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Price Rigidity in Brazil: Evidence from CPI Micro Data

Solange Gouvea *

Abstract

In this paper, I investigate the patterns of price adjustments in Brazil. I derive the main stylized facts describing the behavior of price setters directly from a large data set of the CPI price quotes spanning approximately ten years until 2006. I find that on average prices remain unchanged for 2.7 to 3.8 months, exhibiting, however, a large degree of product and sector heterogeneity. Data on the frequency and sign of price changes show that there is a strong symmetry between price increase and decrease. Conversely, as expected under a positive inflation environment, the magnitude of positive price changes compensates this effect.

I also provide some insights on the determinants of the patterns of price adjustment. The average duration of price spells decreased when the economy was hit by a confidence shock before 2002 presidential elections. The inflation rate of 5.9 % in 2000, jumped to 7.7% in 2001 and hiked to 12.6 % in 2002. Results suggest that substantial disturbances to average inflation imposed a high enough cost of not adjusting prices and triggered more frequent price reviews.

JEL Classification: E31; C40; D40
Keywords: Price rigidity, Duration of price spells, Price setting

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1 Introduction

In this paper, I investigate the patterns of price adjustments in Brazil. I derive directly from a large data set of the CPI price quotes the main stylized facts that describe the behavior of price setters providing micro empirical evidences on the degree and features of price rigidity. The sample is quite extensive, covering products that amount to 85% of the overall CPI, ranging from March 1996 to April 2006, and totaling approximately 9 million observations. I also provide some insights on the determinants of the patterns of price adjustment by inspecting the cross section dimension of the monthly frequency of price adjustment throughout the sample and by assessing the average duration of price spells for different periods. These windows of time were determined by either a change in the conduct of monetary policy or by the occurrence of an important shock that changed substantially the level of the average inflation rate.

The idea that sluggish price adjustment plays a central role in explaining monetary non-neutrality in the short-run dates back to Keynes. Since then, both theoretical modeling and empirical work have been developed showing the real effects of monetary policy when price rigidity is present. During the eighties and nineties, the theoretical literature evolved to dynamic models with costly price adjustment, imperfect competition, and optimizing behavior of firms. This framework, more compatible with microeconomics foundations, was incorporated in a general equilibrium set up where agents are assumed to be rational. These models have been a very useful tool for policy makers to carry out welfare analysis. More recently, such models have also been estimated with Bayesian techniques to help the implementation of forecast exercises.

The solid theoretical foundations together with the presence of nominal rigidities as source of monetary non-neutrality represented an important evolution in research. In these models, firms choose optimal price while facing the constraint on the frequency of price adjustment. Consequently, firms incorporate in the decision problem their expectation about future cost and demand conditions. Despite all these advances, there are still controversies about what underlying assumptions would be reasonably realistic to model price rigidity. Time dependent models of price adjustment have been largely used in this literature. The common set ups follow mostly Calvo (1983), but Taylor (1980) and Rotemberg (1982) were also incorporated into a dynamic general equilibrium framework. Calvo (1983) assumes stochastic opportunity to re-optimize prices. Firms either readjust optimally or keep their prevailing prices. Taylor (1980) is based on the assumption of staggered and overlapping contracts of predetermined duration, and Rotemberg (1982) introduces quadratic adjustment cost of changing prices at the firm level. Moreover, nominal price setting has also been modeled as dependent of the state of the economic conditions.

Theoretical models of price adjustment postulate that firms set prices in

a staggered fashion. A common feature of all these models is the assumption that some kind of friction causes infrequent and staggered price adjustment. Different models claim various reasons for the existence of obstacles impairing prices to be fully flexible. A not exhaustive list runs from co-ordination failure, explicit contract of fixed duration, pricing thresholds, and menu cost.

The implications of these models for inflation dynamics have been severely criticized by the empirical literature. Studies, mostly based on macro empirical evidence, show that standard time dependent purely forward looking theoretical models of price stickiness fail to reproduce endogenously the persistent nature of inflation.[1] As a consequence of these criticisms, price rigidity models have been extended to provide theoretical grounds to the observed sluggish behavior of inflation. Extensions of the Calvo time dependent model motivated by indexation or rule-of- thumb behavior from part of the price setters came into play to reconcile theory and empirical evidence on inflation dynamics.[2] Additionally, incorporation of real rigidities has proven to be an important feature.[3]

The literature on empirical micro evidences on pricing policies has only recently produced works for the aggregate economy. Potentially, this line of research can reveal important information identifying which behavioral assumptions really matter when building structural models of price adjustment. Moreover, it has been a permanent challenge for Central Banks to improve further the knowledge of how the transmission mechanism of monetary policy actually works. A core issue has been to evaluate the degree of inflation persistence, which is essential to achieve more effectiveness in the conduct of monetary policy. Management of monetary policy instruments should take into account the speed with which inflation is likely to move towards the target in the aftermath of a shock. In this context, the investigation of price setting behavior, which is surely associated with the nature of inflation dynamics, can be very clarifying.

This paper looks into what are the patterns of price adjustment at the micro level assessing how much price rigidity there is at the aggregate level. The main stylized facts characterizing nominal price rigidity in Brazil, as average frequency of price adjustment, the mean duration of price spells, and the heterogeneity in price setting, are addressed. Potential dependency of the price setting behavior on actual and expected average rate of inflation is investigated.[4]

Very few works have looked into microeconomic evidence on price adjustment until very recently. Previously, these works were all based on restricted data sets generally concentrated in one sector or product.[5] A serious barrier to the

[1] As stressed in Walsh (2003) chapter 5, inflation persistence in this context is the serially correlated response of inflation in face of a serially uncorrelated shock.

[2] See Gali and Gertler (1999) and Woodford (2003)

[3] See Christiano et al. (2005)

[4] See Taylor (1999) for stylized facts on price setting

[5] Examples are Cecchetti (1986), S. and Tsiddon (1992) and Eden (2001)

development of this kind of study was the availability of a large and broad data set on price quotes. Only recently, a pioneer work by Bils and Klenow (2002) released the first study for the US. Their work is based on unpublished individual price records data that is collected and used by the Bureau of Labor Statistics (BLS) to compute the U.S. consumer price index (CPI). In 2003, the European Central Bank created the Inflation Persistence Network with the purpose of producing both macro empirical studies on inflation persistence and micro empirical studies based on the CPI and the producer price index (PPI) data sets. Surveys were also implemented to complement this research effort. Regarding Latin America, studies are very few and recent. Gagnon (2005) studies the evidence from Mexico, for price setting during low and high inflation. Juan Pablo Medina (2006)report the evidence from micro level data for Chile.

This paper contributes to the literature adding Brazil to the list of countries carrying out this type of research. The micro evidence on price adjustment collected here improves the knowledge about the persistence of inflation in Brazil through a channel of research not explored before. Results suggest some useful policy implications and help to evaluate some alternative assumptions that characterize different theoretical price adjustment models.

Alternative methodologies are used to estimate the frequency of price change and the duration of price spells. I find that, on average, prices remain unchanged between 2.7 and 3.8 months, depending on the method applied. Both approaches robustly show that the price setting behavior exhibits a large degree of product and sector heterogeneity. In the services sector, prices remain unchanged for a relatively longer period. Data on the values of price changes show that there is a strong symmetry between the fraction of price increases and decreases. Again, the services sector is an exception, displaying clearly a downward rigidity in price setting. Conversely, as expected under a positive inflation environment, the magnitude of positive price changes compensates the symmetry on the proportion of price increases and decreases. Price increases are,on average, 27% higher than price decreases.

I also provide some insights on the determinants of the patterns of price adjustment. The average duration of price spells decreased when the economy was hit by a confidence shock before the 2002 presidential elections. At this time, the inflation rate jumped from 5.9 % in 2000 to 7.7% in 2001 and hiked to 12.6 % in 2002. Results suggest that the impact of these levels of average inflation imposed a high enough cost of not adjusting prices and triggered more frequent price reviews.

The remainder of the paper is structured as follows. In the second section, I describe the features of the data set used here as well as all the necessary treatment to the original data base. In the third section, I describe the methodology I implemented to develop the descriptive analysis, namely how to compute the average duration of price spells, the frequency of price adjustments and other

statistics from which I draw the stylized facts addressed in the paper. In the fourth section, I present the results and read them through the lens of related theories of price setting. Finally, in the fifth section, I summarize the empirical findings and discuss some policy implications.

2 The Dataset

2.1 Data Description

The dataset used here consists of individual price quotes of the products collected and used by IBRE/FGV, the Brazilian Institute for Statistics of the Getulio Vargas Foundation, to compute the consumer price index (CPI). The price quotes of approximately 180 thousand different items are collected in 2500 outlets. [6] The whole CPI comprises these items in 487 products and services grouped in seven different sectors (Food, Housing, Apparel, Medical and Personal Care, Education and Recreation, Transportation and Other Goods and Services). The weights of these products and services used in the computation of the index mirror the composition of the budget spent by families receiving income up to 33 minimum wages per month.

Data collection of some products are systematically collected every ten days, whereas price for the remaining products are collected on a monthly frequency. The CPI index is a weighted average of price quotes collected in 12 state capitals. The population of each of these cities is used to represent the weights.

Codes or descriptions make it possible to identify the price of which specific product or service is being collected, when and also where. Although different outlets are identified by codes, these records are under statistical secrecy and it is not possible to know the size or kind of outlet where these price quotes were collected. This would be a very important piece of information in order to study the behavior of price setters under different market structures. Nevertheless, availability of other useful and detailed information made it possible to conduct a quite broad investigation.

2.2 Sample Characteristics and Definitions

In this subsection I describe the sample and define some concepts that will be used in the rest of the paper. The sample spans approximately 10 years, ranging from 1996 to 2006 and is very representative of the overall CPI. It contains 243 categories of product and services representing around 85 % of the CPI

[6] These items are narrowly defined as products or services, with very precise characteristics as brand, packaging, variety/type that are sold in a specific outlet. For instance: rice of type 1, of the brand Tio Joao packaged in a bag of 5kg, which is sold in outlet number 897, in Rio de Janeiro.

computation. The seven different sectors are very well represented as follows: Food 77.9%, Housing 87.4%, Apparel 77.5%, Medical and Personal Care 91.0%, Education and Recreation 88.4%, Transportation 85.4% and Other Goods and Services 95.7%.

The original data sample, previous to some necessary data manipulation, contained around 9 million observations.[7] The concept of an ***observation*** in this context is a price quote of an ***elementary product-outlet***, i.e., a product or service with very precise characteristics such as brand, packaging, variety/type, etc., which is sold on a specific outlet. An ***elementary product*** is a very specific product which is sold in a group of outlets. A ***product-category*** is represented by all ***elementary products*** that belong to the same broad category.

Just to illustrate, the information in the data set describes an ***elementary product-outlet*** by rice of type 1, of the brand Tio Joao packaged in a bag of 5kg, which is sold in outlet number 897, in Rio de Janeiro. Attached to this description is the collection date and the value of the price quote. An ***elementary-product*** is then the product rice of type 1, of the brand Tio Joao, in a packaging described by bag of 5kg, which is sold in a group of outlets. The ***product-category*** is rice.

Surveyors periodically collect the price of these ***elementary products-outlet*** registering a sequence of price quotes over time. This sequence of price quotes collected over the sample period is defined here as a ***price trajectory***. After all necessary data treatment, the final sample dataset ended up comprising around 124.6 thousand ***price trajectories***.

The time interval between two price changes is defined as a ***price spell***. The ***duration of a price spell*** is the amount of time between these two price changes. Censoring occurs when it is not possible to observe the entire spell. Price spells truncated at the beginning of the observation period are defined as ***left-censored spells***, and the ones truncated at the end are defined as ***right-censored spells***.

2.3 Sample treatment

The original data set was manipulated in order to shape it in a more adequate set of information. Firstly, when implementing these adaptations in the data set, the main focus should be the theoretical questions one wants to address using the available information. As mentioned in the introduction, the main objective of this paper is to assess how much price rigidity there is at the aggregate level, investigate the determinants of the patterns of price adjustment, and relate them

[7] See subsection 2.3 on sample treatment for details

to existing theories. Secondly, when performing estimations or computations, it is usually necessary to treat or transform the data in order to avoid technical problems.

Regarding the coverage of products, one major category of products and services was eliminated from the analysis. I have chosen not to work with products that have been regulated throughout the sample period. Obviously, discarding these information impacts the assessment of the aggregate actual level of price rigidity as these products and services represent around 30% of the CPI. However, the behavior of these price setters is surely explained by explicit pre-determined contracts of fixed duration that prevent them from reacting to shocks. Consequently, price rigidity displayed by regulated prices can be easily anticipated by policy makers. Furthermore, by isolating the impact of regulated prices, the captured inertia could then be tested to support some theories of price adjustment as menu costs.

Price quotes classified as sale or promotion were not ignored. These price changes represent an instrument either to attract costumers or to decrease the inventory of a certain product. These episodes are interpreted as being a sale strategy with impacts on the price setting behavior and therefore considered relevant. Moreover, management of inventories should be related to the macro economy to the extent that inventories are cyclical. Outliers and missing values were substituted by the previous observed price record.

Dealing with censoring is another important issue. A ***censored spell*** is an incomplete observed period between two price changes. It may suffer one or even two interruptions. As mentioned in subsection 2.2 ***left-censored spells*** are truncated at the beginning of the observation period and ***right-censored spells*** are truncated at the end. ***Double-sided censored spells*** are the ones for which it is possible to observe neither the beginning nor the end of the spell. There are different reasons for the occurrence of censored spells. In the context of this paper, left-censoring is defined by the fact that the calendar date of the first price quote collected did not coincide with a price change. Right censoring occurs when the last price quote collected did not correspond to a price change. In other words, these were all on going spells at the beginning or at the end of the sample period. [8]

I trimmed the data to exclude left-censored spells for the purpose of computing the frequency of price adjustments. This procedure avoids making assumptions regarding the period that precedes the beginning of the sample.[9] I

[8] There are also cases of attrition. These refer to cases when a certain outlet closes or quit selling a specific product and the surveyor either stops observing it or substitutes it by another one with similar characteristics. Those were not detectable. There were no cases of double-sided censoring.

[9] As pointed out by Heckman and Singer (1984) See section 3 for necessary assumptions behind the frequency approach.

acknowledge that long-lasting spells are more likely to be censored and discarding left-censored spells could potentially lead to a downward bias. However, left-censored spells were not very representative.

3 The Methodology

Using micro data, usually two alternative methodologies are applied to estimate the average and median duration of price spells. In the two following subsections, I present the main details and discuss some important theoretical issues regarding the use of these two approaches. The two last subsections present the method applied to measure the magnitude and the symmetry in the direction of price change.

Considering that my objective is to obtain a comprehensive measure of the duration of price spells, it is important to be concerned with potential heterogeneity in price setting. Therefore, computations were carried out on the basis of most disaggregated data represented by the price quotes of each *elementary product-outlet*. The idea was to capture the behavior of one specific price setter with respect to a particular product. Then, the aggregation procedure built up computations progressively according to the degree of product homogeneity. The results obtained in each of these steps revealed the degree of heterogeneity in price rigidity among different *elementary products*, *product categories*, and CPI or economic sectors. Note that, the weights of the different *product categories* and CPI or economic sectors in the overall CPI index were taken into account in the aggregation procedure. Those weights were resized to consider the fact that not all *product categories* of the CPI are represented in the the sample.

For the next subsections, consider the following notation. Let $s = 1, 2, ..., 7$ denote the sectors of the CPI, and $c = 1, 2, ...\overline{C}$ denote the *product categories* in a sector. Assume $k = 1, 2, ...\overline{K}$ stands for the *elementary product* in a category, and $j_k = 1, 2, ..., \overline{J}$ represents the outlet that sells k.

3.1 Measuring the Duration of Price Spells: The Direct Approach

The direct approach measures the average and median durations of price spells straight from the calculation of the average size of the price spells within each individual *price trajectory* in the dataset. These statistics are then aggregated gradually in homogeneous groups. Below, I describe how the computations were carried out.

The *price spell* of the *elementary product-outlet* (k, j_k) is the observed episode of fixed price $P_k, j_{k,t} = P_{k,j_{k,t-i}}$, so that the end of this *price spell* occurs when there is a price change $P_k, j_{k,t} \neq P_{k,j_{k,t-i}}$. The *duration of this price spell* is then defined by the time interval between the two calendar dates $cd(P_k, j_{k,t}) - cd(P_{k,j_{k,t-i}})$ limiting this *price spell*. The *length of the trajectory* of this *elementary product-outlet* is the size of the time interval that the price of this *elementary product-outlet* P_{k,j_k} was observed, i.e., $TL_{k,j_k} = cd(P_k, j_{k,t_T}) - cd(P_k, j_k, t_1)$.

The computation starts by calculating the average duration of the price spell of each *trajectory* of each *elementary product-outlet* (k, j_k) by:

$$ADT_{k,j_k} = \frac{TL_{k,j_k}}{NS_{k,j_k}} \tag{1}$$

where TL_{k,j_k} is the length of the *trajectory*, and NS_{k,j_k} is the number of spells contained in the trajectory.

The second step is to compute the average duration of the elementary product k by taking the simple average of the durations of the *trajectories* of the elementary-outlet products ADT_{k,j_k} across all outlets that sell the same elementary product k as follows:

$$ADEP_k = \frac{\sum_{j_k=1}^{\overline{J}} ADT_{k,j_k}}{\overline{J}} \tag{2}$$

Similarly, in order to calculate the average duration at the product category level, another simple average of the durations of all *elementary products* that belong to the same *product category* is taken as follows:

$$ADC_c = \frac{\sum_{k=1}^{\overline{K}} ADEP_k}{\overline{K}} \tag{3}$$

In the next step, I use the weights of the *product category* in the respective CPI-sectors to obtain the weighted average duration at the CPI-sector level. This step is given by:

$$ADS_s^w = \frac{\sum_{c=1}^{\overline{C}} \omega_c ADEP_c}{\overline{C}} \tag{4}$$

The aggregate weighted average duration of the CPI is then obtained using the weights of the CPI-sectors in the overall CPI, as follows:

$$ADcpi^w = \sum_{s=1}^{7} \omega_s ADS_s^w/7 \quad (5)$$

The draw back of this method is the restriction to work with uncensored spells only. Potentially, the exclusion of censored spells leads to a downward bias because it is more likely that long-lasting spells are censored and therefore are the spells to be discarded. However, in the context of this specific sample characteristics this selection bias is weak. As emphasized in 2.2 censored spells are not very representative in this sample. Also, the longest price spell duration is much shorter than the period under analysis indicating that eliminating censored spells would not lead to a bias.

It is worth mentioning that the method applied here avoids over representing very short durations by computing the mean duration averaged by individual trajectories according to equation 1. Therefore, the estimated average duration is larger than it would have been if an overall average were computed. [10] Moreover, the direct approach entails two main advantages over the frequency approach described in the next subsection. Every single change in the price of an *elementary product-outlet* is taken into account, and it is possible to obtain the entire distribution of price duration. [11]

3.2 Measuring Duration of Price Spells: The Frequency Approach

I start by presenting the details of computing of the frequency of price changes. Then, I discuss the main assumptions underlying the derivation of the implied average and median duration recovered from the frequency of price changes.

The *frequency of price change* is defined here as the fraction of times prices were changed. It was computed using an indicator variable I_{k,j_k}, for price changes. It was computed for each individual *trajectory* as stated below:

$$I_k = 1 \quad if \quad P_k, j_k, t \neq P_k, j_k, t-1 \,,$$
$$0 \quad \text{otherwise}$$

Firstly, the *frequency of price change* was computed at the elementary product-outlet level by the ratio between the number of times a price change was registered and the sum of the number of times that prices changed plus the number of times prices remained fixed. The *frequency of price change* at the *elementary product-output* level is then given by:

[10] This is the case here because spells with short duration are very frequent in the sample and for a given horizon these spells are therefore overrepresented.

[11] As will be detailed in the next subsection, the frequency approach only considers one price change within a month even if there were more than one.

$$F_{k,j_k} = \frac{NI_{k,j_k} = 1}{NI_{k,j_k} = 1 + NI_{k,j_k} = 0} \tag{6}$$

where $NI_{k,j_k} = 1$ represents the total number of times there was a price change and $NI_{k,t} = 1 + NI_{k,t} = 0$ is the number of times prices changed plus the number of times prices remained fixed.

The next step was to aggregate all these *frequencies of price change* at the elementary products level F_k by averaging over all the outlets that sell the same product and then aggregating at the category product level F_c by averaging over the products that belong to the same category as follows:

$$F_k = \frac{\sum_{j=1}^{\overline{J}} F_j}{\overline{J}} \tag{7}$$

$$F_c = \frac{\sum_{k=1}^{\overline{K}} F_k}{\overline{K}} \tag{8}$$

The weighted frequency at the sector level, F_s^w, is then obtained by aggregating all frequencies at the category level, F_c, that belongs to the same sector applying their respective weights in the sector ω_c according to:

$$F_s^w = \frac{\sum_{c=1}^{\overline{C}} \omega_c F_c}{\overline{C}} \tag{9}$$

Analogously, the weighted frequency at the overall CPI level, $Fcpi^w$, was computed by aggregating all weighted frequencies at the sector level, F_s^w, taking into account the sectoral weights in the CPI as follows:

$$F_{cpi}^w = \frac{\sum_{c=1}^{\overline{C}} \omega_s F_s}{7} \tag{10}$$

Now I turn to the discussion of the implicit relationship between frequency of price changes and average and median duration. The implied average and median duration of a price spell can be derived using the calculated frequency of price change at the elementary product level. This estimation procedure to

compute average and median duration of price spells relies on duration analysis and follows other published works in the literature. [12]

Computing the implied average and median duration is useful in a number of analyses developed here. It is possible to show that, for large samples, the inverse of the frequency of price change is a consistent estimator of the average duration of price spells. Convergence requires simultaneously that price spells are generated under stationary conditions over time and that price setters behave homogeneously in a cross-sectional dimension. [13] Also, it is implicit here the assumption that prices are set in a discrete timing fashion, meaning that whenever prices are changed it occurs once within a given month interval. This relationship is then given by:

$$AT_{d_{cpi}}^{w} = \frac{1}{F_{cpi}^{w}} \tag{11}$$

where $AT_{d_{cpi}}^{w}$ is the overall average duration of price spells.

The homogeneity assumption requires aggregating products that are more akin to each other regarding price setting behavior. However, this implicit similarity is not fully guaranteed. Note that, the bottom level of aggregation considers different outlets as is explicit in equation 7. Price changes are assembled across the different types of outlets implying that it must be the case that the price setting behavior should be dissimilar.[14] Unfortunately, the data set available for Brazil does not discriminate among different kinds of outlets.

Another important remark emphasized in the literature is that this measure may be downward biased due to the procedure of aggregation itself. This caveat, stressed by both Baharad and Eden (2004) and Baudry and Tarrieu (2004), refers to the fact that the method used here implies computing the inverse of the average frequency of price changes instead of the average of the inverse of the frequency of price changes. The former measure is smaller or equal to the latter due to Jensen's inequality. [15] These authors calculated both measures and arrived to a similar order of magnitude for the downward bias.[16]

[12] A broad but not exhaustive list are the series of papers published by the ECB/IPN (include site)and Bils Klenow (2004). For exposition on duration analysis in economics see Lancaster (1990)and Heckman and Singer (1984)

[13] A more detailed discussion of the asymptotic property and the derivation of this relationship can be found in Baudry and Tarrieu (2004)

[14] Other works in which the available data-set allows for discrimination among different kinds of outlets have already reported different average duration of price spells between supermarkets and shoppers corner.

[15] Jensen's inequality implies $E\left(\frac{1}{F}\right) \geq \left(\frac{1}{E(F)}\right)$

[16] Baharad and Eden (2004) finds the weighted average of implied durations is 8.38 while the inverse of the aggregate frequency is 4.77.Baudry and Tarrieu (2004)finds 7.9 and 4.1.

Switching to a continuous time set up, meaning in this context that prices change at any point in time, and provided that the hazard function is independent of time, the relationship between the frequency of price changes and the average duration is given by:[17]

$$AT_{c_{cpi}}^{w} = -\frac{1}{ln(1 - F_{cpi}^{w})} \tag{12}$$

As for the median duration, the relationship with the frequency of price changes is described by:

$$MT_{c_{cpi}}^{w} = -\frac{ln(0.5)}{F_{cpi}^{w}} \tag{13}$$

For the purposes of analyzing data in a cross-section dimension, the frequency of price changes was also computed on a monthly basis. Obviously then, the average frequency per price price trajectory is not computed. Instead, the simple frequency statistics was computed.

The frequency of price change is defined here as the fraction of prices that changed within a given month. Again, using an indicator variable $I_{k,t}$, it was computed if there was at least one price change within a given month across all different *price trajectories* as stated below:

$I_{k,t} = 1 \;\; if \;\; P_{k,t} \neq P_{k,t-1}$,

0 otherwise

Then, the monthly frequency of price changes across the different *price trajectories* was computed in two steps as follows:

$$F_m = \frac{NI_{k,t} = 1}{NI_{k,t} = 1 + NI_{k,t} = 0} \tag{14}$$

where $NI_{k,t} = 1$ represents the total number of times there was a price change at month t and $NI_{k,t} = 1 + NI_{k,t} = 0$ is the number of times prices changed plus the number of times prices remained fixed at month t across the different *price trajectories*.

[17] The hazard function gives the probability that price changes conditioned on the time that has elapsed since prices were last changed, i.e., it takes into account duration dependence. It is represented as follows: $\lambda(s) = ds \overset{lim}{\rightarrow} 0 \; \frac{P[S<s+ds/S \geq s]}{ds}$ *where* λ denotes the hazard function and S is the total duration of the spell

3.3 Measuring the Symmetry in the Direction of Price Changes

In order to measure the symmetry between price increases and decreases, I computed the share of times price changes were positive or negative throughout the sample. The objective was to derive an indicator of the behavior of price setters regarding downward nominal price rigidities.

These statistics were computed for the overall CPI as well as for the breakdown in different sectors. By analyzing the different sectors one by one, it is possible to account for their intrinsic cost structure, which should exert influence on the results.

Firstly, an indicator variable was created to account for positive and negative price changes. Then, the overall share of price increases or decreases were calculated by:

$$S^I_{total} = N^I_{total}/TF_{total}, \tag{15}$$

$$S^D_{total} = N^D_{total}/TF_{total}, \tag{16}$$

where S^I_{total} is the share of price increases, and S^D_{total} is the share of price decreases, and N^I_{total} is the number of price increases, N^D_{total} is the number of price decreases, and finally TF_{total} is the total number of price change. These were all computed for all price trajectories together and along the overall sample. The share of price increases or decreases by sector were computed analogously.

Alternatively, the symmetry in the direction of price changes was also assessed by computing the unweighted average frequency of price increases and decreases on a monthly basis. These computations were carried out as follows:

$$F_{m,i} = \frac{NI_{k,t} = 1}{NI_{k,t} = 1 + NI_{k,t} = 0} \tag{17}$$

where $F_{m,i}$ stands for unweighted monthly frequency of price increase, $NI_{k,t} = 1$ represents the total number of times there was at least one price increase in a given month t across all different trajectories , and $NI_{k,t} = 1 + NI_{k,t} = 0$ is the total number of times prices changed at least once plus the times prices remained fixed at least once within a month t across all different *price trajectories*. The monthly frequency was then averaged over the number of months in the sample period, T

The average of the monthly frequency of price decreases, $F_{m,d}$ was computed analogously.

3.4 Measuring the Size of Price Changes

The magnitudes of price changes were computed by simply calculating the average percentage increase and decrease by *price trajectory* and then applying the same weighting procedure described in 3.2.

4 Empirical Analysis

The main stylized facts characterizing the price setting behavior of the Brazilian economy during the sample period were derived from the results presented in this section. A common feature of theoretical models of nominal price rigidity is that price adjustments are staggered and infrequent. If prices do not change, the explanation may be that the current or expected path of the forcing variables underlying the price adjustment decision process remain stable. Alternatively, prices could be stable because price setters react sluggishly to pressures to change prices. In this latter context, studying the frequency of price changes or the duration of episodes of fixed prices is a way of assessing the degree of nominal price rigidity. Moreover, in this section, other features of the price adjustment mechanism are investigated to provide micro empirical evidence for some of the price setting theories.

4.1 General overview

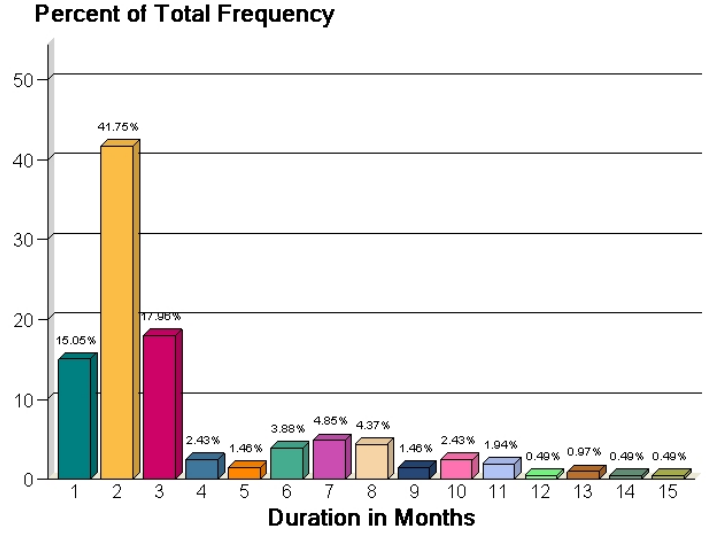
Depending on the computation method applied, the overall CPI average duration of price spells varies from 2.7 to 3.8 months. More specifically, the weighted average frequency of price change amounts to 37% for the whole CPI, and applying the frequency approach, the implied mean duration of price spells is approximately 2.7 months, if the discrete time assumption is considered. Under the continuous time set up the mean duration of price spells is 2.1 months and the median duration is 1.9 months. If computations are done considering the duration approach, average duration of price spells is 3.8 months, while the median duration is 3.2 months. Table 3 reports the statistics on the frequency of price changes and the implied mean and median durations of price spells. Tables 2 and 1 present the direct computation of average and median duration of price spells with two different weighting procedures.

As mentioned in section 3, one of the advantages of using the duration approach is the possibility of obtaining the whole distribution of price spells. Tables 2 and 1 also show the weighted distribution of the duration of price spells. Results show that this distribution is clearly skewed to the left, independently

of the weighting procedure. The median is always below the average, i.e., there is a higher concentration of short spells, but not a very long tail to the right.

A slightly different portrait of the price setter's behavior is obtained from the unweighted distribution of the duration of price spells as shown in Fig 1. The distribution is even more skewed to the left with 56.8 % of the spells displaying duration up to 2 months. The mode tells us that almost 42% of the price spells last 2 months. Variation is quite large with the longest spell lasting 15 months. The long right-side tail is very thin, mainly after spells lasting 7 months. Apparently, at the aggregate level, no seazonality could be identified.

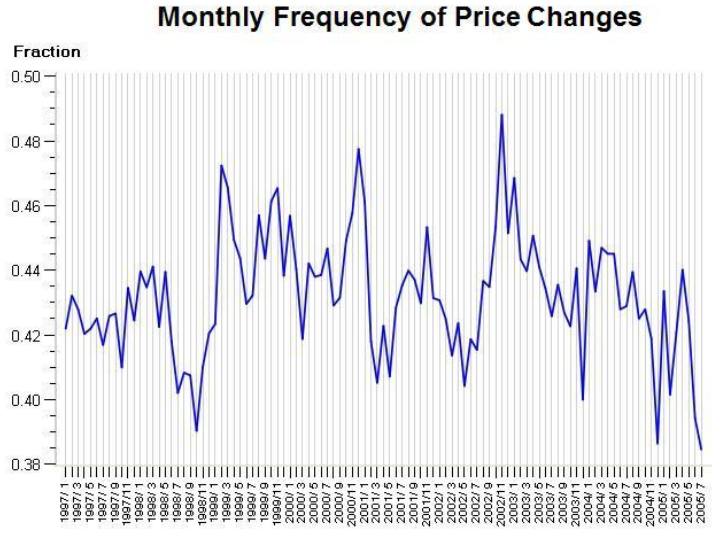
Figure 1: Unweighted Distribution of Spells Duration Overall CPI



It is also possible to make use of these statistics to compute the fraction of prices being changed in a cross-section dimension and how stable this proportion is over time. This investigation can potentially depict, if it is the case, the point in time when a change in the behavior of the price setters took place. I computed the monthly frequency of price changes within each month throughout the sample, and it turned out that some interesting insights on the determinants of the frequency of price adjustment could be derived from this analysis.

Figure 2 plots the monthly average frequency of price changes month by month. It reached its highest level in November of 2002 when the proportion of adjusting prices peaked at 49%. The visual inspection of the graph shows that since then the proportion of prices being readjusted every month exhibits a clear downward trend.

Figure 2: Monthly Frequency of Price Changes



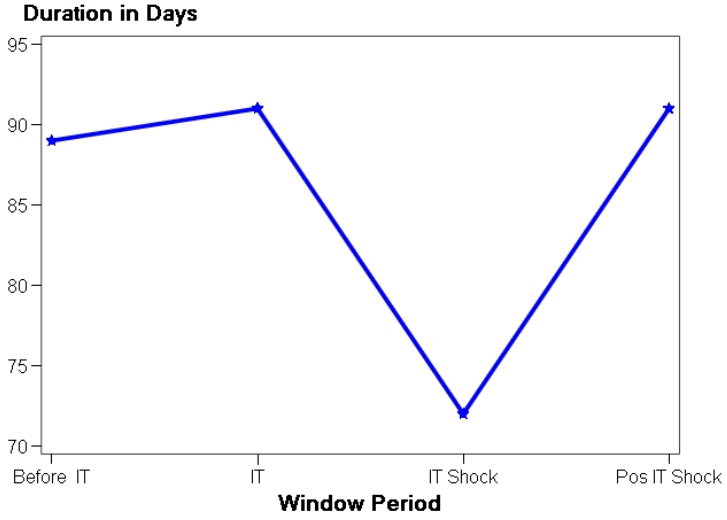
A unique episode affected the Brazilian economy at this point in time. The peak of 49 % in the frequency of price changes coincides with the presidential election of 2002. In fact, it can be observed in figure 2 that this percentage started to increase five months before it reached this maximum in anticipation of a possible change in the conduct of the economic policy. More importantly, agents expectations of a possible change in the monetary regime was translated into the economy as a confidence shock. During this period, cost pressures were already taking place. The exchange rate, Reais/US Dollars, climbed sharply from 1.8 in 2000 to 2.35 in 2001, reaching 2.9 and 3.1 in 2002 and 2003 respectively. These last figures were the highest ones in the last thirteen years. The inflation rate increased from 5.9% in 2000 to 7.7% in 2001, hiking to 12.6% in 2002. Later on, there is an overlapping of the periods of persistent decrease of the frequency of price adjustment displayed by the data and the aftermath of the confidence shock that hit the Brazilian economy at this period.

Apparently, this scenario led to a change in the behavior of part of the price setters. This empirical evidence supports two theoretical findings in the literature. Firstly, recent works by Orphanides and Williams (2003) and Gaspar et al. (2006) show that if expectations are formed under some learning process by agents with imperfect knowledge, ex post inflation persistence is related to the monetary policy regime. Secondly, this scenario suggests that under sufficiently high cost pressures a state dependent structure of price adjustment is necessary to model at least part of the price setting behavior of the aggregate

economy. Sheshinski and Weiss (1983), within the state dependent pricing literature, predicted that the readjustment frequency of nominal prices increases with ascending rate of inflation. Golosov and Lucas (2006) also find the same qualitative result in a model calibrated for the U.S. These authors claim that for this relationship to hold, disturbances to average inflation must be sizable, and that idiosyncratic shocks are mandatory to match the evidence from low inflation environments.

In the light of the sequence of events described previously, I intuited that an analysis by sub-periods could potentially be revealing. For robustness purposes, I switched to the direct approach and computed the average duration of price spells for four different windows of time within the sample. Those periods were determined by either the changes on the conduct of monetary policy or by the occurrence of an important shock. The first period extends until July 1999 when monetary policy was still under the fixed exchange rate regime. At this point, the start of the second period, the conduct of monetary policy changes to the inflation target regime. This period extends until July 2002, when the third period starts marked by the political confidence shock mentioned above and by the transition to the new government. The forth period starts in August 2003 with the reversal of the market expectations with respect to the economic policy implemented by the new government. Fiscal policy pursued increasing primary surpluses and fundamentally there was a clear evidence of the reinforcement of the inflation target regime.

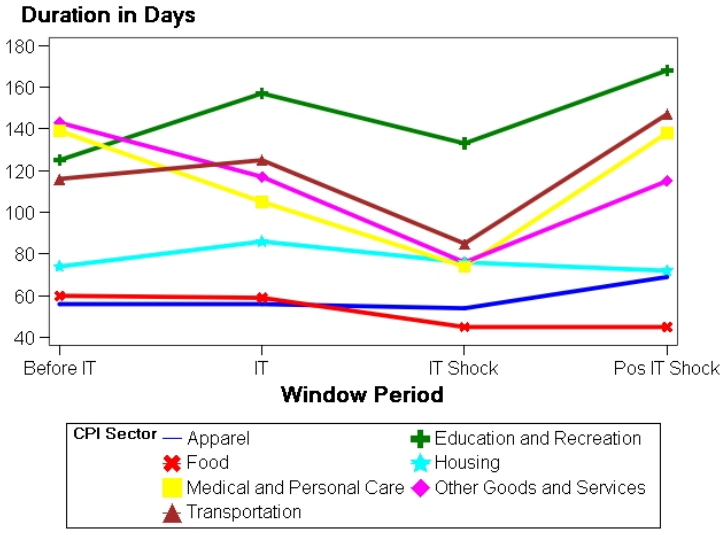
Figure 3: Duration of Price Spells by Window Period



Results suggest that substantial disturbances to average inflation imposed a high enough cost of not adjusting prices and triggered more frequent price reviews. As can be seen in figure 3, during the period characterized by the confidence shock, firms kept prices fixed for 71 days on average. In the aftermath of the shock, however, there is a clear change in the behavior of the firms. On average, prices were maintained fixed for a much longer period of almost 90 days, which is at the level that prevailed during previous periods.

Figure 4 shows that the behavior of price setters across different sectors follows the previous picture with the exception of housing and food that remained reasonably stable. The stability of the housing sector is due to the fact that rent prices are established periodically by contracts of fixed durations. With respect to the food sector, low and stable durations are explained by the huge influence of seasonalities associated with the changing weather conditions producing a sequence of supply shocks that hit the sector constantly.

Figure 4: Duration of Price Spells by Window Period and CPI Sector



4.2 Assessing the Heterogeneity in Price Setting

Below, I present a stratified descriptive analysis of the results by CPI and economic sectors in order to assess the degree of heterogeneity in price setting. I start by presenting the results obtained using the duration approach described in subsection 3.1.

A quick look at figures 5 and 6 representing the average duration of price spells by CPI and economic sector shows that the price setting behavior is in fact heterogeneous across these homogeneous group of products.

Figure 5: Duration of Price Spells by CPI Sector

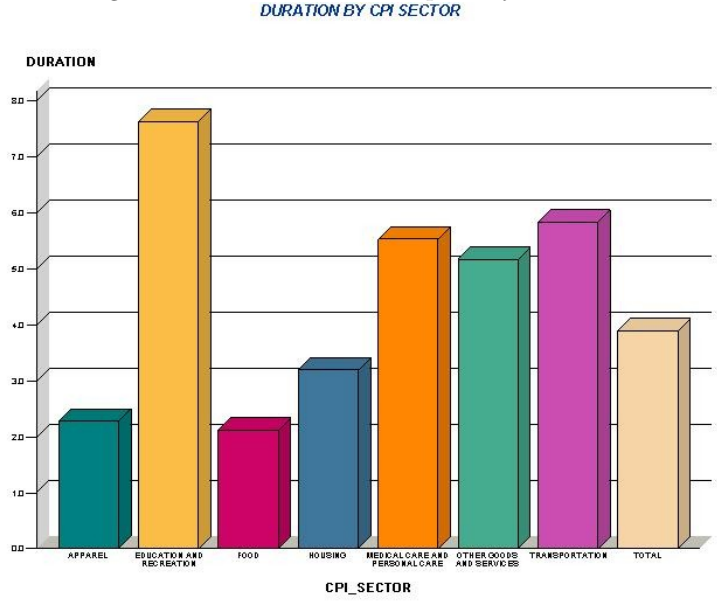


Table 1 shows the distribution of the durations of price spells by CPI sectors. The food sector is clearly the most flexible one mainly because it is influenced by seasonalities. Within this sector, the non processed food items change prices every month on average. Certainly, seasonal effects on the supply, and a unique pricing policy for perishable products are the determinants of the high flexibility displayed the prices of non processed food products. The apparel sector follows the food sector. Similarly, this sector has also to deal with the influence of different seasons in sales. Fashion and weather influence the pricing policy, which is used as strategy to optimize the turn over of stocks at the retail level. The transportation, medical and personal care, and other goods and services sectors readjust prices less frequently and show less concentrated distributions of price spells durations.

Figure 6: Duration of Price Spells by Economic Sector

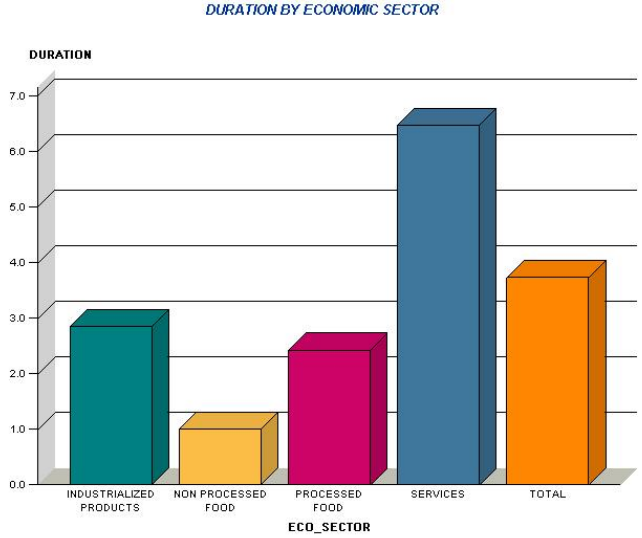


Table 1: Duration by CPI - Distribution

CPI Sector	Average	Min	Max	Q1	Median	Q3
Food	2.1	0.7	8.8	1.0	1.3	1.9
Other Goods and Services	5.2	1.2	9.8	1.8	5.8	6.7
Education and Recreation	7.6	2.2	12.3	6.8	8.2	9.1
Housing	3.2	1.0	9.0	2.0	2.0	3.2
Medical and Personal Care	5.5	1.1	14.4	1.4	5.7	9.4
Transportation	5.8	1.5	10.6	1.5	2.9	10.2
Apparel	2.3	1.7	6.8	2.0	2.2	2.4
Overall CPI	3.9	2.1	7.6	2.1	3.2	5.5

Focusing on the economic sectors reported in table 2, the heterogeneity is evident. The service sector exhibits a much larger rigidity. Whereas in other sectors it takes only 1.0 to 2.9 months for prices to be changed, in the service sector, prices remain fixed for 6.5 months on average. The higher nominal price rigidity displayed by the service sector is mostly explained by the dominance of the wage bill on the composition of the overall sectoral costs. Labor costs are generally established in contracts of fixed and long durations. Additionally, the distribution of price duration is quite concentrated. It seems that the interaction of these contracts impact the aggregate average leading the price spells duration in the service sector to vary mostly within the range between 7 to 10 months. The mode at the duration of 7 months concentrates 21% of the price spells. It is followed closely by the second and third modes at duration of 8 month with 17.5 % and at 10 months with 15%. The distribution of the durations of price

spells in other sectors show equally low dispersions.

Table 2: Duration by Economic Sector - Distribution

Economic Sector	**Average**	**Std dev**	**Min**	**Max**	**Q1**	**Median**	**Q3**
Industrialized Goods	2.9	0.2	1.0	11.0	1.7	2.1	2.6
Non Processed Food	1.0	0.1	0.7	1.8	0.8	0.9	1.1
Processed Food	2.4	0.2	0.8	8.8	1.1	1.4	2.9
Services	6.5	0.5	2.0	14.4	2.0	7.4	9.0
Overall CPI	3.7	1.1	1.0	6.5	2.4	2.9	6.5

Statistics presented below were obtained using the frequency approach described in subsection 3.2. Table 3 reports the average frequency of price changes computed for each different sector of the CPI as well as the resulting implied mean and median durations.

These results corroborate with those obtained using the direct approach. Again, price-setting behavior across different sectors is quite heterogeneous. In the apparel sector 58 % of the prices of the products were changed on a monthly basis implying that prices were maintained fixed on average for less than 2 months. In the Food and Housing sectors, the fraction of products changing prices monthly was 42 and 43% respectively, resulting in a mean duration of price spells of almost 2.5 months. These numbers are a bit lower if the computation of the implied duration of price spells are carried out under the continuous time assumption. On the other hand, sectors characterized by services type of products as in Education and Recreation, and Other Product and Services had only 15 to 19 % of their prices changing monthly. Consequently, implied mean duration of price spells is much higher reaching 5.3 to 6.7 months.

Table 3: Frequency and Implied Duration of Price Changes by CPI Sector

CPI Sector	**Frequency**	**Mean Dur***	**Mean Dur****	**Median Dur**
Food	0.42	2.41	1.86	1.67
Other Goods and Services	0.19	5.29	4.78	3.67
Education and Recreation	0.15	6.68	6.17	4.63
Housing	0.43	2.3	1.75	1.59
Medical and Personal Care	0.25	3.93	3.41	2.73
Transportation	0.35	2.82	2.29	1.95
Apparel	0.58	1.71	1.14	1.19
Overall CPI	0.37	2.68	2.14	1.86

Note: $*$ Assuming whenever prices are changed it occurs once within a given month interval, according to equation 11. $**$ Assuming price can change at any point in time, according to equation 12.

It is worth mentioning that stratifying the frequency of price adjustment by the different sectors captures only partly the differences in price setting behavior due to differences in the market structure. The assessment of the degree of price heterogeneity presented here lacks the analysis of price setting behavior by the type of outlet. The data set available does not disclose any kind of information regarding size or type of the outlets. This information would have made it possible to improve the homogeneity of the groups of products considered here in order to implement all the aggregation procedure. This unobserved heterogeneity between a corner shop and a supermarket is mostly important because these two kinds of price setters belong to different markets with distinct degrees of competition. This implies that for the very same product these two types of outlets will exercise different pricing policies. Intuitively, it is expected that corner shops would change prices less frequently in comparison to supermarkets that must deal with more competition. In competitive markets prices have to be maintained very close to the average price of the competitor in order to avoid exit.

Nevertheless, all the results presented here regarding the degree of heterogeneity in price setting add important insights to the more restricted overview reported previously. Besides uncovering the building blocks masked by aggregation, knowledge of sectoral price heterogeneity at the micro level may have in itself important consequences for the conduct of monetary policy.

Research on inflation dynamics has put a great deal of effort on developing theories of price adjustment to explain the empirically observed delayed reaction of inflation to shocks. More recently, supported by already available micro empirical evidence for the US and Europe, a variety of papers have incorporated heterogeneous price setting when modeling price adjustment.[18]

Carlstrom et al. (2006) and Carvalho (2006) use models with heterogeneous price setters and focus on studying the impact of the heterogeneity hypothesis on aggregate dynamics of inflation. The latter finds that one possible source of the sluggish response of inflation to shocks is the heterogeneous nature of the price setting. Carvalho (2006) models heterogeneous price stickiness by extending the standard Calvo framework to allow sector-specific probabilities of price adjustment. His model is calibrated with the statistics on the monthly frequency of price adjustment for different product categories that are reported by Bils and Klenow (2005) for the US economy. His main results show that the real effects of shocks become larger and more persistent in an economy characterized by heterogeneous price setters.

Another interesting example is Aoki (2002) that models price setting behavior assuming that the economy is composed by one flexible and one sticky price sector and studies the implications for optimal monetary policy. The author

[18]For a brief survey on papers using heterogeneous price setting see Carvalho (2006)

concludes that, from the welfare perspective, a Central Bank should pursue stabilization of a core measure of inflation described by an index of inflation in the sticky-price sector.[19]

4.3 Inspecting the Magnitude and the Direction of Price Changes

In this subsection, I analyze both the magnitude and the direction of price changes. By computing the magnitude and the direction of price changes, I investigate the existence of nominal price downward rigidity. More precisely, the idea is to look for evidence that suggest that firms face more friction to price decrease than to price increases.

The objective is to shed some light on an important theoretical issue. Less resilience in decreasing prices than in increasing them may have policy implications regarding the choice of an optimal inflation target. If the price adjustment mechanism is characterized by a larger downward rigidity, then an inflation buffer would accommodate relative price adjustment. Therefore, this rationale would call for a higher inflation objective. [20]

Ultimately, this literature stresses that the downward rigidities of prices and wages imply that responses to positive demand shocks are larger than to the negative ones. In this context, if the general price level is kept constant then quantities will shift downward leading to lower levels of output and employment than in an economic environment with a positive rate of inflation. Akerlof and Perry (1996) reports evidence of downward nominal rigidity in the U.S. economy and concludes that without an inflation buffer the economy inefficiently allocates its resources and maintains an avoidable high level of unemployment.

Focusing firstly on the magnitude of price changes, computations follow the description in subsection 3.4. The statistics presented in tables 4 and 5 show that, for the whole CPI, the average magnitude of price increases are approximately 27% higher than the average size of price decreases. At the sectoral level, the absolute magnitude of price changes were never below 10 %. Marked heterogeneity is not spread across all sectors. Nevertheless, it is very clear that the larger disparity between the size of price increases and decreases displayed by the Apparel among the sectors of the CPI and in the Non Processed Food among the economic sectors. In these sectors, the asymmetry is much larger reaching a difference of 57.61% for the Apparel products and almost 70% for the

[19] See also Benigno (2004) or Goodfriend and King (1997) on implications of heterogeneity in the degree of price stickiness across sectors and/or countries for what measure of inflation to target

[20] See Akerlof and Perry (1996)for an influential work on sources and implications of downward nominal rigidity. A related more recent work is Gunter Coenen (2003). Other references are Krugman (1998) and Summers (1991)

Non Processed Food items. In the Apparel sector this is explained by pricing policies that frequently make use of sales. The Unprocessed Food items are exposed to recurrent and sharp swings in supply with a low demand elasticity. This perverse combination imposes a large price volatility in this sector. [21]

Table 4: Average Size of Price Increase and Decrease by CPI Sector

CPI Sector	**Size of Price Increase**	**Size of Price Decrease**
Food	17.29	13.63
Other Goods and Services	12.23	11.75
Education and Recreation	15.27	11.49
Housing	11.15	9.40
Medical and Personal Care	19.33	15.38
Transportation	16.61	13.06
Apparel	34.58	21.94
Overall CPI	15.99	12.57

Table 5: Average Size of Price Increase and Decrease by Economic Sector

Economic Sector	**Size of Price Increase**	**Size of Price Decrease**
Industrialized Goods	20.09	14.77
Non Processed Food	27.27	18.81
Processed Food	14.50	12.18
Services	12.35	10.29
Overall CPI	16.57	12.91

As for the analysis of direction of price change, I compute the proportion of price increase and price decrease using two approaches. The first one estimates the fraction of price increase and decrease over the total number of times prices were actually changed. The second method computes the average of the monthly un-weighted frequencies of price increase and decrease, and therefore takes into account the number of times price remained unchanged. The methodology is described in subsection 3.3.

Tables 6 and 7 show the proportion of price increase and decrease using the first approach. Aggregate average for the whole CPI display strong symmetry. Given the positive inflation environment, this result comes about as quite surprising. Regardless of the overall symmetry, some sectors present very different figures. Disaggregation by economic sector shows that the services sector is very asymmetric exhibiting a much lower proportion of price decreases than de-

[21] Sales and promotion prices were not discarded. This procedure surely increases the mean absolute size of price changes reported. Additionally, if price increase follows a price decrease in a promotion and if prices are to return to the previous level, it is obvious that price increases and decreases are not symmetrical.

creases. When computed by CPI sectors, discrepancies emerge for Other Goods and Services, Education and Recreation and Transportation. Notice that these CPI sectors have a strong component of services.

Moreover, if instead, we look at the the average frequency of price increases and decreases, some asymmetry emerges for the overall CPI. The average frequency of price decrease amounts to 19%, whereas the average frequency of price increase is 16% higher reaching 22.2%.

Table 6: Proportion of Price Decrease and Increase by CPI Sector

CPI Sector	**Price Decrease**	**Price Increase**
Food	46.54	53.46
Other Goods and Services	35.99	64.01
Education and Recreation	37.85	62.15
Housing	44.24	55.76
Medical and Personal Care	45.76	54.24
Transportation	33.40	66.60
Apparel	47.86	52.54
Overall CPI	45.51	54.49

Table 7: Proportion of Price Decrease and Increase by Economic Sector

Economic Sector	**Price Decrease**	**Price Increase**
Industrialized Products	44.01	55.99
Non Processed Food	48.46	51.54
Processed Food	45.50	54.50
Services	39.70	60.30
Overall CPI	49.49	50.51

All in all, the evidence suggests that some degree of nominal downward price rigidity was present in the pricing adjustment mechanism of the Brazilian economy during the sample period. Notwithstanding, the overall symmetry in the proportion of price changes reported in tables 6 and 7, the frequencies of price decreases and increases are dissimilar. More importantly, the service sector, whose weight in the CPI is about 32 %, shows quite large asymmetry in the proportion of price increases and decreases. This sector has a strong component of wages in its cost structure. The labor market is generally characterized by downward rigity. In the case of Brazil, this is particularly true because downward nominal wage adjustment is forbidden by law. As for the magnitude of price changes, results are indeed asymmetrical towards positive adjustment. The size of price increases was on average 27% higher than price decreases compensating for the symmetry in the proportion of price changes as expected under a positive inflation environment.

4.4 Inspecting the Magnitude of Price Changes and the Duration of Price Spells

In this subsection I study the relationship between average magnitude of absolute price changes and the corresponding duration of the spells. The relationship between these variables is generally used to derive micro evidence for the importance of menu cost pricing theories.[22]

The computations carried out in this subsection differ from the general methodology described in subsection 3.1 so that the desired relationships between variables can be addressed properly. More specifically, once the size of the price change of each single spell was calculated, I grouped the spells with different durations, from 1 to 11 months or greater, and then computed the average size of absolute price changes for each stratum. Following lvarez and Hernando (2004), I assume that the absolute magnitudes of price changes are proxies for the size of menu costs. Also, the larger the average of the absolute size of price changes the higher the menu costs firms face. When facing high menu costs, firms would tend to postpone price changes. It is intuitive to infer that firms will wait to make sure that the magnitude of price changes to be implemented reaches the level that compensates the costs imposed by the adjustment process. Therefore, evidence supporting the menu cost pricing theories imply a positive relationship between duration of price spells and the magnitude that prices are adjusted.

Based on the computations of the average magnitude of absolute price adjustment of all products by duration of price spells, the estimation of the correlation between these two variables, for the whole CPI, is positive. It reaches + 0.82 supporting the main prediction of menu cost theories. However, on a more disaggregated level, as shown in tables 8 and 9, outcomes by different sectors are quite heterogeneous. The evidence reveals that importance of menu costs are probably concentrated in some sectors.

[22]For similar approach see lvarez and Hernando (2004))

Table 8: Correlation between Magnitude of Absolute Price Change and Duration by CPI Sector

CPI Sector	Correlation
Food	0.34
Other Goods and Services	0.87
Education and Recreation	-0.85
Housing	-0.05
Medical and Personal Care	0.64
Transportation	0.90
Apparel	0.60

Table 9: Correlation between Magnitude of Absolute Price Change and Duration by CPI Economic Sector

Economic Sector	Price Decrease
Industrialized Products	0.16
Non Processed Food	0.55
Processed Food	0.55
Services	-0.81

4.5 Inspecting the Magnitude of Price Change and Past Inflation

So far, I have been looking for micro evidence that is related to the evaluation of the degree of nominal price rigidity. On micro-founded models of inflation dynamics, the presence of nominal price rigidities influence the sensibility of inflation to the current and future developments of its driving variables, but does not play any role in the possible relationship between current and past inflation.

This possible source of inflation persistence has been strongly supported by the macro empirical literature as an important feature describing inflation dynamics. Inspired by this evidence, theoretical models have incorporated intrinsic inflation through the assumption that a fraction of price-setters simply re-price using a rule-of-thumb or an indexation mechanism instead of undertaking an optimization process.[23]. These are known as hybrid models of inflation and, when compared to the standard forward looking models, they have indeed proved to fit the data better. However, there is no actual consensus about the role played by the backward looking component or to the extent to which it explains inflation dynamics.

[23]See Gali and Gertler (1999) and Woodford (2003)

Nevertheless, acknowledging the fact that dynamics of inflation exhibits intrinsic persistence has in itself important policy implications. Recent publications studied optimal monetary policy under both set ups of partial indexation and rule-of-thumbers and conclude that crucial nuances emerge. The results of Levin and Moessner (2005) suggest that a policy maker will be better off assuming a more rigid economy than otherwise.[24]

In this subsection, I depart from the previous analysis related to the degree of nominal price rigidity, and try to identify micro evidence related to the degree of intrinsic persistence in inflation represented by the dependence of inflation developments on its own history. I start by evoking previous results on the frequency of price adjustment. According to subsection4.1the pattern of price adjustment is indeed infrequent. Therefore, contrarily to the assumption of the partial indexation model, some prices do stay unchanged. [25]

Therefore, in what follows, I focus on looking for evidence that would be supportive of the kind of set up described by the rule-of-thumbers model. In this case, tracing a relationship between stylized facts and the theory is not straightforward. As stressed in Dennis (2006), micro empirical findings on price change have been misinterpreted in the light of the theoretical models of price adjustments. On one hand, the extended Calvo model, which results in a hybrid New Keynesian Phillips Curve, assumes that, out of those price setters who are allowed to change prices, a fraction re-optimize and the remainder use a rule-of-thumb. On the other hand, stylized facts on price changes incorporate simultaneously all kinds of re-pricing set ups. Hence, the frequency of price adjustment estimated from micro data is essentially different than the one defined by the Calvo model.

Albeit the analysis of most disaggregated micro data permits detailed inspection of the patterns of the behavior of price adjusters, the distinction between the automatic indexation to past inflation from other features of the price-setting mechanism is not trivial. Nevertheless, if it is the case that past developments of inflation constantly influence current re-pricing, then the magnitude of price changes would be concentrated around either mean or past inflation.

The methodology applied here for the computation of the size of price adjustment follows the description in 4.4. As for the measurement of past inflation some remarks are necessary. In order to obtain a compatible measurement of

[24]See other references therein Levin and Moessner (2005), Woodford (2003) and Walsh (2005) who study optimal policy implications when intrinsic inflation is modeled by the indexation mechanism. The latter author also studies the consequences of miss-specifying the degree of indexation. Parameter uncertainty regarding the degree of indexation is the focus in Levin and Williams (2003), while Kimura and Kurozumi (2003) study uncertainty regarding the fraction of rule-of-thumb price setters.

[25]The indexation model assumes that those who do not re-optimize, change prices indexing to past inflation.

the past inflation for each price spell, I computed the inflation rate occurred between the preceding month of the beginning of each price spell and the preceding month of the end of each price spell. Those inflation rates were grouped by spell duration and then averaged within each stratum.

The first stylized fact investigated was the incidence of times that the magnitude of price adjustment were above and below the correspondent computed past inflation rate. This proportion was very balanced around 50%. Apparently, there is no evidence that this behavior differs across the different sectors. This result could be insightful if the magnitudes of re-pricing were close to the magnitudes of past inflation.

Table 10: Percentual Difference Between Size of Price Change and Past Inflation by Spell Duration

Price Spell Duration	% **Difference: Size of Price Change and Past Inflation**
1	+3.19
2	+2.38
3	+1.95
4	+1.26
5	+1.51
6	+1.14
7	+1.15
8	+1.51
9	+2.67
10	+ 2.37
above 11	-0.68

However, a second stylized fact tells us that when comparing magnitudes, the re-pricing average is always larger than the past inflation regardless the spell duration, as Table 10 above shows. Only, for really long spells, lasting above 11 months, the average magnitude of price change is below the past inflation rate.

This evidence, then, is not conclusive. It is not really possible to infer from these two stylized facts that price setters would re-price taking into account solely the rate of inflation since their product prices were last changed. This kind of result, was typical in other studies developed in the context of the euro area countries.[26] Nevertheless, the fact that average price change is almost always above past inflation suggests that a compound of both effects of past inflation and idiosyncratic shocks play a representative role as the driving force behind repricing mechanism.

[26]SeeAngeloni et al. (2005)

5 Conclusion

The analysis of stylized facts on the price adjustment mechanism reported in this paper improves the knowledge about the degree of nominal price rigidity in Brazil. Important features addressed by this analysis are then related to theoretical models. Below, I list the main empirical findings and point out the associated policy implications when pertinent.

Finding number one: On the degree of nominal price rigidity

The weighted average monthly frequency of price change amounts to 37% for the whole CPI. Implied mean duration of price spells is approximately 2.7 months (discrete time assumption) and is 2.1 months (continuous time set up), while the median duration is 1.9 months. Compared with the US and Euro Area, these numbers reveal that prices are more flexible in Brazil. For the US, the monthly frequency of price changes is 26.1 %, and the average duration of price spells is 3.8 months. For the euro area, the monthly frequency of price changes is 15.3 %, and the average duration of price spells is 6.6 months.

If computations are done considering the duration approach, average duration of price spells is 3.8 months, while the median duration is 3.2 months. There is a clear skew in the distribution of price spells, with the median always located below the average, i.e., there is a higher concentration of short spells, but not a very long tail to the right. The mode, at 2 months, accumulates about 42% of the price spells.

Finding number two: Insights on the determinants of the patterns of price adjustment.

The average duration of price spells decreased when the economy was hit by a confidence shock before 2002 presidential elections. During the period characterized by the confidence shock, firms kept prices fixed by 71 days on average. In the aftermath of the shock, however, there is a clear change on the behavior of the firms. On average, prices were maintained fixed for a much longer period of almost 90 days at the level that prevailed during previous periods. Results suggest that substantial disturbances to average inflation imposed a high enough cost of not adjusting prices and triggered more frequent price reviews.

Finding number three: On the heterogeneity of price adjustment.

There is evident heterogeneity on the price setting behavior at the product and sector levels. A marked discrepancy is displayed by the service sector exhibiting much larger rigidity. Whereas in other sectors, it takes only 1.0 to 2.9 months for prices to be changed, in the service sector, prices remain fixed for 6.5 months, on average. The food sector is clearly the most flexible one mainly because it is influenced by seasonalities. These figures reveal that heterogeneity

in price setting displayed by the different sectors is very similar in Brazil and US or the euro area.[27]

As heterogeneity at the micro level may have in itself important consequences for the conduct of monetary policy, results suggest that theoretical models of price adjustment applied to the Brazilian economy should incorporate heterogeneous price setters.

Finding number four: On the downward nominal price rigidity.

There is a strong overall symmetry in the proportion of price changes. However, the frequencies of price decreases and increases are dissimilar. As for the magnitude of price changes, results are asymmetrical. Positive adjustment are larger than the negative ones. Price increases averaged 27% more than price decreases, compensating for the symmetry in the proportion of price changes, as expected under a positive inflation environment. This evidence suggests that some degree of nominal downward price rigidity is present in the pricing adjustment mechanism of the Brazilian economy. The policy implication in this case regards the choice of an optimal inflation target. The literature stresses that the existence of less resilience in decreasing prices than to increasing them calls for an inflation buffer, an inflation target sufficiently different from zero, to accommodate relative price adjustment.

Finally, two other features were investigated having in mind theoretical models of nominal price adjustment. These investigations were, however, not conclusive. The positive relationship between the absolute size of price change and the duration of price spells is potentially indicative of the existence of menu cost, but evidence for this is mixed. Also, it was not possible to establish a stylized fact about the relationship between the average size of price adjustment and lagged inflation. The aim was to look for evidence that could be suggestive of the use of rule-of thumb-behavior by a fraction of the price setters, as predicted by some theoretical models of price adjustment.

[27] See Dhyne et al "Price setting in the euro area: Some stylized facts from Individual Consumer Price Data " for detailed comparison between the stylized facts on price setting in the euro area and the US.

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