Inflation and Interest Rate: Which one is more persistent in Brazil?

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Abstract

This paper analyzes inflation persistence in Brazil, taking into consideration the period after the implementation of the Real Plan, from August/1995 to May/2008. We make use of Auto-Regressive Fractionally Integrated (ARFIMA) models to examine IPCA (the official inflation rate), inflation expectations, and the Selic interest rate. Furthermore, we examine the impulse response functions of the best model selected for each series. The picture emerged from the results shows that the indices have some degree of persistence but they are all mean-reverting. We can observe that the IPCA is stationary and its persistence decreases with the implementation of the inflation targeting regime. On the other hand, inflation expectations and the Selic Rate are persistent, nonstationary, but with evidences of mean reversion in the long run. This is confirmed by the analysis of the impulse response functions. They show that disturbances to all series tend to disappear considerably in the short to medium run (12 months), although shocks to some indices take longer to vanish than others. In terms of economic policy, this result indicates that the high persistence of interest rates has been an efficient instrument for controlling inflation in Brazil. but insufficient to generate enough credibility to mitigate inflation expectations.

Key Words: Inflation Persistence, Monetary Policy, Time Series Analysis

JEL: C22, E31, E52

Resumo

Este artigo analisa a questão da persistência inflacionária no Brasil por intermédio dos Modelos Auto-Regressivos de Integração Fracionada (ARFIMA). O estudo compreende o período de Agosto/1995 a Maio/2007 e leva em consideração o IPCA, as expectativas de inflação e a Taxa Selic. O resultados mostram uma certa persistência nos índices analisados, mas com reversão a uma média de longo prazo. Sobre o IPCA, observa-se que ele é estacionário e que sua persistência diminui com a implementação das metas de inflação. Por outro lado, as Expectativas de Inflação e a Taxa Selic são persistentes, não estacionárias, mas com reversão à média. Isso é confirmado pela análise das funções de resposta aos impulsos, que mostram uma tendência de desaparecimento dos choques do curto para o médio prazo (12 meses), apesar de algumas perturbações perdurarem mais do que outras. Em termos de política econômica, isso seria um indicativo de que a alta persistência da taxa de juros tem sido um instrumento eficiente para o controle do IPCA, mas insuficiente para adquirir credibilidade capaz de mitigar as expectativas de inflação.

Palavras-Chave: Persistência Inflacionária, Política Monetária, Análise de Séries Temporais
JEL: C22, E31, E52

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1. Introduction

The understanding of the inflation dynamics is of great importance given that it helps economic policymakers within the decision making process by providing accurate approaches to deal with inflation. In other words, when policymakers pay attention to the price behavior in an economy, they can take preventive measures against possible pressure on prices while alleviating costs in terms of inflation tax, GDP, and employment. These issues are related to the inflation persistence phenomenon, which is defined as the implicitly or explicitly predisposition of inflation to converge to the Central Bank's inflation target.

Batini (2006) conceptualizes inflation persistence in three distinct ways: *i*) the disparity between systematic monetary policies and their greatest effects on inflation; *ii*) the inflation lagged response to non-systematic economic policy shocks; and *iii*) a positive serial correlation in inflation. In the first concept, the systematic monetary policies are related to the response of the reaction function to exogenous shocks derived from the private sector. That is, this type of persistence refers to the number of periods necessary to change the monetary environment in such a way that inflation is affected to the highest degree. The second type relates to the number of disparities necessary to make inflation respond to a political shock. The third persistence type, the one used in this paper, has been documented in several countries and, in most of the cases, it has decreased along time mainly because of monetary policies strongly based on price control. In the USA, for instance, Fuhrer & Moore (1995) detected a high serial correlation for the 1965-1990 period while Batini & Nelson (2001) showed that such correlation has significantly declined after 1984 (probably because of the Volcker-Greenspan regime in the FED). In the case of Great Britain, Batini & Nelson (2001) found a significant drop in the autoregressive coefficient for the British inflation after 1992.

A number of developing and developed countries pay especial attention to the dynamics involved within the inflation persistence phenomenon.[1] This question is also of utmost importance to Brazil, a country which faced problems of chronic inflation for such a long time. It was only after the implementation of the *Plano Real* (Real Plan) in 1994 that the Brazilian economy started to show tolerable inflation rates. However, since then, inflation has been controlled based on high interest rates, which makes inflation targets hard to reach.

The aim of this paper is to analyze the Brazilian inflation persistence based on a univariate approach called Auto-Regressive Fractionally Integrated (ARFIMA). We search for answers for the following questions: 1) What is the degree of inflation persistence in Brazil? 2) Inflation expectations is

[1] Recently, the European Central Bank has maintained a research network called Eurosystem Inflation Persistence Network to conduct in-depth studies about inflation persistence.

more or less persistent than the inflation rate itself? 3) Has the introduction of inflation targeting policies decreased inflation persistence? 4) What is the degree of persistence of interest rates and how does it behave in relation to inflation? 5) Do the series converge to the mean in the long run or do they show an explosive behavior?

The estimations made take into consideration the following variables: Consumer Price Index (IPCA), inflation expectations (from July 2001 on) and the Selic rate. Additionally, we conduct an analysis of the impulse response functions of the best models selected. The period under analysis starts in 1995 (a year after the Real Plan's implementation) and goes up until the first half of 2007. In general, the results point toward a varied degree of persistence among the analyzed series. However, all series show reversion to the mean in the long run, discarding the possibility of an explosive behavior. Specifically after the implementation of the inflation targeting framework, the IPCA presents a stationary behavior and a significant drop in its persistence. On the other hand, both Selic rate and inflation expectations show a much more persistent behavior. In other words, our calculations suggest that the Brazilian inflation persistence, measured by the IPCA, does not display high levels of inertia - an indication that economic policies have been efficient in controlling the consumer price index. However, the inflation expectations and the Selic rate are nonstationary, but they revert to the mean in the long run. This is confirmed by the impulse response function analysis in which shocks tend to disappear in the short to medium run (12 months) – albeit some perturbations persist more than others.

As such, we can say that the Brazilian inflation persistence has interesting characteristics. Firstly, inflation is indeed under control while expectations are not. Secondly, there is evidence of a trade-off between interest rates and inflation expectations. Although the high (and persistent) interest rate is able to mitigate eventual inflationary processes, they do not generate enough credibility to mitigate inflation expectations.

The article is structured as follows. Section 2 brings a literature review. Section 3 deals with the econometric methodology. Section 4 describes the data used in the analysis. Section 5 discusses the results, and section 6 concludes.

2. Literature Review

Batini & Nelson (2001) study the British and American cases and Batini (2006) does a similar analysis for the European Union. In both studies, the focus is on the lagged impact of the monetary policy actions in relation to the inflation response. Their results show that the greatest effects (i.e. decreased inflation) of monetary actions take place one year after their implementation. Hondroyiannis

& Lazaretou (2004) analyze the Greek case for the 1975-2003 period. The authors show that the country has reduced inflation since 1997 thanks to effective actions, taken by the Greek Central Bank, against high inflation rates. Gadzinski & Orlandi (2004) analyze inflation persistence in the USA and in other EU countries paying especial attention to existing structural breaks in the series. The authors find moderate cases of persistence and a significant connection between the European and American inflation rates. Benigno & López-Salido (2006) estimate Phillips Curves for Germany, France, Italy, Spain, and the Netherlands seeking for evidence of heterogeneity in the dynamics of inflation in those countries. The authors find inertial behavior (backward looking) for four countries, being Germany the only case of a forward looking behavior.

In relation to the ARFIMA models, Doornik & Ooms (2004) draw inferences concerning the British and North American inflationary processes. For the American case, the quarterly sample (1957:Q1 to 2003:Q4) generates parameters around 0.32, showing stationary series. In the British case, the quarterly sample (1959:Q1 to 2002:Q2) generates parameters varying between 0.47 and 0.59, indicating the possibility of nonstationary series.

Gil-Alana (2005) applies the ARFIMA method for the analysis of the USA inflation rate and concludes that results vary significantly according to how perturbations I(0) are specified in the model. For example, for the white noise specification, the regressions show a stationary inflation with a fractionally integrated parameter equals to 0.25. For perturbations with an autoregressive process, the series integration order is negative, which characterizes an anti-persistent behavior.

For the Brazilian case, the analysis done by Cati et al (1999) covers the period between January/ 1974 and June/1993, a time frame characterized by great influence of the effects resulted from the implementation of stabilization plans. Given that inflation was only temporarily reduced, returning to its initial path after a while, those abrupt governmental interventions acted as inliners. The authors use standard unit root tests and show that the series are stationary and the observed perturbations have temporary effects. However, when statistics that take into account stabilization plans are used, the obtained results show that the stochastic behavior of the Brazilian inflation rate is, in fact, very unstable during that period. As such, the authors conclude that the macroeconomic interpretation of these results is in line with the inflationary inertia hypothesis (Arida & Lara-Rezende, 1985; Bresser-Pereira & Nakano, 1986; among others), which states that inflation perturbations are extremely persistent.

Campêlo & Cribari-Neto (2003) show that the use of robust standard unit root tests can generate the same inference about the series' order of integration, without using dummy variables that take into consideration the existence of inliners. The authors use two monthly series related to the Brazilian inflation rate. The first is similar to Cati et al (1999) and the second covers the period between

February/1944 and February/2000. The main result indicates the presence of inflation inertia, which is small as opposed to the previous results.

Yoon (2003) uses the same data as Cati's et al (1999) to estimate a unit root test proposed by Ng & Perron (2001) and constructs four tests based on the GLS detrending procedure. This technique can generate the same conclusions reached by Cati et al (1999) without the use of dummy variables. The author concludes that inflation rate is nonstationary during the period under analysis.

3. Econometric Methodology: The ARFIMA Models

The analysis of inflation persistence can be performed by the use of several unit root tests found in the literature. Given that the series' order of integration '*d* ' assumes only integer values (i.e. I(0) if stationary, and I(1) if not), its estimation ignores the possibility of noninteger values. The ARFIMA (Autoregressive Fractionally Integrated Moving Average) methodology is a kind of time series model that generalizes ARIMA models (*p*, *d*, *q*) and allows for fractional values of the order of integration '*d* ' between 0 and 1. Low levels of '*d* ' characterize weak persistence in the ARFIMA models, while in the traditional unit root models these are nonexistent persistence. On the other hand, high levels of '*d* ' are considered persistent with reversion to the mean, whereas in the traditional unit root tests such persistence exists but with no reversion to the mean. In sum, the ARFIMA models have the following rules: 1) if $0 \geq d \leq 0.5$ the series is stationary with reversion to the mean and it is a process of long memory; 2) if $0.5 < d \leq 1$, the series is non stationary but still mean reverting; 3) if $d \geq 1$, the series is non stationary and does not have mean reversion.

In other words, the flexibility of the ARFIMA models increases the acuity of the analysis by better defining each series' degree of persistence – a step forward in relation to the rigid unit root tests. Moreover, the ARFIMA models improve the low power behavior of the unit root test and are also capable of modeling the dynamics of short and long run inflationary processes through the estimation of impulse response functions.

A basic ARIMA model (*p*, *q*) can be written in the following way:

$$y_t = \alpha_1 y_{t-1} + \ldots + \alpha_m y_{t-m} + \xi_t + \beta_1 \xi_{t-1} + \ldots + \beta_n y_{t-n}, \qquad t = 1, \ldots, T. \tag{1}$$

Where $\xi_t \sim NID\left[0, \sigma_\xi^2\right]$.

An integrated process of order ' *d* ' can have the following representation:

$$(1-L)^d y_t = \Phi(L) u_t \tag{2}$$

with $\sum_{j=0}^{\infty}\left|\Phi_j\right|<\infty$. Usually, it is assumed d = 1, or that the first difference of the series is stationary. However, these noninteger values of 'd' can be of great use.[2]

Consider the MA representation (∞) in (2). If $d > 0.5$, the reverse of the operator $(1\text{-}L)^{-d}$ exists. That can be seen by multiplying both sides of the first equation by $(1\text{-}L)^{-d}$. The result is as follows:

$$y_t = (1-L)^{-d}\,\Phi(L)u_t \tag{3}$$

The operator $(1\text{-}L)^{-d}$ can be represented by the following filter:

$$(1-L)^{-d} = \sum_{j=0}^{\infty}\lambda_j L^j \tag{4}$$

where $\lambda_0 \equiv 1$ and:

$$\lambda_j = (1/j!)(d+j-1)(d+j-2)(d+j-3)\cdots(d+1)(d) \tag{5}$$

It can be demonstrated that if $d < 1$, λ_j can be approximated towards a large j by:

$$\lambda_j \cong (j+1)^{d-1} \tag{6}$$

Therefore, an MA representation (∞) in which the coefficient of the impulse response λ_j behaves for large j like $(j + 1)^{d-1}$ can be defined as:

$$y_t = (1-L)^{-d}\,u_t = \lambda_0 u_t + \lambda_0 u_{t-1} + \lambda_0 u_{t-2} + \cdots \tag{7}$$

The autocorrelations of the stationary ARIMA series can have an exponential decrease, while fractionally integrated series have hyperbolic decreases. In other words, while the coefficients of an ARIMA stationary impulse-response disappear geometrically, the processes of equation (6) imply a gradual and slower decay. That is why fractionally integrated series are also denominated long memory time series (Hamilton, 1994).

In addition to that, the sequence of the limiting MA coefficients $\{h_j\}_{j=0}^{\infty}$, given in equation (6), can be shown to be *square-summable* so long as $d < 0.5$:

$$\sum_{j=0}^{\infty} h_j^2 < \infty \qquad para \quad d < 0.5 \tag{8}$$

Therefore, for $d < 0.5$, the aim is to difference the process before performing the description presented in equation (3) (Hamilton, 1994). As mentioned above, if $0 \geq d \leq 0.5$ the series is stationary with reversion to the mean and it is a process of long memory. If $0.5 < d \leq 1$, the series is non

[2] See for instance, Granger & Joyeux (1980) and/or Hosking (1981) for a better comprehension of fractionally integrated models.

stationary but mean reverting. If $d \geq 1$, the series is nonstationary and does not have mean reversion (Gil-Alana, 2001). If $-0.5 < d < 0$, the process is called over-differenced.

Three estimation methods of the ARFIMA models are commonly used: Exact Maximum Likelihood (EML), Modified Profile Likelihood (MPL), and Nonlinear Least Squares (NLS).[3] By definition, both EML and MPL impose $-1 < d < 0.5$. If the model includes regressor variables and the sample is small, the MPL is preferred over the EML. The NLS methodology allows for $d > -0.5$ and can be used in the estimation of nonstationary series (Baillie, Chung & Tieslau, 1996).

Given that the series analyzed seem to be nonstationary, the EML methodology does not apply because it is seriously biased downwards for *'d'* values close to 0.5 and greater than 0.5. Therefore, we make use of the NLS methodology, which does not present these usual biases. The NLS estimator is based on the maximization of the following likelihood function:

$$\ell_N(d, \Phi, \Theta) = -\frac{1}{2}\log\left(\frac{1}{T}\sum_{i=1}^{N}\tilde{e}_t\right) \qquad (9)$$

where the residuals $\tilde{e}_t$ are obtained by applying the ARFIMA (p, d, q) model to the u_t and the vectors Φ and Θ represent the autoregressive parameters 'p' and the moving average 'q' respectively.

4. Data

The period under analysis ranges from August/1995 to May/2007, and the monthly data used are seasonally adjusted. The series investigated are: IPCA, Selic Interest Rate and Inflation Expectations accumulated in the following 12 months (from July/2001 to May/2007).

Table 1 presents the descriptive statistics of the data. After the implementation of the Real Plan, the Brazilian inflation rate (IPCA) dropped about 6% per month, a significant result if compared to the monthly 16% of the period previous to the Real Plan. When the series is divided between before and after the implementation of the inflation targeting system, a drop in the average inflation cannot be observed probably due the large shocks suffered by the Brazilian economy (e.g. the 2001 energy crisis and the Lula crisis). Additionally, the inflation targeting policies were able to mitigate the variability of the consumer price index, as verified by the results related to its standard deviation.

[3] Methods available in the OxMetrics package by Doornik & Ooms (2001).

Table 1

Descriptive Statistics

Period	Stat.	IPCA	Inflation Expectation	Selic Rate
1995/Aug 2007/May (142 obs)	Mean	0.582	-	1.793
	Median	0.467	-	1.554
	Maximum	2.899	-	4.262
	Minimum	-0.355	-	1.015
	Std. Dev.	0.463	-	0.711
1995/Aug 1999/Jan (42 obs)	Mean	0.546	-	2.431
	Median	0.406	-	2.040
	Maximum	1.442	-	4.262
	Minimum	-0.355	-	1.584
	Std. Dev.	0.493	-	0.879
1999/Feb 2007/May (100 obs)	Mean	0.598	5.809	1.525
	Median	0.490	5.428	1.418
	Maximum	2.899	12.176	3.334
	Minimum	0.022	3.016	1.015
	Std. Dev.	0.452	1.996	0.393

Source: IBGE

Seasonally Adjusted Series. Inflation expectations: Jul/2001 to May/2007 (71 obs).

Table 2 shows the correlations among the variables analyzed in this article. All relations are strong. However, it is worth noting that the correlation between interest rates and inflation expectations is stronger than between interest rates and inflation. That illustrates the importance of the inflation expectations when dealing with the Brazilian monetary policy.

Table 2
Correlations

	IPCA	Selic Interest Rate	Inflation Expectations
IPCA	1,000		
Selic Interest Rate	0,360	1,000	
Inflation Expectations	0,805	0,682	1,000

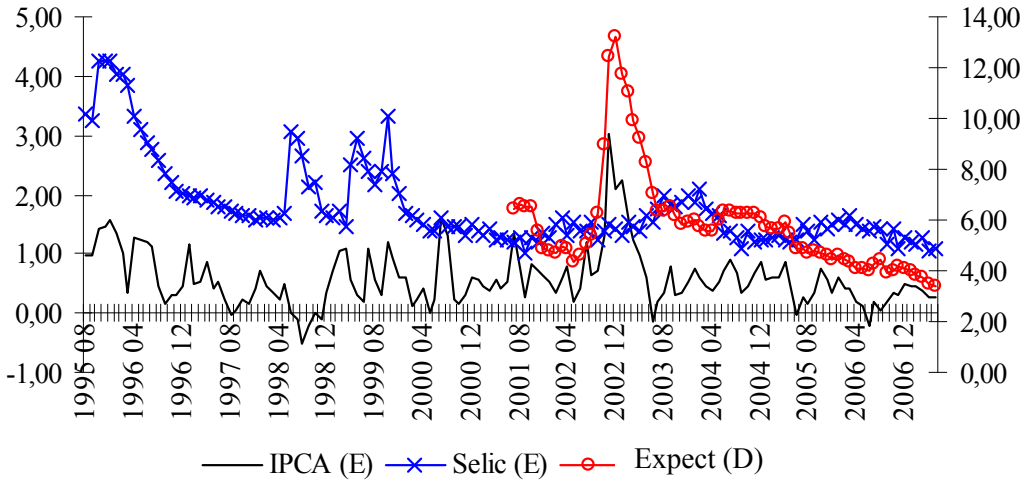
Figure 1 provides a better understanding of the descriptive analysis of Table 2.1.[4] Although inflation has been relatively controlled since the implementation of the Real Plan, significant crisis should be pointed out. Among them, the devaluation of the Real in February of 1999, and the Lula

[4] The data were not seasonally adjusted Figure 1.

crisis in 2002 - they are very distinct in Figure 1 and the main causes are the anxiety generated by measures that could be possibly taken by the President at that time.

Figure 1

IPCA, Selic Interest Rate and Inflation Expectations (1995-2007)



Source: IPEADATA

5. Results

Before analyzing the ARFIMA results, it is important to look at the series autocorrelation reported on Table 3. It is clear that the seasonally adjusted inflation rate has a slow decrease given the significant autocorrelations up until the 12th lag in most of the series. On the other hand, the first difference autocorrelations show negative signs for most of the series, indicating that they can be over-differenced. Only the inflation expectations series seems not to be over-differenced.

Table 3

Auto-correlations – Series in Level and in First Difference

Series	Def.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
IPCA	x_t	0.72	0.47	0.33	0.27	0.17	0.07	0.04	0.09	0.11	0.06	0.00	-0.01	-0.02	-0.03	-0.01	0.07	0.08	0.05
	Δx_t	-0.07	-0.20	-0.15	0.08	0.02	-0.13	-0.14	0.02	0.14	0.00	-0.07	0.00	0.02	-0.06	-0.09	0.10	0.07	0.00
Inflation Expectations	x_t	0.94	0.81	0.67	0.53	0.40	0.28	0.17	0.10	0.04	-0.01	-0.04	-0.04	-0.01	0.04	0.09	0.12	0.13	0.13
	Δx_t	0.57	0.12	-0.02	-0.03	-0.05	-0.17	-0.22	-0.16	-0.08	-0.11	-0.33	-0.36	-0.16	0.01	0.03	0.03	0.03	0.15
Selic	x_t	0.83	0.69	0.59	0.51	0.44	0.37	0.29	0.27	0.27	0.27	0.24	0.21	0.18	0.18	0.18	0.15	0.11	0.07
	Δx_t	0.01	-0.10	-0.04	-0.06	0.07	0.07	-0.20	-0.11	0.02	0.11	0.07	-0.01	-0.16	0.04	0.19	0.07	-0.02	-0.09

For *a posteriori* comparison, we start the analysis by the ADF and KPSS unit root tests.[5] The results reported on Table 4 show that, for the ADF test, only the inflation expectations series does not reject the null hypothesis of nonstationarity. However, Kwiatkowski, Phillips, Schmidt & Shin (1992) argue that testing unit root as null hypothesis may not be viable because such hypothesis is hard to be rejected, unless the opposite evidence is very strong. However, the majority of the economic series might not have enough information to determine if it has or not a unit root.[6] The KPSS procedure proposes an alternative unit root test in which the null hypothesis is the stationarity against the alternative hypothesis of unit root. Table 4 shows that the KPSS results reject the null (stationarity) hypothesis for inflation expectations, in line with the ADF test, and also for the Selic Rate, as opposed to the ADF test. In sum, the unit root tests imply disparities within results leading us to conclude that the long memory models are better alternatives.

Table 4

Unit Root Tests

Series	ADF						KPSS					
	Test Statistics	*Lag*	Critical Values		Reject Ho Unit Root		Test Statistics	*Lag*	Critical Values		Reject Ho Estacionarity	
			5%	10%	5%	10%			5%	10%	5%	10%
IPCA	-4.83	0	-2.88	-2.57	Yes	Yes	0.15	8	0.46	0.34	No	Não
Expectations	-2.74	1	-2.90	-2.58	No	Yes	0.48	6	0.46	0.34	Yes	Yes
Selic	-4.50	0	-2.88	-2.57	Yes	Yes	0.97	9	0.46	0.34	Yes	Yes

Note: Estimations with constant only.

For the ARFIMA (p, d, q) models estimations we follow the standard procedure observed in other works. We made use of autoregressive (AR) and moving average (MA) representations up to the third lag, generating 16 different estimations for each model. Firstly, we estimated models for the entire period of the sample (from August/1995 to May/2007). Secondly, a dummy was implemented for the period after the introduction of the inflation targeting framework. Thirdly, we also divided the sample between before and after the inflation targeting implementation for an in-depth comparison. For the inflation expectations, the complete estimation goes from July/2001 to May/2007 and the second estimation is restricted to the period between July/2003 and May/2007. After the regression of the 16

[5] See Dickey & Fuller (1979) and Kwiatkowski, Phillips, Schmidt & Shin (1992).
[6] Diebold & Rudebusch (1991) show that ADF tests can lead to inaccurate conclusions, that is, series are considered stationary when, in reality, the process is fractionally integrated.

models of each series, we use the Schwarz Information Criterion (SC) to select the best model for each for each of the series.

Table 5 reports the '*d* ' parameters of the fractional integration and of all the regressions performed. Empty cells correspond to models in which there was no convergence. A quick scan of these values shows that all coefficients are lower than 1, with two exceptions related to inflation expectations. As consequence, we can assume that, at least, the Brazilian inflation process is mean reverting in the long run and does not have an explosive behavior. The next step involves the decision about the characterization of each series (i.e. if it is stationary or not).

Table 5

***'d'* Values for all ARFIMA Models (p, d, q)**

ARMA	Period	(0,0)	(1,0)	(0,1)	(1,1)	(2,0)	(0,2)	(2,1)	(1,2)	(2,2)	(3,0)	(0,3)	(3,1)	(1,3)	(3,2)	(2,3)	(3,3)
IPCA	1995/8 2007/5	0.67	**0.44**	0.46	-	-0.90	0.28	0.06	-	-1.67	-0.71	0.34	-1.59	-	-	-	-
	Dummy 1999-2007	0.68	-	0.44	-	-0.95	0.28	0.10	-	**-1.85**	-0.71	0.34	-	-	-	-	-
	1995/8 1999/1	**0.67**	-	0.58	-	-0.66	-	-	-	-	-0.52	0.99	-	-	-	-	-
	1999/8 2007/5	0.68	0.06	0.40	-0.41	-0.87	0.19	-1.63	-0.73	-0.55	**-2.00**	0.23	-2.36	-0.63	-0.33	-0.53	-0.23
Selic	1995/8 2007/5	**0.82**	-	0.69	-	0.40	0.71	-0.38	-	-	0.34	0.72	0.33	-	0.31	0.32	0.31
	Dummy 1999-2007	**0.80**	-	0.63	-	-0.11	0.65	-0.37	-	-0.34	-1.22	0.66	-1.49	-	-1.54	-0.39	-
	1995/8 1999/1	**0.82**	-	0.63	-	-0.25	0.56	-	-	-	-0.73	0.82	-1.28	-	-1.72	-0.33	-
	1999/8 2007/5	0.80	0.92	0.91	0.26	0.12	0.90	0.24	0.44	0.59	0.83	**0.58**	0.61	0.43	0.30	-0.13	-0.25
Inflation Expectations	2001/7 2007/5	1.56	0.91	1.09	0.43	0.54	**0.87**	0.22	0.33	0.16	0.10	0.68	-0.67	0.30	-0.70	-0.01	-0.37
	2003/6 2007/5	0.99	-	0.83	0.68	**0.54**	0.65	-	-	-	0.59	0.72	-0.49	-	-0.56	-0.24	-

Note: Numbers in bold are the models chosen.

We can compare the ARFIMA results (in bold) with those found in the unit root tests in order to detect gains obtained by using long memory models. For the IPCA (1995-2007), both ADF and KPSS detect a stationary series, indicating no persistence at all. The ARFIMA estimations confirm such stationarity, but reject that there is no persistence at all. For the Selic Rate (1995-2007), the unit root tests are the opposite: the ADF detects stationarity whereas the KPSS detects nonstationarity. The ARFIMA models also find nonstationarity but with a mean-reversion in the long run. For the inflation expectations, the unit root tests have also found opposed results at, at least, 10% of significance. On the other hand, the ARFIMA models confirm the nonstationary of the series as with the Selic rate. In sum,

these results make clear that different unit root tests can generate divergent conclusions and, therefore, the long memory models can be of great assistance when deciding whether the series is persistent or not.

5.1 Results of the Best Models Selected

Table 6 shows the best models selected for IPCA, inflation expectations and Selic rate. The results for the entire period (1995-2007) show that the IPCA can be characterized by an ARFIMA (0, 0.441, 1), that is, a long memory process but with reversion to the mean. As a comparison, Cati et al (1999) found an inflation rate extremely persistent between 1974 and 1993. Additionally, Yoon (2003), who used the same database as Cati et al (1999), but with a distinct econometric procedure which did not need the use of dummies to deal with periods of extreme high inflation. The author also found a nonstationary inflation rate. Campêlo & Cribari-Neto (2003) found a small inflation inertia in their results. Internationally speaking, Doormik & Ooms (2004) found a parameter $d = 0.25$ for the American case and $0.47 < d < 0.59$ for the British case. Gil-Alana (2005) found $d = 0.25$ for the American case. In general, the degree of inflation persistence in Brazil has certainly decreased and it is reaching parameters detected internationally, such as in Great Britain.

When a dummy variable is included to take into consideration the periods of inflation targeting, we notice that inflation is negative and significant, which indicates a diminishing persistence. Thus, for a comparative purpose, the sample is divided and, for the period previous to the inflation targeting the best IPCA model is an ARFIMA (0, 0.671, 0), whereas for the period related to the inflation targeting, the model is an ARFIMA (0, 0.408, 0). This represents a considerable drop in the persistence of inflation in the recent period even when the Lula crisis shock is taken into consideration. Therefore, the period after 1999 is characterized by an inflation rate showing signs of stationarity, although it exhibits some degree of persistence. Our results are in line with Minella et al (2003), who analyzed the period from July/1995 to December/2002, and found evidence of a decrease in the IPCA inflation persistence, especially after the introduction of the inflation targeting system.

Table 6

ARFIMA Models (p, d, q): NLS Estimations

Variable	Period	ARMA	*'d'*	AR(1)	AR(2)	AR(3)	MA(1)	MA(2)	MA(3)	Constant	Dummy
IPCA	1995/8 2007/5	(0,1)	**0.441** [0.000]	-	-	-	0.329 [0.001]	-	-	0.683 [0.010]	-
	Dummy 1999-2007	(2,2)	**-1.852** [0.000]	1.975 [0.000]	-0.979 [0.000]	-	0.586 [0.001]	0.228 [0.064]	-	0.665 [0.000]	-0.108 [0.044]
	1995/8 1999/1	(0,0)	**0.671** [0.000]	-	-	-	-	-	-	0.791 [0.154]	-
	1999/8 2007/5	(3,0)	**-2.007** [0.000]	2.627 [0.154]	-2.271 [0.154]	0.641 [0.154]	-	-	-	0.791 [0.154]	-
Selic	1995/8 2007/5	(0,0)	**0.826** [0.000]	-	-	-	-	-	-	0.083 [0.958]	-
	Dummy 1999-2007	(0,0)	**0.802** [0.000]							0.486 [0.714]	-0.191 [0.390]
	1995/8 1999/1	(0,0)	**0.820** [0.000]	-	-	-	-	-	-	0.313 [0.914]	-
	1999/8 2007/5	(0,3)	**0.586** [0.000]	-	-	-	0.134 [0.246]	0.197 [0.049]	0.477 [0.000]	1.165 [0.000]	-
Inflation Expectations	2001/7 2007/5	(0,2)	**0.878** [0.000]	-	-	-	0.850 [0.000]	0.262 [0.077]	-	7.801 [0.055]	-
	2003/6 2007/5	(2,0)	**0.547** [0.019]	0.809 [0.001]	-0.286 [0.036]	-	-	-	-	4.048 [0.003]	-

Note: *i*) only the best model is reported; *ii*) p-values in brackets.

5.2 The Role Played by the Interest Rate

Up until this point, we have focused on the consequences of the economic policy actions implemented by the Brazilian government, that is, in the evolution of the inflation rate and its expectations. However, we are aware of the influence of the interest rate on monetary policy actions. For the period 1995-2007 the estimations of the Selic rate select an ARFIMA (0, 0.826, 0) as best model. This characterizes the series as nonstationary, although reverting to the mean in the long run. The introduction of a dummy for the period after the implementation of the inflation targeting framework shows a small decline in the persistence of interest rates, even though the dummy is not significant (at 5%). The drop in persistence is clearer when the sample is divided, given that the period after and before 1999 shows a Selic persistence equals to 0.56 and 0.82 respectively. It means that the series is characterized as nonstationary in all calculations done, but shows some mean-reversion.

In terms of economic analysis, the persistence found in IPCA and in the Selic interest rate might be a sign that the control of inflation in Brazil is still anchored on high interest rates (with small changes towards more tolerable levels). In other words, inflation is being controlled at the cost of persistent interest rates (no changes) at extreme high levels.

5.3 Inflation Expectations

Although the inflation expectations series has a shorter periodicity, we can analyze its dynamics in comparison with the IPCA and the Selic rate. For inflation expectations, the estimation of the entire period points toward an ARFIMA (0, 0.878, 2) as the most appropriate model, that is, expectations are nonstationary, as detected by the unit root tests (see Table 4), but revert to the mean in the long run. This is an unexpected result, given that, lately, the inflation expectations have converged to the values set by the targets. But we know that the series was strongly affected by the Lula crisis contributing to its high persistence (see Figure 1). In order to test such hypothesis, we limit the sample to the period subsequent to the crisis (June/2003 to May/2007). In this case, the ARFIMA model selected was (2, 0.547, 0), which illustrates a decrease in the series' persistence. This result also shows that inflation expectations in Brazil seem to getting closer to the IPCA inflation.

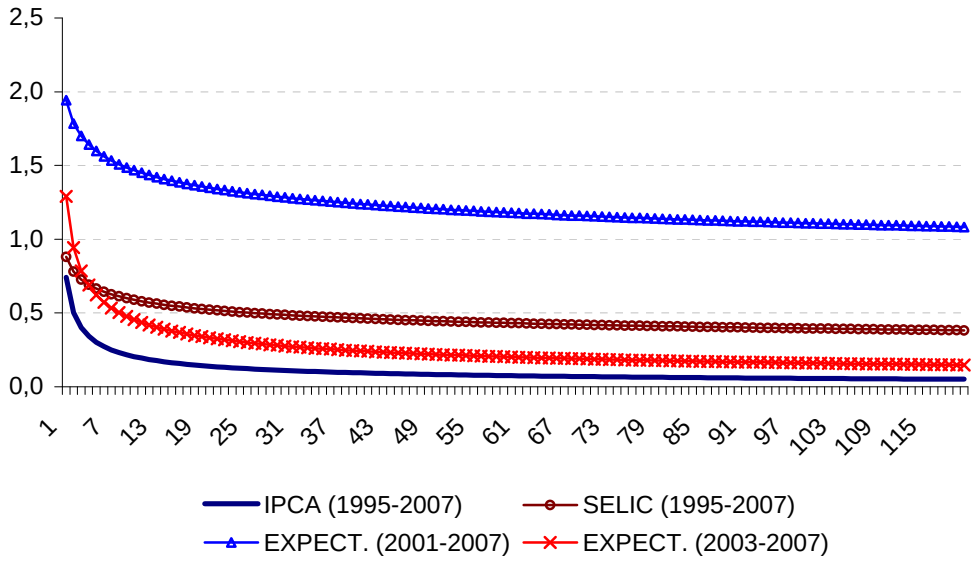
The inflation expectations results can also help understand the prudent monetary policy actions adopted by the Central Bank in relation to the drop on interest rates, given that expectations are not completely under control. Bevilaqua, Mesquita & Minella (2007) argue that inflation targeting can promote the anchoring of inflation expectations. To prove such point, the authors test whether a systematic deviation of the inflation expectations, in relation to inflation targets, is present. This phenomenon was found within the estimations results for the period January/2000 – August/2006. The same period was used to test if inflation expectations where anchored to the targets. The results show that the latter significantly shape the former. Additionally, the authors observe that the coefficient associated to the inflation targeting vary considerably (depending upon the different stages of the analysis) as shown by the calculations described in the previous paragraph. For a subsample concentrated on the 2002 confidence crisis, one can observe a displacement of expectations in relation to the inflation targeting regime. Nevertheless, the anchoring phenomenon is verified in the period after the Lula crisis.

5.4 Impulse Response Functions

The impulse response functions are important within the analysis of persistence given that they show the behavior of the variables in the long run, taking into account the parameters AR and MA of the models. Figures 2 and 3 display the impulse response functions for 12 years for the best ARFIMA models of the entire sample and of broken sample. We can see that there is convergence of the series, even though some converge only in the long run.

Figure 2

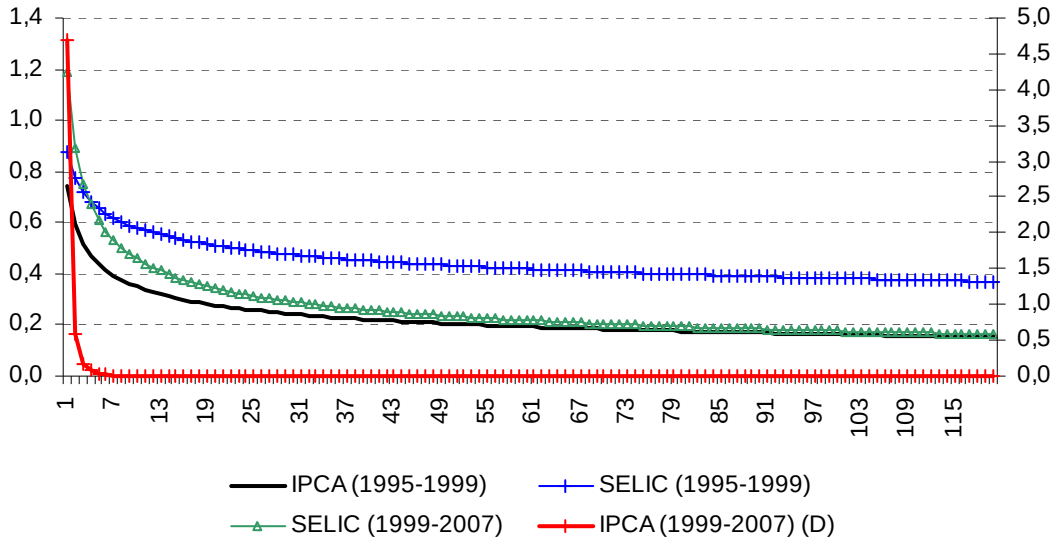
Impulse Response Functions I



For the entire period, the convergence of the interest rates and the inflation expectations is slower. When we compare the period previous and subsequent to the inflation targeting regime, we can observe that inflation converge more quickly after 1999, while the other variables show a more slowly convergence (Figure 3). As for the inflation expectations, they show a considerable decrease in their persistence when the Lula crisis period is disregarded (Figure 2). It means that inflation expectations tend to converge to IPCA values and will probably be anchored by the inflation targets as defined by Bevilaqua, Mesquita & Minella (2007).

Figure 3

Impulse Response Functions II



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6. Conclusion

This article aimed at analyzing inflation persistence in Brazil since the implementation of the Real Plan, with an emphasis on inflation targeting period. We also analyzed the persistence of inflation expectations and of the Selic Interest Rate. Persistence parameters were calculated by the use of ARFIMA models. The first two questions raised by the article refer to the degree of persistence of inflation after the implementation of the Real Plan and after the introduction of the inflation targeting system. In these cases, the results showed that the inflation has a stationary behavior (a low degree of persistence) for the 1995-2007 period. The results also showed that such persistence diminishes after the implementation of the inflation targeting frameowork. As for inflation expectations, they have

shown to be nonstationary but are non-explosive in the long run. In turn, the interest rate is able to control the IPCA inflation without obtaining the same success of the total anchoring of inflation expectations. As such, the Selic interest rate is characterized as very persistent along the years with a very slow changing process. In other words, the evidence shows that the Brazilian economic policy is based on a trade-off between a low IPCA persistence and a high Selic rate persistence, which is still unable to mitigate the process of inflation expectations.

Lastly, this measure of inflation persistence shows that the conduct of monetary policy in Brazil goes beyond the Central Bank Headquarters. It is related to constructing credibility within the government as a whole. It is also related to having some coordination between monetary and fiscal policies. Such factors can certainly contribute to a decrease on inflation expectations in the country and, as a consequence, to a decrease of the Brazilian high interest rates.

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