0.55	0.930*	0.131***	-0.002	0.063
	0.60	0.933*	0.158**	-0.002	0.050
	0.65	0.926*	0.180*	-0.004	0.059
	0.70	0.914*	0.236*	-0.002	-0.001
	0.75	0.906*	0.248*	-0.005	-0.019
	0.80	0.918*	0.213*	-0.007	-0.139

0.85	0.921*	0.188*	-0.009	-0.394**
0.90	0.907*	0.133*	-0.012	-0.704*
0.95	0.904*	0.145*	-0.009	-0.632*

Note: Elaborated by the authors. All standard error estimates and the covariance matrix of the regressions were based on the MBB method. (*) is relative to 1%, (**) 5% and (***) 10%.

The fiscal credibility coefficients present asymmetric behavior at 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. Below, we present figure with estimates and confidence intervals (95%) for all percentiles:

Figure 1 – HNKPC Coefficients



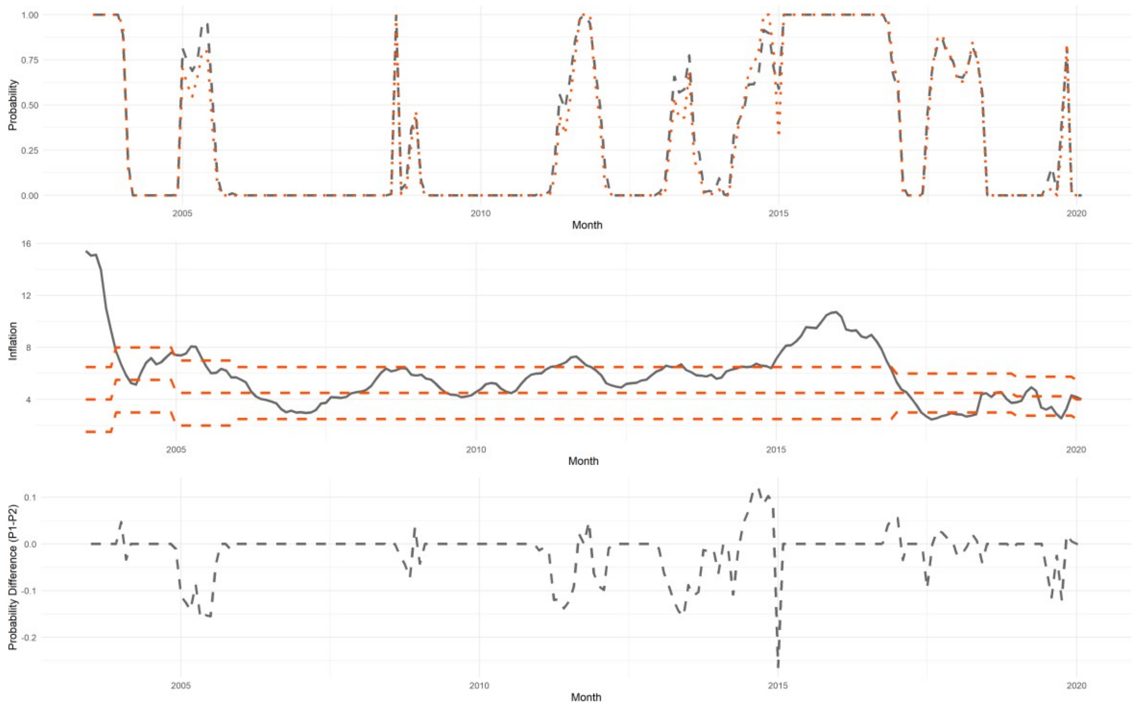
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

This result illustrates a behavior not yet documented by the Brazilian literature: for low levels of accumulated inflation, fiscal credibility can exert a perverse effect, boosting the index of aggregate prices in the economy. Following this, to capture the 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 +1 standard deviation each month. Most of the time (when the probability is non-zero), fiscal credibility reduces price deviation and helps the maintenance of the target regime (an expected result, considering the observations of MISHKIN; SAVASTANO, 2001; DEMIREL, 2012; MENDONÇA; HAUEL, 2016; HU; ZARAGAZA, 2018).

But in some cases, our contrafactual results confirm the previously suggested hypothesis: After periods of monetary stability, specific moments of uncertainty may allow that a positive shock in fiscal credibility can lead to an increase in the probability that accumulated inflation will violate the target bounds.

Figure 2 – Probability Curves and Inflation Target



Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

To better illustrate these periods, we highlight some conjunctural facts of the Brazilian economy[11]: In August and December 2011, amid an international crisis and a new president in Brazil, some signs of economic weakness could be observed by the contraction of Gross Domestic Product and price index advances. These facts reinforce market fears, accentuating macroeconomic uncertainty, especially regarding the new conduct of monetary and fiscal policies. Similar facts characterized the national conjuncture at the end of 2014: After pro-impeachment protests, there was a new wave of insecurity concerning public management. Finally, between 2018 and 2019: After the presidential election, strong divergences in public opinion (leveraging market uncertainty), and poor economic performance, another increase in probabilities occurred. Therefore, sometimes the average effect can lead us to a sub-representation of the picture and undesired dynamics. To validate the findings, we submit the New Keynesian Phillips Curve to some changes (maintaining 95% confidence): proxies for economic activity, the inclusion of the exchange component and the use of alternative fiscal credibility indexes[12] and current data:

1- Use of Wage Mass as a measure of economic activity

2- Use of IBC-Br Gap as a measure of economic activity

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

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

7- Mendonça and Machado (2013) Fiscal Credibility Index

8- Mendonça and Silva (2016) Fiscal Credibility Index

9- Pandemic Period (2020:02-2021:08).

When we replace the gap measure (Industrial Production) with wage mass[13],

[11] We do not intend to explore causal relationships. Decomposition of causes in macroeconomics is complex and beyond the scope of this paper. However, instrumental analysis focused on marginal effects provides good *insights* about credibility and expectations, respecting Lucas' (1972) recommendations.

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

[13] Considering the extinction of the Monthly Employment Survey – PME (in March 2016), we have a limited time horizon (2003:01–2016:02).

we observe similar results. First, the backward-looking component oscillates between 0.70 and 0.90 within the 2SLS confidence interval. The inflation expectations have stable behavior (with a small downward trend) over the quantiles, and the wage mass variable presents no statistical significance. However, the fiscal credibility index shows a strongly decreasing behavior and is significant at the extreme quantiles, changing the sign (positive to negative) but less volatile. Furthermore, when we replace the industrial gap with the IBC-Br, the results remain without improvements of significance. In other words, economic activity parameters are not affected by this proxy changes.

We revalue the probability curves to verify if improvements in fiscal credibility can affect the probability that accumulated inflation will close the month within the target. Again, most of the time, there is evidence that an improvement in fiscal credibility can reduce the probability that accumulated inflation does not remain within the target regime bands. For wage mass, the reduction reaches a maximum value of 20%. However, it is possible that improvements in credibility positively affect the chance of cumulative inflation closing the month outside the target. Moreover, it usually occurs after long periods of stability (within the target), reinforcing the previous results of the positive coefficients at the lower quantiles of the conditional distribution of the accumulated inflation. Similar behavior arises when we use IBC-Br: the reduction reaches 25%. Moreover, we note the return of the previously verified pattern (in the same periods): a possible increase in the probability of cumulative inflation being out of target after improvements in fiscal credibility.

Moving to the pass-through component, we can observe that the results for the backward and forward-looking terms are stable, as well as the non-significance of the real variable remains. The unemployment[14] proxy presents a slight gain of significance at central quantiles. The inclusion of the labor market variable allows us to better visualize 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 at extreme quantiles. The

[14] Considering the extinction of the Monthly Employment Survey - PME (in March 2016), we have a limited time horizon (2003:01-2016:02).

coefficients for the exchange rate are small or non- significant. We proceeded to reevaluate the conditional probabilities and analyze how an improvement in fiscal credibility can affect the accumulated inflation dynamics and the effectiveness of the inflation target, considering a generalized increase of +1 standard deviation on the monthly fiscal credibility index. Once again, the results already observed are verified.

Alternatively, when we consider the fiscal credibility indexes by Mendonça and Machado (2013) and Mendonça and Silva (2016), we can notice similar results (magnitude and significance). Hence, regardless of the index, fiscal credibility asymmetrically affects inflation and conditional probabilities seem to be strengthened with peaks in the beginning of 2015.

Finally, considering the contemporary debate about economic policies and pandemics, in the last robustness test we included data up to August 2021 (covering the Covid-19 period) and a dummy variable for control. The patterns are similar to the previous ones, but data inclusion has implications for the probability curve. The results indicate that in periods of global uncertainty, higher fiscal credibility (historically +1 standard deviation) could reduce the probability of inflation target violations (after March 2020). Although the best data inclusion strategy for the pandemic period is not consensual[15], this counterfactual exercise using quantile regressions reinforces the verified asymmetry and importance of government commitment.

5 Conclusion

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 99 quantiles. We found a mean-central behavior (across quantiles) for the coefficients of lag component, expectations, and product gap. Moreover, the asymmetry of the fiscal credibility index has a positive effect at the 5–20% quantiles and a negative one at

[15] See Lenza e Primiceri (2020) and Huber *et al.* (2020).

the 70–99% quantiles of the accumulated inflation.

This unexpected behavior is reinforced by 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 probability by up to 25% of accumulated inflation to break the target limits. However, there are exceptions. After long periods of monetary stability, recessions and uncertainty may allow fiscal credibility to increase (up to 10%) the probability that accumulated inflation will violate the inflation target bounds through expectations.

In other words, our main conclusion is not about the effectiveness of fiscal credibility (validated in most of the periods), but about the exceptions for Brazil. Agents may understand the short-term improvement in fiscal stability as future discretionary behavior. Then, they adjust prices upwards and make inflation rise. Future papers could calculate the persistence of accumulated inflation shocks, use nonlinear quantile regressions and extend both fiscal credibility parameters and control variables for pandemic.

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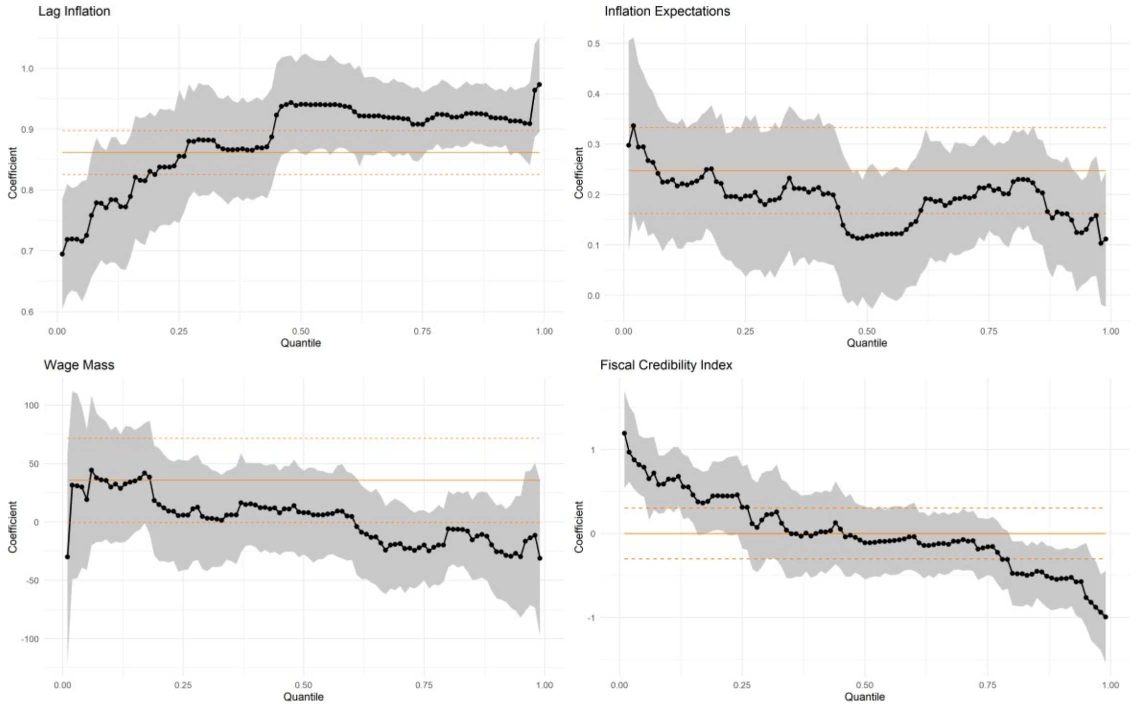
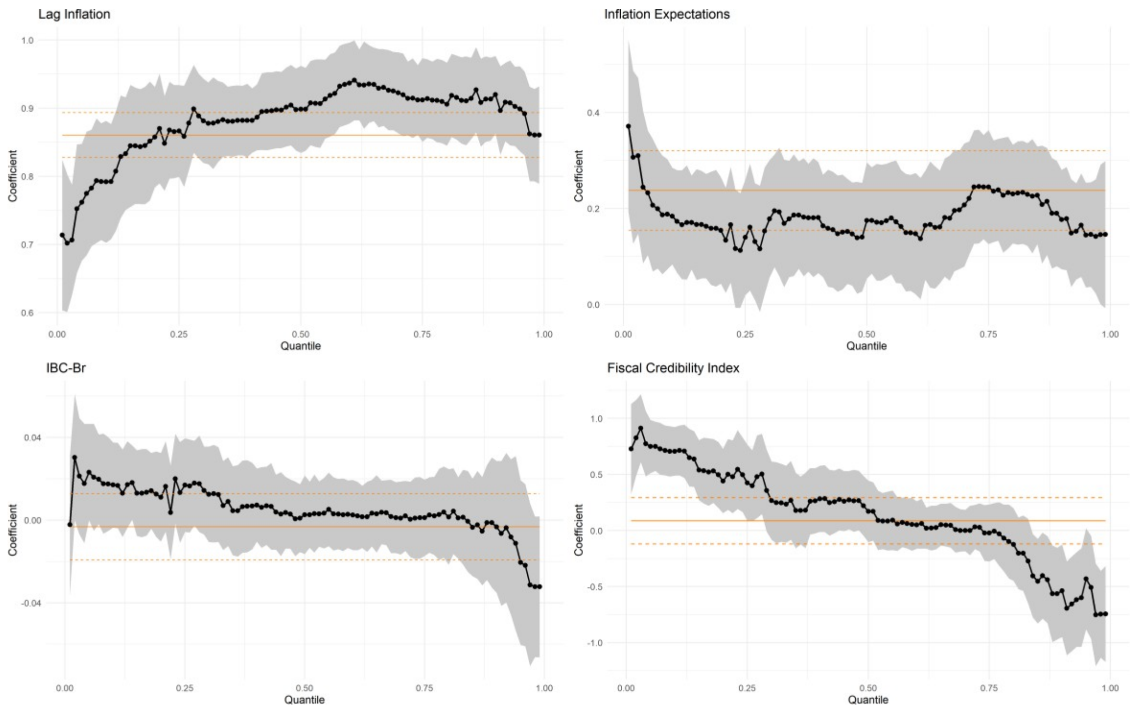
Appendix

Figure 3 – Robustness (1): Coefficients



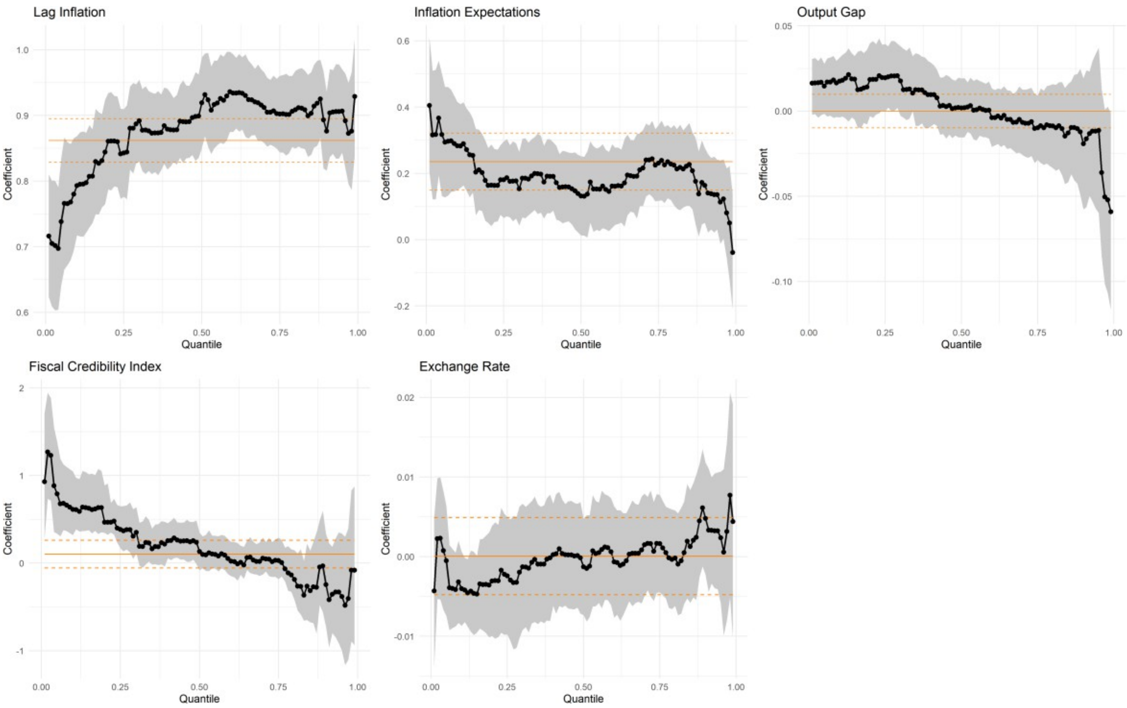
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 4 – Robustness (2): Coefficients



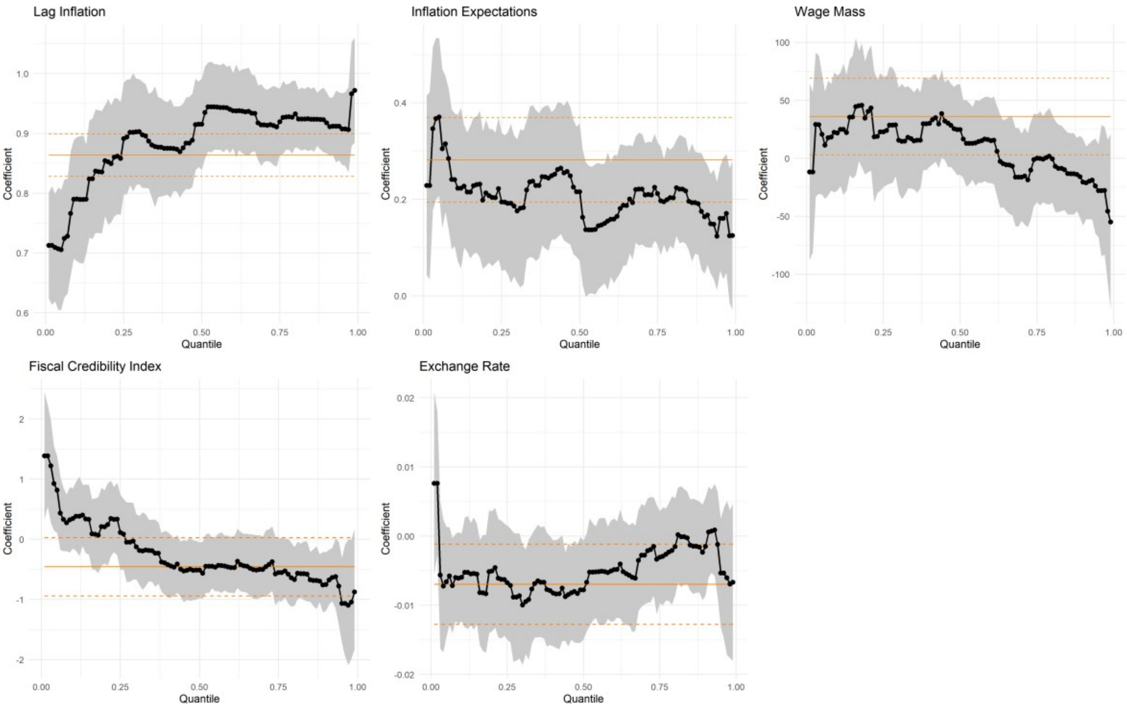
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 5 – Robustness (3): Coefficients



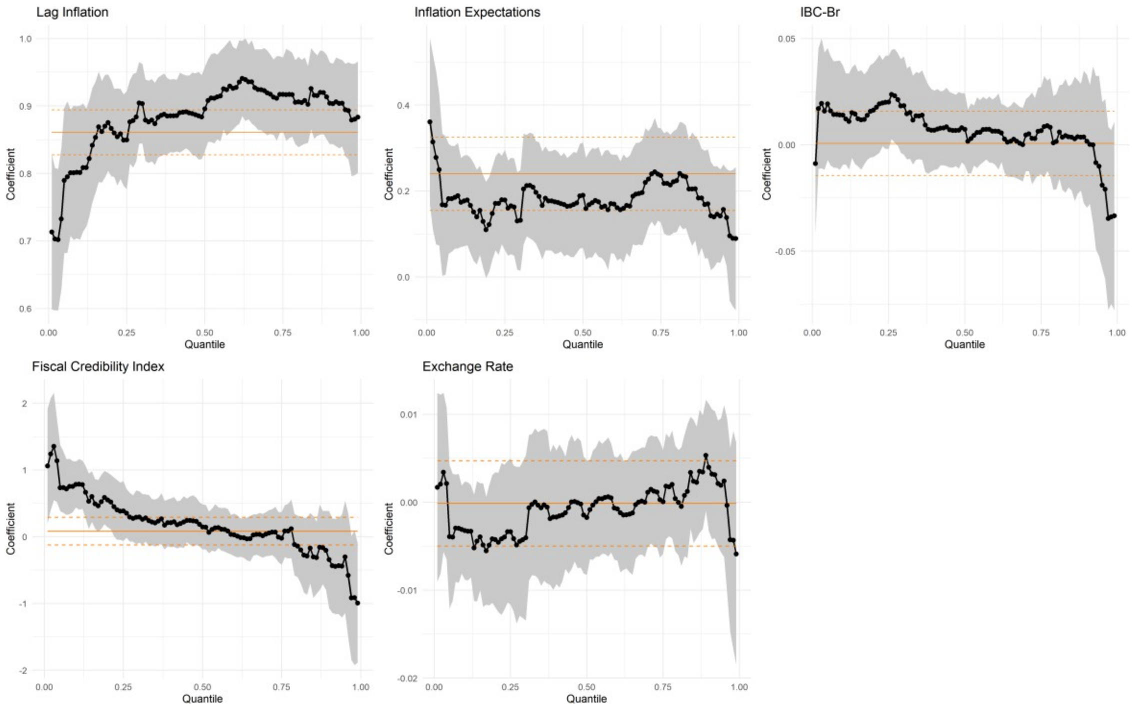
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 6 – Robustness (4): Coefficients



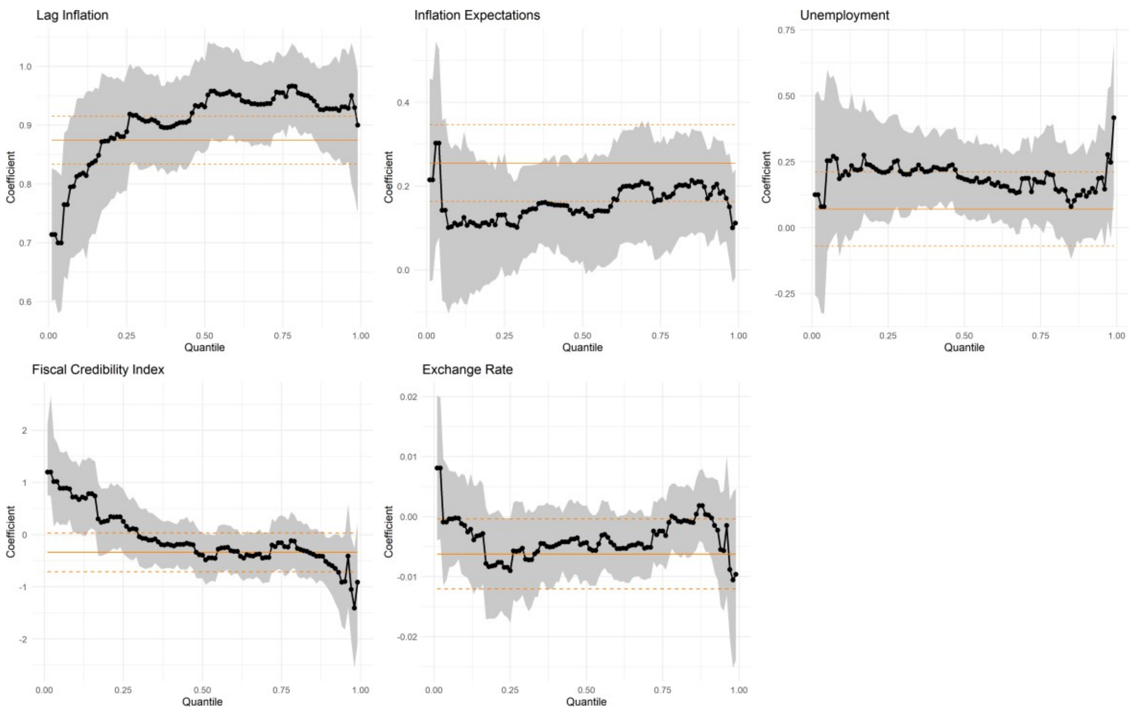
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 7 – Robustness (5): Coefficients



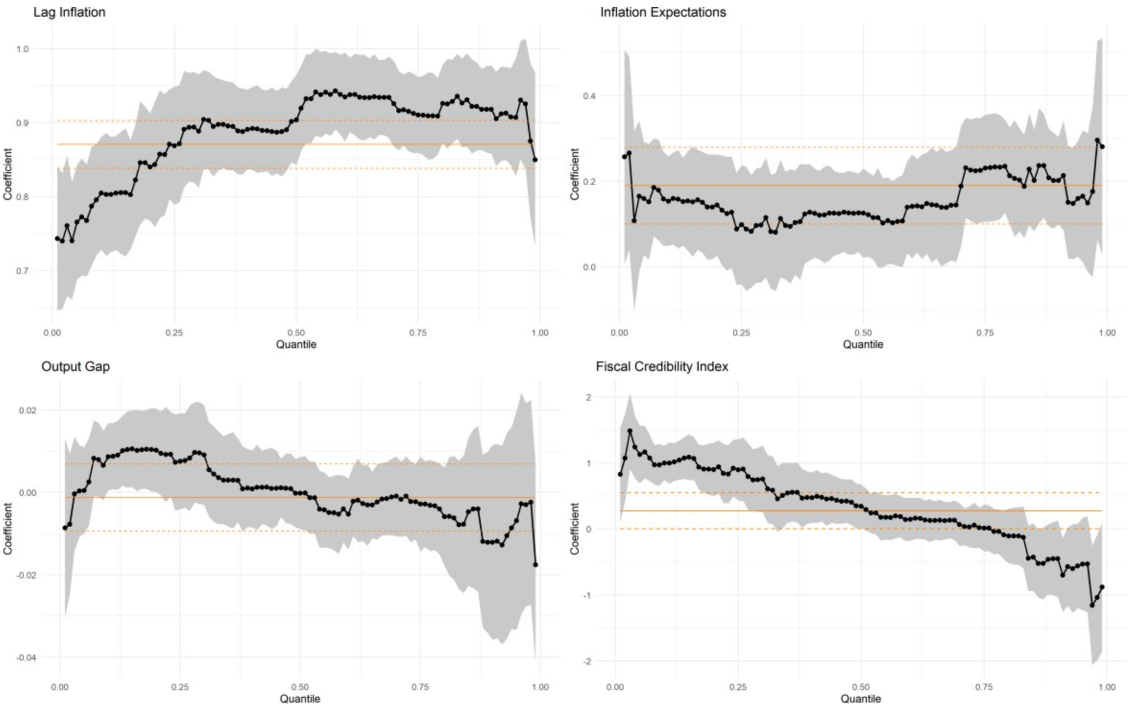
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 8 – Robustness (6): Coefficients



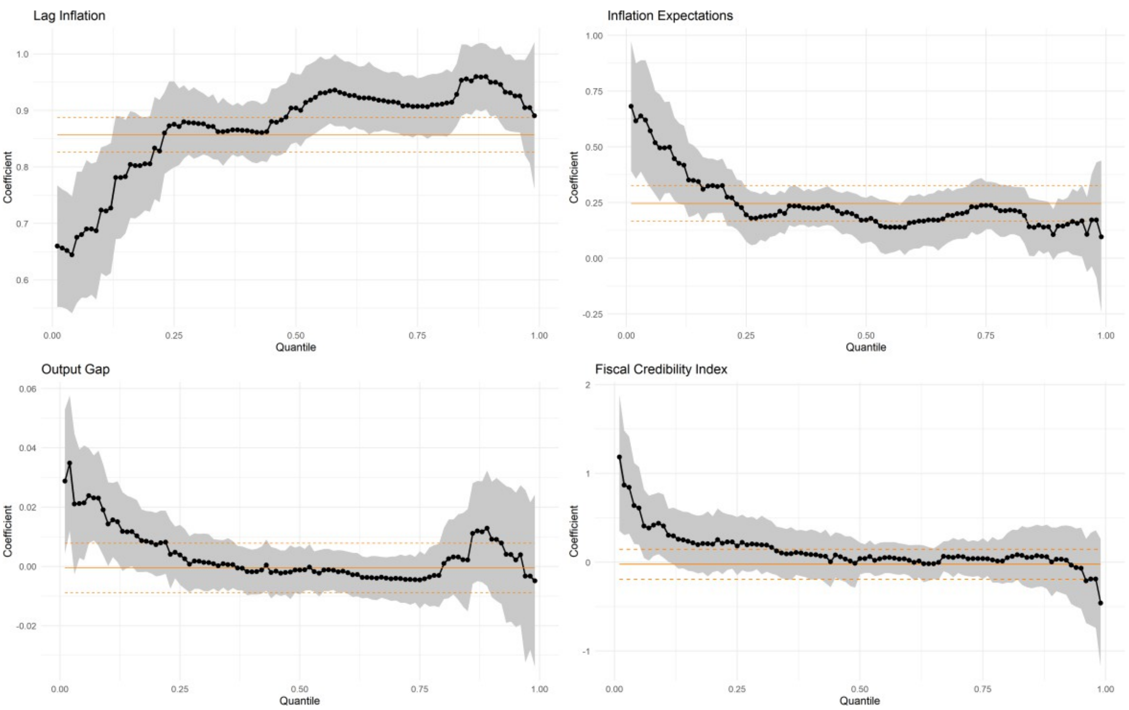
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 9 – Robustness (7): Coefficients



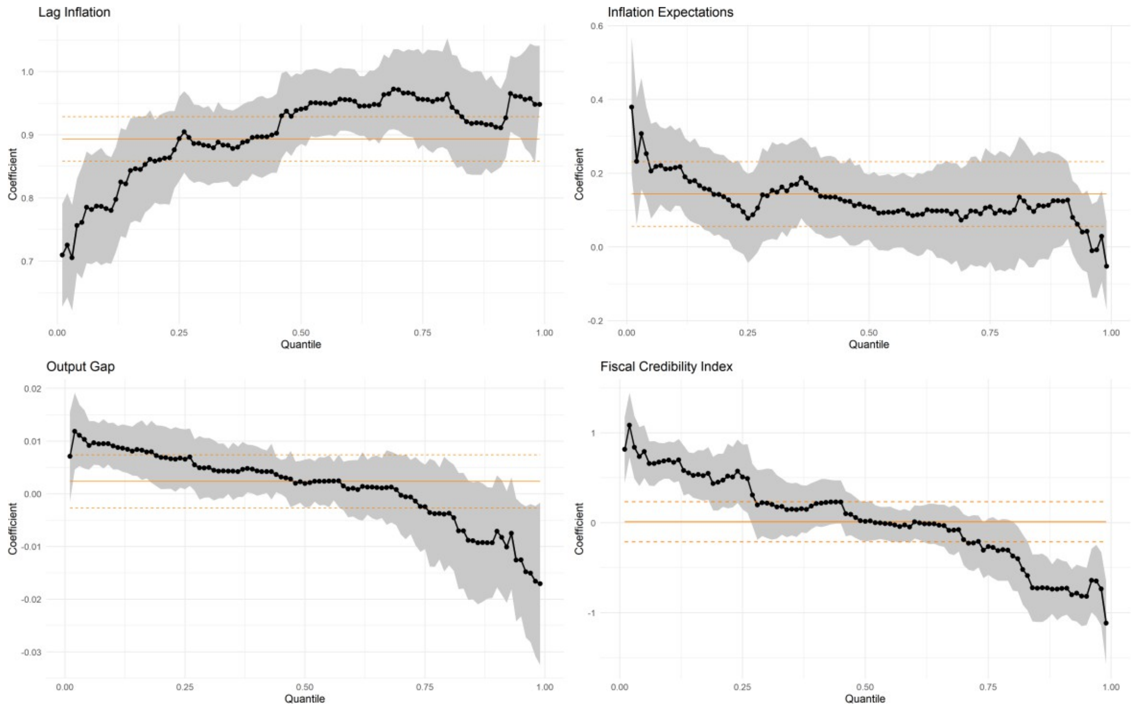
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 10 – Robustness (8): Coefficients



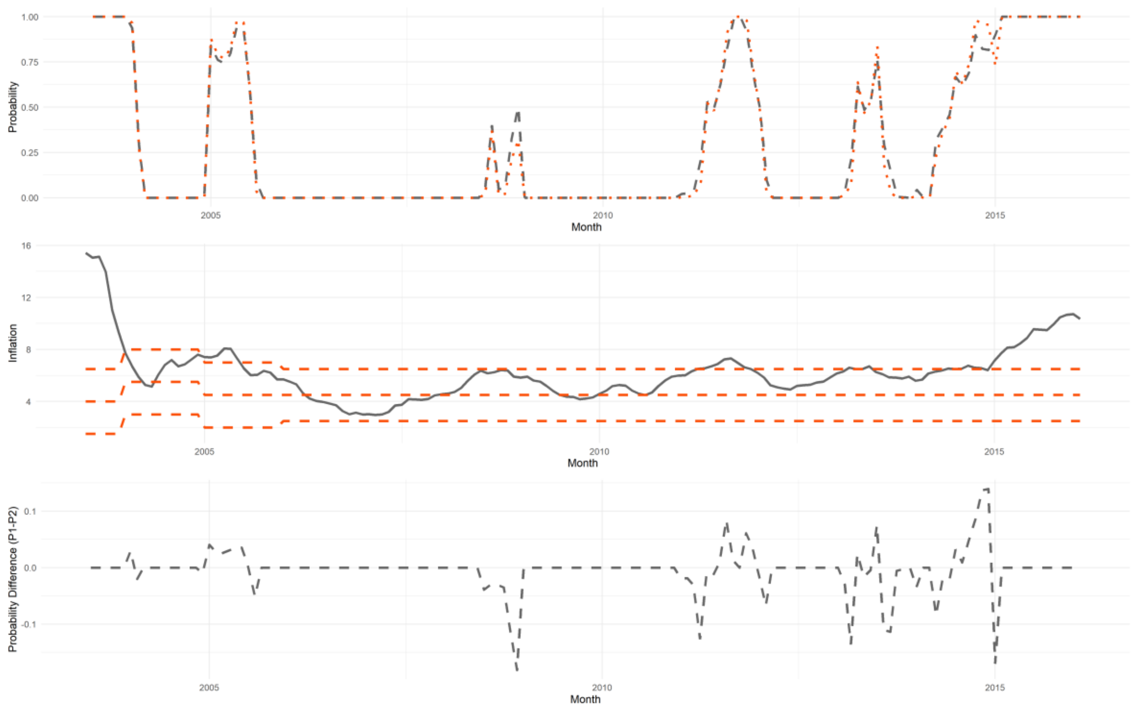
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 11 – Robustness (9): Coefficients



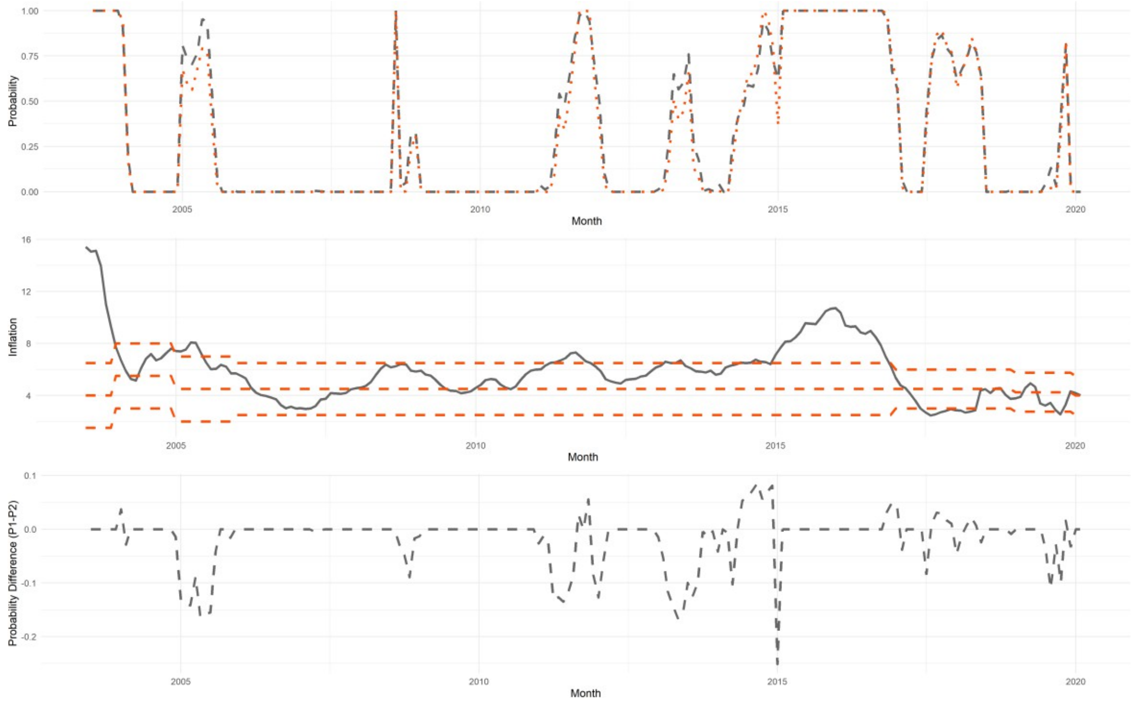
Note: The y-axis indicates the value of the coefficient, and the x-axis is the quantile analyzed. The black dotted line represents the estimated coefficients for each quantile and the shaded region shows the confidence interval for these estimates. Moreover, the horizontal lines represent 2SLS (orange) values with their respective confidence intervals (dashed orange lines).

Figure 12 - Probability Curves and Inflation Target Coefficients: Robustness (1)



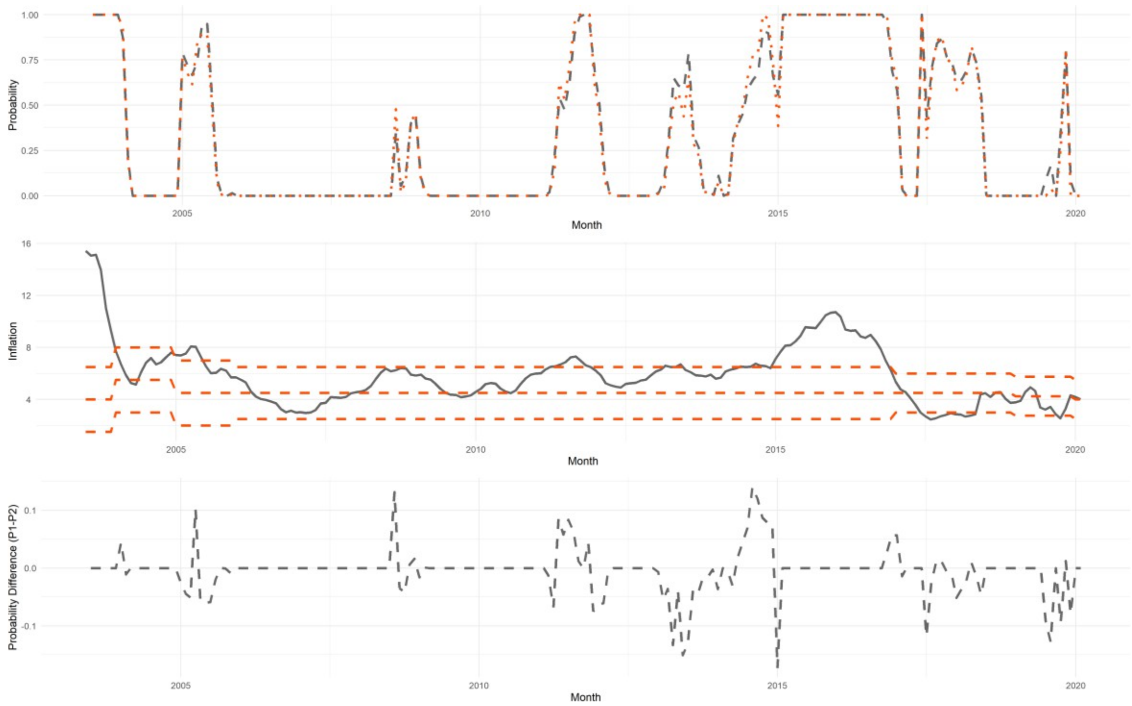
Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

Figure 13 - Probability Curves and Inflation Target Coefficients: Robustness (2)



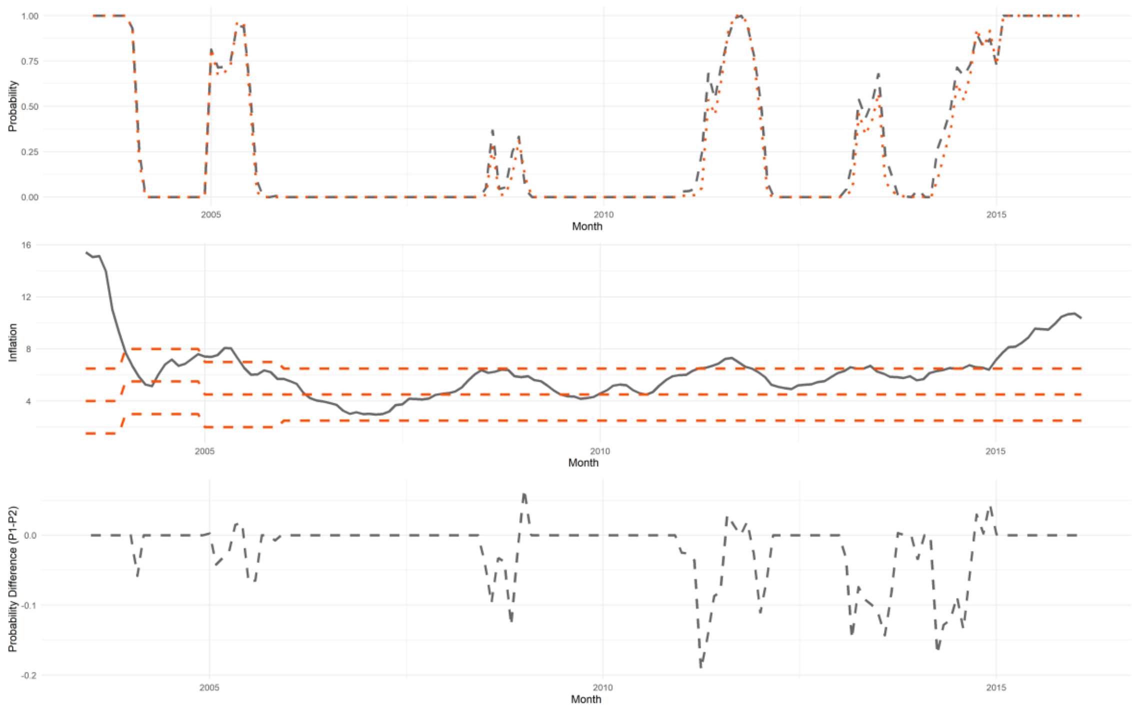
Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

Figure 14 - Probability Curves and Inflation Target Coefficients: Robustness (3)



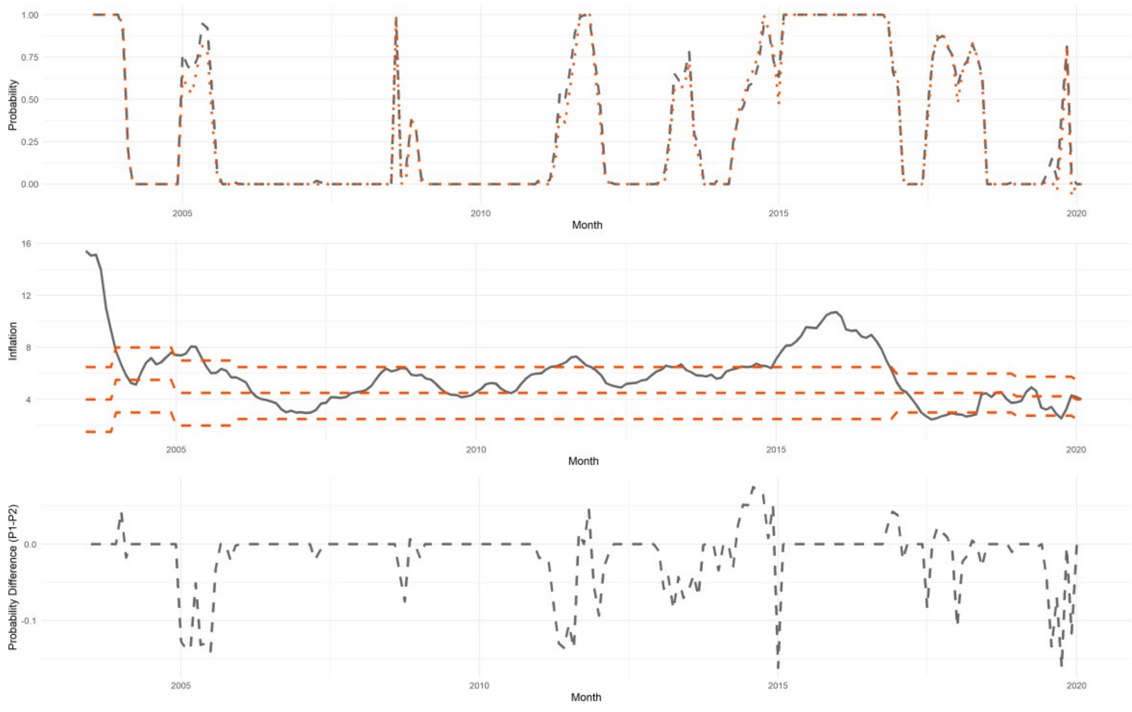
Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

Figure 15 - Probability Curves and Inflation Target Coefficients: Robustness (4)



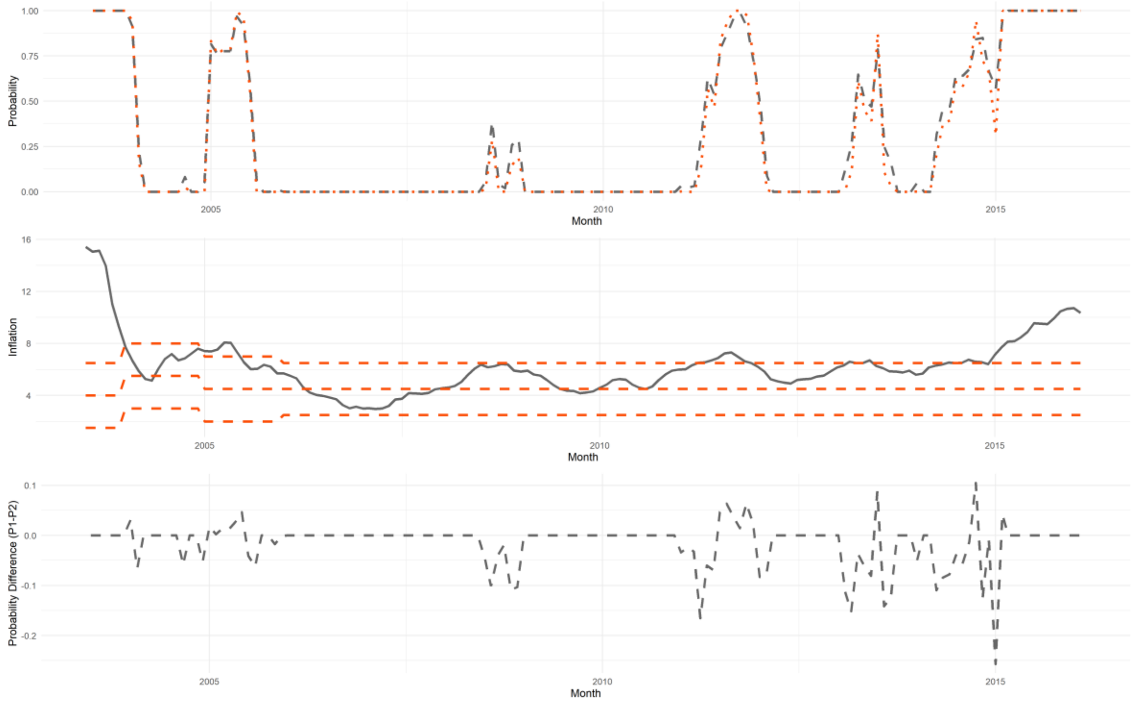
Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

Figure 16 - Probability Curves and Inflation Target Coefficients: Robustness (5)



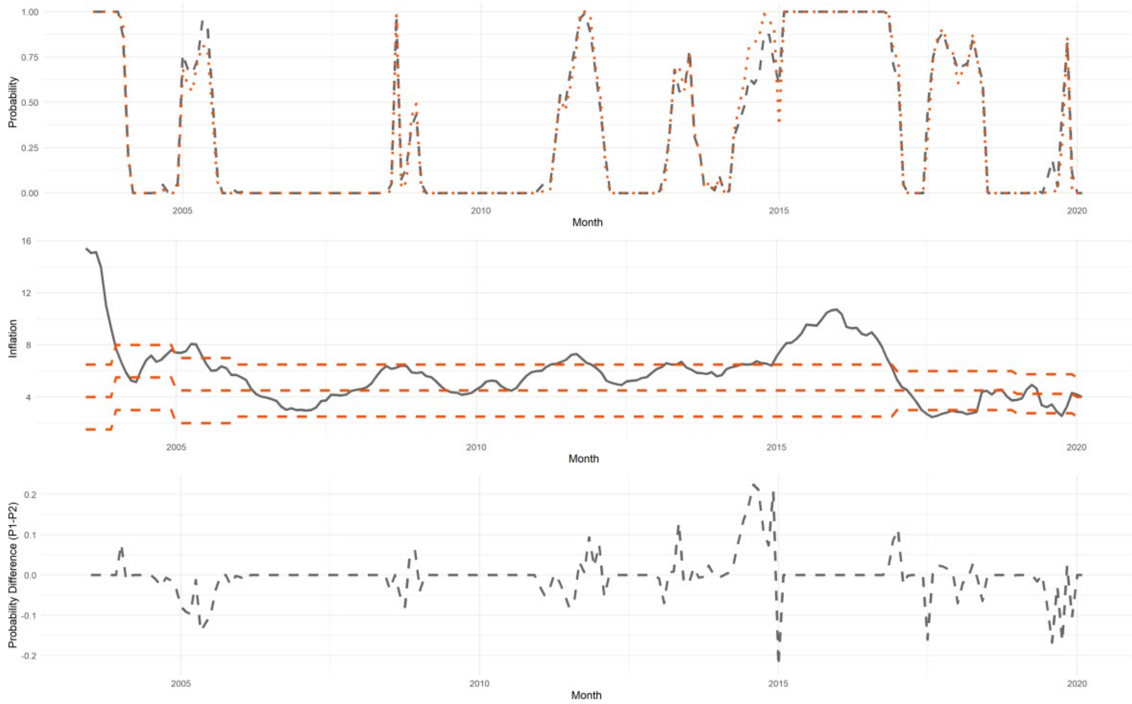
Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

Figure 17 - Probability Curves and Inflation Target Coefficients: Robustness (6)



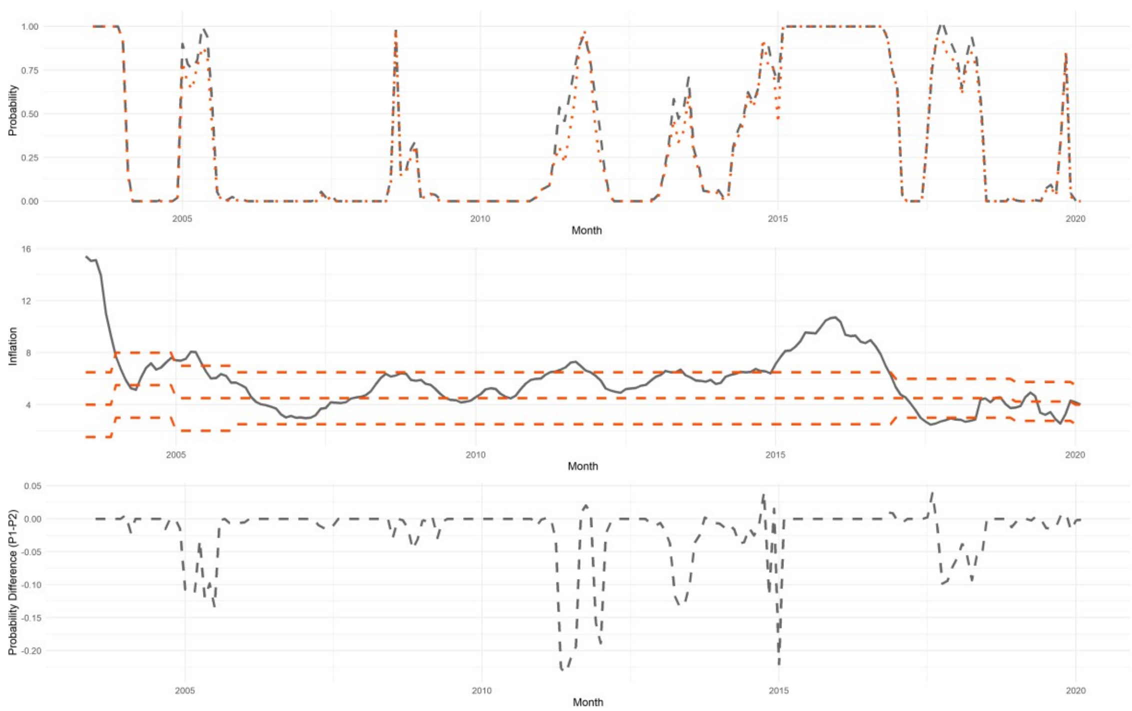
Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

Figure 18 - Probability Curves and Inflation Target Coefficients: Robustness (7)



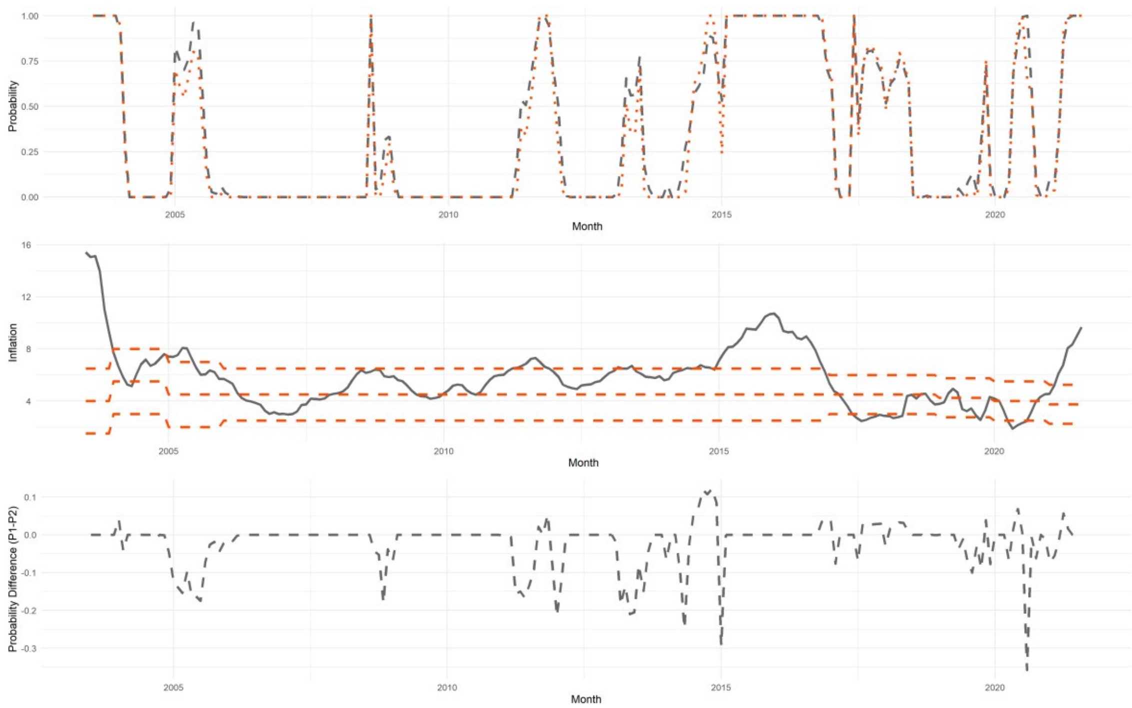
Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

Figure 19 - Probability Curves and Inflation Target Coefficients: Robustness (8)



Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.

Figure 20 - Probability Curves and Inflation Target Coefficients: Robustness (9)



Note: In the top figure, we have the monthly conditional probability curves (break target). The second one represents the behavior of 12-month accumulated inflation, with the respective inflation targets. Finally, in the bottom figure, we calculate probability differences between two conditional states of break: 1 - Density is estimated monthly based on the observed values of the variables, and 2: The density is estimated based on the same data, but with the addition of +1 standard deviation in the fiscal credibility index for each month.