# Relative price variability in Brazil:

## an analysis of headline and core inflation rates

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**Key Words**

Relative Price Variability, Inflation, Monetary Policy

**JEL Classification**

C33, E31, E52

**Palavras-Chave**

Dispersão dos Preços Relativos, Inflação, Política Monetária

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**Resumo**

O objetivo deste artigo é estudar a relação causal entre inflação e variabilidade de preços relativos no Brasil, para o período entre janeiro de 1995 e junho de 2011. O foco é o IPCA e seu núcleo, levando-se também em conta o período das metas de inflação. A análise de séries temporais mostra que: 1) a correlação entre inflação e dispersão de preços relativos é positiva e significante (o mesmo se aplica ao núcleo da inflação); 2) para o período referente às metas para a inflação, há queda da dispersão de preços; 3) há bi-causalidade entre inflação total e dispersão total de preços, ao passo que a causalidade é do núcleo de inflação para sua respectiva variabilidade; 4) as funções de respostas a impulsos mostram que choques no núcleo do IPCA não afetam a dispersão dos preços do núcleo tanto quanto os choques ao IPCA total afetam a dispersão total de preços; 5) a decomposição de variância relacionada ao núcleo do IPCA e seu respectivo RPV parece estar reduzida em relação aos dados do IPCA cheio.

**Abstract**

*The aim of this article is to study the causal relationship between inflation and relative price variability in Brazil. The period under analysis spans from January 1995 to June 2011. It focuses on both headline and core inflation rates, and also takes the inflation targeting regimeinto account. The time series analysis shows that: i) the correlation between inflation and relative price variability is positive and significant (the same applies to core inflation); ii) price dispersiondecreases after the implementation of inflation targeting; iii) there is bi-causality between Headline-IPCA and Headline-RPV, but causality from Core-IPCA to Core-RPV; iv) the impulse response functions show that shocks to Core-IPCA don't affect Core-RPV as much as shocks to Headline-IPCA affect Headline-IPCA; v) the variance decomposition related to Core-IPCA and Core-RPV seems to be reduced when compared to headline inflation.*

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## 1_Introduction

Theoretical and empirical researchers pay special attention to the relationship between inflation and relative price variability (RPV). This is a legitimate concern given that it significantly contributes to the understanding of inflationary processes, its transmission mechanisms, and the welfare costs involved in (dis)inflation policies.

This issue is even more relevant when the conduct of the monetary policy is embedded in a context of low inflation.[1] The economic environment depends on the relationships involving relative prices for the allocation of scarce resources. Any discrepancy in these prices causes a similar discrepancy in the decisions of economic agents. Consequently, the allocation of resources within the economy is not maximized.

In other words, it is well-established that price stability is essential and positive. Therefore, the assessment of the effects of inflation on the relative price dispersion (and vice-versa) can provide policy makers with effective instruments in relation to actions against inflation pressures, at the lowest possible cost, in terms of product and employment variability.

This discussion is also important for Brazil, especially following the implementation of the Real Plan in 1994, which ended a long period of high inflation in the country. In 1999, the country abandoned the fixed exchange regime, after years of an anchored exchange rate system, and implemented a monetary reform with a nominal anchor based on an inflation targeting (IT) regime.

The goal of this article is to analyze thecausal relationship between inflation and relative price variability in Brazil. The analysis starts in 1995 and continues until the middle of 2011, taking into consideration the Brazilian Consumer Price Index (IPCA) and its core inflation. We also look at the period after the adoption of inflation targeting.

By making use of OLS estimations, as well as Generalized Impulse Response Functions, Generalized Variance Decomposition and Granger Causality tests, the main findings are: *i*) the correlation between inflation and relative price variability is positive and significant (the same applies to core inflation); *ii*) price dispersion decreases after the implementation of inflation targeting; *iii*) there is bi-causality between Headline-IPCA and Headline-RPV, but causality from Core-IPCA to Core-RPV; *iv*) the impulse response functions show that shocks to Core-IPCA do not affect Core-RPV as much as shocks to Headline-IPCA affect Headline-RPV; *v*) the variance decomposition related to Core-IPCA and Core-RPV seems to be reduced when compared to headline inflation.

In addition to this introduction, the article provides an empirical literature review in Section 2. Section 3 addresses the RPV measures and the database used. Section 4 discusses the econometric methodology. Section 5 reports the estimation results and the final section concludes.

## 2_Literature Review

From a theoreticalperspective, the relation between inflation and RPV is explained by two main approaches: i) signal extraction (imperfect information) models; ii) menu cost models.

According to the signal extraction models (Lucas, 1973; Barro, 1976; Hercowitz, 1981; Cukierman, 1984), nominal imperfection occurs when the producer observes a variation in the product's price which can either be identified as a relative price variation, altering the optimum quantity being produced, or a change in the aggregated level, maintaining the optimum production unaltered. As expected, the producer attributes part of the change to an increase in the price level and part to an increase in the relative price (Romer, 2001). Given this information asymmetry, when a general aggregated demand shock hits the economy, each producer interprets the variation inthe general price level as a relative price variation (at least in part) and increases the supply of the product being produced. Consequently, the aggregated demand shock can induce involuntary increases of aggregated supply and, therefore, yield a production deviation in relation to its natural level even within rational expectations. In other words, within an imperfect information environment, a higher inflation rate renders aggregated demand shocks less predictable. As such, in comparison to firms with low supply elasticity, those with high supply elasticity make small price adjustments in reaction to unexpected demand shocks (Bakhshi, 2002).

As such, we can say that the imperfect information model demonstrates that unanticipated changes in price levels and RPV increases are the result of unanticipated alterations in the money stock. If, in individual markets, the change in supply elasticity is different from the change in demand elasticity, the relative price variations will result in effective alterations. Given that the real economic conditions remain unaltered, changes in relative prices cause poor allocation of resources. Finally, this approach assumes that shocks result in inflation and relative price dispersion; and such dispersion only occurs when there is an erroneous perception of inflation –although the opposite does not hold true (Fischer, 1981).[2]

As for the second approach, the New Keynesians started to seek to provide microfoundations for the nominal prices stickiness phenomenon, as researchers began to observe that nominal prices were not so flexible because of two main reasons: the decision to adjust prices involved costs and the decision not to adjust did not substantiallyalter the firm's profits. These models are known as Menu Costs (Rotemberg, 1982, 1983; Ball & Mankiw, 1994, 1995). As an example, derisory costs of price changes involved in the making of a new menu for a restaurant lead to sporadic and scaled price adjustments which, in turn, result in a slow adjustment of inflation. Firms respond dynamically to inflation through an appraisal rule based on superior and inferior limits. Nominal prices are kept constant until a reduction of real prices reaches the inferior limit. Only then are nominal prices adjusted up to the superior limit. If, hypothetically, firms are incapable of increasing prices simultaneously, the menu costs model anticipates that a rise in inflation also increases the optimum difference between the superior and inferior limits (Bakhshi, 2002). Therefore, menu cost models predict a positive relation between RPVand anticipated/unanticipated inflation and assume that inflationary processes cause price dispersion.

Another approach related to menu cost models uses the asymmetric responses of prices to perturbations, i.e., prices are more flexible when they increase than when they decrease. This approach derives a positive association between inflation and RPV. For example, suppose that: *i*) prices are flexible downwards; *ii*) in the absence of relative perturbations, the price level remains unaltered; and *iii*) individual markets are affected by relative shocks. In this case, if the excess of demand increases, prices will also increase. On the other hand, if there is an excess of supply, the effective price does not decrease. Consequently, the greater the relative variability in perturbations, the higher the average inflation rate (Fischer, 1981).

Ball & Mankiw (1994) propose a model in which firms make regular price changes and, when paying for the costs of a new menu, make additional pricing adjustments in response to perturbations. In this model, asymmetries occur naturally with a tendency of additional positive inflation. As such, positive shocks in prices, chosen by firms, generate a larger adjustment if compared to negative shocks of the same magnitude. Intuitively, inflation process decreases the firm's relative prices automatically among adjustments. When a firm wants smaller relative prices, it does not need to pay for a menu cost, because inflation alone does all the necessary work. In contrast, a positiveshock generates an increase in the firm's relative price (desired), but also generates an increase in its relative effective price. As a result, a large gap between the desired and the effective prices is created. Therefore, the possibility of price adjustments is more eminent in cases of positive shocks than in cases of negative shocks. Thus, the authors' model is consistent with the evidence documented by Fischer (1981), among others: inflation and RPV are positively correlated, with causality of inflation to dispersion. Nevertheless, such causality can go in the opposite direction if price stickiness is asymmetric as pointed out by Fischer (Ball & Mankiw, 1994).

According to Gali (2008), the fact that firms do not adjust their prices continuously constitutes a source of inefficiency due to two main reasons. Firstly, it implies that, in response to shocks, the economy´s average markup will vary over time. This violates the efficiency condition as it entails either too low or too high a level of aggregate employment and output. Secondly, the lack of synchronization in price adjustments means that the occurrence of RPV has no link to changes in preferences or technologies. Therefore, prices are not adjusted in the same period, causing distortions which will lead to the production and consumption of different goods in distinct quantities. As a result, efficiency is once again violated.

Regarding the empirical literature, one of the first works about the relation between inflation and RPV wasthat of Mills (1927), who analyzed the American case. Another important article, by Parks (1978), developed one of the most famous measures of relative price variability, which is used in this article. In order to find the positive correlation between inflation and RPV, Parks (1978) used disaggregated data of consumption goods from the USA and the Netherlands and showed that changes in relative prices are related to alterations in supply, in real income, and in unanticipated inflation (the difference between the effective rate and the observed perturbations).

After Parks (1978), several researchers contributed to the related literature. For the American case: Vining & Elwertowski (1976), Parsley (1996), Debelle & Lamont (1997), Jaramillo (1999), Chang & Cheng (2000), and Caglayan & Filiztekin (2003). All the results corroborated the positive relationship between inflation and RPV. On the other hand, Drifill, Mizon & Ulph (1990) and Bomberger & Makinen (1993), among others, emphasized that those results were due to the inclusion of variables related to large supply shocks.[3]However, Jaramillo (1999) showed that the results found by Parks (1978) could be obtained when asymmetric responses to episodes of inflation and disinflation were included in the regressions. As such, Jaramillo(1999) expanded Park's sample up until 1996 and used a distinct database with a greater disaggregation. The results obtained were robust even when observations related to oil shocks were excluded. Chang & Cheng (2002) also revisited Park's article and showed that when the author's sample was expanded, Bomberger & Makinen's (1993)argumentcould be refuted. Furthermore, they argued that the positive relationship between inflation and RPV strengthened when the downward price stickiness phenomenon was taken into consideration.

Fielding & Mizen (2008) studied the functional relationship between RPV and inflation using quarterly PCE data in the U.S. for the period ranging from 1967 to 2003. According to the authors "the empirical RPV function yields a plausible 'optimal' value of inflation in the region of five percentage points." Bick & Nautz (2008) studied the impact of inflation on RPV in U.S. cities and argue that "if monetary policy aims at minimizing the impact of inflation on relative prices, our estimates suggest that U.S. inflation should range between 1.8 percent and 2.8 percent."

Following this line of research, other authors looked at relative price dispersion in different countries. Domberger (1987), for instance, analyzed the British case; Fielding & Mizen (2000) investigated 10 European countries; Van Hoomissen (1988) and Lach & Tsiddon (1992, 1993) considered the Israeli case; Tommasi (1993) and Dabus (2000) looked at the Argentinean case; Nautz & Scharff (2005) explored the German context; Berument, Sahin & Saracoglu (2009) studied the Turkish case, while Choi (2010) focused on Japan and the USA.

In relation to Brazil, Moura da Silva & Kadota (1982) examine the correlation between RPV and inflation for the period between 1972 and 1979. The main interest of the authors was to show that the price dispersion was connected to the Brazilian inflationary process at that time. A higher inflation rateused to produce a greaterstandard deviation of relative prices. Moreover, this greater relative price dispersion was associated with inflation outbreaks derived from supply shocks. Resende & Grandi (1992) used Granger causality tests to study the price variability of goods included in the wholesale price index for the 1976-1985 period. The authors did not reach a solid conclusion regarding the direction of the causal relation (Fava & Cyrillo, 1999). Fava & Cyrillo (1999)made use of a price index elaborated by FIPE-USP for the period between 1977 and 1997. The authors examined the theoretical approach of the menu cost models and also the asymmetric response of prices to random shocks. The results implied a dual causality between inflation and RPV, which did not corroborate with the menu cost theory. On the other hand, the asymmetric response theory was not refuted in cases of sub-periods of the analysis.

## 3_Data and Measures of Relative Price Variability

The disaggregated data set used in this article is extracted from the IBGE Database and refers to goods included in the Consumer Price Index (IPCA), which is the Brazilian official inflation rate used in the inflation targeting system. The purpose of analyzing the Core-IPCA is to take into account the possibility of endogeneity among variables given that higher prices strongly associated with supply shocks can be eliminated from the RPV. The period under analysis spans from January 1995 to June 2011. After this initial analysis, we consider the period after the adoption of IT, from August 1999 to June 2011, since it is important to study the behavior of important items included in the IPCA during theIT period.

For the RPV calculation, we use an 8-digit disaggregation available at IBGE´s database[4]. As in Debelle & Lamont (1997), this article uses the following RPV definition: the price variation in several goods and services categories around an average inflation rate of consumer prices, which is a measure of inter-market prices variability.

In line with Parks (1978), Fischer (1981), Domberger (1987), and Nautz & Scharff (2005), among others, our RPV measure takes into account the weight related to each one of the items used in the final price index. This is important assome categories are more (or less) important within the final calculation of the consumer inflation. Therefore, the RPV is calculated as follows:

$$RPV_t = \sqrt{\frac{1}{n}\sum_{i=1}^{n} w_i \left(\pi_{it} - \pi_t\right)^2} \qquad (1)$$

where is the price variation related to item '$i$' in the period '$t$';is the monthly inflation measured by IPCA in the period '$t$'; '$n$' is the number of categories;'$w$' is the category's weight.

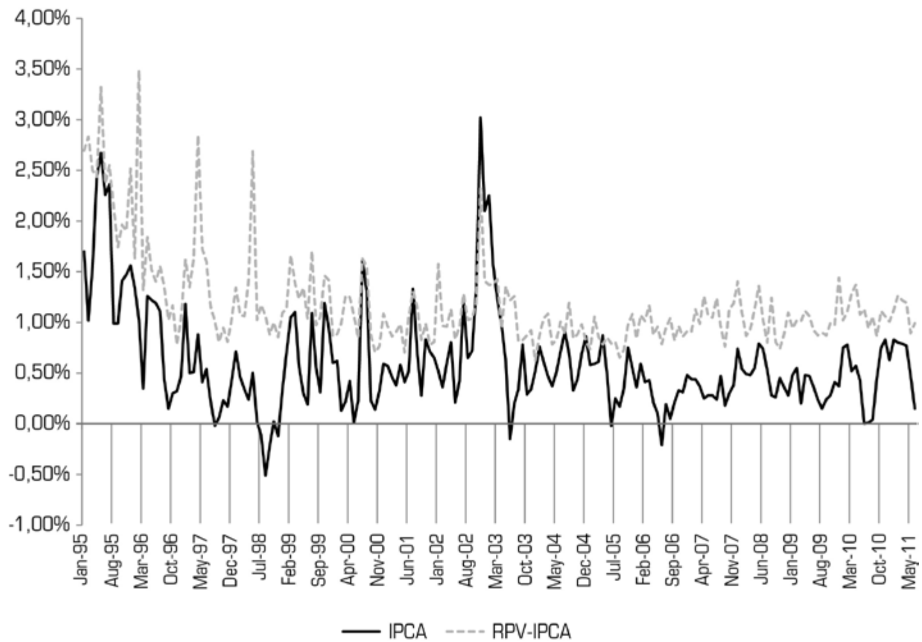
Table 1 reports the descriptive statistics of the data used in this article. When the IPCA and Core-IPCA are compared, we notice that the values related to the latter are more prominent, which is something that has to be analyzed more deeply.

Table 1_Inflation and RPV: Descriptive Statistics (Jan/1995 – Jun/2011)

| | Headline-IPCA | Headline-RPV | Core-IPCA | Core-RPV |
|---|---|---|---|---|
| Mean | 0.60 | 1.18 | 1.19 | 0.58 |
| Median | 0.48 | 1.04 | 1.04 | 0.47 |
| Maximum | 3.02 | 3.48 | 3.49 | 2.70 |
| Minimum | -0.51 | 0.61 | 0.62 | -0.35 |
| Std. Dev. | 0.52 | 0.47 | 0.49 | 0.46 |
| Obs. | 198 | 198 | 198 | 198 |

Source: IBGE

Figure 1_Headline-IPCA and Headline-RPV (Jan/1995 – Jun/2011)

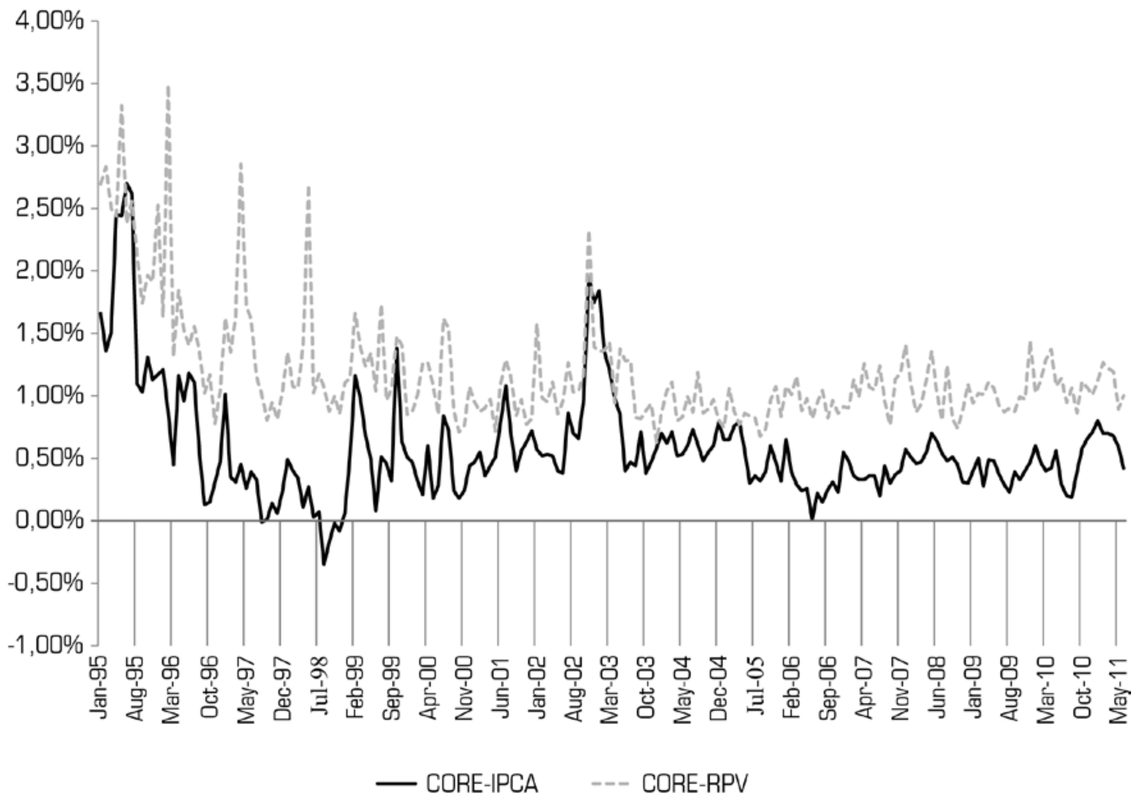



Source: IBGE

Figures 1 and 2 show the behavior of inflation and RPV for the Headline-IPCA and Core-IPCA, respectively. For the consumer price as a whole, Figure 1 shows four significant peaks in the RPV between 1995 and 1998, which are not associated with strong inflationary processes. The causes relate to several international events, such as the Russian and Asian crises. Moreover, it is easy to see that the 1999 exchange rate flexibility did not produce a considerable variation in relative prices. For the period after IT was adopted, the most outstanding relative price dispersion refers to the Lula crisis, and it is correlated to the inflation of that period. It is also possible to see that the period after the exchange rate flexibility shows a decrease in RPV, approaching the country's inflation rate.

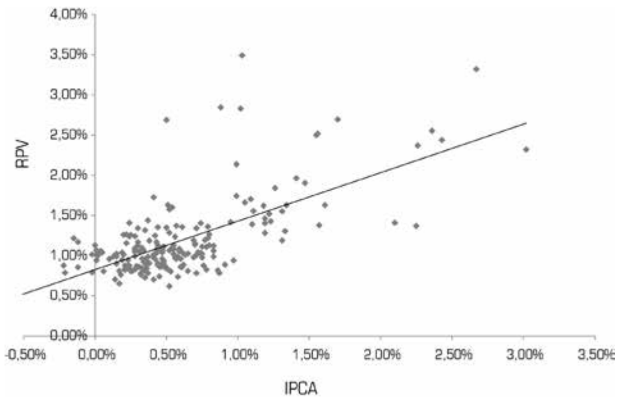
Considering the Core-IPCA, Figure 2 does not show prominent peaks as in the case of the Headline-IPCA. For instance, the outstanding relative price dispersion referred to the Lula crisis, very clear in the former figure, does notoccur in the case of Core-IPCA and its Core-RPV.

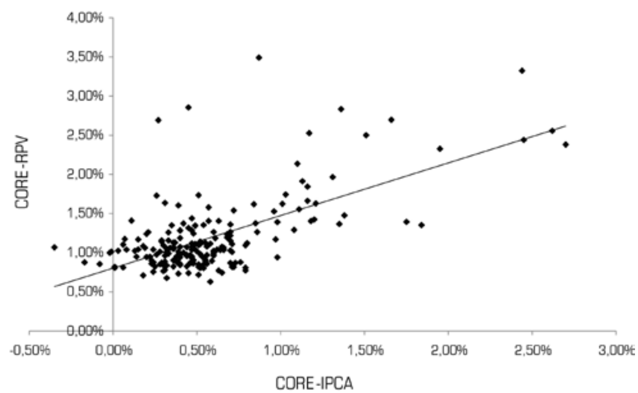
**Figure 2_Core-IPCA and Core-RPV (Jan/1995 – Jun/2011)**




Source: IBGE

**Figure 3_Scatter Plot: Headline-IPCA vs Headline-RPV and Core-IPCA vs Core-RPV**




Source: IBGE

Figure 3 displaysscatter plot graphs between inflation and RPV for all the series analyzed. One can see that the regression lines, generated in both graphs, have a positive slope, which indicates that, at least visually, there is a positive relationship between RPV and inflation in the Brazilian case.

## 4_Econometric Approach

The first stage of the analysis is the following estimation:

$$RPV_t = \beta_0 + \beta_1 |\pi_t| + \beta_2 RPV_{t-p} + \varepsilon_t \qquad (2)$$

where $RPV_t$ is the square root of the relative price variability and $|\pi_t|$ is the absolute value of the inflation rate. We should also mention that other lags of RPV may be used as an RHS variable. Our aim is to study whether the positive relation between inflation and RPV holds and whether the lagged RPV is important when different measures of IPCA are taken into consideration.

In addition to this basic model, we examine the role of the disinflationary processes in the RPV, aiming to test if prices respond symmetrically or asymmetrically to inflation and disinflation cases. This methodology is also used in several works, such as in Parks (1978), Debelle & Lamont (1997) and Jaramillo (1999) for the American case, Tommasi (1993) for the Argentinean case, and Caglayan & Filiztekin (2001) for the Turkish data. The procedure is as follows:

$$RPV_t = \beta_0 + \beta_1 |\pi_t| + \beta_2 RPV_{t-p} + \beta_3 d_{abs} * |\pi_t| + \varepsilon_t \qquad (3)$$

where is the multiplication of the absolute value of inflation and a dummy variable ($d_{abs}$), which is equal to 1 for disinflation and 0 for inflation. As mentioned by Jaramillo (1999), this term takes into account the distinct degrees of RPV response to shocks derived from inflation or disinflation and, as such, it allows for different slopes of disinflationary periods. In sum, if the data used in the analysis disregards any asymmetry in the response to inflation or disinflation processes, the $\beta_3$ parameter in equation (3) should not be significantly different from zero.

$$RPV_t = \beta_0 + \beta_1 |\pi_t| + \beta_2 RPV_{t-p} + \beta_3 dummy_{IT} + \varepsilon_t \quad (4)$$

In the second stage of our analysis, we apply Granger Causality tests and VAR methodology,as in Fischer (1981), in order to analyze inflation and RPV reactions when perturbations are imposed on the variables. We make use of Generalized Impulse Response Functions and Generalized Variance Decomposition.

## 5_Results

First of all, we start by estimating ADF and Phillips-Perronunit root tests for all series (Table 2). For all estimations, the null hypothesis of a unit root (nonstationarity) is rejected, using a 5% level of significance.

Table 3 shows the estimations related to equations 2 and 3. In general, we notice that the usual result is a positive correlation between inflation, as reported by the graphs in Figure 3. For the Headline-IPCA the coefficient found is 0.391 and, when the asymmetric adjustment

**Table 2_Unit Root Tests**

| | ADF | | | | | | Phillips-Perron | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Test Statistics | Lag | Critical Values | | Reject $H_0$ Unit Root | | Test Statistics | Bandwidth | Critical Values | | Reject $H_0$ Unit Root | |
| | | | 5% | 10% | 5% | 10% | | | 5% | 10% | 5% | 10% |
| Headline-IPCA | -5.64 | 0 | -2.87 | -2.57 | Yes | Yes | -5.53 | 3 | -2.87 | -2.57 | Yes | Yes |
| Headline-RPV | -7.09 | 0 | -2.87 | -2.57 | Yes | Yes | -7.16 | 7 | -2.87 | -2.57 | Yes | Yes |
| Core-IPCA | -4.54 | 0 | -2.87 | -2.57 | Yes | Yes | -4.11 | 11 | -2.87 | -2.57 | Yes | Yes |
| Core-RPV | -4.64 | 1 | -2.87 | -2.57 | Yes | Yes | -6.80 | 0 | -2.87 | -2.57 | Yes | Yes |

Note: Estimations with constant only.

**Table 3_Estimation Results**

| | $\lvert\pi_t\rvert$ | $RPV_{t-1}$ | $RPV_{t-2}$ | Constant | $d_{abs} * \lvert\pi_t\rvert$ | DW | LM Auto-corr. F stat. |
|---|---|---|---|---|---|---|---|
| | 0.391 | 0.229 | 0.251 | 0.363 | | 1.959 | 0.271 |
| | (0.055) | (0.069) | (0.081) | (0.052) | | | [0.762] |
| | [0.000] | [0.001] | [0.002] | [0.000] | - | | |
| **Dependent Variable** | 0.389 | 0.228 | 0.252 | 0.364 | -0.019 | | 0.283 |
| **Headline-RPV** | (0.056) | (0.069) | (0.082) | (0.053) | (0.054) | 1.960 | [0.753] |
| | [0.000] | [0.001] | [0.002] | [0.000] | [0.719] | | |
| | 0.363 | 0.247 | 0.252 | 0.368 | | 2.026 | 0.116 |
| | (0.059) | (0.079) | (0.091) | (0.060) | | | [0.890] |
| | [0.000] | [0.002] | [0.005] | [0.000] | - | | |
| **Dependent Variable** | 0.356 | 0.256 | 0.252 | 0.369 | -0.133 | | 0.067 |
| **Core-RPV** | (0.064) | (0.086) | (0.094) | (0.059) | (0.094) | 2.022 | [0.934] |
| | [0.000] | [0.003] | [0.008] | [0.000] | [0.159] | | |

Note: OLS Estimations. Newey-West Robust Standard Errors in parenthesis. P-values in brackets.

**Table 4_Estimation Results (with Inflation Targeting Dummy)**

| | $\left\|\overline{\pi}_t\right\|$ | RPVt-1 | RPVt-2 | Constant | Dummy IT | DW | LM Auto-corr. F stat. |
|---|---|---|---|---|---|---|---|
| Dependent Variable Headline-RPV | 0.423<br>(0.048)<br>[0.000] | 0.144<br>(0.068)<br>[0.034] | 0.160<br>(0.081)<br>[0.051] | 0.742<br>(0.123)<br>[0.000] | -0.259<br>(0.075)<br>[0.000] | 1.952 | 0.160<br>[0.852] |
| Dependent Variable Core-RPV | 0.490<br>(0.060)<br>[0.000] | 0.204<br>(0.080)<br>[0.011] | - | 0.909<br>(0.139)<br>[0.000] | -0.360<br>(0.085)<br>[0.000] | 2.064 | 2.545<br>[0.081] |

Note: OLS Estimations. Robust Standard Errors in parenthesis. P-values in brackets.

is taken into consideration, the coefficient practically remains the same (0.389).In both cases, the regression delivers a coefficientrelated to the asymmetry, which is not statistically significant, meaning that prices are flexible downwards. In addition to that, RPV is strongly determined by its lagged value.

As for the Core-IPCA, there is a slight decrease in price dispersion with and without the asymmetric response, even though the latter is not statistically significant. In all cases, prices vary downwards in the same way as they do upwards, which means that they increase in the same proportion as they decrease. Thus, we can infer that RPVis higher for the headline inflation and there is no difference when prices go up or down, although there are only around ten cases of disinflation.

Table 4 shows the estimations related to equation 4, which accounts for the IT period. We also notice that the usual positive relationship between inflation and RPV is found.Furthermore, it is clear that the IT dummy is negative and statistically significant.

This is a very important result because it means that inflation shocks increase relative price variability in Brazil, as usually found in other countries. It also means that the introduction of the targets played an important role in the process of anchoring inflation in Brazil and, as a result, reduced the variability of prices.

Having shown the usual positive correlation between inflation and relative price variability, we now turn to Granger Causality Tests to address some other issues more specifically for the whole period (January 1995 – June 2011), with or without a dummy variable for the inflation targeting period.

### 5.1_Granger Causality Tests

Granger causality tests are useful to answer the question whether how much of a current value can be explained by past values of other variables, and if additional lags are also needed[5]. In this stage, we aim to analyze if the causal relationship between inflation and RPV, as anticipated by the menu cost models, is applicable to the Brazilian case. If the prediction made by Sheshinski & Weiss (1977) is correct, the causality relationship should range from inflation to the dispersion of prices. However, the opposite causality could occur, or there could be no causality at all.As we needed to estimate Granger causality tests with an exogenous variable (IT dummy), and address autocorrelation problems in the estimations as well, we ran specific test regressions.

**Table 5_Granger Causality Tests**

| Null Hypothesis | Lag | Wald Test F-Statistic | Reject H0? | LM Auto-Corr. F-Statistic |
|---|---|---|---|---|
| IPCA does not Granger Cause RPV (without dummy IT) | 3 | 4.779 [0.003] | Yes | 1.894 [0.153] |
| IPCA does not Granger Cause RPV (with dummy IT) | 3 | 8.899 [0.0002] | Yes | 2.318 [0.101] |
| RPV does not Granger Cause IPCA (without dummy IT) | 3 | 5.836 [0.0008] | Yes | 2.873 [0.059] |
| RPV does not Granger Cause IPCA (with dummy IT) | 3 | 5.584 [0.001] | Yes | 2.782 [0.064] |
| Core-IPCA does not Granger Cause Core-RPV (without dummy IT) | 3 | 4.302 [0.005] | Yes | 1.934 [0.147] |
| Core-IPCA does not Granger Cause Core-RPV (with dummy IT) | 1 | 30.201 [0.005] | Yes | 2.813 [0.062] |
| Core-RPV does not Granger Cause Core-IPCA (without dummy IT) | 1 | 0.037 [0.845] | No | 0.924 [0.398] |
| Core-RPV does not Granger Cause Core-IPCA (with dummy IT) | 1 | 0.00044 [0.983] | No | 1.934 [0.147] |

Note: P-values in brackets

The models to be analyzed are the following:i) *Model 1*: Headline-IPCA and Headline-RPV (withoutIT dummy); ii) *Model 2*: Headline-IPCA and Headline-RPV (with IT dummy); iii) *Model 3*: Core-IPCA and Core-RPV (without IT dummy); iv) *Model 4*: Core-IPCA and Core-RPV (with IT dummy). In order not to run the risk of estimating causalities with wrong lags, we estimated OLS regressions until we found the correct lag via Wald tests.

Table 5 presents these results. For the Headline IPCA and RPV, the null hypothesis is rejected in all four cases, meaning that there is a bi-causality, IPCA Granger-causes RPV and RPV Granger-causes IPCA (with and without the IT dummy). As for the core inflation, Core-IPCA Granger-causes Core-RPV (with or without the IT dummy). But the opposite is not true, i.e., Core-RPV does not Granger Cause Core-IPCA. It means that the Granger causality tests show that the direction goes from core inflation to the dispersion of core prices, which is inline with the findings of Sheshinski & Weiss (1977).

### 5.2_VAR Estimations

The Granger causality tests do not show a clear pattern of time precedence between RPV and Headline-Inflation, even though causality was found for core inflation. According to the tests, it is still uncertain whether any of the variables should be considered predominant. Probably, each variable causes the other, or both are affected by the same disturbances. Most likely, this mutual causality between inflation and RPV can be examined using the VAR methodology (Fischer, 1981). The models to be analyzed are Models 1 through 4 described previously. We then make use of the statistics related to VAR models: *i*) Generalized Impulse Response Functions; *ii*) Generalized Forecast Error Variance Decomposition.

Table 6 reports the models selected, via Schwarz Information Criterion (SC). Model 1 requests 2 lags to be estimated, whereas models 2, 3 and 4 request 1 lag. However, when VAR Residual Serial Correlation LM Tests

Table 6_VAR Lag Order Selection - Schwarz Information Criterion (SC)

| Lag | IPCA | | Core-IPCA | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 |
| | Without IT Dummy | With IT Dummy | Without IT Dummy | With IT Dummy |
| 0 | 1.72 | 1.49 | 1.32 | 1.06 |
| 1 | 1.05 | 0.95* | 0.46* | 0.35* |
| 2 | 1.04* | 1.00 | 0.47 | 0.42 |
| 3 | 1.10 | 1.06 | 0.56 | 0.51 |

* indicates lag order selected by the criterion.

are applied, it is clear that 1 lag is not enough to address autocorrelation problems in models 2, 3 and 4. Therefore, all models are estimated with 2 lags.

### 5.2.1_Generalized Impulse Response Functions

We employ the Generalized Impulse Response Functions[6] to further study the properties of the system. The analysis of the response functions to impulses is of great importance because if firms adjust their prices more frequently, along with an unanticipated inflation rise, a greater initial increase is expected in the average price of a certain product proportionalto the inflation rate.

Figure 4_Generalized Impulse Response Functions

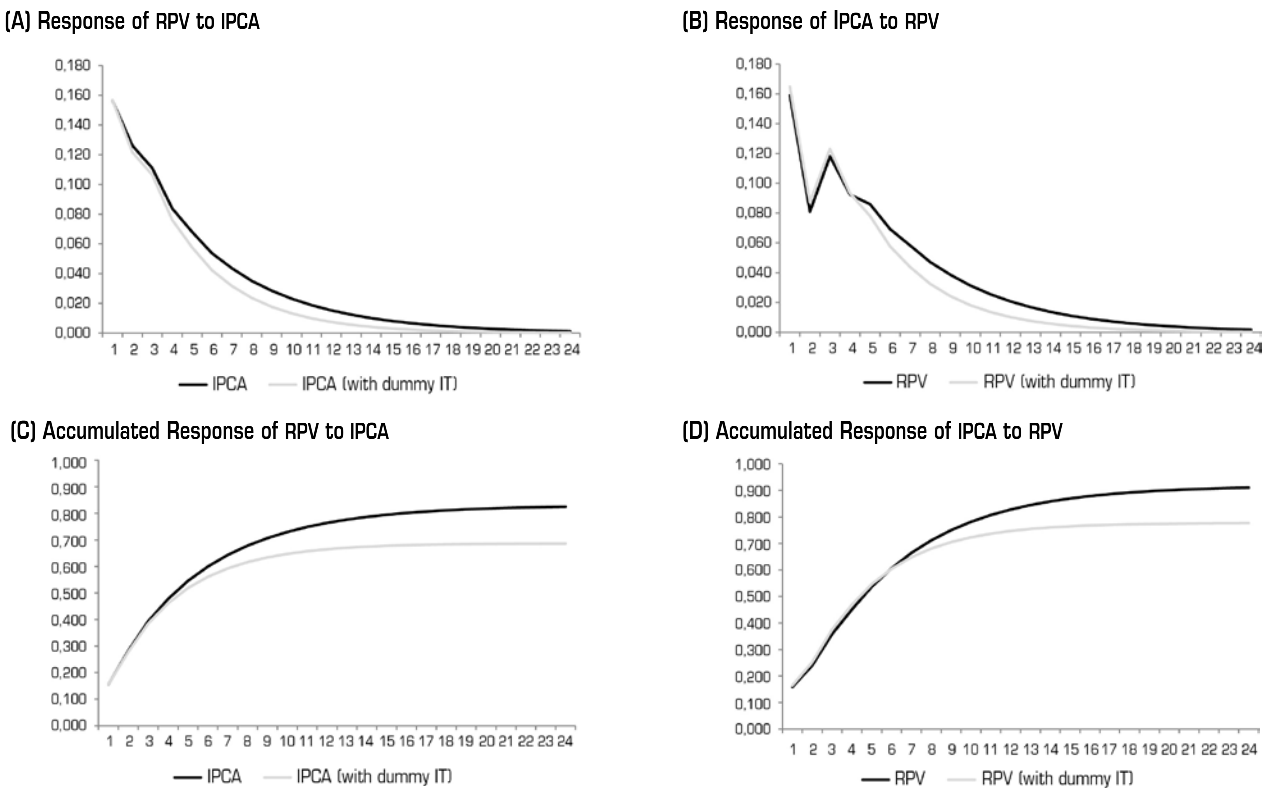
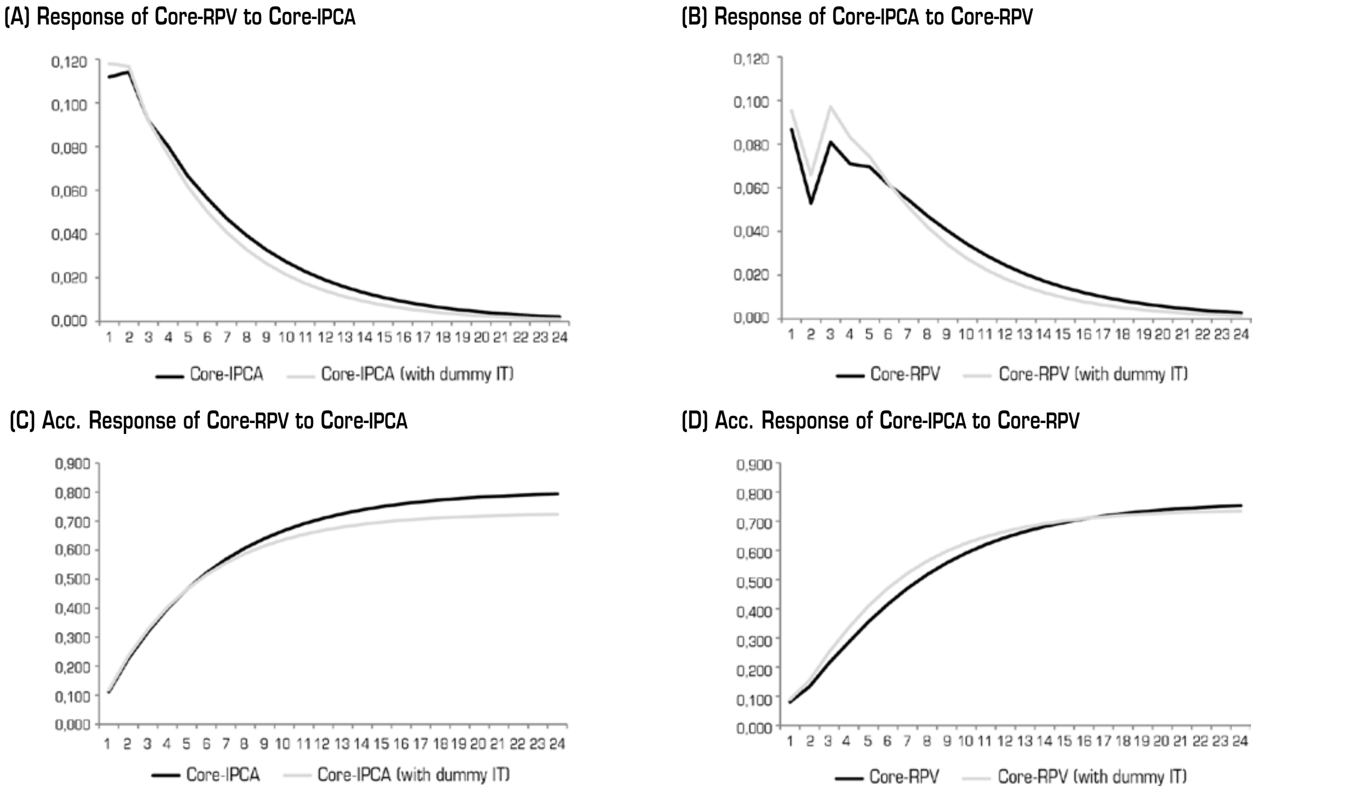


Figure 4 displays the Generalized Impulse Response Functions for the Headline-IPCA and its RPV. Graphs A and B show the responses of RPVto IPCA, and vice-versa. Shocks to the IPCA (RPV) cause a positive effect in the RPV (IPCA) with complete dissipation only after 2 years. It means that the positive relationship between inflation and RPV is confirmed, as it was in the previous tests: a shock in inflation increases the variability of prices in Brazil.Graphs C and D display the accumulated impulse response functions.

When a dummy for the inflation targeting period is included, responses are less intensive, irrespective of if they come from RPV or IPCA. As already mentionedthe adoption of the inflation targeting system seems to be an important step towards a lower dispersion of relative prices in Brazil, as IT is able to anchor inflation expectations and, as result, increase efficiency in the economy.

Figure 5 shows the Generalized Impulse Response Functions for Core-IPCA and Core-RPVas the result of shocks coming from both variables.Graphs A and B show that both shocks generate responseswhich areless intensive than those observed in the Headline-IPCA,

**Figure 5_Generalized Impulse Response Functions**



even though the convergence of the responses is quite similar. This could be an indication that when volatility is excluded from the Headline-IPCA, shocks to core inflationdo not affect Core-RPV, and vice-versa. Notice, also, that the accumulated response of Core-RPV (Graph D)is closer when one compares the series with and without the IT dummy. Again, this indicates that only when the core inflation is analyzed, does the dispersion of prices respond less intensively.

#### 5.2.2_Generalized Forecast Error Variance Decomposition

As in the case of the Impulse Response Functions, the Generalized Forecast Error Variance Decomposition is also invariant to the ordering of the variables[7]. Table 7 shows that, for the Headline IPCA (with and without a dummy for IT), the results are very similar, that is, after one year, 75% of the variance decomposition is related to the variables themselves. For the RPV, after one year, 71% do the Forecast Error Variance Decomposition is explained by the RPV itself, whereas 29% is explained by the CPI inflation. When the IT dummy is taken into consideration there is not much change in the figures: 68% for the RPV and 32% for the IPCA.

Table 8 shows the results for the Core-IPCA and its RPV (with and without a dummy for IT). For the Core-IPCAwithout a dummy for IT, the results are very similar to the ones reported on Table 6: after one year, 75% of the variance decomposition is related to the Core-IPCA itself. On the other hand, for the Core-IPCAwithout a dummy for IT, the results differ. For the RPV, after one year, 71% do the Forecast Error Variance Decomposition is explained by the RPV itself, whereas 29% is explained by the CPI inflation. When a dummy is included, the results are 68% and 32% respectively. Again, this has something to do with the exclusion of volatile prices from the core inflation.

Another interesting comparison can be made between the results reported on Tables 7 and 8. Comparing the Generalized Forecast Error Variance Decompositions for IPCA (Table 7) with Core-IPCA (Table 8), the results remain almost the same, when a dummy for the inflation targeting

Table 7_Generalized Forecast Error Variance Decomposition (Headline IPCA and RPV)

| Generalized Forecast Error Variance Decomposition for Variable IPCA | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Horizon | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Without Dummy IT | IPCA | 0.81 | 0.85 | 0.82 | 0.80 | 0.78 | 0.77 | 0.77 | 0.76 | 0.76 | 0.76 | 0.75 | 0.75 | 0.75 |
| | RPV | 0.19 | 0.15 | 0.18 | 0.20 | 0.22 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.25 | 0.25 | 0.25 |
| With Dummy IT | IPCA | 0.80 | 0.83 | 0.80 | 0.79 | 0.78 | 0.77 | 0.77 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 |
| | RPV | 0.20 | 0.17 | 0.20 | 0.21 | 0.22 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| **Generalized Forecast Error Variance Decomposition for Variable RPV** | | | | | | | | | | | | | | |
| Without Dummy IT | IPCA | 0.19 | 0.25 | 0.27 | 0.28 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 |
| | RPV | 0.81 | 0.75 | 0.73 | 0.72 | 0.72 | 0.72 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 |
| With Dummy IT | IPCA | 0.20 | 0.27 | 0.30 | 0.31 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| | RPV | 0.80 | 0.73 | 0.70 | 0.69 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 |

Table 8_Generalized Forecast Error Variance Decomposition (Core-IPCA and RPV)

| | Horizon | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Generalized Forecast Error Variance Decomposition for Variable Core-IPCA** | | | | | | | | | | | | | | |
| Without Dummy IT | Core-IPCA | 0.89 | 0.82 | 0.81 | 0.79 | 0.78 | 0.77 | 0.77 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 |
| | Core-RPV | 0.11 | 0.18 | 0.19 | 0.21 | 0.22 | 0.23 | 0.23 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| With Dummy IT | Core-IPCA | 0.88 | 0.79 | 0.76 | 0.74 | 0.73 | 0.72 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 |
| | Core-RPV | 0.12 | 0.21 | 0.24 | 0.26 | 0.27 | 0.28 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 |
| **Generalized Forecast Error Variance Decomposition for Variable Core-RPV** | | | | | | | | | | | | | | |
| Without Dummy IT | Core-IPCA | 0.11 | 0.09 | 0.12 | 0.13 | 0.15 | 0.16 | 0.17 | 0.18 | 0.18 | 0.18 | 0.19 | 0.19 | 0.19 |
| | Core-RPV | 0.89 | 0.91 | 0.88 | 0.87 | 0.85 | 0.84 | 0.83 | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 |
| With Dummy IT | Core-IPCA | 0.12 | 0.11 | 0.15 | 0.17 | 0.18 | 0.19 | 0.20 | 0.20 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| | Core-RPV | 0.88 | 0.89 | 0.85 | 0.83 | 0.82 | 0.81 | 0.80 | 0.80 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |

system is not included, and are slightly smaller (around 5 percentage points) in favor of Core-IPCA with the inclusion of a dummy for inflation targeting.

On the other hand, results change when one makes a comparison between the Generalized Forecast Error Variance Decompositions for RPV (Table 7) and Core-RPV(Table 8). Without a dummy for the inflation targeting period, the variance decomposition for Headline-RPV shows that 71% of the error comes from the variable itself. This figure increases to 81% when the Core-RPV is analyzed. With a dummy for inflation targeting, the percentages are 68% and 79%. It means that the variance decomposition of RPV faces important changes (around 10 percentage points) between the headline and core calculations.

## 6_Conclusion

This article proposed an empirical analysis of the correlation between inflation and relative price variability in Brazil. To this purpose, we focused on both headline and core inflation rates, and also took into account the inflation targeting regime. The period under analysis went from January 1995 to June 2011. We found a positive and significant correlation between inflation and relative price variability in all estimations (the same applying to core estimations). As well as that, wefound a significant decrease in the relative price variability after the implementation of the inflation targeting framework.In addition, bi-causality between Headline-IPCA and Headline-RPV was reported. Impulse response functions showed that shocks to Core-IPCA did not affect Core-RPV as much as shocks to Headline-IPCA affected Headline-RPV. Lastly, the variance decomposition related to Core-IPCA and Core-RPV seemed to be reduced when compared to headline inflation.

In sum, our results show that, as it is usually found in other countries, inflation shocks increase relative price variability in Brazil, Our results also illustrate that the introduction of the inflation targeting framework was very important in anchoring inflation in Brazil and, consequently, reducing the variability of prices. It was also possible to notice that that relative price variability has declined over the years in Brazil and that part of such dispersion is related to the presence of volatile prices as core inflation seems to deliver less price dispersion.

In terms of economic policy, the dispersion of relative prices, in the face of inflationary shocks, can disrupt allocative efficiency, as mentioned in Gali (2008). This might beevidence that the lack of synchronization in price adjustments may cause welfare losses, meaning that monetary policy tools are important in fighting inflation. Therefore, the adoption of an inflation targeting framework is an important tool for anchoring inflation expectations and bringing social welfare gains and more credibility to monetary policy actions.

## Notes

[1] In a context of high inflation, costs are usually related to inflation tax, among others.

[2] In simplified versions of these models, anticipated changes in the money stock do not affect relative prices, and as such, the anticipated inflation should not be associated with additional RPV. In sophisticated versions, the anticipated inflation may not be neutral and might affect the real interest rate and, therefore, the relative prices. Nevertheless, the emphasis is on the role of unanticipated changes in the money stock (Fischer, 1981).

[3] See Danziger (1987) for a detailed discussion.

[4] In relation to this, Fischer (1981) highlights that the RPV is more effectively measured the more disaggregated the price index is, which is our case. If resource allocation failures, associated with unexpected inflation, are the result of excessive searching, such demand might be due to the belief in price differences of very similar goods.

[5] It is helpful to remember that Granger causality does not imply causality, as popularly meant, but is related to precedence and information content.

[6] The impulse response functions, proposed by Pesaran & Shin (1998), avoid the use of the Cholesky decomposition in the definition of the most suitable variable ordering. It is well known that the results can be substantially affected by arbitrary orderings.

[7] See Pesaran & Shin (1998).

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