Rigidezes dos Preços ao Consumidor Colombiano

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Este artigo estuda a formação de preços dos varejistas de bens e serviços colombianos, baseado em 12.052.970 relatórios de preços dos artigos que conformam o IPC colombiano para o período de 1999.03 a 2008.05. Os principais resultados são resumidos como segue: (1) os preços ao consumidor na Colômbia são mais rígidos que os do Chile e de Portugal e poderiam ser mais flexíveis que aqueles da Eurozona. (2) Quarenta por cento das mudanças nos preços são reduções. (3) As mudanças absolutas nos preços são maiores que a inflação (4) Na Colômbia, quando a inflação se reduz: a rigidez dos preços aumenta, a variabilidade e o viés da distribuição das mudanças nos preços diminuem, e as rigidezes nominais em queda na frequência das mudanças nos preços é invariante à inflação (5) foi encontrada uma leve rigidez em queda (6) a sincronização das mudanças nos preços é baixa (7) aproximadamente 32% do IPC corresponde a contratos Taylor, 34% a outras regras dependentes do tempo e 34% a regras dependentes do Estado. Estes resultados fornecem alguns elementos fundamentais para o desenho da política monetária.

Classificação JEL: E31, E52, E58.

Palavras chave: comportamento de fixação de preços, preços rígidos, IPC.

Rigideces de los Precios al Consumidor Colombiano

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En este artículo se estudia la formación de precios de los minoristas de bienes y servicios colombianos con base en 12.052.970 reportes de precios de los artículos que conforman el IPC colombiano para el período de 1999.03 a 2008.05. Los principales resultados se resumen así: (1) los precios al consumidor de Colombia son más rígidos que los de Chile y Portugal y podrían ser más flexibles que los del Eurozona. (2) Cuarenta por ciento de los cambios en los precios son reducciones (3) los cambios absolutos en los precios son mayor que la inflación (4) cuando la inflación se reduce en Colombia: la rigidez de los precios se incrementa, la variabilidad y sesgo de la distribución de los cambios en los precios disminuye y las rigideces nominales a la baja en la frecuencia de los cambios en precios es invariante a la inflación (5) se encontró una ligera rigidez a la baja (6) la sincronización de los cambios en los precios es baja (7) cerca del 32% del IPC corresponde a contratos de Taylor, 34% a otras reglas dependientes del tiempo y 34% a reglas dependientes del estado. Estos resultados proveen algunos fundamentales microeconómicos para el diseño de la política monetaria.

The Stickiness of Colombian Consumer Prices

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The price setting behavior of Colombian retailers of goods and services was studied based on a unique dataset containing 12,052,970 individual price reports covering all items in the Colombian CPI from March 1999 to May 2008. The main results are summarized as follows: 1. Colombian consumer prices were found to be stickier than those in Chile and Portugal and might be more flexible than those in the Euro Area and some European countries. 2. Price reductions are not rare. Forty percent of price changes were found to be reductions. 3. Absolute percentage price changes were found to be larger than inflation. 4. As inflation is reduced in Colombia, the following happens: (i) price stickiness increases, (ii) the distribution of price stickiness concentrates on the rigid side, (iii) the variability and bias of the distribution of percentage price changes decreases, and (iv), nominal downward rigidities in the frequency of price changes are invariant to inflation. 5. A slight downward nominal price rigidity was detected in the data. 6. Price change synchronization was found to be low. 7. About 32% of the CPI corresponds to Taylor contracts, 34% to other time dependent rules and 34% to state dependent rules. These findings provide some of the micro fundamentals for the design of staggered contract models for monetary policy analysis in Colombia.

I. INTRODUCTION

One of the most important questions in macroeconomics is why monetary policy has short to medium-term real effects on the economy? The answer is that there are temporary price and wage rigidities. Prices are flexible if after an innovation, they satisfy two conditions: (i) they shift towards the market-clearing levels and (ii) these changes are synchronized among firms. If any of these conditions fail to happen, the real effects of monetary policy arise. See Taylor (1999) and Blanchard (2008).

There is mounting international evidence on price rigidities. Following Means (1935), researchers around the globe are studying price stickiness in the databases underlying the calculation of producer and consumer price indexes. These analyzes are complemented through surveys on the pricing practices of firms. The evidence is summarized in the following stylized facts: (1) After an innovation to costs or demand, firms keep their prices constant for extended periods of time. (2) There is a great deal of heterogeneity in price setting. (3) Price changes are not synchronized. (4) Price stickiness relates to inflation. See Blinder (1994), Taylor (1999), Altissimo *et al.* (2006), Alvarez *et al.* (2005), Dhyne *et al.* (2006), Bils & Klenow (2004), Nakamura & Steinsson (2008), and the references in Table 1 for international evidence as well as Jaramillo & Cerquera (1999), Espinosa, Jaramillo & Caicedo (2001), Misas, Lopez & Parra (2008), Hofstetter (2008), and Julio & Zárate (2008) for evidence in Colombia.

This paper has three objectives: First, to determine whether or not price stickiness is present in Colombian consumer prices. Second, to determine the empirical validity of common explanations and features of price stickiness theories in Colombia. And

third, to establish the implications of the results, in terms of the micro fundamentals, for the design of *staggered contract models* for policy analysis in the country.

The first goal relates to the soundness of the framework that underlies monetary policy models. In fact, monetary theory has shown that price stickiness is the source of short to medium-term non-neutrality of monetary policy, and therefore, has a significant effect on the response of key macroeconomic variables to economic shocks. See Bils & Klenow (2004), Taylor (1980), and Rothemberg (1982).

More specifically, the response of inflation to marginal cost innovations and the optimal response of monetary policy to particular shocks are heavily dependent on the flexibility of prices. In fact, simple widespread theoretical models show that the degree of price stickiness determines the slope of the New Keynesian Phillips curve and, therefore, the response of inflation to marginal cost innovations. Hence, it is widely acknowledged that "the study of nominal price and wage setting is one of the hot topics of macro today." See Blanchard (2008), Walsh (2003), and Angeloni *et al.* (2006).

The second goal has to do with the empirical validity of common theories explaining price stickiness. Under rational expectations, price stickiness is the optimal response of firms. Market structure theory proposes that firms with market power keep their prices unchanged for long periods of time as it allows them to implement price-smoothing policies. Under menu costs, firms keep their prices unchanged until mark-up gain or loss is larger than these costs. In the manufacture level theory, prices of items that require more manufacturing steps are stickier than items with fewer manufacturing steps because of "snake effects, *i.e.*, [unsynchronized] movements in factor prices slowly transmitted to intermediate and final good prices." See Blanchard (1982).

The third goal relates to the features of the models and the stylized facts of the economy they are meant to reproduce. *Staggered contract models* focus on the nature of the price decision itself and, due to their mathematical complexity, rely on fairly simple and unrealistic price-setting rules. The assumptions of representative firms, homogeneous goods and the use of Taylor contracts and Calvo pricing are common in these models[1]. See Taylor (1980) and Calvo (1983).

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1 *Staggered contract models*, however, still raise persistence puzzles in monetary policy analysis. To remedy the inflation persistence puzzle, for instance, Fuhrer & Moore (1995) proposed setting current price inflation based on expected inflation. Inflation indexing is a useful tool to get

In this paper, the price-setting behavior of Colombian goods and services retailers is studied based on a unique dataset that contains 12,052,970 monthly price reports covering the entire CPI from March 1999 to May 2008.

Our dataset compares well with those in a set of individual country studies and the Euro Area reviewed in Table 1. The coverage of our dataset, 100% of the CPI, is only matched by the study done in Chile. With respect to the size (number of records), our dataset is larger than all the datasets except for those used in the studies done in France and Belgium. Moreover, the time span (10 years) covered by our dataset is only matched by the time spans covered in Brazil and Mexico.

The size and coverage of this dataset is unprecedented in sticky-price studies for Colombia. Jaramillo & Cerquera (1999) studied weekly price reports from June 1991 to February 1994 on 39 food items, less than 20% of the Colombian CPI basket, from 5 hypermarkets in a small, Colombian city. Espinosa, Jaramillo & Caicedo (2001) studied daily price quotes on 209 goods from 1989 to 1999 reported by one supermarket in Bogotá. Their sample covered about 30% of the CPI. More recently, Hofstetter (2008) studied the stickiness of a set of monthly newspaper and magazine prices, which is less than 0.25% of the Colombian CPI basket, between 1960 and 2005.

The dataset presents other important features. First of all, it covers the time when Colombia was closest to its 3% long-run target, which makes our results useful for the final stage of the inflation stabilization program and after its goals have finally been achieved. Secondly, it contains a period of decreasing inflation, March 1999 to June 2006, and one of increasing inflation, June 2006 to May 2008. This feature provides enough sample variation to explore the relationship between inflation and the distribution of the Frequency of Price Changes, FPC (See Julio & Zárate, 2008), over time.

However, the database does not identify sales offered to the general public (in contrast to known clientele) for more than a day. This fact reduces our measures of

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around the inflation persistence problem for empirical analyses but opens new puzzles with regards to the micro foundation of the procedure as noted by Taylor (1999). Because of the inflation persistence problem, DSGE models used nowadays in most central banks are not staggered contract models and, thus, include some sort of inflation indexing in their pricing rules. See, for instance, Eichembaum & Fisher (2003).

price spell duration; thus, our estimates are a lower limit to the true price stickiness in Colombia.

The remainder of this paper is organized as follows. In Section II we describe the dataset, the CPI weighing structure, and the methodology. In Section III we summarize the stylized facts on price stickiness in Colombian CPI prices. In Section IV we conclude and present a brief discussion and directions for future research.

Table 1
Coverage and Size of CPI Datasets in Individual Country Studies

Country	Reference	Period	% of CPI	Records (Millions)	Average Inflation
France	Baudry et al (2004)	January 1994 - February 2003	65	13.2	1.5
Chile	Medina, Pappaport, Soto (2007)	January 1999 - July 2005	100		2.7
US	Bils and Klenow (2004)	January 1995 - December 1997	70		2.4
Brazil	Guovea (2007)	March 1996 - April 2006	85	9.0	3.9
Mexico	Gangon (2005)	January 1994 - December 2004	63	6.0	12.0
Euro Area	Dhyne et al (2006)	January 1996 - December 2000			1.98
Belgium	Aucremanne and Dhyne (2004)	January 1999 - December 2001	68	18.5	2.2
Italy	Veronese et al (2005	January 1996 - December 2003	20	0.8	2.9
Portugal	Dias, Dias and Neves (2004)	January 1992 - January 2001	95	5.5	2.6
Spain	Alvarez and Hernando (2004)	January 1993 - December 2001	70	1.6	3.1

II.   METHODOLOGY AND THE DATA SET

In this section the dataset under analysis, the definitions, and previous treatment of the dataset are described. In Subsection A the dataset and the basic definitions for our analysis are described. In Subsection B the CPI weighing composition and some methodological issues are summarized.

A.   THE MICRO DATA UNDERLYING THE COLOMBIAN CPI

Following Aucremane & Dhyne (2004) and Julio & Zárate (2008), we defined *a particular item* as a unique good or service with a clearly defined brand, presentation, and unit of measure along with other features. A *minimal class* is the smallest basket of items for which the CPI is statistically representative for each of the cities and levels of income considered by DANE, the Colombian statistics bureau.

A *price spell* is defined as an uninterrupted sequence of price reports associated with one particular item during which the price remains constant. Thus, a price spell is an episode of fixed prices that can be described in terms of three elements: the date of the first quote, the price level, and the duration of the spell. A *price sequence* is a continuous progression of price reports belonging to a particular item.

The original dataset consisted of 9,330,000 price reports gathered by DANE to calculate the Colombian CPI. These reports are scattered among 176 minimal classes. The dataset spans the period from March 1999 to May 2008, and averages 80,431 price reports per month. Minimal classes contain, on average, seven particular items each. Moreover, the dataset covers 100% of the Colombian CPI goods and services. In this study, 3,252,930 price spells were identified, that is, an average of 72 price spells per minimal class.

Each of the price quotes in the dataset is accompanied by the following information: the minimal class code, a unique code that identifies a particular item within each minimal class, the city the retailer is located in, the socioeconomic category of the area served by the retailer, a unique informant code within each city, the report frequency, and the type of outlet. In addition, there is a set of indicator variables for the following events: the imputation of non-reported prices, the change of item features, product turnover, and a code to indicate that the record was used in the calculation of the CPI. Unfortunately, the dataset does not include a control variable to indicate the VAT reforms. Consequently, the FPC for January 2001, when these changes took place, could be slightly overestimated.

Based on all the information from the dataset, the price sequences were determined. Graph 1 displays two price sequences related to potatoes at a particular hypermarket and a fresh food market.

Graph 1
Price Sequences of Potatoes
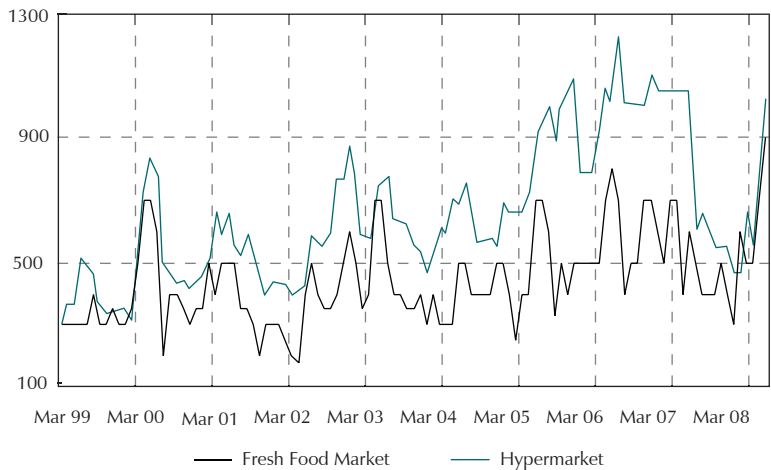
Price quotes gathered by DANE correspond mostly to transaction prices and are collected at different frequencies as required by the CPI administrator. Collection frequencies extend up to once every four months, but 53.1% of the quotes correspond to records collected monthly. Price quotes recorded less frequently were carried forward until the next collection date. After this expansion, the database ended up with 12,052,970 records. The distribution of price records by type of record and frequency of reporting is given in Table 2.

Table 2
Distribution of Price Records by Type of Record and Frequency of Reporting

Type of Records	Number of Records	Percent
Observed Price	11,384,086	94.4
Imputed Price	668,884	5.7
Frequency of Reporting	Number of Records	Percent
Monthly	6,400,509	53.1
Two-Months	2,034,677	16.9
Quaterly	2,481,312	20.6
Four-Months	1,136,472	9.4

In order to obtain robust and reliable estimates, prior processing of the dataset was done following the guidelines of Julio & Zárate (2008). Price reports displaying unrealistic prices (outliers) and prices not used for the CPI calculation were deleted. At the same

time, product turnover induced new price sequences and missing reports within product sequences were carried forward for three months at most. The extent of our imputation was below 1% of the total sample.

An important feature of our dataset is that 44.1% of the price quotes belong to food items. Given that food is just 30% of the Colombian CPI, there is a significant over-sampling of food items. Therefore, our estimates are weighted according to the CPI weighting system. The rest of the price quotes are distributed as follows: 9% corres-pond to apparel and 46.9% to other groups, such as recreation and culture, housing, medical care, education, transportation and communications, and other expenditure. The composition of the final dataset under analysis is provided in Table 3.

Table 3
Composition of the Colombian CPI Database

Group	Weight	Records	% Records	Sequences
Food	29.51	5,312,550	44.1%	118,786
Housing	29.41	2,520,921	20.9%	90,290
Apparel	7.31	1,083,331	9.0%	24,864
Medical Care	3.96	648,147	5.4%	10,239
Education	4.81	947,824	7.9%	17,195
Recreation and Culture	3.60	297,420	2.5%	8,077
Transportation and Comunications	13.49	286,283	2.4%	6,144
Other expenses	7.89	956,494	7.9%	17,590
All Items	**100.00**	**12,052,970**	**100.0%**	**293,185**

B.   METHODOLOGY

Summary statistics presented in this paper are similar to those reported in individual country studies of the Inflation Persistence Network, IPN. A detailed description of these statistics may be found in Aucremane & Dhyne (2004). Each month, the Fre-quency of Price Changes, FPC, is calculated for each particular item as the ratio of the number of price changes to the number of valid price records. Aggregate measu-res related to the FPC are calculated using the CPI weights, and the implied duration of price spells is determined as the inverse of the FPC. A detailed explanation of the Colombian weighting system can be found in DANE (2002).

In this paper, price rigidity is studied using the distributions of FPCs at the level of minimal classes as the starting point. The distribution of the FPCs corresponds to the collection of the FPCs and weights of the 176 minimal classes of the Colombian CPI. The distributions for each month in the sample and the sample aggregate are studied. Summary statistics, *i.e.*, the mean, median, quartiles, and percentiles of the distribution of the FPCs are calculated using the CPI weights. Moreover, the distribution of implied durations can also be estimated by calculating the duration implied by the FPC for each minimal class.

The distribution of price records by type of retailer is given in Table 4. About half of the price records, 49.6%, are recorded in supermarkets and specialty stores, while only 2.1% come from hypermarkets.

Table 4
Distribution of Records by Type of Retailer

Group	Number of records	Percent
Fresh Food Markets	607,760	5.0
Supermarkets	3,781,217	31.4
Cooperatives	778,809	6.5
Traditional Corner Stores	891,741	7.4
Specialty Stores	2,192,481	18.2
Pharmacies	523,394	4.3
Services Specialized Stores	1,499,011	12.4
Restaurants or Chain Food Establishments	138,726	1.2
Others including renting houses	1,214,555	10.1
Hypermarkets	249,960	2.1
Others	175,316	1.5
Total	**12,052,970**	**100**

III.   RESULTS

A.   PRICE STICKINESS

In order to determine how sticky Colombian consumer prices are, the median Frequency of Price Changes, FPC, was calculated for increasingly aggregated baskets starting with product categories. Statistics at aggregate levels employ the weighting structure underlying the calculation of the Colombian CPI.

Results are summarized in distributions of FPC and the corresponding distributions of durations of price spells. The distribution for the sample aggregate was studied. However, given that our sample is not homogeneous as inflation has not been on a steady path, they were also studied for each period of time in the sample.

In addition, since prices of imputed rent (the rent prices of owner-occupied housing) are somewhat controversial and, therefore, usually excluded from individual country studies, results with and without these items are provided. Finally, the distributions of the FPC for goods and services were studied.

In Subsection III.A.1 sample aggregate results are reviewed and in Subsection III.A.2 time series results are summarized.

1.   Sample Aggregate Results

Graph 2 displays the distribution of the Frequency of Price Changes, FPC, (top panel) and the distribution of the implied duration of price spells for all items (bottom panel). The bars (left scale) indicate CPI weight and the continuous line (right scale) corresponds to cumulative weights.

The distribution of the FPC (top panel) is skewed to the right where low frequencies of price changes (high implied durations) are located. This corresponds to a distribution of implied durations (bottom panel) skewed to the left. Forty-one percent of the CPI has an implied duration of more than 10 months. The implied duration of 50% of the CPI is more than 8.4 months and the implied duration of 65% of it the CPI is more than 5.0 months. Therefore, just 35% of the Colombian CPI has an implied duration of less than 5.0 months.

Graph 2
Distributions of the FPC (top) and Duration in Months (bottom)
for All Items in the CPI

% of Price Changes / Month

■ CPI Weight (Left)   — Cummulative CPI Weight (Right)

Duration of Price Spells (months)

■ CPI Weight (Left)   — Cummulative CPI Weight (Right)
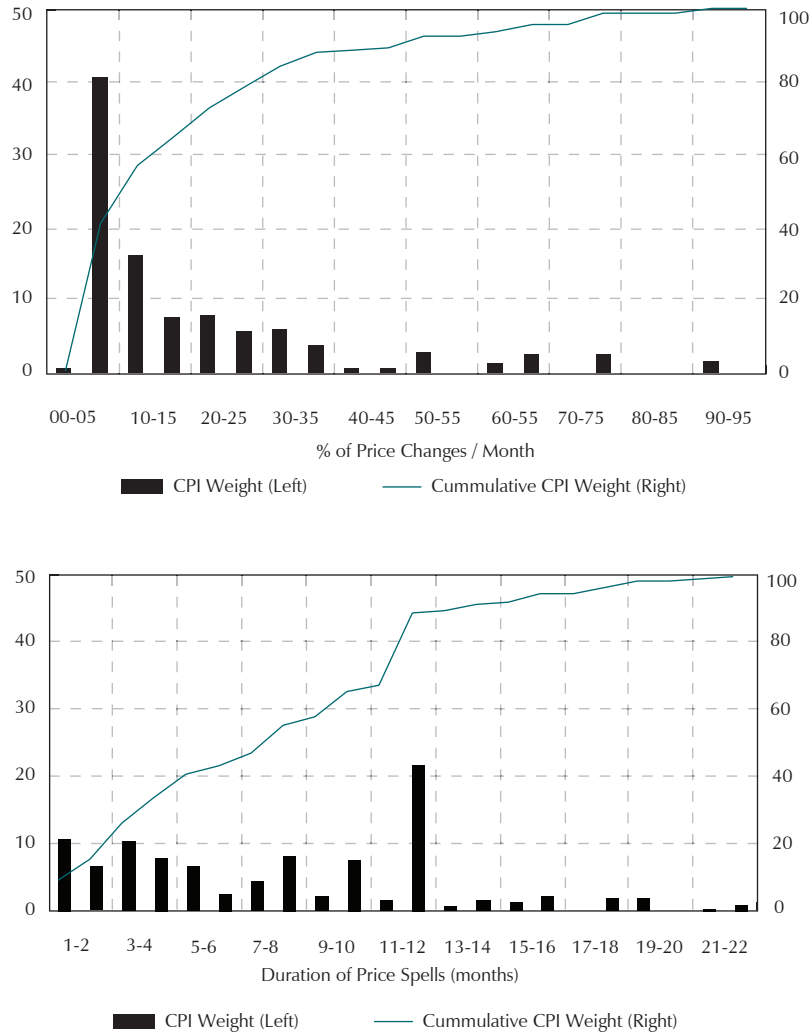
Skewness to the left in the distribution of durations relates to an excess weight of items displaying durations of between 7 and 13 months. These items correspond mainly to rent, food away from home, apparel, ground transportation, and other expenditure, in that order. Items displaying durations of between 7 and 13 months show a surprising weight of 45.5% of the CPI.

The combined weight of items with durations falling into the 7 to 12 month interval is 23.9% and corresponds to all food away from home items, most of the apparel items, all ground transportation items, and some other expenditure items with weights of 6.45%, 6.30%, 4.5%, and 3.2% of the CPI, respectively.

By the same token, the combined weight of items which have price spell durations that fall into the 12 to 13 month interval is 21.6% of the CPI and corresponds to rent and imputed rent items whose weights are 5.0% and 15.6% of the CPI, respectively. Current regulations in Colombia restrict housing rent to once a year increases, at most, and to an amount not higher than the CPI inflation. Therefore, housing rent contracts typically last one year, which corresponds to our duration estimate for these items.

Except for the behavior of imputed rent items, the shape of the distribution of implied durations in Graph 2 resembles the one found in Belgium. Unfortunately, comparison to the duration distribution of other countries is not possible as their studies show the unweighted distribution of durations, which have a shape that reflects sample imbalances with respect to the CPI weights.

Table 5 displays the distribution of the FPC for all CPI items, the main groups of the CPI classification, all CPI items excluding imputed rent, and all CPI items classified as either goods or services. Distributions are described through percentiles and quartiles as well as their means, standard deviations, and implied median durations.

The median product category in the CPI changes its price 11.9% each month, which corresponds to a median implied price spell duration of 8.4 months. In other words, 50% of the Colombian CPI has a duration of more than 8.4 months, while the remaining 50% shows durations of less than 8.4 months. Moreover, the mean FPC for all items is 21.1% a month, an implied mean duration of 4.7 months.

The more flexible items correspond to household utilities, perishable food, transportation combustibles, and airfare; the less flexible items correspond to services based on long-term relationship with customers, LTR. Items such as tomatoes, potatoes, oranges, onions, etc. as well as electricity, water supply, transportation fuel, and airfare have durations of less than 2 months. Durations of higher than 1.5 years are associated with video rental, other services, tailor services, apparel rental, apparel tailoring, apparel repair, and gambling, in that order. These findings resemble those of the Euro Area, Dhyne *et al.* (2006), and the US, Bils & Klenow (2004).

Table 5
Distributions of the Frequency of Price Changes

Group	P5	Q1	Median	Mean	
Food	11.5%	17.0%	30.5%	32.8%	
Housing	6.7%	8.0%	8.0%	17.2%	
Transport and Commun	5.2%	11.2%	16.7%	23.3%	
Other Goods and Services	5.4%	9.8%	14.2%	14.7%	
Apparel	7.8%	9.4%	9.7%	9.7%	
Education	5.9%	6.1%	6.3%	7.2%	
Medical Care	5.3%	5.4%	7.6%	12.4%	
Recreation and Culture	2.0%	14.3%	15.0%	14.4%	
All items	**6.1%**	**8.0%**	**11.9%**	**21.1%**	
All items but Imp Rent	5.5%	9.7%	15.7%	23.6%	
Goods	**7.9%**	**11.5%**	**20.5%**	**24.3%**	
Services	**5.2%**	**6.3%**	**9.8%**	**22.1%**	

The most flexible group is food and the least flexible is education. Table 5 shows that the median implied duration for food is 3.3 months. This is explained by the fact that 66% of food corresponds to perishable and semi-processed items, which have price spell durations that tend to be short. The median implied duration for education is 16 months. Education contains a diverse set of goods and services related to school and college education. In Colombia preschool, elementary school, middle school and high school tuition is distributed as a yearly fee and equal monthly payments throughout the school year. The prices of these items along with those of school uniforms, all of which total 56% of education, have a median implied duration of close to 16 months.

Not surprisingly, the prices of housing and medical care items show durations of closer to a year, 12.5 and 13.1 months, respectively. In fact, 70% of housing corresponds to imputed rent and effective rent items, which have implied durations of 12 months. Moreover, the durations of price spells for health items are spread over a wide range of 4.1 to 18.3 months.

The prices of transportation and communications and recreation and culture items show durations of 6.0 and 6.7 months, respectively. About 46.0% of transportation and communications corresponds to transportation fuel, airfare, fixed phone service, and automobiles, which have durations of 1.3, 2.0, 2.8, and 4.3 months, respectively. Moreover,

	Q3	P95	Std	Implied Duration	Weight
	38.0%	68.0%	2.4%	3.3	29.5
	8.0%	77.3%	4.2%	12.5	29.4
	23.1%	75.4%	4.5%	6.0	13.5
	20.5%	23.0%	1.5%	7.1	7.9
	10.2%	10.6%	0.4%	10.3	7.3
	8.9%	10.1%	0.6%	16.0	4.8
	19.9%	19.9%	2.4%	13.1	4.0
	16.9%	19.5%	1.0%	6.7	3.6
	29.2%	**68.9%**	**1.5%**	**8.4**	**100.0**
	30.5%	68.9%	1.5%	6.4	84.4
	30.5%	**62.1%**	**1.4%**	**4.9**	**51.4**
	15.0%	**92.6%**	**3.9%**	**10.2**	**48.6**

72% percent of recreation and culture corresponds to TV sets, newspapers, tourism, small electronics, stereo sets, books, and movies, with durations of 5.1, 5.5, 5.7, 5.7, 5.9, 6.4, and 6.7 months, respectively. The rest of recreation and culture items are spread out over a long range of durations lasting from 6.7 to 50.1 months.

Consumer price stickiness is reduced when imputed rent items are excluded from the calculation. The share of imputed rent items in the CPI is a non-negligible 15.6%, and prices of these items have durations of 12 months. By excluding imputed rent, the median implied duration falls to 6.4 months and the mean implied duration drops to 4.25 months[2].

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2 Controversy over the measurement of rent prices of owner-occupied housing arises from the fact that these are not transaction but imputed prices. In an ideal world, this price corresponds to the mean rent price of a sample of rented housing units with "similar features" to the unit in the sample that is occupied by its owner. This "ideal procedure" is too expensive because of the information requirements to assure the homogeneity of each subsample over time. Current practice in the US, for instance, is to impute the monthly growth of rent prices from a sample of rented houses "as similar as possible" to the unit in the sample that is occupied by its owner. This weaker imputation procedure is justified by the fact that the growth of rent prices tends to be homogeneous between non-homogeneous housing units thus reducing homogenizing information requirements. This procedure might reduce the duration of price spells in owner-occupied housing compared to the duration of rented housing units as price changes of rented units are not synchronized. Therefore, this procedure updates the imputed prices to reflect current market conditions. See Poole et al. (2005).

Moreover, prices are more flexible for goods than for services and the duration distribution for goods has a smaller spread than that for services. The median implied price spell durations of goods and services are 4.9 and 10.2 months, respectively, and the 90% percentile ranks of durations are 11 and 18.1, respectively. These results are similar to those in other countries. See Bils & Klenow (2004) for the US and Dias *et al.* (2004) for Portugal, for instance.

Differences between the distributions of price spell durations of goods and services relate to price regulations on services, the nature of the service, the share of wages, and rent in the cost structure of service providers and seasonality. Services contain a wide array of items which weights are unevenly distributed throughout duration, as shown above. Price regulation induces a short duration of price spells in utilities and transportation combustibles, which also have a significant share of the CPI weight. Price regulation induces long price spell durations in ground transportation and education. Prices of food away from home items might have long durations because the cost structure of these outlets includes an influential share of wages and rent, two items with durations that are close to a year.

Table 6 displays a summary of the results of a set of studies on price stickiness of consumer prices carried out for individual countries and the Euro Area. The

Table 6
Summary of the Results of Individual Country Studies and the Euro Area on Price
Stickiness in Consumer Prices

Country	Average FPC	FPC Hetereogeneity	Downard Price Rigidity	
France	20.9	Si	60/40	
Chile	46.1	Si		
US	26.1	Si	Yes	
Brazil	37.3	Si	50/50Yes	
Mexico	30.4	Si		
Euro Area	15.1	Si	60/40	
Belgium	17.6	Si	No	
Italy	10.0	Si		
Portugal	21.1	Si	No	
Spain	13.3	Si	No	

n.a: Not available.

table includes the results for the average FPC, FPC heterogeneity, downward price rigidity, price change synchronization, the percentage size of increases and decreases, and the dependency of price rules on state and time factors.

The coverage of CPI items in the individual country studies in Table 6 is not homogeneous nor is the prevailing inflation during the sample. Therefore, comparison of price stickiness between countries is quite difficult but it is customarily done as an indication of relative stickiness.

Given that inflation relates to price stickiness in Colombia (as will be seen in the next subsection), a comparison to countries having lower inflation rates is straightforward as long as the samples under analysis cover similar shares of the CPI in each study. The coverage of our dataset is similar to the coverage of the databases studied in Chile and Portugal, which also included shelter.

Colombian consumer prices are clearly less flexible than those of Chile and Portugal. Chilean consumer prices are surprisingly flexible, a mean FPC of 46.1% a month, given the inflation prevailing during the sample, which was 2.7%. Even after removing imputed rent items, the mean FPC of Colombian consumer prices, 23.6% a month, is still lower than Chile's. Moreover, when Colombia reaches the same level of inflation as Chile, the stickiness of Colombian consumer

Synchronization	Size %Incr / %Decr	State/Time Dependency	Average Inflation
0.19	8.3/11.0	T/S	1.5
0.37		S	2.7
n.a.		T/S	2.4
n.a.	15.9/12.6	n.a.	3.9
n.a.		T/S	12.0
0.18	9.4/11.4		1.98
0.18	7.6/7.8	T	2.2
0.24	7.5/8.5		2.9
0.17	10.1/11	S	2.6
0.15	8.2/10	T/S	3.1

prices will be higher than that shown in the sample aggregate[3]. Likewise, the mean FPC in Portugal is 21.1% a month, a result that is similar to ours. Given that Portugal's study also includes rent and since stickiness relates inversely to inflation in Colombia, when Colombia reaches the level of inflation Portugal has, that is, an average of 2.6%, Colombian consumer prices will be less flexible than those of Portugal.

Comparison to the aggregate results of other individual country studies is difficult because of sample coverage differences. However, a raw comparison with the results of Belgium, Italy, Spain, and the Euro Area might suggest that Colombian consumer prices are more flexible than those of these countries.

2.   Time Series Results

a.   Inflation and the Location of the Distribution of the FPC

Price stickiness relates inversely to inflation in Colombia. Graph 3 shows the relationship between inflation and consumer price stickiness. The left panel displays the relationship between inflation and the seasonally adjusted median FPC[4]. The right panel displays the relationship between inflation and the seasonally adjusted implied median duration of price spells for each period of time. Each point corresponds to a particular month in the sample.

We found a statistically significant correlation of -0.6 between CPI inflation and the seasonally adjusted median implied duration. When inflation was reduced from 10% in May 1999 to 4% in May 2006, the median implied duration of price spells increased from 6 to 10 months. When inflation went back up to 5.7% in April 2008, the median implied duration of price spells decreased to 9.6 months.

---

3 The surprising flexibility of consumer prices in Chile might arise from the fact that, given Chile's history of hyperinflation, the price of many items is usually tied to "Unidades de Fomento," UF, an index that depends on past inflation. Rent prices, for instance, may change quarterly, and wages may change twice a year. The price flexibility of rent and wages might also be transmitted to the price flexibility of other items in the economy through costs of production factors. Price flexibility accompanied by low inflation is also present in Brazil and Mexico, two countries that have experienced episodes of hyper inflation as well. See Table 6.

4 The seasonal adjustment is performed with the X12-method, which employs a series of linear filters and adopts a recursive approach.

A similar analysis follows for the median FPC on the left panel. Therefore, when Colombian CPI inflation reaches the long-run target of 3%, the median FPC will likely be between 9% and 10% a month, a median implied duration of between 10 and 12 months.

Graph 3
Inflation and Consumer Price Stickiness
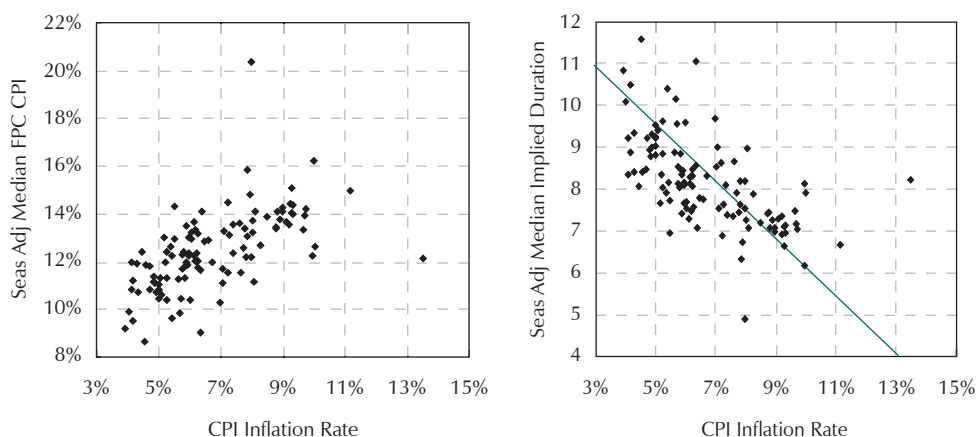
This finding is consistent with previous CPI and PPI stickiness studies for Colombia and is a recognized empirical fact worldwide. In a period when the average CPI inflation was 28%, Jaramillo & Cerquera (1999) found that CPI prices remained constant for two months. Espinosa, Jaramillo & Caicedo (2001) found that duration increased to four months when the average CPI inflation fell to 25%. Our results show a median implied duration of 8.4 months for a period when the CPI inflation was 7% on the average. A similar result for Colombian producer prices was found by Julio & Zárate (2008), and analogous results are widespread in cross country comparisons and individual country studies. See Golosov & Lucas (2007), for instance.

The fact that inflation relates to price stickiness contradicts time-dependent rules. Under Calvo pricing, for instance, firms update their prices based on an exogenous constant hazard and decide only on the size of the price change. Under state-dependent rules, such as menu costs, firms which prices are most "out of line" are more likely to change their prices; thus, the timing of a price change relates to inflation. Therefore, this evidence suggests that state dependency is an influential component of the price-setting behavior in Colombian consumer prices.

Taylor (1999) identifies the relationship between inflation and price stickiness as "a stylized fact in market economies", and Golosov & Lucas (2007) argue that this relationship is a major criticism against Calvo pricing under menu costs.

b.   Inflation and the Variability of the Distributions of the FPC and Percetage Price Change

Inflation relates directly to the variability of the FPC and percentage price change distributions. Graph 4 portrays the relationship between inflation and the variability of the FPC (left panel), and inflation and the variability of percentage price changes (right panel). Variability is measured as the seasonally adjusted 90% inter-percentile rank (the difference between the 95% and 5% percentiles) of the corresponding distribution. Each point corresponds to a month in the sample.

According to Friedman (1977), when inflation is related to inflation variability, welfare losses due to this relationship diminish as inflation goes down. A statistically significant correlation of 0.44 between inflation and the seasonally adjusted variability of percentage price changes was found. Therefore, as inflation is reduced in Colombia, so are the welfare losses due to this relationship. This finding supports the choice of low, stable inflation in Colombia. See Partow (1995), also.

Graph 4
Inflation and the Variability of the FPC and Percentage Price Change
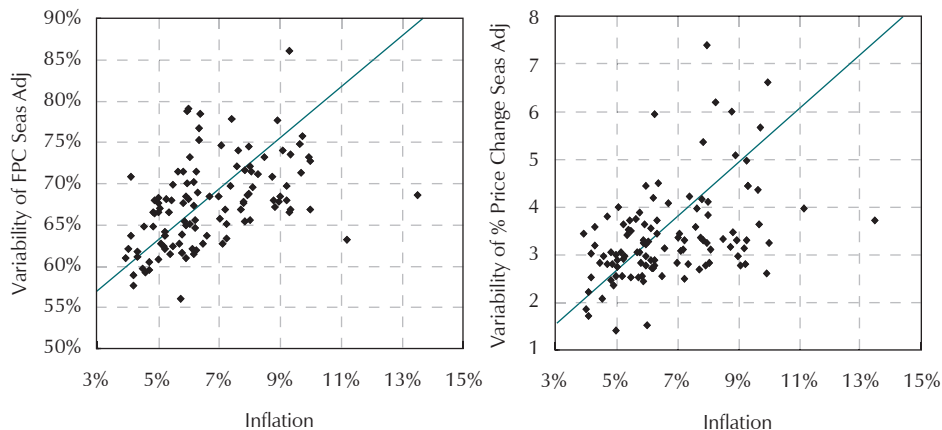

The variability of price stickiness diminishes along with inflation; therefore, durations tend to concentrate on long values. In fact, a statistically significant correlation of 0.47

between inflation and the seasonally adjusted variability of the FPC was found. This finding, along with the fact that inflation relates to price stickiness, means that as inflation falls, the distribution of durations concentrates around long values.

c.   Inflation and the Skewnwaa of the distributions of the FPC and Percentage Price Change

As inflation drops, the lack of symmetry in percentage price changes diminish but downward nominal rigidities in FPC do not. Graph 5 displays the relationship between inflation and the skewness of the FPC distribution (left panel), and inflation and the skewness of the distribution of percentage price changes (right panel). Skewness is measured as the seasonally adjusted difference between the mean and median of the corresponding distribution. Each point in either Graph corresponds to a month in the sample.

Graph 5
Inflation and the Skewness of the Distributions of the FPC
and Percentage Price Change
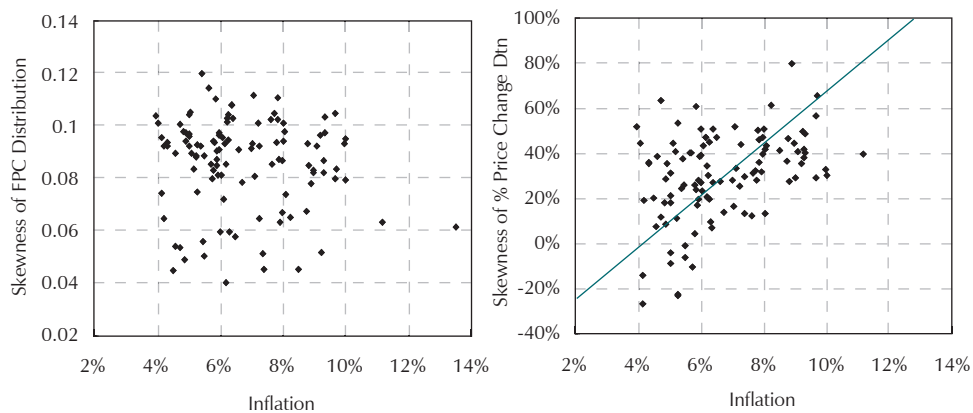
As inflation goes downward, price rigidity due to lack of FPC symmetry remains unchanged. The skewness of the FPC distribution is invariant to inflation variations as the correlation between inflation and the skewness of the FPC distribution is not statistically significant.

However, downward price rigidity in percentage price changes tends to diminish as inflation falls. There is a statistically significant correlation of 0.40 between inflation

and the skewness of the distribution of percentage price changes. Therefore, as inflation drops, the distribution of percentage price changes tends to symmetry.

d.   Inflation and the FPC of Flexible Item

The price spell duration of flexible items is invariant to inflation. Graph 6 illustrates the relationship between inflation (right scale on each panel) and the seasonally adjusted FPC of potatoes, electricity, and transportation fuel, in that order (left scale on each panel). The flexibility of the prices of these items remains regardless of inflation. Variations of the FPC of electricity and transportation fuel at the beginning of the sample relate to changes in regulation. Therefore, movement and clustering of items along the FPC axis, as inflation is reduced, happens for items with prices that are sticky already. A similar result was found by Bils & Klenow (2004) for the US.

e.   Seasonality

Differing degrees of seasonality are present in the median FPC of all CPI groups in Colombia, which points to significant time dependency in the pricing rules of Colombian retailers. Graph 7 displays the median FPC (continuous line) and the seasonally adjusted median FPC (dashed line) for the main groups of the CPI.
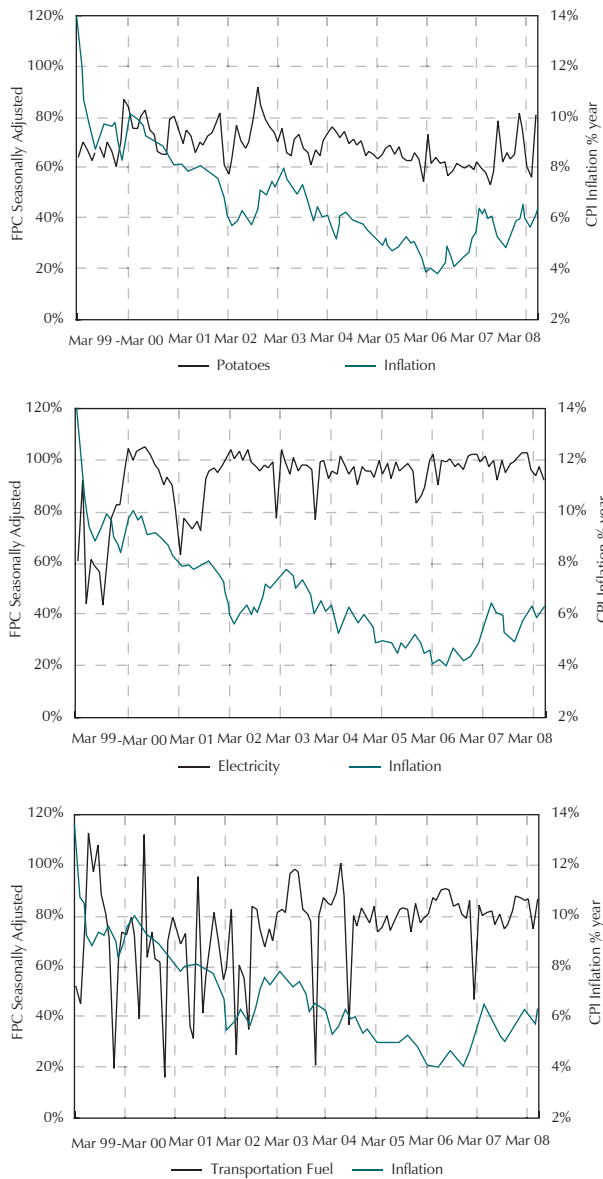
Strong seasonality in the FPC arises in regulated services and this increases price change synchronization for services. Price changes in education related goods and services gather during school registration. About 85% of the price changes observed every year in this group happen during the first quarter while most of the rest occur in August and September. Likewise, 37% of the price changes observed in health related goods and services during the year occur during the first quarter and the other 63% of these are spread out over the rest of the year. A similar pattern arises for transportation and communications items. Therefore, strong price change synchronization related to seasonality may be expected in these groups, especially in education.

Important seasonal patterns in the FPC also arise in goods such as food. The frequency of price changes for food items increases smoothly from October to March and then goes down again following the same pattern throughout the rest of the year.

Slight seasonality also appears in the FPC of other goods and services, housing, apparel, recreation and culture, and other expenditure. Seasonal increases in the FPC

in these groups occur between January and April each year. Moreover, the seasonal peak in the FPC of apparel items has been shifting from March to April while at the same time its size has been falling over time.

Graph 6

Inflation and the Seasonally Adjusted FPC for Some Flexible Items

Graph 7
Median FPC and Seasonally Adjusted Median FPC for Main CPI Groups

Food

Housing

Transport & Communication

Other Goods and Services
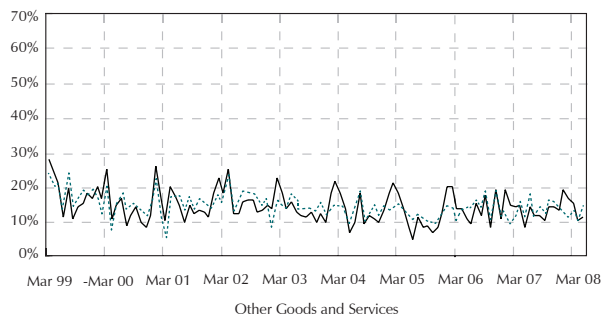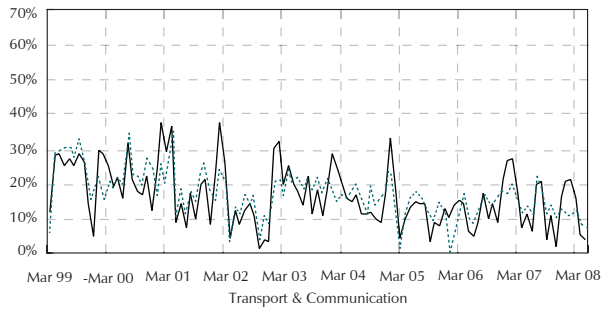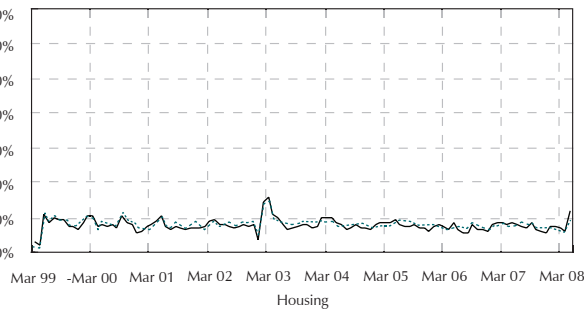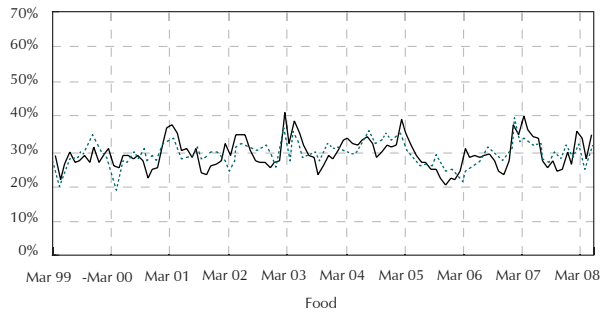
Medium FPC   ....   Seasonally Aadjusted Median FPC

Graph 7
Median FPC and Seasonally Adjusted Median FPC for Main CPI Groups (continued)

Apparel

Education

Medical Care

Recreation and Culture

—— Medium FPC   .... Seasonally Aadjusted Median FPC
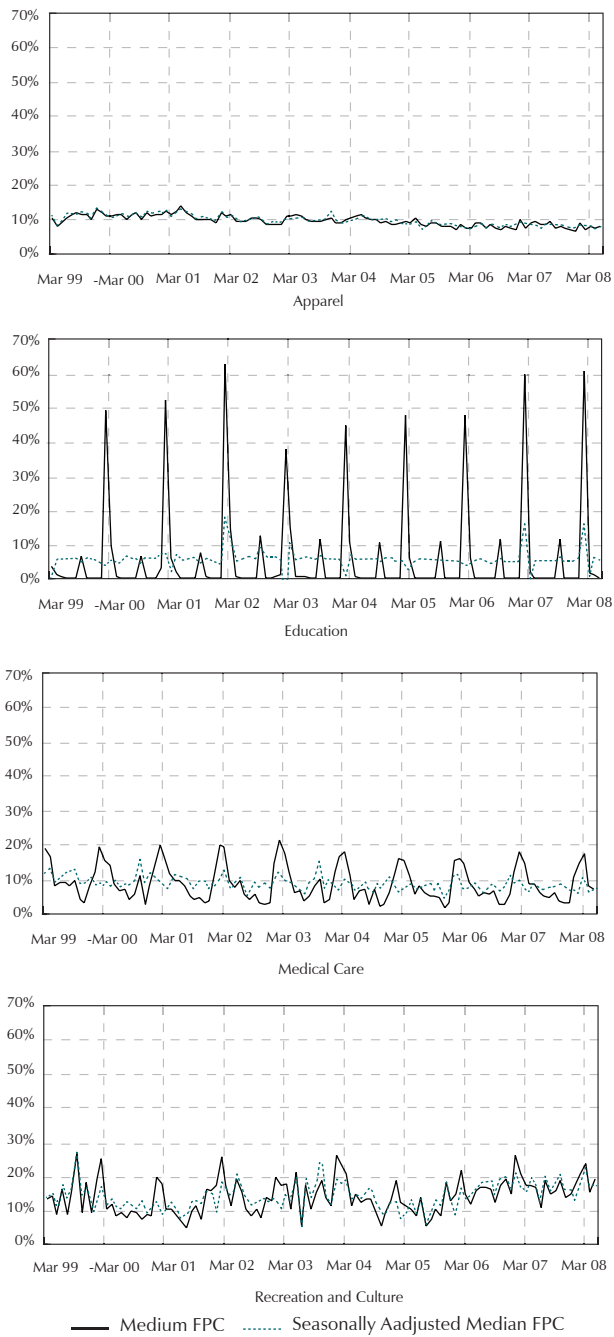
Previous results are summarized in Graph 8, where the distributions of percentage price changes (top panel) and the distributions of FPC (bottom panel) are displayed over time. Each panel shows the evolution of the main quartiles and percentiles of the corresponding distribution.

The distributions of percentage price changes show clear, seasonal increases in their variability during the first quarter of the year with a small, seasonal increase sometime during the rest of the year. Likewise, the distributions of the FPC show seasonal shifts in their skewness, median, and variability during the first semester of the year. Therefore, there is a significant level of time dependency in the pricing rules of Colombian retailers.

Graph 8
Distributions of Percentage Price Changes (Top Panel) and FPC
(Bottom Panel) over Time.
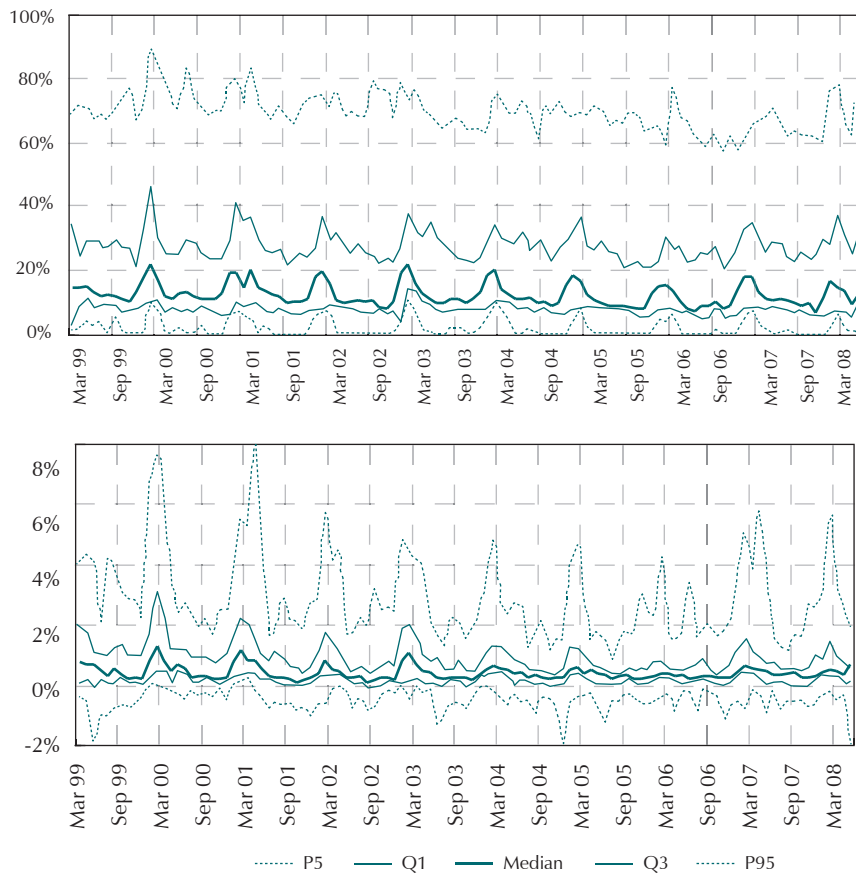
B.   HETEROGENEITY OF THE FREQUENCY OF PRICE CHANGES

According to Taylor (1999), a stylized fact of market economies is a great deal of heterogeneity in price-setting rules. Our results show a sizable degree of heterogeneity in the FPCs between product classes and categories of CPI items. For instance, the 90% inter-percentile rank of the implied duration for the CPI is 16.4–1.4=15 months. This contrasts sharply with the surprisingly low 90% inter-percentile rank of the implied duration for apparel of 3.38 months.

There are several theories that explain price stickiness heterogeneity, *i.e.*, market structure and level of processing of goods. Both of these theories match our results nicely, particularly for goods. In addition, the source of goods also plays an influential role.

In order to explain price stickiness heterogeneity in Colombian consumer prices, a "stickiness homogenizing classification" is built in II.B.1 and matched in II.B.2 to the two theories explaining price stickiness heterogeneity mentioned above.

1.   The Stickiness Homogenizing Classification

To understand the heterogeneity of stickiness in the minimal classes, a cluster analysis on the median FPC of the minimal classes was performed[5]. For this classification, goods and services were treated separately and goods were split into food and non-food items. Rent was studied separately because its duration is clearly influenced by the length of rent contracts and because of the imputed rent measurement issue. Clusters are studied and matched with groups from various classifications. Once matches were made, the clusters were redefined. Therefore, overlapping is unavoidable, but the redefinition provides economic meaning to our stickiness homogenizing classification.

Table 7 shows the distribution of the FPC by the groups derived from the redefinition of groups that were the result of the cluster analysis on price stickiness.

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5 Cluster analysis is a collection of algorithms; it was used in this paper to classify FPC. The classification aims to reduce the dimensionality of the data set by making use of the similarities among FPCs. Homogeneous groups were formed according to the Euclidian measure and the clustering algorithm based on single linkage (see Peña, 2002) .

Food items are classified into four groups: perishable food, semi-processed food, processed food, and food away from home, with very low overlapping. Perishable food items such as tomatoes, potatoes, oranges, onions, etc. have flexible prices that last between 1.3 and 1.9 months. Prices of semi-processed food items such as bread, cooking oil, sugar, poultry, fish, meat, milk, eggs, etc. show median implied durations of between 1.9 and 3.4 months. Prices of processed food items, *i.e.*, cornstarch and other flours, breakfast cereals, canned and dried food, frozen meals, chocolate, spaghetti, juice, soft drinks, and other nonalcoholic beverages have median implied durations of between 3.4 and 6.6 months. Finally, the price spell durations of food away from home items cluster together in a range of 7.5 to 12.2 months.

Non-food items are classified into three groups: consumables, durables and apparel, with some overlapping. The price spell durations of consumable items such as house cleaning and personal care supplies, cigarettes, alcoholic beverages, etc. tend to cluster together in the implied duration interval between 0.0 and 5.0 months. The duration of price spells for durable items, for example, home appliances, linen, home electronics, home furniture, household utensils, etc. tend to concentrate in the implied duration interval of 6.0 months and above. Minor overlapping (the range between 5.0 and 6.0 months) relates to the duration of price spells for durable items (*i.e.*, other transportation vehicles, some home appliances, and tires) and consumable items (*i.e.*, medicine, beer, cleaning utensils, personal care items, diapers, floor wax, and newspapers). Strong overlapping of the distribution of consumables and durables is explained by one single item, automobiles, a durable with an implied duration of just 4.3 months. Because of the influential weight of automobiles, which is 3% of the CPI and 43% of durables, the distribution of the price spell duration of durables strongly overlaps the distribution of consumables. Surprisingly, the duration of price spells for apparel items clusters tightly together in the implied duration interval between 8.8 and 12.9 months, with almost all of them within the 9.4 to 10.7 month range.

Consumer services, excluding rent, classify into six clearly differentiated groups: services related to unit production cost, transportation and communications, other services, personal services, education and health, and services related to long-term relationships with customers. Services related to unit production costs, such as utilities, transportation fuel, and airfare have prices with durations of less than 2.8 months. Most of the weight of the transportation and communication items is concentrated in price spell durations of between 7 to 10 months. The duration of price spells for other services is spread over a wide range of between 5.7 and 10.8 months. Prices of personal services, *i.e.*, post and parcel, domestic service, and photography have durations of between 11.3 and 15.9 months. The duration

of price spells for education and health services is spread over a wide range but their weight is concentrated within 11.0 and 18.9 months of duration. Prices of services related to long-term relationship with customers exhibit durations of more than 18.9 months. Rent is treated separately from other services as the duration of effective measurements of rent prices (5.05% of CPI) is highly influenced by the duration of rent contracts and because imputed rent (15.6% of CPI) prices are not observable.

2. Explaining Price Stickiness Heterogeneity in Colombian Consumer Price

It may be possible to interpret the stickiness homogenizing classification of goods through the market structure and level of processing theories of price stickiness heterogeneity. Moreover, the source of goods also plays an important role since prices of imports are more flexible than produced and consumed goods. In addition, the heterogeneity of price stickiness of services relates strongly to regulation and the stickiness of cost innovations.

The results of Table 7 seem to agree with the level of processing theory for goods. According to this theory, price stickiness relates to the number of manufacturing steps required to produce goods. This fact is clearly true for food items except food away from home and seems to be true also for non-food items such as durables. These, because of their nature, might be subject to more manufacturing than consumables.

At the same time, according to the market structure theory, price stickiness relates to the market power of firms. This explanation seems to agree with the classification of food and non-food items.

However, the source of goods might also help explain the heterogeneity. For consumable and durable items, prices of imports are more flexible than prices of produced and consumed goods. In fact, consumable items, such as hair shampoo, detergent, alcoholic beverages other than beer, oral care goods, and insecticide, which are mostly imports, display lower price spell durations than wax, newspaper, magazines, and books, which are mostly produced and consumed goods. Moreover, durable goods with a high share of imports, *i.e.*, automobiles, home appliances, and home electronics show lower price spell durations than linen, curtains, home furnishing, furniture, pillows, and mattresses, which account for a lower share of imports. Similarly,

Table 7
Distribution of the FPC for the Stickiness Homogenizing Classification of CPI Items
and tradables & Non tradables

Group	P5	Q1	Median	Mean	
Perishable Food	52.8%	61.3%	67.0%	64.2%	
Semi Processed Food	29.2%	29.2%	31.3%	34.2%	
Processed Food	17.0%	17.0%	23.5%	22.2%	
Food Away From Home	11.5%	11.5%	11.5%	11.6%	
Consumables	17.1%	18.7%	19.9%	20.3%	
Durables	10.9%	14.3%	19.5%	18.5%	
Apparel	8.9%	9.5%	9.7%	9.7%	
Services Indexed to UPC	35.6%	43.0%	75.4%	65.2%	
Transportation and Communications	9.2%	11.2%	12.5%	11.6%	
Other Services	9.8%	9.8%	9.8%	11.8%	
Personal Services	6.7%	6.7%	6.7%	7.0%	
Education and Health Services	5.4%	5.9%	6.1%	6.8%	
Services Indexed to LTR	2.0%	5.2%	5.2%	4.9%	
Rent	7.9%	7.9%	7.9%	7.9%	
Tradables - goods	9.4%	12.2%	19.9%	20.2%	
Tradables - services	6.5%	35.6%	35.6%	41.5%	
Nontradables - goods	7.9%	8.0%	11.5%	21.1%	
Nontradables - services	5.2%	6.1%	9.8%	18.6%	

Note: The items used to form this groups does not match exactly the CPI groups

the stickiness of prices for apparel seems to agree with this explanation since apparel items are mostly produced and consumed goods.

This evidence matches the results obtained by Julio & Zárate (2008) nicely. They found that the median price spell durations for imports and produced and consumed industrial goods were 4.05 and 6.50 months, respectively. Table 8 shows the median FPC for final consumption producer prices by source of goods and industry.

A comparison of the results from tables 7 and 8 reveals that there are important similarities between the behavior of producer and consumer prices in Colombia. The median implied duration of consumables, durables, and apparel (all of which contain imports and produced and consumed items) are 5.0, 5.1 and 10.3, respectively. These durations, taken together, are similar to the price spell durations of final consumption manufacturing items of the PPI, which are 3.9 months for imports and 8.0 for produced and

Q3	P95	STD	Duration	Weight
68.9%	79.0%	1.9%	1.5	4.8
38.0%	51.1%	1.5%	3.2	15.3
25.2%	29.0%	1.4%	4.2	2.7
11.5%	12.7%	0.4%	8.7	6.7
21.7%	24.2%	0.5%	5.0	8.3
23.1%	23.1%	0.8%	5.1	6.9
10.4%	10.5%	0.2%	10.3	6.7
77.3%	92.6%	9.7%	1.3	6.6
12.5%	12.8%	0.6%	8.0	4.6
15.0%	17.7%	1.1%	10.2	5.1
6.7%	7.8%	0.3%	14.9	2.0
7.6%	8.9%	0.4%	16.3	6.7
5.2%	5.4%	0.3%	19.2	2.9
7.9%	7.9%	0.0%	12.7	20.7
23.1%	39.2%	1.0%	5.0	30.0
75.4%	75.4%	8.5%	2.8	4.3
30.5%	67.0%	3.5%	8.7	42.0
12.5%	92.6%	4.1%	10.2	23.7

consumed goods. Likewise, the median implied duration of price spells for perishable food, 1.5 months, is remarkably similar to the duration of produced and consumed final consumption agricultural items in the PPI, which is 1.4 months.

Table 8
Median Frequency of Price Changes for Final-Consumption Producer Prices

		Source	
		Imports	Produced and Consumed
Industry	Agriculture, Animal Husbandry, Hunting, Forestry and Fishing	2.5	1.4
	Manufacturing	3.9	8.0
All Final Consumption		**4.1**	**6.5**

In contrast, the heterogeneity of price stickiness in services relates strongly to price regulations and the stickiness of marginal cost innovations. Services tied to unit production costs, for example, utilities, transportation fuel, and airfare are subject to frequent price changes as unit production costs are updated often. The effects of regulation and the nature of the service on price stickiness are also clear for education services, in which price changes concentrate during school registration, and for transportation and communications services, where price changes are tied to regulation.

The heterogeneity of price stickiness of non-regulated services obeys different factors. Services related to long-term relationship with customers, such as apparel tailor, apparel repair, apparel rental, haircut, etc. may have long durations because, in these markets, the customer is not anonymous and may resist price changes. See Dhyne *et al.* (2006) and Bils & Klenow (2004) for evidence from the Euro Area and the US.

C.   PRICE CHANGE SYNCHRONIZATION

Prices are flexible if they satisfy two conditions after an innovation: (i) they shift towards the market-clearing level and (ii) price change is synchronized among firms. Therefore, lack of price change synchronization indicates the existence of price stickiness. The synchronization of price changes was measured by means of the Fisher & Konieczni (2000) synchronization index. The synchronization index is one under perfect synchronization and zero under perfect staggering. The synchronization index for all items as well as for each group in the stickiness homogenizing classification was calculated.

Measures of price change synchronization reveal significant features of the price-setting rules used by retailers. In Calvo pricing, for instance, the timing of price changes follow a constant hazard and are thus unsynchronized, *i.e.*, staggered. In Taylor contracts, in contrast, prices change at deterministic lengths of time inducing perfect synchronization.

Graph 9 depicts the distribution of the Fisher-Konieczni synchronization index for the minimal classes of the Colombian CPI. Vertical bars and the continuous line indicate CPI weight for each interval and the cumulative weight, respectively.

Graph 9 reveals that, throughout the sample aggregate, price change synchronization in Colombia is low and comparable in degree to the individual country studies in Table 6 except for Chile. The median minimal class in Colombian consumer prices

has a synchronization index of 0.147. Moreover, 80% of the CPI has a synchronization index which is below 0.38 and just 10% of the basket has one above 0.463. The remarkably high FPC found in Chile induces a synchronization index of 0.37.

Graph 9
Distribution of the Fisher-Konieczni Synchronization Index
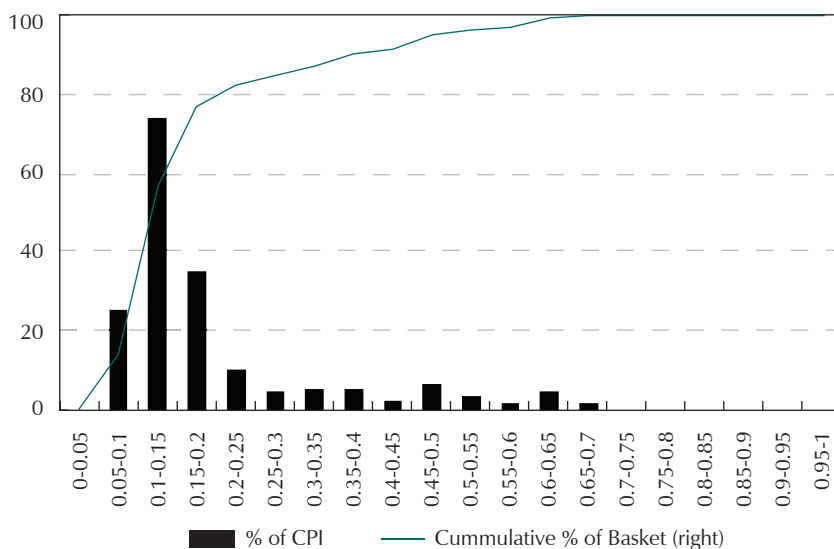
Graph 10 shows the distribution of the Fisher-Konieczni synchronization index for each group of the stickiness homogenizing classification. Vertical bars indicate CPI weight for each interval.

Not surprisingly, strong price change synchronization is found in regulated services such as education and health and transportation and communications. Moreover, services tied to unitary production costs reveal strong price change synchronization as their FPC rank among the highest in the CPI basket. As expected, very low price change synchronization is found in rent, food, apparel, services related to long-term relationships with customers, and consumable items. Slightly high price change synchronization is seen in durables and other services, which relates to price change synchronization for automobiles and banking services, respectively.

A Taylor contract of one year might be a good approximation of the pricing rules of regulated services such as education, health, transportation, and communications and rent, which is a surprising 32% of the CPI.

Graph 10
Distribution of the Fisher-Konieczni Synchronization Index for Each Group of the
Stickiness Homogenizing Classification
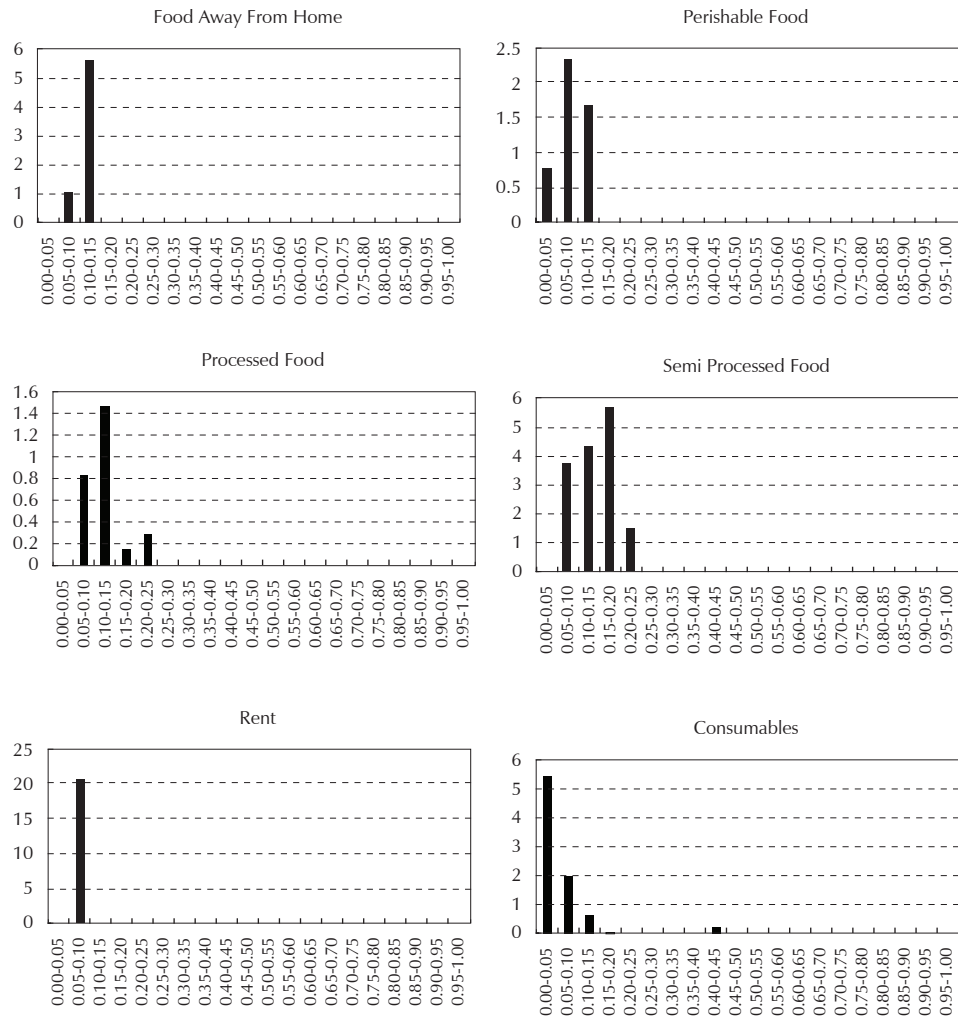
Graph 10
Distribution of the Fisher-Konieczni Synchronization Index for Each Group of the Stickiness Homogenizing Classification (continued)

Durables

Other Services

Education and Health Services

Services Related to LR Relat

Services Indexed to UPC

Personal Services

Transportation and Commun Services

Apparel
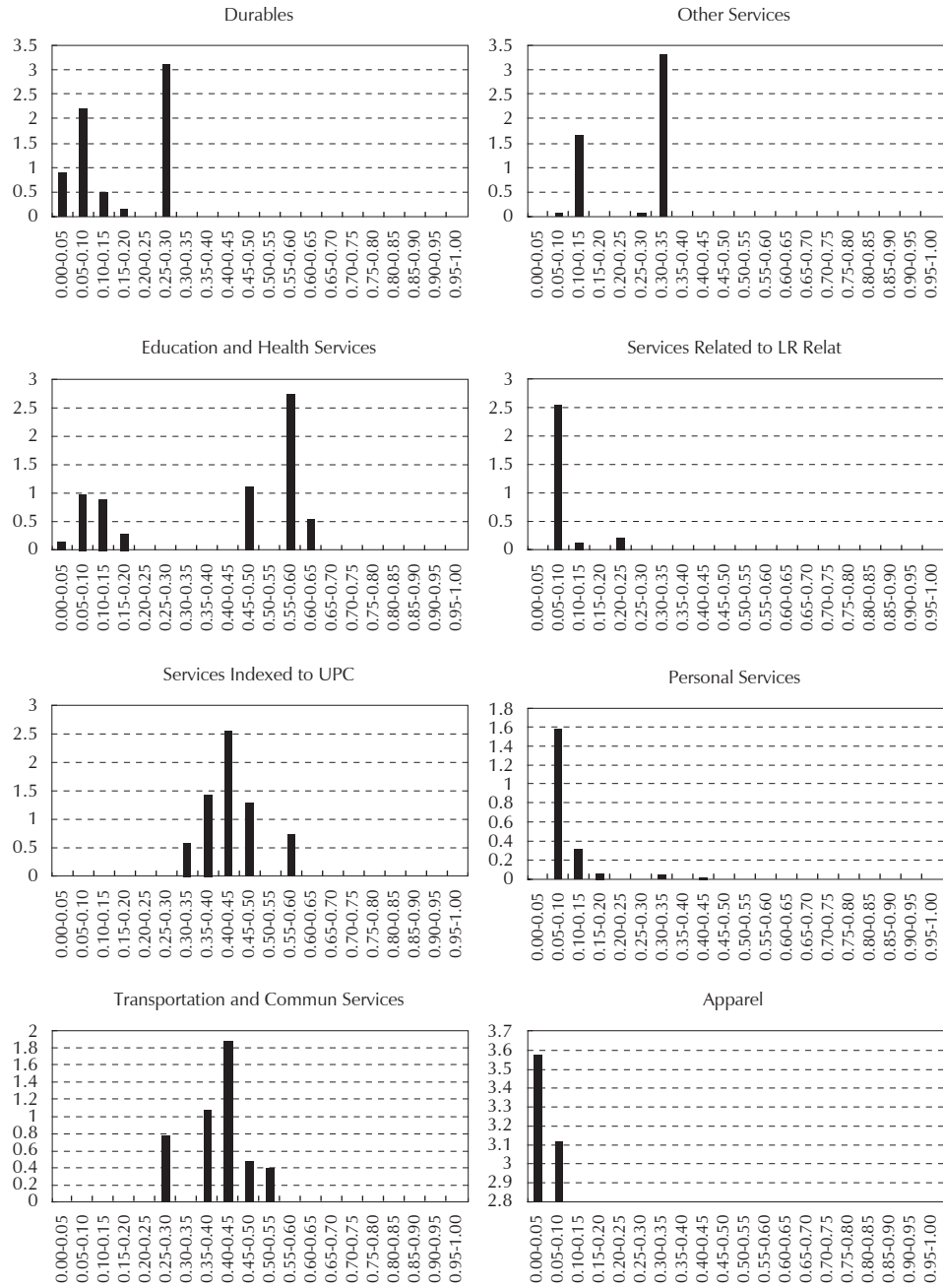
D.   FREQUENCY OF PRICE INCREASES AND REDUCTIONS

Strong downward nominal price rigidities increase welfare losses of inflation-reducing policies. When prices are downwardly rigid, monetary policies to reduce inflation have stronger real effects on the economy than policies to increase inflation. In order to determine the presence of nominal downward price rigidity, the frequency of price increases is compared to that of reductions at the level of minimal classes in Graph 11. Each point in the graph corresponds to a minimal class in the sample.

Graph 11
Frequency of Price Reductions and Frequency of Price Increases
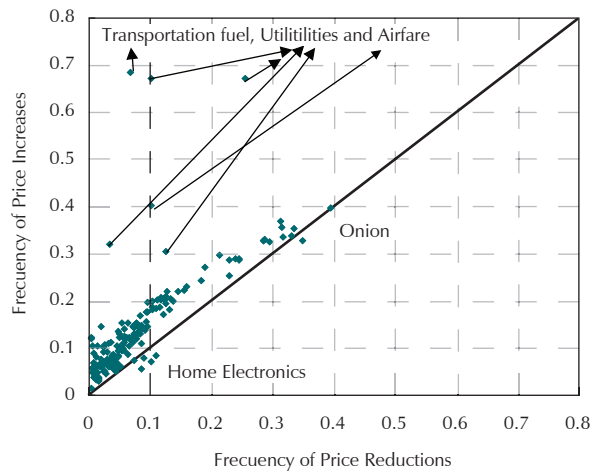
The existence of slight nominal downward price rigidity in Colombian consumer prices can be deduced from Graph 11. Most of the minimal classes in the CPI display a frequency of increases close to, but slightly higher than, the frequency of decreases. Therefore, most of the cloud of points is located close the 45-degree line where they would lie in the absence of nominal rigidities.

Strong downward nominal price rigidities are seen in transportation fuel, utilities, and airfare. However, these minimal classes were shown to be flexible; therefore, high costs of reducing inflation are compensated by low stickiness. Moreover, very slight nominal upward price rigidity appears in home electronics and onion.

Colombian consumer prices show lower downward nominal price rigidities than consumer prices in several countries. Graph 11 shows a higher concentration of

points around the 45-degree line than the figures reported in the studies carried out in Belgium, France, and Portugal, for instance. See Aucremane & Dhyne (2004, Graph 6), Baudry *et al.* (2004), and Dias *et al.* (2004).

Finally, price reductions are not rare. We found that 40% of price changes correspond to reductions. Similar results were found by Espinosa, Jaramillo & Caicedo (2001) for Colombian consumer prices, by Baudry *et al.* (2004) for France, and by Dhyne *et al.* (2006) for the Euro Area (see Table 6). This is a key parameter for calibrating menu cost models. See Nakamura & Steinsson (2008), for instance.

E.   THE SIZE OF PRICE CHANGES

A common explanation for price stickiness is the presence of menu costs. When a firm faces menu costs, it keeps its prices unchanged for long periods of time and then, occasionally, shifts them to a new level when mark-up loss (or gain) is higher than these costs. However, when the cost of changing prices is convex on the percentage price change, retailers tend to avoid big price changes and prefer small, more frequent ones.

Graph 12 shows the relationship between percentage price reductions and percentage price increases when price changes occur. Each point in the graph corresponds to a minimal class and the 45-degree line corresponds to the price change symmetry.

Percentage price increases tend to be higher than percentage reductions. Absolute percentage changes of considerable size take place in school tuition (the yearly fee and monthly payments), college technical and other school tuition, and graduate studies. This evidence is consistent with the long duration of price spells found for these items under moderate inflation. The median implied duration of price spells is 16 months for school tuition, 11.2 months for college technical and other schools tuition, and 15.9 for graduate studies.

Slight price change asymmetry (when the percentage increase is higher than the percentage reduction by 5%) takes place in an array of perishable food items (tomatoes, onions, carrots, fresh legumes and vegetables, potatoes, and other fresh fruit), some apparel items (blouses and other women's apparel, women's sneakers, female children's apparel, and women's pants and jeans), some education related goods (school books and other school expenses), video devices other than TV sets, and books.

Moreover, percentage price increases that are higher than percentage reductions and a higher frequency of price increases than reductions are both consistent with moderate inflation, which is between 4% and 14% a year in our sample.

Graph 12

Percentage Price Reductions and Percentage Price Increases
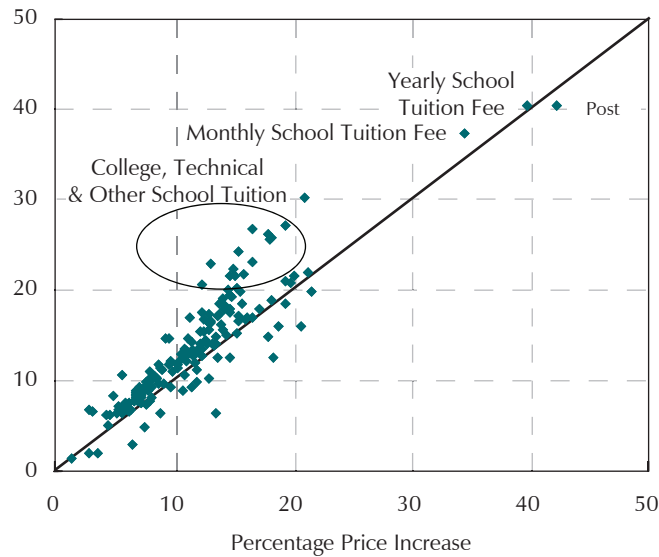
Graph 12 also shows that absolute percentage price changes are higher than the average monthly inflation for the sample period (0.54% a month) for all the minimal classes in the CPI. Finally, big price changes (with respect to inflation) are common, which rules out a convex function of price changes in Colombian consumer prices.

F.   STATE AND TIME DEPENDENCY

The shape of pricing rules in monetary policy models has a significant effect on understanding the effect of monetary policy shocks. Monetary policy models rely on pricing rules that are broadly classified as state-dependent or time-dependent. In time-dependent rules, the effect of monetary policy shocks on prices does not depend on the state of the economy through the timing of price updates but only through the size of the price change. In state-dependent rules, however, the probability of a price update depends on the state of the economy; therefore, the effect of monetary shocks on real activity and inflation depends on the timing of price updates. Firms that

follow state-dependent rules may change their prices when, for instance, the price is sufficiently "out of line" with respect to the size of menu costs thus inducing self selection. Therefore, it is recognized that state dependency affects the speed of the effect of monetary policy innovations. See Dias *et al.* (2005) and Golosov & Lucas (2007).

The share of time dependency in pricing rules is usually determined through the Klenow & Kryvtsov (2003) inflation variance decomposition[6]. The total variation of inflation is split into two components; one that is commonly found in time-dependent rules in theoretical models and the variation that is due to state dependency.

Table 9 shows the share of state and time dependency in the Klenow-Kryvtsov inflation variance decomposition for each of the groups in the stickiness homogenizing classification.

Not surprisingly, a high share of time dependency is found in rent and services for which periodical price updates are established by regulation just as they are for education and health services and transportation and communications. Rent contracts have a known duration of 12 months. Education services, because of their nature, may change their prices every year or semester depending on the type of school. And ground transportation regulations determine the timing of price updates.

Services which marginal cost innovations are heavily dependent on (minimum) wages and that are reset yearly, such as food away from home, personal services, and services related to long term relationships with customers are also highly (70%) time-dependent. Strong time dependency was also found in other services because of the significant weight of banking services.

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6 According to Klenow and Krivtsov, the inflation rate might be decomposed as the product of the FPC and the percentage price change as $\pi_t = FPC_t \, D(P_t)$, where P_t is the price level and D is the difference operator. The volatility of the first term figures prominently in many state-dependent models, and the volatility of the second is the only source of fluctuations in time-dependent pricing models. By writing $\pi_t = \overline{FPC_t} \, \overline{D(P_t)} + \overline{FPC_t} \, D(P_t) + (FPC_t - \overline{FPC_t})(D(P_t) - \overline{D(P_t)}) - \overline{FPC_t D(P_t)}$, an exact variance decomposition is found, $V(\pi_t) = \overline{FPC_t^2} V(D(P_t)) + V(FPC_t \, D(P_t)) + (FPC_t - \overline{FPC_t})(D(P_t) - DPt + 2Covt$, where $Covt = Cov(FPCtDPt, \quad FPCtDPt + FPCt - FPCtDPt - DPt)$. In the variance decomposition equation the first term is time-dependent and the remaining two are the state-dependent ones.

Table 9
Klenow-Kryvtsov Inflation Variance Decomposition for Each of the Groups in the
Stickiness Homogenizing Classification

Group	State Dependency	Time Depencendy	Weight
Perishable Food	81.6%	18.4%	4.8
Semi Processed Food	38.0%	62.0%	15.3
Processed Food	28.4%	71.6%	2.7
Food Away From Home	30.0%	70.0%	6.7
Consumables	56.0%	44.0%	8.3
Durables	41.9%	58.1%	6.9
Apparel	39.0%	61.0%	6.7
Services Indexed to UPC	72.4%	27.6%	6.6
Transportation and Communications	16.9%	83.1%	4.6
Other Services	34.2%	65.8%	5.1
Personal Services	29.6%	70.4%	2.0
Education and Health Services	10.7%	89.3%	6.7
Services Indexed to LTR	28.0%	72.0%	2.9
Rent	9.0%	91.0%	20.7
Weighted Average	34.0%	66.0%	100.0

An influential share of time dependency in the pricing rules for durable and apparel items is also shown in Table 9. Time dependency in apparel items might arise because of the seasonality of fashion collections, and time dependency in durables might arise from wage bonuses paid to Colombian workers every December as established by law.

Moreover, a not surprisingly high share of state dependency in the pricing rules of consumables, 56.0%, is also seen in Table 9.

Substantial state dependency was found in the pricing rules of perishable food items and high time dependency in those of semi-processed and processed food items.

Finally, the weighted mean portion of state dependency in the pricing rules of Colombian consumer prices is 34%. Table 10 displays a summary of the results about the pricing rules in Colombian consumer prices.

Based on the results from price change synchronization, Taylor contracts might be a good approximation for items that have strongly synchronized price changes, *i.e.*, education and

health and transportation and communications, and, obviously, rent. All of these have a combined weight of 32%. According to the Klenow-Kryvtsov inflation variance decomposition for all items, 34% of the CPI follows a state-dependent rule, such as menu costs, and the remaining 34% of the CPI might have a time-dependent rule, such as a Calvo rule.

Table 10
Distribution of Pricing Rules

Type of Rule	Percent of CPI
Taylor Contracts	32%
Other Time Dependency	34%
State Dependency	34%
All items	**100%**

G.   DETERMINANTS OF THE PROBABILITY OF PRICE CHANGES, INCREASES, AND REDUCTIONS

The shape of pricing rules can also be studied through analyses of the stochastic structure of individual price sequences. In this section, we attempt to estimate an aggregate model for the probability of price changes. Therefore, our results are aggregate in nature and are simply an indication of the relative weight of state and time dependency in aggregate pricing rules. An analysis of the shape of pricing rules at more disaggregated levels is left for future work. However, aggregate models were also estimated for price increases and price reductions that relate to competing hazards in duration models.

The relationship between pricing rules and the probability of a price change is straightforward for common pricing rules. In Calvo pricing, firms update their prices at exogenously determined stochastic periods of time based on a constant unconditional probability of price changes. In a Taylor contract for k periods of time, the unconditional probability of a price change is zero within each price spell and then, suddenly, jumps to one at the end of the contract. In state-dependent rules, the unconditional probability of a price change varies with the economic environment the firm faces within each period of time.

However, both this approach and duration models are sensitive to heterogeneity when the estimation is done for more than one price sequence, *i.e.*, when the model

is aggregate. In this study, a series of factors were introduced to reduce the degree of observed heterogeneity in the sample and thus produce reliable aggregate estimates.

These factors relate to the geographical location of the retailer, the type of outlet, the main CPI group, and the group in the stickiness homogenizing classification the item belongs to. Moreover, the year the prices were reported in was added to detect shifts in the probability of these events related to the specific year but not to other variables.

The economic environment the firm faces within each period of time is determined through the GDP gap and the exchange rate devaluation of the Colombian currency as well as through the inflation rate, the cumulative inflation since the last price up-date, and the percentage difference between the price and the average market price. All of the last three variables are measured for the minimal class in the city where the retailer is located.

The role of the last three variables depends on the economic model to explain price stickiness but, in any case, they are indicators of state dependency. In menu cost mo-dels, firms keep their prices constant until the deviation with respect to the optimal price is smaller than the cost of changing prices. Therefore, in these models the pro-bability of a price change increases with inflation or cumulative inflation. In market structure models, in which market power relates to price stickiness, the response to the percentage difference of the price with respect to the average price of the market depends on the market power held by the firm. The response of the firm to this varia-ble is thus an indicator of their market power.

Table 11 displays the Type III analysis of variance of logistic models for price change (left panel), price increase (center panel), and price reduction (right panel) events. The two latter models correspond to competing risks of these events in the literature dealing with duration models. Type III analysis of variance indicates the share of variability of the dependent variable, which is explained by a particular factor in the model. Therefore, the Type III analysis measures the relative importance of each factor in explaining the occurrence of each event.

The results shown in Table 11 reproduce the magnitude of heterogeneity in the price-setting rules in Colombian consumer prices found above. The stickiness homoge-nizing classification, the geographic location of the retailer, the type of outlet, and the main CPI group explain a significant part of the variability of the corresponding event in each panel.

Table 11
Type III Analysis of Variance for Logit Models for a Price Change, Price Increase and
Price Reduction Respectively

Effect	DF	Wald Chi Square	Pr > ChiSq
Stickiness Homog Classification	13	465787.80	<.0001
Cummulative Inflation	1	438608.85	<.0001
Inflation	1	382169.99	<.0001
Geographic Location	12	27931.11	<.0001
Seasonality	11	24696.07	<.0001
Type of Outlet	9	17851.37	<.0001
Year	9	6748.44	<.0001
Main CPI Group	6	4593.14	<.0001
Real GDP Gap	1	357.11	<.0001
Exchange Rate Devaluation	1	49.95	<.0001
Percent Diff wrt Average Price	1	0.37	0.5448
Inflation	1	437365.77	<.0001
Cummulative Inflation	1	278055.19	<.0001
Stickiness Homog Classification	13	152430.30	<.0001
Seasonality	11	22798.55	<.0001
Percent Diff wrt Average Price	1	13320.12	<.0001
Geographic Location	12	8744.18	<.0001
Type of Outlet	9	6898.29	<.0001
Year	9	4163.18	<.0001
Main CPI Group	6	3984.92	<.0001
Real GDP Gap	1	110.71	<.0001
Exchange Rate Devaluation	1	32.65	<.0001
Stickiness Homog Classification	13	202232.71	<.0001
Cummulative Inflation	1	92392.30	<.0001
Percent Diff wrt Average Price	1	54667.88	<.0001
Geographic Location	12	15962.69	<.0001
Type of Outlet	9	14628.87	<.0001
Seasonality	11	2183.73	<.0001
Main CPI Group	6	2013.32	<.0001
Year	9	928.40	<.0001
Real GDP Gap	1	244.31	<.0001
Inflation	1	105.39	<.0001
Exchange Rate Devaluation	1	6.03	0.014

Previous results about the importance of seasonality and Taylor contracts (due to the price regulation of services and seasonal increases in the FPC) appear in these results as *seasonality*, which explains an important share of the variability in the probability of the corresponding event in each panel. Therefore, at the most aggregate level, time dependency in the form of Taylor contracts and other forms of time dependency, *i.e.*, Calvo prices, emerge in the results.

Moreover, there is a slight portion of year-to-year variability for these probabilities not accounted for by the economic regressors in the model. Fortunately, the share of the variability of these probabilities due to year-to-year variation is low but statistically significant.

Not surprisingly, macroeconomic variables, *i.e.*, exchange rate devaluation and real GDP gap explain a negligibly part of the variability of the probabilities for the three events. This result, along with the fact that price changes are high with respect to the average monthly inflation during the sample period, seems to agree with Mackowiak & Smets (2008) in the sense that "sectoral price indices respond quickly to sector-specific shocks", and, at the same time, "prices respond slowly and by small amounts to macro shocks," as state dependency of pricing rules affects the speed of response to monetary shocks.

There is also evidence of competing risks in the explanation of a price change. A comparison of the ordering and variability explained by each factor between the two panels to the right shows evidence that the relative importance of the factors relating to price increases differs from those of a reduction. This is easily seen, for instance, by comparing the explanatory power of the inflation of the minimal class in the city where the retailer is located on each panel. Therefore, retailers use the information differently when deciding on a price increase or a price reduction.

Price increases strongly covary with inflation and the cumulative inflation since the last price change for the minimal class in the city the retailer is located in. However, they do not covary as strongly with the percentage difference of the price and the average market price for each of the particular products in the city the retailer is located in.

Price reductions, on the other hand, are strongly heterogeneous across goods and covary with the cumulative inflation since the last price change and the percentage difference of the price and the average market price for each of the particular items.

These results point to an aggregate pricing rule that has elements of both time and state dependency. Moreover, the evidence suggests that retailers use the information differently when deciding on a price increase than when deciding on a price reduction, which may help explain the downward price rigidity shown above.

IV.   CONCLUDING REMARKS

Our conclusions are summarized as follows:

* *The median implied duration of price spells in Colombian consumer prices over the sample aggregate is 8.4 months. If the rent price of owner-occupied housing is excluded, this duration falls to 6.4 months.*

    The more flexible items correspond to perishable food, utilities and transportation combustibles; the more rigid ones are services related to long-term relationship with customers. Similar results were found by Bils & Klenow (2004) for the US.

    In addition, the distribution of the price spell durations shows significant weight on items which implied duration is long. These items correspond to rent, food away from home, apparel, ground transportation, and other expenditure items.

    However, this result might be misleading as our dataset is not homogeneous over time. In fact, inflation has not been on a steady path during the sample. Therefore, the distributions of the FPC were studied for each period of time and their moments were related to inflation.

* *Inflation reduction in Colombia is accompanied by an increase in the duration of price spells, a higher concentration of durations in long values, a reduction in the variability of percentage price changes, and a reduction in downward price rigidity in percentage changes but not in the frequency of price changes.*

    According to Taylor (1999), a covariation between inflation and the FPC is a "stylized fact of the price-setting behavior in a market economy," and according to Golosov & Lucas (2007), this evidence is a major criticism of Calvo pricing under menu costs. Thus, this result may suggest that menu costs could be present in Colombian consumer prices.

Moreover, as inflation falls in Colombia, so do the welfare costs of inflation when related to inflation volatility as argued by Friedman (1977). This result supports the choice of a small and stable inflation over the long run.

However, the duration of price spells of flexible items is invariant to inflation. Therefore, movement and clustering, as inflation diminishes, happens for items which prices are already sticky. A similar result was found by Bils & Klenow (2004) for the US.

- *When the Colombian CPI inflation reaches its long-run target of 3%, the duration of consumer price spells will likely be between 10 and 12 months.*

Taylor (1999) argues that in a market economy "wage changes and price changes have about the same average frequency—about one year," a likely result in consumer prices when Colombia reaches its long-term inflation target. However, Taylor's claim does not seem to be true in several other countries.

- *When Colombia reaches its long-run inflation target of 3%, the median of the FPC distribution will likely be between 8.3% and 10.0% a month; its variability (measured as the 90% central percentile rank) will likely be between 55% and 60% a month, and its skewness (measured as the difference between the mean and median FPC) will likely be between 4% and 10% a month.*

Our emphasis on the role of the first three moments of the FPC distribution arises from theoretical results obtained by Carvalho & Schwartzman (2008), who concluded that "for empirically plausible shocks, we [Carvalho & Schwartzman] find that the first three moments of such distribution [of the FPC] suffice to characterize the extent of monetary non-neutrality, according to our measure." These authors studied a staggered contract model that included price and information stickiness heterogeneity with pricing rules specified through general hazard parameterizations.

- *Our findings suggest that Colombian consumer prices are less flexible than those of Chile and Portugal.*

This comparison takes into account the effect of imputed rent on the FPC and the covariation between inflation and the FPC. Comparison to the results from other countries is difficult as the coverage of the corresponding CPI baskets is

heterogeneous in individual country studies. However, a raw comparison might lead to the conclusion that Colombian consumer prices are more flexible than those of the Euro Area and some European countries.

- *Seasonality plays a significant role in explaining the variation over time of the price change distribution thus showing that time dependency is an influential factor affecting the price-setting rules used by retailers.*

  Differing degrees of seasonality were found in the FPC of all CPI groups. Moreover, the pricing rules for about 32% of the CPI might be approximated by Taylor contracts.

- *A great deal of heterogeneity in price stickiness is present across consumer prices in Colombia.*

  According to Taylor (1999), another stylized fact of market economies is a great deal of heterogeneity in price setting. Price stickiness heterogeneity seems to have a substantial effect on the dynamic behavior of staggered contract models. Carvalho (2006), in his celebrated Arrow Prize in Macroeconomics paper, points to important quantitative and qualitative effects of *ex-ante* price setting heterogeneity on the dynamic behavior of policy models[7].

  Based on a stickiness homogenizing classification and a comparison to previous Colombian PPI stickiness results from Julio & Zárate (2008), we found that the source of goods (imports and produced and consumed items), the market structure, and level of manufacturing theories might explain price stickiness heterogeneity in Colombian consumer goods, which are 58.7% of the CPI.

  Price stickiness heterogeneity of services depends on regulation and the particular features of the supply and demand of the service as well as the stickiness of cost innovations.

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7 Carvalho (2006) finds that "monetary shocks tend to have larger and more persistent real effects in heterogeneous economies when compared to identical-firms economies with similar degrees of nominal and real rigidity." Therefore, introducing stickiness heterogeneity may solve the real GDP persistence puzzle of staggered contract models. Additionally, Carvalho & Nechio (2008) show that the introduction of stickiness heterogeneity helps explain "the sluggish dynamics of real exchange rates observed in data" in a model for an open economy in comparison to a one sector staggered contract model with the same degree of stickiness. See also Aoki (2001) and Benigno (2004).

- *Colombian consumer prices show slight downward rigidity.*

  Downward nominal rigidity in the FPC relates to flexible items, and downward nominal rigidity in percentage price changes relates to items with long price spell durations in an environment of moderate inflation.

- *Price reductions are common in Colombian consumer prices. Forty percent of price changes correspond to reductions.*

  This is a key parameter in the calibration of menu cost models as in Golosov & Lucas (2007).

- *Absolute price changes are larger than monthly average inflation. Moreover, big price changes are not uncommon.*

  The fact that large price changes are common might be interpreted as evidence against convex cost functions of changing prices.

- *Over the sample aggregate, price change synchronization in Colombian consumer prices is low.*

  Not surprisingly, strong price change synchronization is found in services such as education and health and transportation and communications. The degree of price change synchronization is comparable to those in the individual country studies we compared our results to except for Chile.

- *There is evidence of both state and time dependency in the pricing rules of Colombian retailers.*

  The pricing rules of 32% of the Colombian CPI might be approximated by Taylor contracts; 34% by other types of time-dependent contracts, for example, Calvo rules; and the remaining 34% of the CPI by state-dependent rules, which might relate to menu costs. This last result arises from the Klenow & Kryvtsov (2003) inflation variance decomposition.

- *In deciding price increases, retailers take into account different information than when deciding price reductions.*

The decision to increase prices covaries strongly with inflation and the cumulative inflation since the last price update. The decision to reduce prices is highly heterogeneous between different groups of goods and services and covaries with the cumulative inflation since the last price update and the percentage difference of the price with respect to the average price of the market. Therefore, in deciding a price reduction Colombian retailers are more careful than when deciding an increase. The relationship between the decision of updating prices and inflation, and/or cumulative inflation, might suggest the existence of menu costs in a portion of the Colombian CPI.

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