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Testing for asymmetric adjustment in weekly Brazilian inflation

Teste para ajuste assimétrico na inflação semanal brasileira

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Abstract

This study analyses the nature of weekly inflation response to shocks in the Brazilian economy by adopting a generalized quantile autoregression model in which the autoregressive parameter is allowed to be quantile-dependent. We test for unit root at different conditional quantiles of the response variable, by characterizing its asymmetric dynamics along the business cycle. The method allows us to estimate the magnitude, sign, and the significance of actual shocks that affect Brazilian inflation. We evaluate the robustness of results by adopting a bootstrap procedure. Concerning previous studies, we find evidence of stronger asymmetric persistence in inflationary dynamics in which an inflationary shock below the average dissipates very fast when compared to an inflationary impulse occurring above the average. Location, size, and the sign of a random shock might be essential for inflation adjustment towards long-run equilibrium. The results do not support the full inertia hypothesis.

Keywords

inflation, local persistence, asymmetric dynamics, quantile regression, bootstrap.

JEL Codes C14, C22, C13.

Resumo

Este estudo analisa a natureza da resposta da inflação semanal a choques na economia brasileira, adotando um modelo autorregressivo generalizado de quantis, no qual o parâmetro autorregressivo pode ser quantil-dependente. Testamos para raiz unitária em diferentes quantis condicionais da variável resposta, caracterizando sua dinâmica assimétrica ao longo do ciclo de negócios. O método nos permitiu estimar a magnitude, o sinal e a significância dos choques que afetam a inflação brasileira. Avaliamos a robustez dos resultados adotando um procedimento de bootstrap. *Em relação a estudos anteriores, encontramos evidências de uma persistência assimétrica mais forte na dinâmica inflacionária em que um choque inflacionário abaixo da média se dissipa muito rapidamente quando comparado a um impulso inflacionário ocorrendo acima da média. A localização, o tamanho e o sinal de um choque aleatório podem ser essenciais para o ajuste da inflação em direção ao equilíbrio de longo prazo. Os resultados não suportam a hipótese de inércia total.*

Palavras-chave

inflação, persistência local, dinâmica assimétrica, regressão quantílica, bootstrap.

Códigos JEL *C14, C22, C13.*

1 **Introduction**

The adoption of the Inflation Targeting Regime (ITR) in advanced and developing countries since the early 1990s is the primary paradigm in central banking monetary policy decisions. As a formal framework, it assumes that policymakers can reduce inflation by reducing the output level. The output loss is lower when the inflation persistence is small. In Brazil, this framework was adopted in mid-1999, moving from an asymmetric crawling peg to a floating exchange rate system (Bogdanski *et al*., 2001). The inflation response to shocks is related to the output loss throughout the degree of inflation persistence. Persistence (or inertia) refers to the pace at which the inflation rate returns to its mean or conditional quantile following a shock.

This study examines the nature of local persistence in the Brazilian weekly inflation to test whether it exhibits unit root behavior in quantiles resulting in asymmetric dynamics along the business cycle. We adopt the generalized Quantile Autoregression model (QAR) proposed by Galvao (2009) which allows the inclusion of stationary covariates and deterministic time trend. Koenker and Xiao (2004; 2006) initially proposed the QAR model in a more restricted version. In both approaches, a random shock can change the location, scale, and shape of the conditional inflation distribution, not only the average inflation rate.

To the best of our knowledge, there are only two studies for Brazilian inflation persistence that adopt quantile regression methods. Maia and Cribari-Neto (2006) applied the QAR model using monthly inflation data to the period ranging from August 1994 to April 2004. More recently, Gaglianone *et al*. (2018) applied the QAR model to analyze the Brazilian monthly inflation based on samples ranging from January 1995 to May 2017. Both studies use only the restricted version of the QAR model. Based on Monte Carlo simulations, Galvao (2009) shows that the generalized QAR model presents power gains when compared to the QAR model initially proposed by Koenker and Xiao (2004; 2006).

Our main findings indicate that we cannot reject the unit root at the 5% level in a broader set of upper-tail quantiles (τ = [0.75;0.95]) relative to Gaglianone *et al*. (2018) and Maia and Cribari-Neto (2006). However, there is strong evidence that the weekly Brazilian inflation rate is not a unit root process at the average and lower quantiles. The asymmetric dynamics of inflation is stronger relative to previous studies, and the persistence parameter is higher for lower quantiles. Since our data are free of the pegged exchange rate effects, we speculate that the current monetary policy regime is associated with an exacerbation of asymmetric inflation dynamics. Further, as the power of the ADF type tests depends upon the sampling frequency and the sample size, we get more precise estimators (lower uncertainty) and higher power of the test relative to Gaglianone *et al*. (2018) and Maia and Cribari-Neto (2006).

The existing empirical literature that analyses the inflation persistence in Brazil typically employs constant-coefficient time series models that concentrate only on the conditional mean of the response variable (Roache, 2013; Minella *et al*., 2002; Figueiredo and Ferreira, 2002). This assumption is in stark contrast with the theoretical assertion made by Fraga *et al*. (2003, p. 389): the optimal response of monetary authorities may depend upon the nature and size of the shock that affects the economy.

Because the government might choose to alter almost continuously the exchange rate in a pegged exchange rate regime as means of dampening inflation in the short run (Dorbunsch *et al*., 1990), the period under analysis in this paper is focused only on a floating exchange rate system. Maia and Cribari-Neto (2006) and Gaglianone *et al*. (2018) use monthly observations that include the pegged exchange rate regime and the floating exchange rate system. Our estimates avoid such mixed effects on the inflation level and its persistence. The agents' monetary anchor has changed from (peg) exchange rate policy (1994-1998) to inflation targeting based on a floating exchange rate system from mid-1999 to the present.

Our main contributions, compared to the existing literature on Brazilian inflation, may be summarized as follows. First, we adopt a model with a time trend after applying a specification test instead of using the restricted version of the QAR model. Second, we use more massive sample data (weekly instead of monthly data) to improve the power's test and efficiency. Third, we calculate the half-life and impulse response functions for weekly inflation. Lastly, we estimate the magnitude and sign of actual shocks and test its significance based on wild bootstrap.

All these aspects are absent in the previous studies and add significant information to better understand the dynamics of inflation dynamics in Brazil. Using these additional procedures and data, we hope to find more robust and reliable conclusions.

In developing countries, the currency crises can be interpreted as a source of inflationary shock because the exchange rate depreciation affects the internal prices (Minella *et al*., 2002). That was the case of Brazil in 2002, when the economy faced a negative swing of US$ 30 billion in capital flows (6% of its gross domestic product – GDP), leading to a nominal depreciation of 50% in the exchange rate and higher domestic prices. In contrast, because product or process innovations are the main drivers of the productivity factor enhancement in the manufacturing industry, the trade liberalization in Brazil in the early 1990s can be interpreted as a significant source of a (deflationary) positive supply shock (Lopes, 1985; Franco, 1998; Hayakawa and Matsuura, 2017). If a deflationary supply shock can cause a *permanent* reduction in the inflation level, it contributes to the operation of the ITR by the Central Bank, mitigating the inflationary process.

If an external or a domestic fiscal inflationary shock produces a permanent effect, and a supply deflationary shock does not, the focus of policymakers and their response to monetary policy issues must be limited to the former. Shocks occurring below the average may have transitory effects, and shocks above the mean may produce permanent rising prices. Besides, according to the inertial inflation hypothesis, the degree of persistence (inertia) may depend upon the level of inflation (Resende, 1985b, p. 130; Lopes, 1985, p. 137; Simonsen, 1985, p. 27).

Arida and Resende (1985, p. 10-11) observe: “On a deeper conceptual level (...), under trigger point indexation, the nominal readjustment occurs whenever inflation reaches a given magnitude, say 20%. (...) Indexation is a natural response of agents in processes of inertial inflation.” Similar observations can be found in Modiano (1985, p. 8). Resende (1985b, p. 130) also observes that typically high inflation requires indexation, and indexation prevents the reduction of inflation. We cannot test these theoretical claims using a constant-coefficient linear time series model based only upon conditional mean regression methods.

Conditional mean regression assumes that the speed of inflation adjustment is constant, no matter how far the inflation is above or below its long-run level (or how big the negative or positive shock is affecting the prices). In contrast, the generalized QAR model can be viewed as a case of a random-coefficients model in which the autoregressive coefficient is dependent on the specified quantile, $\tau \in (0,1)$. Thus, it can describe the entire conditional distribution of a response variable, providing a complete picture of its dynamics. The level of inflation might correlate with the degree of indexation (inertia).

We test the unit root hypothesis not only on the conditional mean of the inflation path but also on the tails of the distribution in specific quantiles. Hence, we can distinguish between the response to shocks when the inflation realizations are high or low concerning previous periods. Besides, most of the studies use only monthly datasets since it is difficult to collect data and compute inflation indexes at a greater frequency.

The sampling frequency can affect the power of unit root tests. In a study based on Monte Carlo simulation, Choi and Chung (1995) show that, in the case of ADF-type tests, using high-frequency data (weekly observations instead of monthly, for example) can provide a considerable improvement in the finite sample power of the unit root test. Hence, we hope to reach more robust and reliable results when compared with studies for inflation persistence based only on monthly data, as done by Maia and Cribari-Neto (2006) and Gaglianone *et al*. (2018).

Bogdanski *et al*. (2001) and Fraga *et al*. (2004) argue that Brazilian inflation persistence may depend on a series of state-regulated prices like indexed wage contracts, public transport fare, gasoline, Diesel oil, electricity, telephone and post office rates, education, health plan rates, and many other prices (see Figueiredo and Ferreira, 2002, p. 6). These goods and services have their pricing rules based on contractual law, which is unrelated to supply and demand, and the government is an important supplier. Thus, besides the demand and supply shocks, institutional rules created by the government give rise to a perpetuation of inflation inertia after the implementation of the Real Plan (Carvalho, 2014).

In addition, in the private sector, the results presented by Correa *et al*. (2016) indicate that the majority of firms in Brazil adjust their prices according to a monopolistic structure in a closed economy, where mark-up pricing is the dominant pricing strategy: 67% of firms in the private sector change prices only after knowing how competitors have readjusted their prices. The main drivers of price changes are the costs of intermediate goods and the inflation rate. This pricing rule also tends to perpetuate inertia overall.

The main findings of the present paper do not support the hypothesis of symmetric response to economic shocks. We present econometric evidence that the degree of indexation depends upon the level of inflation, as suggested by the theoretical models designed to describe the inertial inflation in Brazil, such as Lopes (1985), Arida and Resende (1985), and Simonsen (1985). In general, inflationary shocks occurring above the average of inflation have permanent effects on their level, while deflationary shocks occurring below the average produce transitory effects on the inflation level.

The remainder of the paper is organized as follows: Section 2 briefly reviews the works seeking to measure inflation persistence in Brazil and discusses their findings. Section 3 outlines the methodology and describes the data. Section 4 presents the results and discusses the main parameters, while Section 5 concludes the paper.

2 **Inflation Persistence in Brazil**

Koenker and Xiao (2004) proposed the Quantile Autoregressive model. Galvao (2009) extended it, allowing the inclusion of stationary covariates and a deterministic time trend. This generalization ensures a more flexible specification and presents power gains in unit root testing relative to the initial version. Quantile unit root tests have been used to describe asymmetric persistence behavior as a viable alternative to conditional mean regression models. Hosseinkouchack and Wolters (2013) apply the unit root test in quantiles to test whether the 2008 financial crisis produced a permanent or a transitory effect on the US GDP. Lima *et al*. (2008) investigate fiscal sustainability by using the QAR model with Brazilian data. Koenker and Xiao (2006) apply the QAR model to analyze whether the response of the US unemployment rate and the weekly gasoline price to expansionary or contractionary shocks may be asymmetric.

The inflation persistence in Brazil is a significant issue in economic policy since the implementation of ITR in mid-1999. Early theoretical works on inertial inflation, especially Lopes (1985), Arida and Resende (1985), Resende (1985b), and Simonsen (1985) emphasized the need to abolish the indexation of wages, prices and other forms of state-induced rules for price setting that are independent of supply and demand.

Dornbusch *et al*. (1990) examine the same theoretical and empirical issues of indexation and hyperinflation problems in a large number of countries, including Brazil. The policy prescriptions derived by the authors are all in line with early theorists of the inertial inflation hypothesis. However, even after many years of hyperinflation and efforts to reach low and stable inflation since the Real Plan, the government still maintains mechanisms that may stimulate indexation rules in the economy. All these formal and informal rules contribute to increasing the inflation persistence, resulting in a relatively higher output loss which follows a given economic disturbance (see Bacha (1998) for a detailed account of Real Plan).

Some studies have been conducted to analyze the inflation persistence in the Brazilian economy, most of them by using monthly databases for several periods. In general, these studies report a reduction in inflation persistence after the Real Plan, even when employing only conditional mean regression methods. Minella *et al.* (2002) find evidence of change in inflation rate dynamics. Their results suggest that after ITR, the inflation persistence dropped from 0.81 to 0.23 using monthly data from July 1999 to August 2002. Minella *et al.* (2002) conclude that there had been a substantial reduction in the degree of inflation persistence after ITR. This finding implies a lower output loss to reduce average inflation. When comparing the average inflation after ITR and few years before it, they conclude that "the smaller average of the inflation rate is, to a large extent, a consequence of the pegged exchange rate regime, which turned out to be unsustainable in the medium run" (Minella *et al.*, 2002, p. 10).

Figueiredo and Marques (2009) analyze several sub-samples of the Brazilian monthly inflation rate by applying the unit root test introduced by Zivot and Andrews (1992). They concluded that shocks have a transitory effect on the inflation path using monthly data ranging from 1994 to 2008 (IGP-DI index). Further, the fractional coefficient ($\hat{d}$) is 0.25, which indicates that after the Real Plan, the Brazilian inflation faced a lower persistence and can be considered stationary.

Figueiredo and Marques (2011) employed a model which accounts for regime-changing and estimates the fractional coefficient for the Brazilian inflation using a monthly dataset ranging from 1944 to 2009 (IGP-DI index). They conclude that the inflation rate can be considered stationary after the Real Plan.

Maia and Cribari-Neto (2006) applied similar methods to the ones used here for the monthly Brazilian inflation rate. They employed the restricted QAR model to test for a unit root in a range of quantiles using monthly data ranging from 1994 to 2004. The datasets used in that work were the IGP-DI index computed by Fundação Getúlio Vargas and the IPCA (Índice de Preços ao Consumidor Amplo) computed by the Instituto Brasileiro de Geografia e Estatística (IBGE). In the same vein, Gaglianone *et al*. (2018) investigated the behavior of Brazilian inflation based on the restricted QAR model using the IPCA monthly index ranging from January 1995 to May 2017.

The findings of both studies indicate an asymmetric behavior in inflation persistence, supporting the hypothesis of a unit root in the Brazilian inflation rate only for the IPCA index at specific quantiles. Maia and Cribari-Neto (2006) could not reject the unit root hypothesis at quantiles $\tau = 0.85$ and $\tau = 0.90$ at the 5% level, but they were able to reject the null hypothesis of infinite persistence in all lower quantiles. Gaglianone *et al*. (2018) could not reject the unit root hypothesis only at quantiles $\tau = 0.80$ and $\tau = 0.90$ at the 5% level.

In both studies, the authors use a smaller (and lower frequency) sample size of data collected in different regimes of exchange rates in Brazil which included both the pegged exchange rate regime and the floating exchange rate system. Since, in developing countries, internal prices typically depend on the movements of the exchange rate (Dorbunsch *et al*., 1990; Minella *et al*., 2002), we suspect their findings reflect the mixed effects of pegged and floating exchange rates.

3 **Methodology**

3.1 **Description of the data**

The data used in this study are the IPCS (Índice de Preços ao Consumidor Semanal, %) computed by Fundação Getúlio Vargas, ranging from February 06, 2003, to March 31, 2017, corresponding to 15 years of weekly observations ($T = 688$). We have made this choice based on three reasons. First, while Maia and Cribari-Neto (2006) and Gaglianone *et al*. (2018) used only monthly sample data which included both the pegged exchange rate regime (1994-1998) and also the floating exchange rate system (1999 to the present), we wish to avoid such mixed effects on the inflation level and its persistence estimates (Minella *et al*., 2002). Second, the data availability covers only the above period. Lastly, based on Monte Carlo simulations, Choi and Chung (1995) have shown that in the case of ADF-type tests, using greater frequency data (weekly instead monthly) can provide improvements to the power of the unit root test.

The mixed sample sizes used by Maia and Cribari-Neto (2006) and Gaglianone *et al*. (2018) correspond to 17% (T=117/688) and 39% (T=269/688) of ours, respectively. The IPCS inflation (%) is defined as $IPCS = 100 * (IP_t - IP_{t-1}) / IP_{t-1}$, where IP_t and IP_{t-1} are consumer price levels in current and previous period. The dataset is available at *http://www14.fgv.br/fgvdados20/consulta.aspx*. Table 1 presents the descriptive statistics.

Table 1 **Descriptive statistics for the weekly inflation rate (%)**

Summary statistics	
Mean	0.52
1º Quartile	0.28
Median	0.49
3º Quartile	0.73
Minimum	−0.44
Maximum	2.16
Skewness	0.48
Kurtosis	4.18
JB test	66.57***
SW test	0.98***

*Notes: *** Significant at 1% level. JB is the Jarque-Bera test statistic (Jarque and Bera, 1980) and SW is the Shapiro-Wilk test statistic (Shapiro and Wilk, 1965).*

Source: author's elaboration.

The data presents positive skewness indicating that most of the time, the inflation rate stood above the average of the sample. The kurtosis and statistical tests for normality suggest that the data does not fit in a normal distribution. We reject the null of the normal distribution in both the Jarque-Bera and the Shapiro-Wilk tests at 1% level. The positive skewness and departure from normality highlight the virtue of the QAR modeling approach, which is robust for these data characteristics and may better describe the changes in the conditional distribution of the response variable.

3.2 **The generalized QAR model**

Let Y_t be the weekly inflation rate. The generalized QAR(q) process at quantile τ can be expressed by:

$$Q_\tau(y_t \mid y_{t-1},\dots,y_{t-q}) = \alpha_0(\tau) + \alpha_1(\tau)y_{t-1} + \beta(\tau)t + \sum\nolimits_{i=1}^{q} \varphi_{i+1}(\tau)\Delta y_{t-i} \tag{1}$$

where the τ th conditional quantile function of the response y_t is expressed as a linear function of lagged values of the response plus deterministic components. By estimating (1) at different quantiles $\tau \in (0,1)$, we obtain a set of persistence parameter estimates $\alpha_1(\tau)$. Hence, we shall be concerned more specifically with $\alpha_1(\tau)$ and its t-ratio statistic under the hypothesis of unit root, in which $\alpha_1(\tau) = 1$. We use the t-ratio statistic as developed by Koenker and Xiao (2004) and Galvao (2009) to implement the hypothesis testing. The parameter estimate $\alpha_1(\tau)$ is the main focus of this work, since it is the basic persistence measure and can be used for posterior analysis, *e.g.*, the impulse response functions (*IRF*) and half-life (*HL*) computations (Andrews, 1993).

Following Andrews (1993), we calculate the length of time until the impulse response function of a unit shock to the inflation rate is equal to half of its original magnitude – the half-life of a unit shock (*HL*). This number represents (in weeks) the most likely duration of inflation in response to shocks in each specified quantile and is defined by:

$$HL(\hat{\alpha}_1(\tau)) := \frac{\log(1/2)}{\log(\hat{\alpha}_1(\tau))} \tag{2}$$

along with the impulse response function (*IRF*) defined by,

$$IRF(\hat{\alpha}_1(\tau)) := \hat{\alpha}_1^t, \forall t = 1,2,\dots \tag{3}$$

which can also be found in Andrews (1993). The magnitude of the *IRF* across different time horizons according to the value of t in weeks gives an indication of the extent of the persistence of shocks in inflation level. By following the intuitive interpretation given in Taylor and Taylor (2004), we can say that the inflation rate reverts towards its mean (or conditional quantile) at the rate of $(1 - \hat{\alpha}_1(\tau))$ per period.

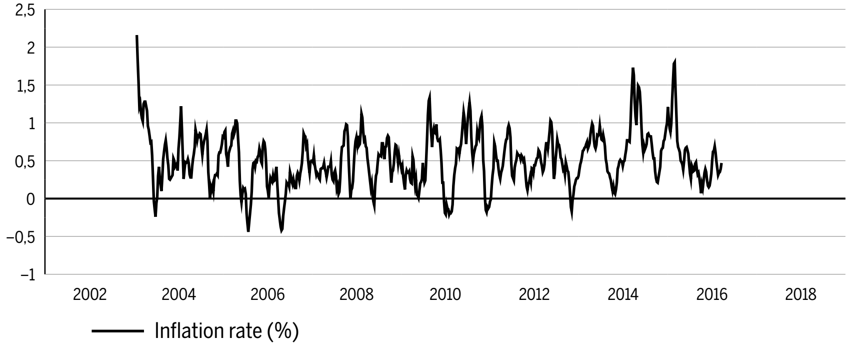
We adopt a bootstrap procedure designed to QAR methods introduced by Feng *et al*. (2011). This procedure works as the results' robustness check against fat tailed or GARCH-type effects (or both) on the estimator improving its efficiency. Baur *et al*. (2012) conducted a Monte Carlo study to verify the GARCH-type effects on quantile autoregression. The simulation results revealed no deviations from the simulated autoregressive parameter across the entire range of quantiles.

4 **Results and discussion**

Figure 1 shows the path of Brazilian inflation over the years. We can observe higher peaks between 2014 and 2016 associated with the more recent effects of the political crisis, the pervasive corruption in the country, and the price suppression (*e.g.*, energy prices), regime change, monetary and fiscal policy changes (such as the abandonment of the fiscal surplus target as a percentage of the GDP).

Despite a seemingly absent time trend, we estimate a restricted version of Eq. (1) and we reject the null of $\beta = 0$ at the 5% level (F-statistic = 5.8745; p-value = 0.0156) by adopting q = 13 based on Bayesian Information Criterion. Hence, we select the full specification given in Eq. (1) (*i.e.*, a model with a constant and a time trend) in all estimated models. Gaglianone *et al*. (2018) and Maia and Cribari-Neto (2006) applied the restricted version of the QAR model *assuming* $\beta = 0$ in their estimations.

Figure 1 **Weekly Brazilian inflation rate: 2003-2017**



Source: author's elaboration.

At first, to verify whether the inflation rate may be considered as a globally stationary process, we apply three unit root tests to the level of the series. The results of ADF (MAIC)-Dickey and Fuller (1979), KPSS (1992) and Zivot & Andrews (1992) tests to allow for structural change at an unknown date are shown in Table 2. All three tests corroborate the low degree of inflation persistence in the Brazilian economy by considering only its conditional mean. These results are consistent with the conclusions presented in Section 2: the Brazilian inflation rate can be considered globally stationary by methods designed to account only for its conditional mean. We are able to reject the null of unit root at the 5% and the 1% levels. The estimated date of structural change is October, 15, 2014. This may suggest that the underlying economic processes are subject to an abrupt change or was recently affected by a shock in Brazilian economy. The dummy coefficients are all significant at the 1% level.

Table 2 **Tests for global nonstationarity of the weekly inflation rate (%)**

Type of the test	Constant	Constant and trend
ADF (MAIC)	−5.63***	−5.82***
KPSS	0.22	0.10
Zivot & Andrews	−7.92***	−8.23***

*Notes: *** Significant at the 1% level.*

Source: author's elaboration.

The estimate of Eq. (1) gives the persistence measure $\alpha_1(\tau)$ over different quantiles of the conditional distribution, for $\tau \in (0,1)$. Table 3 presents results for the unit root test using the generalized QAR model given by Eq. (1), based on 10000 bootstrapped critical values of the *t*-ratio test $t_n^*(\tau)$ statistic, following Koenker and Xiao (2004, Section 3.2). We choose the lag length based on the Bayesian Information Criterion following Cho *et al*. (2015). We find the best lag length of $q = 13$ and apply this for all 19 considered quantiles $\tau \in [0.05, 0.10, \ldots, 0.95]$.

The results presented in Table 3 allow drawing the following conclusions. First, at the upper tail of the distribution, we are unable to reject the unit root hypothesis at a broader range of quantiles (from $\tau = 0.75$ to $\tau = 0.95$). We find evidence of stronger asymmetric dynamics in the inflation level. Besides, we reject the null unit root at the 5% level in all quantiles at the average and the lower tail of the distribution. Second, as for the previous results of Maia and Cribari-Neto (2006) and Gaglianone *et al.* (2018) for the monthly inflation rate collected in mixed periods, the noticeable difference is that we are unable to reject the null at a broader range of quantiles. Since our data are collected only at the ITR period without the pegged exchange rate effects, we may speculate that the current monetary policy regime is associated with an exacerbation of asymmetric inflation dynamics relative to previous studies that used mixed periods of exchange rate policy regimes.

Table 3 **Null hypothesis: $\alpha_1(\tau) = 1$ for $\tau \in [0.05, 0.10, \ldots, 0.95]$ – Weekly inflation**

τ	$\hat{\alpha}(\tau)$	*t-statistics*	*critical values* ($t_n^*(\tau)$)	*HL* in weeks	*IRF* (t = 16)
0.05	0.7979	−4.8028**	−2.4658	3.8619	0.0566
0.10	0.8324	−6.7873**	−2.5199	3.9620	0.0609
0.15	0.8229	−7.3037**	−2.6600	4.1418	0.0687
0.20	0.8430	−6.9126**	−2.7794	4.6351	0.0914
0.25	0.8475	−6.6330**	−2.8549	4.7681	0.0977
0.30	0.8797	−6.6835**	−2.8792	4.5922	0.0894
0.35	0.8798	−6.9434**	−2.9630	4.7681	0.0977
0.40	0.8628	−6.1585**	−3.0578	5.4271	0.1296
0.45	0.8833	−6.0707**	−3.0137	5.5453	0.1353
0.50	0.8804	−5.9842**	−3.0479	5.8188	0.1487
0.55	0.8907	−5.9704**	−3.1114	5.9138	0.1533
0.60	0.9156	−5.1751**	−3.1915	6.9904	0.2046
0.65	0.9282	−4.3641**	−3.1204	8.2591	0.2611
0.70	0.9355	−3.6816**	−3.0804	9.6226	0.3158
0.75	0.9450	−2.6362	−3.1262	11.5393	0.3825
0.80	0.9756	−2.4371	−3.1332	11.4986	0.3812
0.85	0.9711	−1.7917	−2.9384	13.3761	0.4364
0.90	0.9558	−1.4230	−2.9015	13.1357	0.4299
0.95	1.0144	−0.7080	−2.7692	21.5174	0.5973

*Notes: ** Significant at the 5% level.*

Source: author's elaboration.

These findings imply that an inflationary shock near (above) the average now may result in a permanent effect over future rising prices. This result indicates that some monetary policy decisions might gain fine-tuning by using data of greater frequency, such as price index or other indicators of economic activity in Brazil.

As predicted by theory, by analyzing Table 3 results, we also have found a positive association between the magnitude of the autoregressive coefficient and the conditional inflation level. Higher inflation implies rising indexation (inertia), as initially observed by early theoretical works for inflation in Brazil.

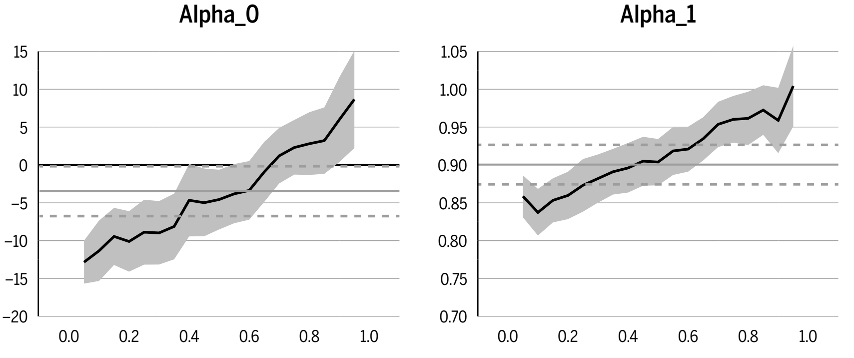
Figure 2 shows the increasing degree of inflation response to shocks along 19 quantiles, $\tau \in [0.05,0.10,...,0.95]$. The grey area corresponds to the bootstrap confidence interval of 95% generated by the procedure of Feng *et al*. (2011) based on 3000 bootstrap replications for $\alpha_0(\tau)$ and $\alpha_1(\tau)$ parameters. The straight red line at the center shows the Ordinary Least Squares result for the conditional mean with the 95% confidence interval.

Based on our findings and following the analysis of Tsong and Lee (2011), we analyze the behavior of inflation at each specific quantile, and we notice that estimated values for $\alpha_0(\tau)$ and the autoregressive coefficient $\alpha_1(\tau)$ are not constant along quantiles, neither its significance. As observed by Tsong and Lee (2011), the $\alpha_0(\tau)$ parameter represents the size of the observed shock within the τ th quantile that affects the price inflation. A negative sign indicates a negative shock, which may result from a central bank reaction (*e.g.*, tightened monetary policy). In contrast, a positive sign reflects a positive shock over the inflation level as a result of a flexible monetary policy or a credit expansion.

At the 0.50 and 0.60 quantiles, the shock magnitude is significantly different from zero at the 5% level. This result strongly contrasts with the case of a sample of 12 OECD countries studied by Tsong and Lee (2011), except Japan. The Brazilian case is different from OECD countries when it comes to shocks occurring at the average: their magnitude is statistically different from zero at the 5% level.

If we consider the magnitude and sign of actual shocks occurring below the average of the distribution, all of them are statistically significant at the 1% level, negative and large in magnitude. If we compare the length of the largest shock found by Tsong and Lee (2011) for Ireland (–4.19) with the same figure in Brazil, we may infer that Brazilian inflation seems to be much more dispersive since the values of $\hat{\alpha}_0(\tau)$ parameter range from –12.83 to –4.57, in which the value of largest negative shock which affects the Brazilian inflation is –12.83 units in magnitude. All the shocks at average and below it are statistically significant and different from zero at both the 1% and 5% levels.

Figure 2 **Size, sign and significance of shocks along the inflation persistence parameter – Brazil.**



Source: author's elaboration.

This finding helps to explain why there exists a wide variation in half-life response measures below and above the long-run value of inflation in Brazil as presented in Table 3. When a random negative shock affects inflation operating below the average, the pace of mean-reversion is fast. The contrary occurs when inflation is running above the average (see Figure 2).

The Brazilian inflation path can be considered globally stationary. However, the novelty is that in the peaks of the business cycle shown in Figure 3, a demand or an external shock may produce a permanent effect on future rising prices if the inflation is above the mean. In contrast, the return of inflation to its long-run level is very fast if the shock is negative and current inflation is operating below the average.

The asymmetric persistence also translates into very different behavior for *HL* and *IRF* at different conditional quantiles. For lower quantiles, the *HL* is around 4 weeks, and, in contrast, for upper-tail quantiles, the *HL* is roughly 12 weeks. The duration of a random shock above the average is roughly three times longer than shocks occurring below the average. This asymmetric behavior also can be observed along with the values of *IRF* as we move from low-extreme quantiles to the upper-tail quantiles.

5 **Conclusions**

This study examines the nature of local persistence in the Brazilian weekly inflation by testing whether it exhibits unit root behavior in quantiles resulting in asymmetric dynamics along the business cycle. By applying the generalized QAR model proposed by Galvao (2009) along with a dataset of greater frequency – weekly inflation rates – we find evidence of more substantial asymmetry in inflation dynamics when compared to the existing literature.

The main findings suggest that weekly inflation exhibits asymmetric behavior in which the response to shocks depends upon the location of price changes concerning the previous periods. In general, inflationary shocks above the average have permanent effects on the inflation path. In contrast, deflationary shocks below the average have temporary effects. We are unable to reject the unit root at 5% in a set of upper-tail quantiles (τ = [0.75;0.95]).

These results indicate that the asymmetric dynamics of Brazilian inflation is stronger relative to previous studies and the persistence parameter is higher for lower quantiles than previous findings as reported by Gaglianone *et al*. (2018) and Maia and Cribari-Neto (2006).

Since our data were collected only in the ITR period under the floating exchange rate system, we may speculate that the current monetary policy regime is associated with an exacerbation of asymmetric inflation dynamics when compared to previous studies that used mixed sample periods involving both the pegged and floating exchange rates. Furthermore, as the power of the ADF type tests depends upon the sampling frequency and the sample size, since the used sample is three times larger than that of the studies as mentioned earlier, we get more precise estimators (lower uncertainty) and higher power of the test.

One policy implication derived from these findings is that, in the Brazilian case, the sign and size of an inflationary (or deflationary) shock might be essential for optimal response in monetary policy. The asymmetric nature of inflation persistence in Brazil suggests that the Central Bank must have a larger concern for the inflationary shocks occurring only above the average and not below it.

The full inertia hypothesis of the *New Consensus Economics* is not supported, because we find evidence of only locally nonstationarity (see Busato *et al.*, 2009, p. 110). As demonstrated by Koenker nd Xiao (2006), a time series may exhibit unit root-like tendencies, or even temporarily explosive behavior. However, occasional episodes of mean reversion within a specific range of quantiles (as the case here) are sufficient conditions to ensure global stationarity.

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