Changes in Brazilian Inflation Persistence[1]

Michelle Chan
Banco BBM

Silvia Matos
EPGE and IBRE/FGV

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Abstract

This paper employs the recently developed unobserved components model with stochastic volatility to model Brazilian inflation persistence over the last fifteen years. Following Stock and Watson (2007)'s methodology, we found that the persistence of the permanent component of consumer price inflation has declined after the confidence crisis that preceded president Lula´s election in 2002. In addition, the variances of the permanent and the transitory disturbances also decreased, with the reduction in permanent component being more pronounced. Moreover, applying standard autoregressive models commonly used in the literature, we confirm a lower persistence coefficient after 2003. In terms of economic policy, these results show the consolidation of disinflation process in Brazil.

Keywords*:* Inflation Persistence, Unobserved Components Model, Sum of Autoregressive Coefficients

JEL classification: C22, E31, E52
ANPEC: Section 3 – Macroeconomic, Monetary Economy and Finance

Resumo

Este artigo utiliza o recém desenvolvido modelo de volatilidade estocástica dos componentes não observáveis para modelar a persistência inflacionária brasileira nos últimos quinze anos. Seguindo a metodologia do Stock e Watson (2007), observamos que o componente permanente da inflação desacelerou depois da crise de confiança que precedeu as eleições de Lula à presidência em 2002. Observou-se também uma desaceleração das variâncias dos distúrbios permanentes e transitórios com destaque para a maior redução do componente permanente. Além disso, ao utilizarmos os modelos padrões auto-regressivos comumente utilizados na literatura, confirmamos um menor coeficiente de persistência após 2003. Em termos de política monetária, esses resultados mostram a consolidação do processo de desinflação no Brasil.

Palavras-Chave: Persistência Inflacionária, Modelos de Componentes Não-observáveis, Soma dos Coeficientes Auto-regressivos

JEL: C22, E31, E52
ANPEC: Área 3 - Macroeconomia, Economia Monetária e Finanças

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[1]The views expressed in this paper are those of the author and do not necessarily reflect the position of the IBRE-FGV. E-mails: michellechan@bancobbm.com.br, silvia.matos@fgv.br.

1. Introduction

Price setting behavior plays a significant role both in inflation dynamics and in the monetary policy transmission mechanism. This relevance has promoted a large body of empirical research on inflation persistence and price stickiness in recent years. Overall the research approaches can be divided in two groups: an approach based on aggregate/sectoral price indices and the another based on micro-data underlying these price indices. The latter approach is more recent since, only in the past few years, access to vast amounts of micro price data has been available. Starting with the seminal paper by Bils and Klenow (2004), the use of disaggregated data has produced hard evidence on the various aspects of price setting, including the frequency and size of price changes, for a very wide range of goods and services in several countries.[2] The former approach is more widespread because it is direct and doesn't require any unpublished individual price data.[3]

In this literature, inflation persistence denotes the extent to which future values of inflation are related to past shocks or, in other words, the speed of adjustment toward its long-run value. Consequently, the measure of inflation persistence is a concern among economists and central bankers. For instance, from the monetary policy perspective, the cost of disinflation depends on the amount of inertia present in the inflationary process, if persistence is high, the output costs will be large. Thus, in order to design the optimal monetary policy, it is crucial to know this important parameter of the economy.[4] Therefore, a wide body of literature has emerged examining the degree of inflation persistence in both developed and developing countries.

Applied macroeconomists have typically looked at structural and reduced empirical form measures of inflation persistence. The first approach is based on a specific model that identifies the sources of inflation persistence. Basically, under the Calvo price setting assumption, we derive the workhorse New Keynesian Phillips Curve (NKPC) that relates current inflation to expected future inflation and a measure of current real activity. Indeed, the inability of the NKPC to replicate the high inflation persistence found U.S. data encourage research on generating inflation persistence into macroeconomic models. Accordingly, a hybrid version of the NKPC (HNKPC) has been estimated to provide a better fit with aggregate data. [5]

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[2] See Klenow and Malin (2010) for an accurate, self-contained survey about "Microeconomic Evidence on Price-Setting".

[3] In general, micro-data is provided by countries's statistics institutes with restricted data access policy.

[4] However, it is important to note that inflation persistence doesn't have the same meaning in periods of high inflation as in periods of low inflation. When inflation is low and stable higher persistence means lower inflation in the future as well.

[5] Rudd and Whelan (2005) estimate a HNKPC and show that inflation persistence in the United States is low and has been decreasing.

In the second one, in general, the estimated measure is determined by estimating autoregressive models, whose popularity is due to their good fit in the time domain (see e.g. Levin and Piger (2004); O'Reilly and Whelan (2005); Pivetta and Reis (2007); Benati (2008), and the literature cited therein). Among other econometric methods include the unobserved components model with stochastic volatility developed by Stock and Watson (2007). Their model decomposes inflation into a permanent component, modeled as a random walk, and a transitory component. Also, the volatility of both disturbances is allowed to vary over time. This paper has been drawing attention since discusses inflation's volatility, an important issue related to the debate on the Great Moderation. A possible source of the reduction in the volatility of macroeconomic variables is inflation stabilization.

For the U.S. inflation, Stock and Watson (2007) found that there have been large changes in the variance of the permanent disturbance, whereas the variance of the transitory disturbance has remained essentially constant since the mid 1950s. Moreover, persistence has declined and predictability has increased over time.

For the Brazilian case, Cribari-Neto and Cassiano (2005) found that the degree of inertia was large but decreased after the implementation of the Real Plan. They apply different variants of the variance ratio, a measure of long-run persistence of shocks developed by Campbell and Mankiw (1987) and Cochrane (1988). Recently, Gomes and Leme (2008) and Oliveira and Petrassi (2009) have addressed this issue. In particular, Gomes and Leme (2008) through a univariate approach called Auto-Regressive Fractionally Integrated (ARFIMA) found that inflation is stationary and its persistence is low and has decreased with the implementation of the inflation targeting regime. Oliveira and Petrassi (2009) by estimating an autoregressive model and a HNKPC also showed that inflation persistence in Brazil is low and stable.

Other studies that estimate a HNKPC for Brazil and discussed changes in the inflation process are Tombini and Alves (2006) and Chan (2009). Tombini and Alves (2006) estimate a time-varying coefficients model using the Kalman filter method, considering the free market inflation only.[6] They found a lower persistent coefficient after the adoption of the inflation targeting regime in mid-1999, but there is a structural break in 2002, which translates to a higher inertia coefficient.

Chan (2009) applied the Phillips Curve for the quarterly data of the free market inflation from the second quarter of 2000 until the second quarter of 2009. The result showed an average estimated persistent coefficient of 0.45 for the period. Interesting was the result obtained by the rolling regression that presented a decline of the persistence during the period. The estimated coefficient declined from 0.46 in the last quarter of 2001 to 0.37 at the end of 2009. Pretrasi and Oliveira (2009) also used a similar model to estimate the coefficient persistence of the headline inflation of Brazil. They found a similar average estimated persistence coefficient of 0.441 for the period of 1999 until 2009.

[6] In this group we exclude monitored prices. Free market prices are determined by the supply and demand conditions in the market and are more sensitive to monetary policy decisions.

The aim of this paper is to analyze the Brazilian inflation persistence over the last fifteen years. We conduct our analysis using the Stock and Watson (2007)'s methodology and the standard autoregressive models commonly used in the literature. With respect to the second approach, we also consider the sum of autoregressive coefficients derived from the Dickey–Fuller generalized least squares (DFGLS) tests. Furthermore, for a robustness check, we employ a non- parametric estimation procedure developed by Marques (2004) and Dias and Marques (2010). To the best of our knowledge, this paper is the first study of inflation persistence in Brazil applying Stock and Watson (2007) ´s method. [7]

To preview our empirical results, we find that the persistence of the permanent component of consumer price inflation has declined after the confidence crisis that preceded president Lula´s election in 2002. In addition, the variances of the permanent and the transitory disturbances also decreased, with the reduction in permanent component being more pronounced. Moreover, applying standard autoregressive models commonly used in the literature, we confirm a lower persistence coefficient after 2003. In terms of economic policy, these results show the consolidation of disinflation process in Brazil.

It is important to note that this study focus only on aggregate inflation data. However, using disaggregate inflation data may prove a useful way to identify the key drivers of aggregate inflation persistence. This is the approach followed by Matos (2010) who presents results for 468 sub-indices of the Brazilian consumer price index calculated by IBRE/FGV.

The paper is organized as follows: in the next section we briefly overviews inflationary developments and changes in the monetary policy framework in Brazil since 1994. Section 3 discusses different reduced-form measures of inflation persistence commonly applied in the literature. Section 4 describes the Stock and Watson (2007)'s model. Section 5 presents a description of the data set used in the current study and the empirical results. Section 6 concludes.

2. The Inflationary Process in Brazil

The dynamics of inflation in Brazil has changed a lot in the last decades. The inflation rate decreased abruptly from 1000% a year in 1980 to least than one single digit inflation rate nowadays. The advent of low inflation has coincided with the change of regime. On July 1999, Brazil adopted the inflation targeting regime as monetary policy, less than six months after moving from a crawling peg exchange rate to a floating exchange rate. The Broad Consumer Price Index (IPCA) was chosen for the purpose of gauging inflation targets.

In this paper we focus on the period from the year of 1999 until 2009. During this period the inflation rate has been maintained in a low level despite some inflationary shocks. In particular, in the years of 2001 and 2002, Brazil suffered some episodes that cause sizeable

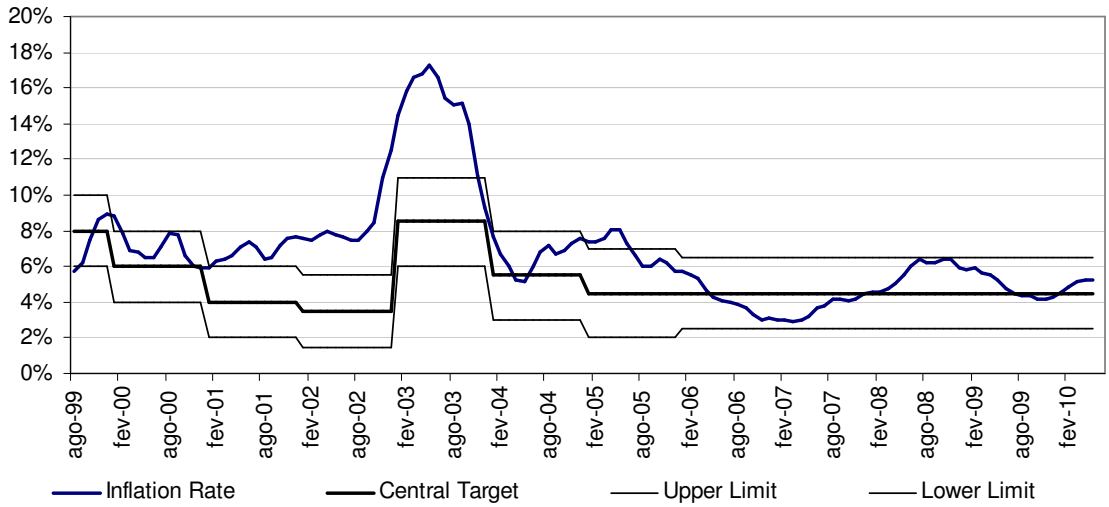
[7] We are not aware of previous studies that estimate persistence using DFGLS tests and Marques (2004) and Dias and Marques (2010) ´s approach.

variation in inflation. The year of 2001 is marked with the blackouts and energy rationing in Brazil, the slowdown of the global economy's growth, the September 11 terrorist attack in the United States and the Argentine's economy crises. In 2002, Brazil's policy faced a confidence crisis in the future performance of the Brazilian economy with the victory of a left wing presidential candidate. These episodes caused a "sudden stop" in capital inflows to the country and generated a significant nominal depreciation of the exchange rate that impacted the inflation rate.

As Figure 1 illustrates at the beginning of the period, in January 1999, the annual inflation rate was 1.7%. With the Asian Crises in 1999, the inflation rate accelerated and picked to 8.9% at the end of the year. From 2000 until mid 2002, the inflation rate floated between 6% and 8%. With the confidence crises that hit Brazil in 2002, the inflation rate rose abruptly and spiked to 17.2% in May 2003. During the years of 2001 until 2004, the inflation rate floated above the upper limit of the band. The exchange rate depreciated in average 28% and 26% in 2001 and 2002 respectively. In September 2001 it reached a depreciation of 45% and in December 2002 it depreciated 53%. In this context, the Central Bank raised the interest rate significantly, 375bps in the year of 2001 and 750 bps between January 2002 and February 2003. After the new government announced the intention to follow the orthodox policies, the inflation rate started to decreased and since 2004 it has been fluctuating between the inflation rate regime tolerance bands.

Despite these stress episodes, the inflation rate has been floating inside the tolerance band implemented by the Central Bank. This is an evidence that the adoption of the inflation targeting regime has been playing an important role to the stabilization of the inflation at low levels.

Figure 1: Inflation Targets (upper limit, central target and lower limit) and Inflation Rate (%p.a.)



3. The "Traditional" Empirical Measures of Inflation Persistence

We compare several measures of inflation persistence based on different econometric methods that have been proposed in the literature. Firstly, we consider the standard methodology developed by Andrews and Chen (1994) and Levin and Piger (2003), where persistence is measured by the sum of autoregressive coefficients in a univariate process of inflation. Let π_t be the headline consumer inflation at time t, α the intercept term and ε_t, the serially uncorrelated shock:

$$\pi_t = \alpha + \sum_{k=1}^{K} \beta_k \pi_{t-k} + \varepsilon_t \ , \tag{1}$$

where:

$$\rho^{SAR} = \sum_{k=1}^{K} \beta_k \, , \tag{2}$$

is the best scalar measure of inflation persistence, given that there exists a monotonic relationship between ρ^{SAR} and the cumulative impulse response function (CIRF) of π_{t+k} to ε_t . We recast (1) into the following expression:[8]

$$\pi_t = \alpha + \rho^{SAR} \pi_{t-1} + \sum_{k=1}^{K-1} \phi_k \Delta \pi_{t-k} + \varepsilon_t \, , \tag{3}$$

where:

$$\phi_k = - \sum_{m=k+1}^{K} \beta_m$$

It is noteworthy that the representation (3) summarizes the impact of past levels of inflation on current inflation through the single coefficient ρ^{SAR}. We focus on the estimation of the parameter ρ^{SAR} in this regression. If $\rho^{SAR} = 1$, the inflation process has a unit root, if $|\rho^{SAR}| < 1$, the process is stationary. The lag order is chosen by AIC criteria, where $K^{MAX} = 12$.

We apply the Breusch-Godfrey test for higher-order of serial correlation. To detect heteroskedasticity we consider the Breusch-Pagan test. If we reject the hypothesis that there is no serial correlation, we report Newey-West robust standard errors. Moreover, we conduct a Wald test of $\rho^{SAR} = 1$.

There are other measures of inflation persistence based on parametric autoregressive models that are less widely used in the literature, as the *AR(1)* and the largest autoregressive root. However, all these standard procedures rely on the assumption of time-invariant

[8]The $\rho^{SAR} = 1 - CIR^{-1}$, where the CIR is the cumulative impulse response (Andrews and Chen, 1994)

coefficients - hence; this is an important issue to be addressed. One way to overcome this problem is to account for structural breaks in (3). We may test for changes in inflation persistence overtime through rolling regression in which estimation is done over sequences of short rolling samples. Another possibility is to allow for time-varying coefficients. In this paper we apply the first strategy.

In the second approach the estimation strategy is non-parametric. We explore the procedure developed by Marques (2004) and Dias and Marques (2010). They suggest that less persistent inflation is more likely to cross the long-run mean of inflation rate (possibly a time-varying mean). In this approach inflation persistence is measured as $\delta=1-n/T$ where n is the number of times the series crosses its long-run mean and T is the number of observations. Dias and Marques (2010) conduct Monte Carlo simulations and they found that the method´s bias is always smaller than derived from (3) for any sample size considering inflation as I(0) process. Moreover, this method is more robust to structural breaks.

In order to decide which measure represents our inflation series dynamics, we have to test the series' stationary properties. We consider two common procedures in time-series analysis: the DFGLS test developed by Elliott, Rothenberg, and Stock (1996) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS). In addition, these tests generate two other inflation persistence measures: the first one is computed by the regression coefficients of the DFGLS individual tests and derives from the probability of rejecting the null hypothesis of unit root, i.e., higher DFGLS *p*-values mean more persistent data; the last one is the KPSS *t* –statistics which represents the persistence measure (higher *t* values translate into higher persistence coefficients).[9]

4. Stock and Watson (2007) Approach´s[10]

Stock and Watson (2002 and 2007) used an unobserved component model with stochastic volatility to (UC-SV) examine the evolution of the inflation process. In this model inflation is approximated as the sum of a permanent component (τ) and a transitory component (η). The permanent component captures the trend in inflation and has a unit root while the transitory component captures the deviations of inflation from its trend. The relative importance of the permanent and transitory components depends on the variance of the permanent component $\sigma^2_{\eta t}$ and the variance of the transitory component $\sigma^2_{\varepsilon t}$ which follows the process below. This model is very interesting since it allows the variability of both the trend and the temporary components to change over time, consequently the inflation persistence changes over time. In this model, the logarithms of the variances of η_t and ε_t

[9] The DFGLS Stata routine performs a modified Dickey-Fuller t test for a unit root in which the series has been transformed by a generalized least-squares regression. Also, this routine includes a very powerful lag selection criterion, namely the "modified AIC" (MAIC) criterion proposed by Ng and Perron (2001). The KPSS Stata routine implements an alternative test for stationarity proposed by Kwiatkowski et al. (1992), which has a null hypothesis of stationarity. Inference from this test is complementary to that derived from tests based on the Dickey.Fuller distribution.

[10] This section is build on Chan (2009).

evolve as independent random walks. The model is specified as:

$$\pi_t = \tau_t + \eta_t$$
$$\tau_t = \tau_{t-1} + \varepsilon_t$$

where:

$$\eta_t = \sigma_{\eta,t}\xi_{\eta,t}$$
$$\varepsilon_t = \sigma_{\varepsilon,t}\xi_{\varepsilon,t}$$

and:

$$\ln\sigma^2_{\eta,t} = \ln\sigma^2_{\eta,t-1} + \nu_{\eta,t}$$
$$\ln\sigma^2_{\varepsilon,t} = \ln\sigma^2_{\varepsilon,t-1} + \nu_{\varepsilon,t}$$

where:

$$\xi_t = (\xi_{\eta,t}\xi_{\varepsilon,t}) \sim N(0,1)$$
$$\nu_t = (\nu_{\eta,t},\nu_{\varepsilon,t}) \sim N(0,\gamma I_2)$$

Both ξ_t and v_t are independently distributed Gaussian distribution and γ is the only parameter of the model and it controls the smoothness of the stochastic volatility process. This parameter can be estimated using a Markov Chain Monte Carlo or chosen a-priori. The magnitude of the logarithms of the variances of η_t and ε_t depends on the variances of $v_{\eta t}$ and $v_{\varepsilon t}$. In the case that $var(v_{\eta t})=0$, then $\sigma^2_{\eta t}$ is constant and there is no stochastic volatility in the transitory component. In contrary, when $var(v_{\eta t})$ is large, $\sigma^2_{\eta t}$ will increased period by period. In order to allow the possibility of infrequent large changes in the variances, $v_{\eta t}$ is modeled as the mixture of two normal distribution: $v_{\eta t} \sim N(0, \gamma_1)$ with the probability p and $v_{\eta t} \sim N(0, \gamma_2)$ with probability $1- p$. Considering an elevated p and $\gamma_1 < \gamma_2$, the variance of $v_{\eta t}$ will be low in the most draws but it will be observed large variances of $v_{\eta t}$ occasionally. The same model is used for $v_{\varepsilon t}$.

With the parameters γ_1, γ_2 e p, the initial values of the variances ($\sigma^2_{\eta t}$ and $\sigma^2_{\varepsilon t}$) and the inflation series that is going to be analyzed, we can estimate the values of η_t and ε_t and the permanent component of the inflation τ_t. The following step consists of estimating the variances using the draws obtained before. The results of the model are presented as the average and standard deviations of all of the draws obtained for the permanent component and the variances of the permanent and transitory components.

In this paper we applied the UC-SV model to study the inflation process of the Brazilian inflation. We followed the parameters of the model dispose in Gauss program at the Mark Watson website (http://www.princeton.edu/~mwatson). The model defines a priori that γ=0.2. The variances of $v_{\eta t}$ and $v_{\varepsilon t}$ are modeled as the mixture of two normal distribution: $v_{\eta t} \sim N(7.472, \gamma_1)$ with the probability p and $v_{\eta t} \sim N(0.698, \gamma_2)$ with probability $1- p$, where $p = 0.086$ and $\gamma_1 = \gamma_2 = 1.411$. The same values are used to model $v_{\varepsilon t}$.

The sensibility of the parameter γ was also tested. It was observed that the volatility of the permanent component decreases when γ increases. On the other hand, the volatility of the transitory component increases with the increase of γ. More important is that the inflation persistence path during the period doesn't change with the movements of this parameter.

5. Empirical Findings

5.1. Data set

For the purpose of this paper, we will focus on five key inflation measures. The five series are the Broad Consumer Price Index (IPCA) and the four core versions of the IPCA. We denote this four series throughout as "IPCA free", "Core EX1", "Core EX2" and "Core DP". The official inflation rate IPCA is reported by the National Bureau of Geography and Statistics (IBGE). The IPCA covers a sample of families with personal income between 1 and 40 minimum wages and has broad geographical basis. It includes nine metropolitan areas (São Paulo, Rio de Janeiro, Belo Horizonte, Porto Alegre, Recife, Belém, Fortaleza, Salvador and Curitiba) as well as Goiânia and the Federal District. The core measures are calculated and published by the Brazilian Central Bank.

As mentioned in the footnote 6, the free market inflation ("IPCA free") include only prices that are determined by the supply and demand conditions in the market and are more sensitive to monetary policy decisions. The others core versions of the IPCA abstract from the high frequency noise that can be introduced by volatile food and energy prices, prices set by contracts and other type of noises

The "Core EX1" excludes the items from the food at home sub-group and all monitored prices. The "Core EX2" and "Core DP" are the two new core measures reported by the Central Bank since December 2009. The "Core EX2" series is constructed to exclude the items that show high volatility in a consistently manner. Following this procedure, the "Core EX2" excludes twelve items which represents in average 15.5% of the IPCA`s basket. It excludes ten items from the food at home sub-group and two items from the monitored prices sub-group. In the other hand, the "Core DP" does not exclude any item; it re-weights the items of the IPCA considering the volatility of each item in the total volatility of the IPCA. This means that the higher the volatility of an item, the lesser is its importance in this series.

Our data set runs from 1996 until 2009. But we focus on the dynamics of the inflation persistence only after January 1999, which was when the crawling-peg exchange rate policy was abolished. In order to understand the dynamics of the inflation persistence during this period we tested monthly and quarterly data of this five key inflation index in all economic procedures mentioned above. Also the seasonally adjusted data of this series (obtained with the X-12 method) are also tested in all this methods.

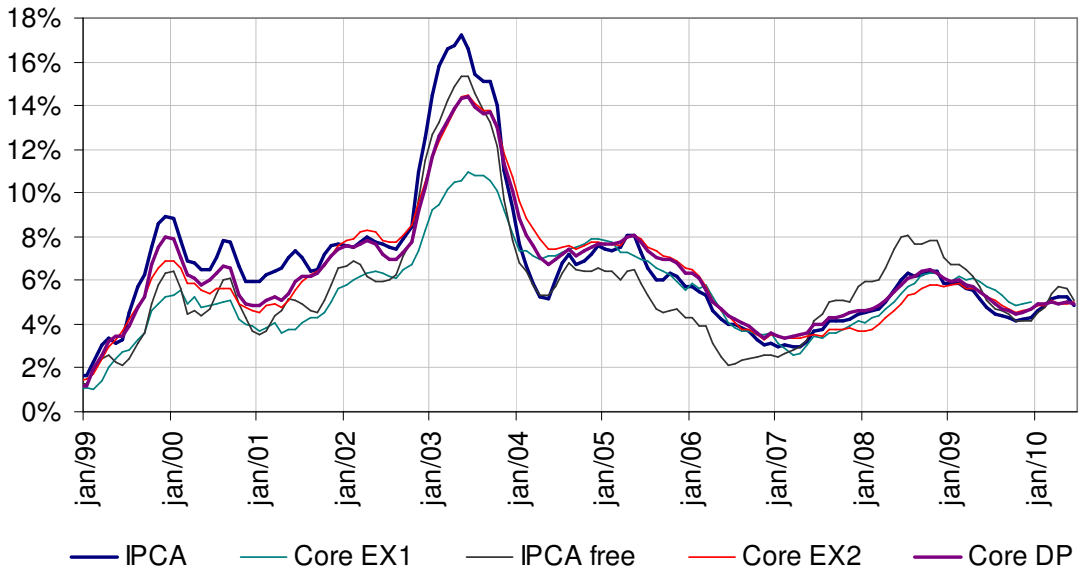
Table 1 provides summary statistics for the five inflation series. Evident in the Figure 2 and in the table are the drop in the level of all inflation measures, the decline in the variance of all measures and the conversion of IPCA´s volatility to the core´s volatility.

Table 1: Summary statistics for all inflation measures

Series	Mean		
	1996-09	1999-09	2004-09
IPCA	7.1%	6.7%	5.3%
Core EX1	5.3%	5.6%	5.5%
IPCA free	6.1%	5.9%	5.2%
Core EX2	7.1%	6.4%	5.6%
Core DP	6.8%	6.5%	5.7%

Series	Variance		
	1996-09	1999-09	2004-09
IPCA	0.16%	0.10%	0.02%
Core EX1	0.05%	0.04%	0.02%
IPCA free	0.14%	0.08%	0.03%
Core EX2	0.19%	0.08%	0.03%
Core DP	0.14%	0.07%	0.02%

Figure 2: Brazil inflation measures (%p.a.)



5.2. Autoregressive Results

In this section we present the results for the seasonally adjusted series.[11] Also, given our short sample size, we focus on the monthly data. First of all, we examine to what extend the individual series are characterized by a stationary pattern. If the time trend is included in the DFGLS test, we reject the null hypothesis of non-stationarity at a 5% significance level for all series; otherwise only for the Core EX1 we can refute the null hypothesis of non-stationarity. Regarding the KPSS test with time trend, we reject the null hypothesis of stationarity for IPCA only, considering its 10% significance level. If the time trend is not included, the KPSS tests indicate that all series are stationary. Since we cannot reject the non-stationarity of our series we also report the persistence coefficients delivered by the DFGLS tests.

Table 2 shows all persistent measures discussed in Section 3, considering two sample periods: one from 1999 to 2009 and the other from 2004 to 2009. In general, Dias and Marques (2010)´s method (hereafter DM) delivers the lowest values, whereas the DFGLS´s without time trend, the highest ones. For the IPCA, the persistence coefficient ranges from 0.59 to 0.84 considering all period of the sample. Similar results are found in Matos (2010) using the aggregated consumer prices indices computed by Fundação Getulio Vargas (FGV).[12]

With respect to the other inflation series, the IPCA free provide analogous values when we compare to the IPCA. If we look at the others Core series, all econometric strategies yield higher estimated coefficients that range from 0.62 to 0.92, disregarding the *AR(1)* method.[13]

Now we investigate the empirical findings for the short sample from 2004 to 2009. First of all, we observe a remarkable reduction on the estimated persistence for all series, independently of the econometric model used. In particular, the IPCA´s coefficients range from 0.47 to 0.58. Similar evidence is observed when we inspect all the core measures.

[11] It is important to note that inflation series have a seasonal pattern. Consequently, for the autoregressive regression, we consider seasonally adjusted series only.

[12] For the aggregated CPI-FGV, the estimated coefficient ranges from 0.56 to 0.79.

[13] Wald test reject at the 5% $\rho^{SAR} = 1$ for all *AR(p)* regressions.

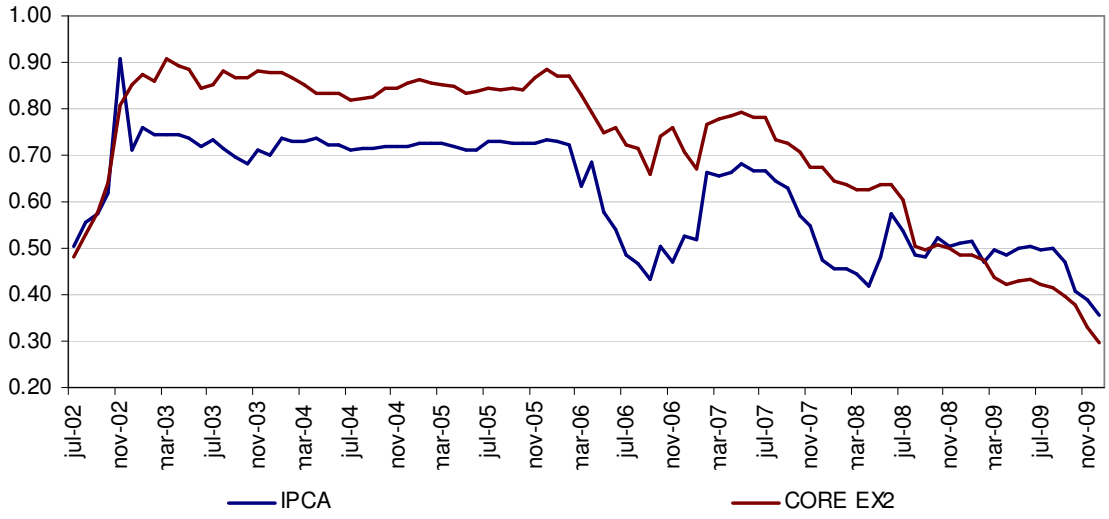
Table 2: Annualized Seasonal Adjusted Monthly Inflation Persistence – "Traditional" Measures

Measure	Sample	AR(1)	AR(p)	DM	DFGLS[1]	DFGLS[2]
IPCA	1999-09	0.71	0.71	0.59	0.68	0.84
	2004-09	0.58	0.58	0.47	0.48	0.53
CORE EX1	1999-09	0.57	0.70	0.68	0.72	0.75
	2004-09	0.63	0.63	0.60	0.67	0.74
IPCA free	1999-09	0.71	0.71	0.58	0.71	0.82
	2004-09	0.58	0.58	0.51	0.58	0.59
CORE EX2	1999-09	0.81	0.81	0.66	0.83	0.93
	2004-09	0.69	0.69	0.60	0.75	0.81
CORE DP	1999-09	0.74	0.74	0.62	0.79	0.91
	2004-09	0.71	0.71	0.56	0.70	0.75

Notes (1) with time trend, (2) without time trend

For robustness, the structural stability of inflation persistence is examined through rolling regressions. Figure 3 presents rolling estimates of the persistence parameter considering a 40-month window for both IPCA and Core EX2 series. By inspecting a sequence of the rolling estimates and comparing the estimates across different samples and with the full sample results, we found evidence of a decrease in inflation persistence in the last four years.

Figure 3 – Rolling-sample Estimates of the Sum of *AR(p)* Coefficients for the Seasonal Adjusted Monthly IPCA and Core EX2 (40-month Window)



With respect to the quarterly regressions, as expected, the estimated coefficients are lower when compared with monthly estimates for all econometric procedures. This is a statistical effect that was mentioned by Bilke (2005). He also pointed that monthly frequency could introduce additional noise (sales effect for instance) which implies a reduction in the persistence measure when compared with quarterly frequency. However, the empirical

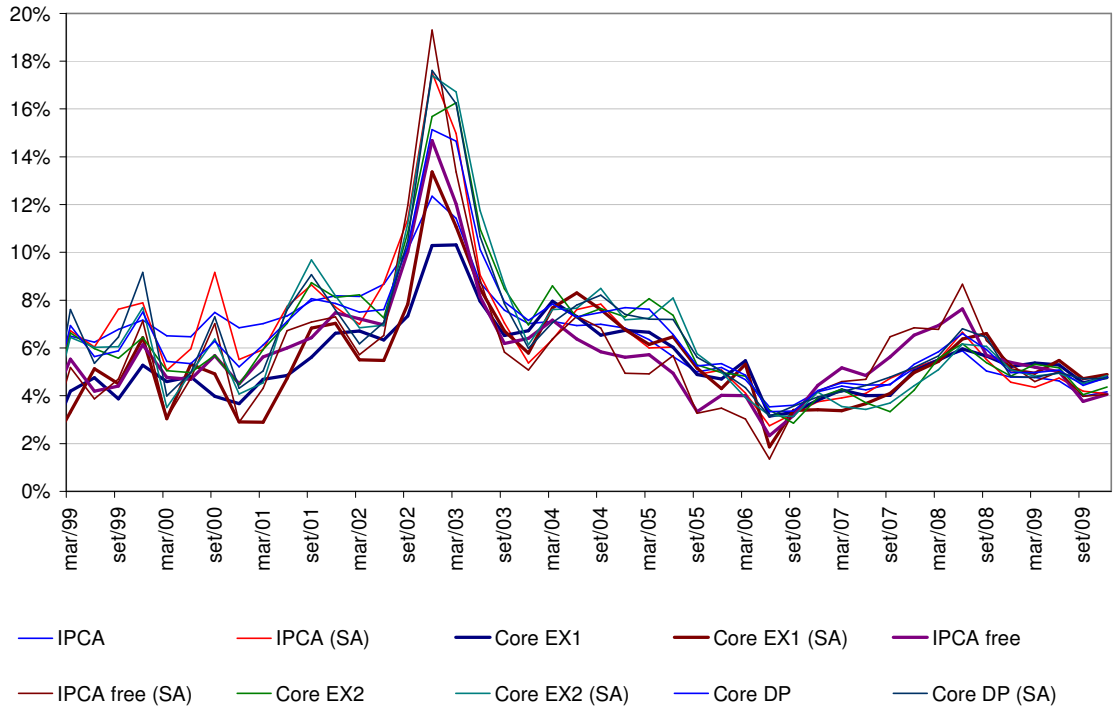
results indicate that the first effect dominates the second one.

5.3. Stock and Watson´s Results

This section summarizes the results obtained using the Stock and Watson's methodology for the seasonally adjusted and not seasonal adjusted quarterly annualized series of IPCA and its core measures. The estimates for the trend and the volatility of the permanent and transitory components of the inflation are reported in two sample periods: one from 1999 to 2009 and the other from 2004 to 2009 in Table 3.

We observe a reduction on the average estimated permanent component for all series as shown if Figure 4. For example, the average of the estimated permanent component of the IPCA has fallen from 6.4 percent from 1999 to 2009 to 5.1 percent from 2004 to 2009. All the other measures of the core inflation showed a similar pattern. The estimated permanent components of the core measures declined from a range of 5.6 to 6.6 percent from 1999 to 2009 to a range of 5.1 to 5.5 percent from 2004 to 2009.

Figure 4 – Estimated Permanent Component for all Inflation Measures



Regarding the volatility of the permanent and the transitory component we also observed a decline during the period for almost all the inflation measures as shown in Figure 5 and 6. The volatility of the permanent component declined for all the measures except for two measures: the CORE EX1 and the IPCA free. The volatility of the permanent component declined from a range of 1.0 to 2.3 from 1999 to 2009 to a range of 0.9 to 1.9 from 2004 to 2009. The volatility of the permanent component of the CORE EX1 and the IPCA free didn't change during the period of the sample. On the other hand, the volatility of the transitory component declined for these two measures during the period.

It is interesting to notice the increase of the permanent component and the volatility of the permanent and the transitory components in almost all the inflation measures at the end of the year of 2002 until mid 2003. The increase of this volatility is related to the victory of the left wing president Lula in 2002. The volatility only decrease after the announcement of the new government of its intention to maintain the orthodox policies.

Figure 5 – Estimated Volatility of the Permanent Component for all Inflation Measures

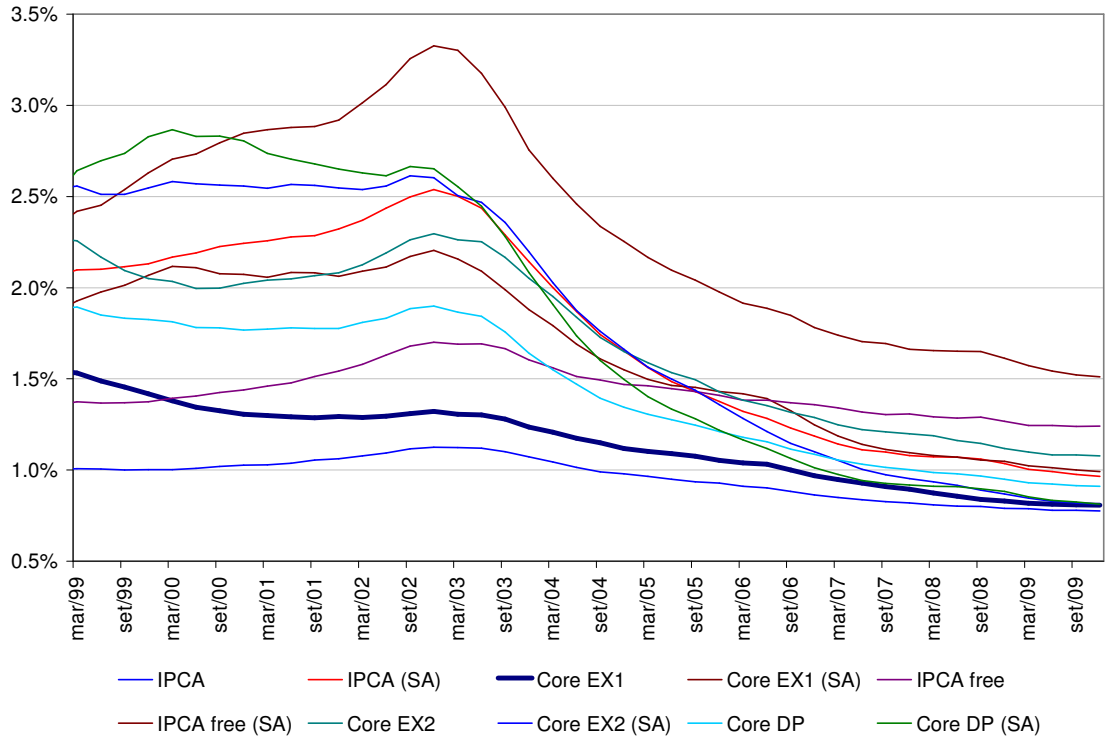


Figure 6 – Estimated Volatility of the Transitory Component for all Inflation Measures

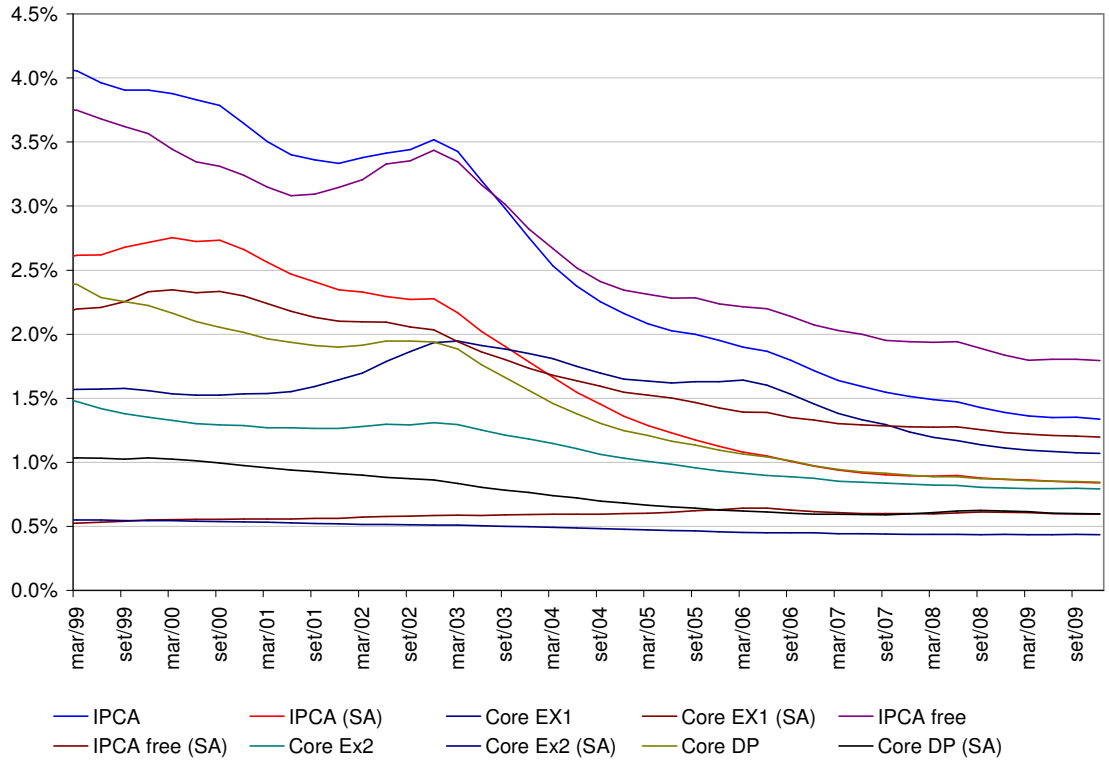


Table 3: Estimated Results for all Inflation Measures – Stock and Watson's Methodology

Measure	Sample	Permanent Component	Volatility Permanent Component	Volatility Transitory Component
IPCA	1999-09	6.4%	1.0%	2.6%
	2004-09	5.1%	0.9%	1.8%
IPCA (SA)	1999-09	6.5%	1.7%	2.3%
	2004-09	5.1%	1.3%	1.5%
CORE EX1	1999-09	5.6%	1.1%	1.5%
	2004-09	5.3%	1.1%	1.4%
CORE EX1 (SA)	1999-09	5.6%	1.6%	0.6%
	2004-09	5.3%	1.3%	0.6%
IPCA free	1999-09	5.9%	1.4%	2.6%
	2004-09	5.1%	1.4%	2.1%
IPCA free (SA)	1999-09	6.0%	2.3%	1.7%
	2004-09	5.1%	1.9%	1.4%
CORE EX2	1999-09	6.5%	1.7%	1.1%
	2004-09	5.3%	1.4%	0.9%
CORE EX2 (SA)	1999-09	6.6%	1.8%	0.5%
	2004-09	5.3%	1.2%	0.5%
CORE DP	1999-09	6.6%	1.4%	1.5%
	2004-09	5.5%	1.1%	1.0%
CORE DP (SA)	1999-09	6.6%	1.8%	0.8%
	2004-09	5.5%	1.2%	0.6%

For the understanding of the inflation persistence it is important to focus on the permanent component and its volatility. The results obtained by the Stock and Watson methodology showed that both has declined during the period for the IPCA and for its core measures and it is an evidence of the disinflation process in Brazil.

Chan (2009) also found a disinflation process in Brazil. They applied the Stock and Watson (2007)'s model to a longer data series, the Broad Consumer Price Index of Rio de Janeiro (IPC-RJ). The results showed that the inflation persistence was very high in the mid of the 80's and started to slowdown in 1994. This moderation of the inflation persistence has coincided with changes in policy, such as the introduction of an economic reform program in mid 1994 and the implementation of the inflation targeting in mid-1999.

Stock and Watson (2007) and Cecchetti et al. (2007) applied the Stock Watson's methodology to other countries and they also observed a decline of the inflation persistence in those countries.

Stock and Watson (2007) used the annualized quarterly change in GDP to study the inflation dynamics of United States from the first quarter of 1953 until the last quarter of 2004. The paper concluded that inflation is much less volatile than it was in the 1970s or early 1980s and that the inflation persistence has declined during the period. This structural change in inflation has made easier to forecast the inflation of United States.

Cecchetti et al. (2007) used this model to analyze the inflation dynamics of the G7 countries from 1960 until 2006. They concluded that the inflationary process is very similar in different countries. The level and the volatility of the permanent component displayed coincident hump-shaped patterns at the end of the decade of 60 and showed a synchronized inflation stabilization in the mid of the 80s. This synchronization of the inflation process allowed established the start of the Great Inflation as the late 1960s and the beginning of the Inflation Stabilization as the mid 1980s. The results showed that the average estimated permanent component of the G7 countries has declined from 7.99 percent in the period of 1970 to 1979 to 1.43 percent from the period of 2000 to 2006. The volatility of the permanent component has also displayed a similar pattern; it declined from 1.118 percent from the period of 1970 to 1979 to 0.003 percent from the period of 2000 to 2006. The report also concluded that the slowdown of the inflation persistence was explained by the change in monetary regime adopted by the different countries in mid 1980s.

Our results are consistent with a vast literature that shows that inflation persistence has decreased over time.

6. Conclusion

There is little agreement in the extant literature on how best to measure the inflation persistence. In this paper, we examined some measures that attempt to capture the evolution of the Brazilian inflation persistence for the IPCA and its core measures. We employed some "traditional" empirical measures such as: (i) the sum of the autoregressive coefficients in a univariate process of inflation, (ii) the Marques (2004) and Dias and

Marques (2010)'s methodology and (iii) the DFGLS method. We also conduct our analysis using the Stock and Watson's (2007) methodology. This model is very interesting since it decomposes the inflation into a permanent and transitory component. It also let the permanent component and the volatility of both disturbances to vary over time.

From the "traditional" measures, we observe a remarkable reduction on the estimated persistence for all the series, independently of the econometric model used. In general, Dias and Marques (2010)'s method delivers the lowest values while the DFGLS's model without time trend delivers the highest values of persistence coefficient. In particular, the "tradicional" measures showed an IPCA's persistence coefficients that range from 0.47 to 0.58 from 2004 to 2009.

The results of the Stock Watson's model enable us to verify a decline in the permanent component and its volatility for all measure of inflation after the confidence crisis that preceded President Lula's election in 2002. In particular, the permanent coefficient of the IPCA declined from 6.4 percent in 1999 to 2009 to 5.1 percent in 2004 to 2009. The volatility of the permanent component reduced to 0.9% in 2004 to 2009 while the transitory component reduced to 1.8% in this same period.

In summary, all the results of the models showed that the persistence of the inflation in Brazil has declined since 1999, which coincided with the time of the adoption of the inflation targeting regime in Brazil. The pursuit of more aggressive monetary policy to control inflation and the achievement of more anchored inflation expectation explain in part this disinflation process observed during this period. To the extend that improved policy gets some of the credit, then one can expect at least some of the moderation to continue as long as the policy regime is maintained.

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