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Inflationary Dynamics, Persistence, and Prices and Wages Formation

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INFLATION DYNAMICS, PERSISTENCE, AND PRICES AND WAGES FORMATION

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Prologue

In 2005, the Board of Governors of CEMLA, at the request of the president at that time, Martin Redrado, took the decision to encourage joint research activities among the Center's member central banks in order to bolster economic research on topics of mutual interest and leverage collaboration. Thus, in July of that same year the heads of studies at the central banks on the Steering Committee of CEMLA's Central Bank Researchers Network met to analyze the best way to implement a joint research program. After reviewing the projects being carried out at each central bank on the Committee, they identified the topics of interest that could be addressed by employing a common methodology. It was also suggested that these papers be presented at the annual meetings of the Researchers Network and published in a special book. The proposal was formally approved in October 2005 under the framework of the X Meeting of CEMLA's Researchers Network. The terms of reference for the first joint research project were elaborated in 2006, leading to publication of the first book in 2008 entitled *Estimating and Using Unobservable Variables in the Region.*

Since then, CEMLA has encouraged annual joint research projects among its members. Research topics are selected by the heads of studies at central banks on the Researchers Network Steering Committee. Meanwhile, representatives from participating central banks act voluntarily as coordinators for each of these projects.

Under this context, in 2009 a joint research project named Inflation Dynamics, Persistence, and Prices and Wages Formation was carried out. The importance of this topic is plain to see: a proper understanding of inflation dynamics is essential for modeling and formulating monetary policy.

The articles were divided into three topics: *i)* inflation persistence; *ii)* price formation; and *iii)* wage rigidities. Regarding the first of these, the book includes six papers focusing on identifying general changes in inflation trends, as well as on the degree of inflation persistence. The second topic brings together four papers studying price formation from a macroeconomic viewpoint, using direct surveys of producers, or calculations of frequency and duration using microdata from consumer price indexes or retail points of sale. After analyzing this information, the authors identify the general behavior of producers for setting prices and changes resulting from inflation shocks. The book ends with two articles on wage rigidities, which are also taken from a macroeconomic standpoint. The researchers use individual surveys and surveys aggregated by the type of firm or business sector. This information allows them to identify some relations between wage levels (and their rigidity –degree and direction–) and the average age of workers, the type of firm and the state of the economy, among other factors, in order to obtain information for supporting economic policy decision-making.

Although these topics have been extensively analyzed in recent years, in the case of Latin America work had been focused on certain economies of the region and had not made efforts to analyze them under the framework of a common effort. The 12 articles included in this book were written by researchers from Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Uruguay and Venezuela. We would like to thank them for their interest and enthusiasm in developing the joint research, which, we are sure, will be extremely useful for those interested in the topic from both inside and outside our region.

Javier E. Guzmán Calafell
General Director, CEMLA
January 2013

COORDINATORS OF SUB-TOPICS

The sub-topics of this joint research project were coordinated by Laura D'Amato (inflation persistence); Enrique López Enciso (price formation); and María Teresa Ramírez Giraldo (wage rigidities). Below are brief biographies of these three coordinators and coeditors of this publication.

Laura D'Amato

Deputy head of Economic Research at the Banco Central de la República Argentina (BCRA) since December 2005. Prior to this she worked as senior analyst in said area and as an analyst in the Monetary Studies Department and the International Reserves Management Department of the BCRA.

She received a PhD in Economics from the Universidad Nacional de La Plata and has a Master's degree in Public Policies from the Universidad Torcuato Di Tella. She obtained a bachelor's degree in Economics from the Universidad de Buenos Aries.

Her current Economic Research responsibilities include coordinating and managing research projects; carrying out studies in the area of monetary economics, macroeconomics and banking and financial economics; and developing macroeconomic forecasting models.

Laura D'Amato has published articles in various regional and international academic journals on monetary economics, macroeconomic and microeconomic banking topics, among others: "Prudential regulations, restructuring and competition: the case of the Argentine banking industry" (in collaboration), in *Research in Banking and Finance*, Vol. 1, 2000; "On the kindness of strangers?: The impact of foreign entry on domestic banks in Argentina (in collaboration), in "The Internationalization of financial Services", S. Claeesens and M. Jansen editors, *The World Bank, Kluwer Law International*; "The Argentine Banking and Exchange Crisis of 2001: Can we Learn Something New About Financial Crisis?" (in collaboration), in *Money Affairs*, CEMLA, XVI, 2003; "Understanding the money-prices relationship under low and high inflation regimes: Argentina 1977-2006" (in collaboration), in *Journal of International Money and Finance*, Vol. 28, 2009; and "Using the Flow of High Frequency Information for Short Term Forecasting of Economic Activity in Argentina" (in collaboration), in *Ensayos Económicos*, BCRA, Vol. 1(64), 2011.

She is also a professor of Macroeconomics, and Economics and Monetary Policy topics in the Economics Faculty of the Universidad de Buenos Aires.

Enrique López Enciso

Senior researcher in the Research Unit of the Banco de la República and advisor to the Programming and Inflation Department at said institution. He graduated as an economist from the Universidad Nacional de Colombia with a prize-winning thesis entitled Investigación y Cambio Tecnológico en la Agricultura Colombiana. He made specialized studies in Paris at the School for Advanced Studies in the Social Sciences (Ensae), the School for Higher Education (École normale supérieure, ENS) and the Graduate School of Economics, Statistics and Finance (Ensae), where he obtained a diploma in advanced studies (DEA) in Economic Analysis and Policy. He participated as an advisor on the Misión de Estudios del Sector Agropecuario and the Consejo Superior de Comercio Exterior. He is coauthor and author of several books including: Estrategia industrial e inserción internacional (Fescol, 1992); Estrategia industrial e inserción internacional (Fescol, 1992); La academia y el sector rural (CID-Universidad Nacional, 2004); La agricultura colombiana en el siglo XX (FCE-Banco de la República, 2006); Economía Colombiana del siglo XX: Un análisis cuantitativo, edited by Miguel Urrutia and James Robinson (FCE-Banco de la República, 2007); Estimating and using non-observable variables in the region, Joint Research Program (CEMLA, 2008); Nueva Historia Económica de Colombia (Universidad de Bogotá, Jorge Tadeo Lozano y Taurus, 2010); Mecanismos de Transmisión de la Política Monetaria en Colombia, edited by Lavan Mahadeva and Munir Jalil (Banco de la República and Universidad Externado de Colombia, 2011); The Colombian Economy in the 20th Century: A Quantitative Analysis (Harvard University, David Rockefeller Center Series on Latin American Studies, 2011); Formación de precios y salarios en la economía colombiana (Banco de la República, 2012). In light of his work as a researcher he was awarded an Honorific Mention by the Alejandro Angel Escobar Foundation in 2005, and won first and second place in the competitions held by the Banco de Guatemala in 2009 and 1999. He has had various articles on sectorial and macroeconomic topics published in national and international journals. He was a professor in the Macroeconomic and Monetary Policy area at the

Universidad Externado de Colombia and Universidad Externado de Javeriana. He is currently associate professor in the macroeconomics area of the Faculty of Economic Sciences of the Universidad Nacional de Colombia.

María Teresa Ramírez

Economist at the Universidad de los Andes in Bogotá, with master's degrees in Economics from the Universidad de los Andes and the University of Illinois at Urbana- Champaign, and a PhD in Economics from the University of Illinois. María Teresa Ramírez currently works as senior researcher in the Researchers Unit of the Banco de la República. Her research work has mainly been focused on economic growth, labor economics and economic history. She is the author of various articles published in books and national and international journals, and the editor of academic books and journals.

Among her publications it is important to mention: Wage Adjustment Practices and the Link Between Price and Wages: Survey Evidence from Colombian Firms (*Lecturas de Economía*, 2012); ¿Son los salarios rígidos en Colombia?: Análisis empírico con base en salarios a nivel de firma (*Monetaria*, CEMLA, 2011); Incrementos y rigideces de los salarios en Colombia: Un estudio a partir de una encuesta a nivel de firma (*Revista de Economía del Rosario*, 2011); Depressions in the Colombian Economic Growth during the XX Century: A Markov Switching Regime Model (Banco de la República, 2005); Spatial Dependence and Economic Growth: Evidence from a Panel of Countries (Banco de la República, 2002); Long Run Income and Price Elasticities of Demand for Colombian Non Traditional Exports: a Multivariate Cointegration Framework (*Applied Economics,* 2004); Institutions, Infrastructure and Economic Growth (*Journal of Development Economics,* 2004); and Los ferrocarriles y su impacto sobre la economía colombiana (*Revista de Historia Económica-Journal of Iberian and Latin American Economic History*, 2001).

Inflation Persistence

Introduction

Laura D'Amato

This book brings together a number of studies which are part of a joint research agenda carried out by several central banks in the region within the framework of the CEMLA's Central Banks Researchers Network. The research aims at enhancing our knowledge about inflation persistence of inflation and price formation in our countries. These issues have been central to the research agenda of both macroeconomists and central banks in the last few years on two grounds. On the one hand, the downward trend in inflation recorded in developed and emerging economies in the last decade of the 20th century and the first decade of the 21st century might have caused sustantial changes in inflation dynamics, which lead to a revision of the notion of inflation as a highly persistent process.[1] On the other hand, the widespread use of macroeconomic models based on assumptions of nominal rigidity raised the need to corroborate the support of these assumptions on an empirical basis.

Part I comprises six studies which focus on the analysis and measurement of inflation persistence following different methods.

From an intuitive perspective, persistence stands for the speed at which a variable returns to its trend or long-run value after a shock. During many decades, inflation was considered a highly persistent process. From a policy perspective the immediate consequence of this feature of inflation is a high sacrifice ratio in terms of percentage points of unemployment required to curtail inflation, if inflation returns slowly to its trend value. This was reflected in the first versions of the Phillips curve

[1] See in this respect Cogley and Sargent (2005), Cogley, Primicieri and Sargent (2009), Stock and Watson (2007), Cogley and Sbordone (2008), Angeloni et al. (2006) and Levin and Pigier (2004), among others.

which included an inertial component as a proxy for adaptative expectations based on a nominal rigidity pattern.

The modeling of inflation as an inertial process was challenged by rational expectations (RE) models. During the 1980s, Taylor (1982), Rotemberg (1982 and 1983), and Calvo (1983), among others, developed price formation RE models with price-level stickiness, in an attempt to reconciliate the theory with the observed behavior of the time series. During the 1990s, Furher and Moore (1995) showed that these models implied a degree of persistence much lower than that present in the data, making clear that further research was required to get a better understanding of inflation dynamics and different sources of persistence and in particular, it was relevant to disentangle intrinsic inflation persistence, which may derive from a price formation process from that derived from the dynamics of the GDP and from monetary policy itself.

As noted by Furher (2011), it is worth striking the difference between *reduced-form* persistence, which stands for an empirical property of the inflation time series, and the structural persistence of inflation which arises from identifiable macroeconomic sources, such as the behavior of GDP or monetary policy. Recently, the empirical research has focused on the relation between macroeconomic sources of inflation persistence, and the time series properties of inflation. Such evidence shows, to a significant extent, that *reduced-form* persistence has fallen in recent years in line with the adoption of regimes that –focused on inflation anchoring– managed to shrink persistence on a substantial and permanent basis.[2] Such evidence implicitly suggests that the long-run or trend inflation is not necessarily constant and that its value may be related to changes in the central bank policy function.

Based on this evidence, Cogley and Sbordone (2008) study inflation persistence assuming that long-run inflation is not constant but rather has a trend. Furthermore, Cogley and Sargent (2005), and Cogley, Primicieri and Sargent (2010) study inflation dynamics using models with variable coefficients that assume learning rather than rational expectations, in which the value of long-run inflation is subject to change. Cogley and Sargent (2005) find a high positive correlation between inflation persistence and trend inflation for the United States. They further corroborate that the persistence of inflation fell once the Federal Reserve adopted a more active policy to maintain inflation under control by the mid 1980s.

[2] See in this regard Levin and Pigier (2004) and Benati (2008).

Part I comprises six studies that focus on the analysis and measurement of inflation persistence, providing a rich empirical evidence on the dynamics of inflation in the region. Some papers use different methodologies to assess the presence of changes in trend inflation and measure inflation persistence. In others, regime switching models are developed to identify regime changes and measure inflation persistence. Finally, one of them studies the transmission of common shocks to aggregate inflation through the dynamics of sectorial inflation rates. A common finding across almost all the studies is the presence of breaks in trend inflation and the reduction of persistence that came along with the lowering of inflation in the region in the 1990s and 2000s. Table 1 sums up the findings of the six studies concerned with inflation dynamics in the region.

Castagnino and D'Amato analyze inflation dynamics in Argentina and the United States over the period ranging from 1960 to 2006. Using a dynamic factor model and frequency domain analysis they study the transmission of aggregate shocks to inflation based on sectorial inflation dynamics. They find that the impact of aggregate shocks translates into an increase of the comovement of sectorial inflation rates, but their incidence depends on the inflationary environment. When inflation is high shocks lead to strong comovements among sectorial inflation which tend to perpetuate; where inflation is low, the adjustment of relative prices prevails over the comovements, shocks rapidly dissipating.

In the case of Costa Rica, Carlos Chaverri Morales and Carlos Torres Gutiérrez study the presence of structural breaks in inflation and its relation with persistence. They find that, in the case of Costa Rica, inflation persistence is sharply reduced when evaluated in terms of the deviations from a changing mean. They attribute their findings to the high weight of a long-lasting period of low inflation exhibited in their sample. Indeed, the assessment of inflation persistence over the latest period (1997-2009) reveals that the estimated persistence is higher. They further evaluate the level of inflation persistence in terms of the mean duration of shocks.

D'Amato and Garegnani study inflation persistence in Argentina over a long period of time: 1961- 2006. They analyze the relation between changes in the mean of inflation and its autoregressive component and changes in the monetary regime. By using tests for multiple structural breaks and recursive estimation they identify changes in trend inflation that coincide with regime changes. They find that in Argentina inflation was a highly persistent process during the 1970s and 1980s, close to a random walk. On the contrary, persistence fell dramatically when inflation

TABLE 1. INFLATION PERSISTENCE

Study	*Country*	*Sample*	*Methodology*	*Persistence*	*Comments*
D'Amato – Garegnani	Argentina	1960-2006	Evaluate changes in mean and estimate persistence with constant and changing mean	Constant mean: $\rho = 0.78$ Non-constant mean $\rho = 0.31$	Persistence decreases along with the lowering of inflation
Castagnino– D'Amato	Argentina and the USA	1960-2006	Study the transmission of aggregate shocks to inflation focusing on the dynamics of sectoral inflation rates: Frequency domain analyisis and factor model	High inflation induces a generalized comovement among sectoral inflation rates that persists over time	
Echavarría - López - Misas	Colombia	1990-2010	Regime switching model	Inflation: ρ between 0.336 and 0.226 Inflation gap: $\rho = 0.88$	Do not find changes in persistence across regimes
Echavarría - Rodíguez – Rojas	Colombia	1979-2010	Unobserved components model	Evaluated using impulse response functions:persistence increases between 1979-1989 and 1989-1999 and decreases between 1999 and 2010	
Chaverri Morales - Torres Gutiérrez	Costa Rica	1953-2009	Evaluate changes in mean and estimate persistence with constant and changing mean. Also estimate persistence through the mean life of shocks	Constant mean: $\rho = 0.78$ Non-constant mean $\rho = 0.31$	Results biased toward low inflation due to the high weigth of a low inflation period within the sample: Increases to 0.31 (for the period 1997-2009 and with a changing mean)
Oliveira – Petrassi	23 developed and 17 underdeveloped countries	From 1995 onwards	Estimate reduced form inflation models: AR(p) models, New Keynesian hybrid Phillips curve, and an inflation reduced-form model with wage rigidity	Reduced and stable persistence in general and lower for developed economies	Persistence is lower in those economies that experienced hyperinflation in the recent past

sharply decreased in the early 1990s. With the introduction of the managed floating exchange rate scheme in 2002, inflation persistence slightly increased. Their findings corroborate the relevance of assessing structural breaks for modeling inflation dynamics and, particularly, for estimating its persistence. Their results also indicate that persistence, in the case of Argentina, is not inherent to inflation but dependent on the monetary regime.

Juan Echavarría, Norberto Rodríguez and Eduardo Rojas study inflation persistence in Colombia over a long period: 1979-2010. They estimate an unobserved component model for inflation that allows for regime changes and use it to estimate the persistence of the inflation-gap. They identify statistically significant changes in the persistence of inflation which, defined in terms of impulse-response functions increased between 1979 and 1989 and between 1989 and 1999, to then decrease to its lowest level during the 1999-2010 period with the adoption of inflation targeting in 1999.

Juan Echavarría, Enrique López and Martha Misas also study inflation persistence in Colombia over the period ranging from 1990 to 2010 by using a regime change model for both inflation and the inflation gap, bearing in mind, as suggested by Cogley, Primicieri and Sargent (2010), that the persistence of inflation could be caused by the persistence of the monetary authority's inflation target. Even though, they find evidence that inflation went down and became less volatile as from the adoption of an inflation targeting regime in 1999, they cannot account for a statistically significant reduction in the persistence of inflation.

Finally, Fernando Olivera and Myrian Petrassi estimate inflation persistence in several industrial and emerging countries since 1995 onwards using different *reduced-form* models of inflation: autoregressive models, a New Keynesian Phillips curve and a *reduced-form* inflation model with wage rigidity. Their findings reveal that the persistence of inflation has been reduced and remains stable in both groups of countries in the recent past, being lower in industrial economies.

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Regimes and Underlying Inflation Dynamics: Generalized Comovement or Relative Price Adjustment?

Tomás Castagnino and Laura D'Amato[*]

1. INTRODUCTION

Inflation is usually defined as a generalized and persistent increase in the price level. The scope of this notion seems to be restricted to à la Cagan high inflations of a monetary origin, in which absolute price adjustment prevails. It is not obvious, however, that inflation dynamics is always dominated by a strong comovement in sectoral prices, or that absolute price changes prevail over relative price adjustments. Even more, according to the empirical evidence in the literature (see Reis and Watson, 2007) in normal times, when inflation remains at relatively low levels, temporary movements in relative prices account for a high portion of inflation variability, because inflation does not follow a trend but has instead erratic movements that on average tend to cancel out. Under high inflation, the presence of a trend in aggregate inflation would reflect a higher importance of the common component in price variations. That is, more comovement in price adjustments, which not necessarily implies the absence of persistent or medium-term relative price adjustments under

[*] Banco Central de la República Argentina (BCRA). The authors thank Daniel Heymann, Sebastián Katz, Andrew Levin and George McCandless for their valuable comments on different versions of this paper, as well as all the comments and suggestions received at the XII Meeting of CEMLA's Researchers Network, at Banco de España, Madrid, November 5-7, 2007 the XLIII AAEP Annual Meeting, in November 19-21, 2008 and the 2010 LACEA Meeting. The opinions expressed here are of the authors and do not necessarily reflect those of the BCRA.

high-inflation contexts (Reis and Watson, 2007, and Castagnino and D'Amato, 2008).

Inflation is the result of multiple price decisions in response to changes in costs of production, demand conditions and economic policy signals. The type of response to these impulses depends on the environment in which agents make their price decisions. Inflation dynamics is, in this sense, *regime specific* since it depends on the way that economic policy, in general, and monetary policy, in particular, operate.

The dependence of inflation dynamics on the monetary regime was first noted by Fisher (1982), who emphasized that loose monetary policies could have perpetuated the effects of supply shocks in the United States case during the 1970s. More recently, Ball and Mankiw (1995) also discussed how sectoral price adjustment distribution could be influenced by the inflationary environment.

However, the notion of regime has remained fairly vague in the literature probably because it is an *unobservable* related to institutional factors that define a framework for the interactions between economic policy and private agents, influencing their expectations and decision-making. We begin by identifying regimes based on the outcomes of these interactions. In particular, we assume that the trend inflation prevailing in an economy can be considered as a proxy for the prevailing monetary regime.[1] From an empirical perspective, the recent empirical literature on inflation persistence provides evidence that changes in trend inflation are associated to changes on the monetary regime.[2]

However, the use of trend inflation as a criterion to identify regimes leaves aside an important feature of inflation behavior: The sectoral price adjustment dynamics behind a given trend inflation. On the one hand, in terms of the underlying relative price dynamics, a regime may precede its manifestation when a shock occurs. On the other hand, the prevalent dynamics is not necessarily the same in the different economies. In small open economies, frequently subject to external disequilibria, macroeconomic policy itself may be an important source of relative price variability, usually through currency devaluations that aim at correcting disequilibria in the real exchange rate. In this regard, the tradable-non tradable price

[1] See in this respect Kiley (2006), Blake and Fernández-Corugedo (2006), and Ascari and Ropele (2007), among others.

[2] See, for example, Levin and Pigier (2004), Altissimo et al., Mojon and Zaffaroni (2004), Altissimo et al. (2006) and Angeloni et al. (2006) and D'Amato et al. (2007) for the Argentine case.

dynamics can be relevant to explain inflation behavior in emerging countries, unlike industrial economies where the shocks to energy and food prices seem to prevail. In both cases, it is interesting to study how the pass-through of aggregate shocks of different nature to inflation may change in terms of its generalization and persistence, depending on the inflationary environment.

We study inflation dynamics and its relation with the monetary regime in Argentina and the United States over the last 50 years. Over this period both countries experienced high, moderate and low inflation. The differences in size and development between both economies are quite significant, as well as the in the type of aggregate shock to which they were typically subject to. In the United States, shocks to energy and food prices hit the economy in the 1970s and 1980s, while in Argentina, policy shocks, usually in the form of exchange rate adjustment aiming at correcting external imbalances or stabilizing inflation, prevailed.

Our purpose is to study to what extent inflation dynamics may change depending on the inflationary environment and the nature of shocks. In Section 2 we identify regimes using the Bai-Perron test (2003). In Section 3, we characterize regimes by studying the differences in the comovement induced by aggregate shocks to sectoral inflation rates under different inflationary environments. In Section 4, we use frequency-domain analysis to identify sectoral patterns in the responses to aggregate shocks. Finally, Section 5 concludes.

2. INFLATION REGIMES: A FIRST APPROXIMATION USING THE BAI-PERRON TEST

We identify regime changes trough breaks in trend inflation, which in this context is considered a proxy of the regime, using the Bai-Perron test. In Table 1 we present the trend inflation rates corresponding to the different regimes identified in Argentina and the USA.

In the case of the USA, we identify a low inflation regime between 1961 and 1967, a moderate inflation regime between 1967 and 1972, and one of high inflation between 1974 and 1981. As stressed by De Long (1995) and Sargent (1999), the persistent intends by policy makers to exploit the inflation-unemployment trade-off over these years created an inflationary environment, in which the successive oil shocks that hit industrialized economies between 1974 and 1981, led to a high trend inflation in the

USA.[3] This period was followed by a disinflation between 1982 and 1990 under Volker's administration of the Federal Reserve. The last period, 1991-2007, can be considered as a low inflation regime in which the Fed was successful in maintaining inflation under control, despite the shocks to food and energy prices that prevailed since 1999.

TABLE 1. MONETARY REGIMES AND TREND INFLATION: ARGENTINA AND UNITED STATES, 1960-2007

Argentina		*United States*	
Regime	*Monthly CPI inflation (mean)*	*Regime*	*Monthly CPI inflation (mean)*
Moderate inflation 1961m01-1974m12	2.09	Low inflation 1960m01-1966m12	0.13
High inflation 1976m07-1982m06	6.08	Moderate inflation 1967m01-1972m12	0.32
Very high inflation 1982m07-1988m06	9.74	High inflation 1974m01-1981m12	0.47
Low inflation 1993m01-2001m12	0.04	Disinflation 1982m01-1990m12	0.32
Low-moderate inflation 2003m01-2006m12	0.67	Low inflation 1991m01-2007m12	0.18

In Argentina, regime changes frequently appear associated to *i)* sharp devaluations of the currency, following an external or financial crises or *ii)* the implementation of stabilization programs based on the use of the nominal exchange rate as an anchor for inflation. We identify a moderate inflation regime between 1961 and 1974, a high inflation period between 1976 and 1981 and a very high inflation regime between 1982 and 1988. This last regime ended up in two hyperinflationary episodes in 1989 and 1990. Leaving aside both, the hyperinflations episodes and the disinflation following the implementation of a currency board regime known as the *Convertibilidad* (the period between 1991m4 and 1992m12), we identify a low inflation regime between 1993 and 2006. When this last period is considered separately, it is possible to identify two regimes: one of very low inflation corresponding to the Convertibility regime (1993-2001) and a moderate-low inflation period between 2003 and 2006, after a sharp devaluation of the currency in 2002 and the adoption of a managed float.

[3] We deliberately exclude the observations corresponding to 1973 from the high inflation period, due to the strong impact of the first oil stock that took place on this year on the dynamics of USA inflation, what could distort the results for this period.

A salient feature of Table 1 is the sharp difference in trend inflation between Argentina and the United States, especially in the moderate and high inflation regimes. It is also worth noting that trend inflation in the low inflation regime in Argentina is considerably lower than that of the United States (0.04% vs. 0.18%), that can be explained by the fact that Argentina experienced a deflation during part of this period, whereas in the USA inflation does not follow any trend. This suggests that the underlying inflation dynamics could be different between this two economies.

Although both economies are very different in size and economic development, what shows up in the very different composition of their consumption baskets, the comparison between Argentina and the United States is especially interesting because of the different nature of the shocks that contributed to explain inflation dynamics in both countries: In the United States, the shocks to food and energy prices have been an important source of innovations to the inflation rate while in Argentina, as in other emerging economies, policy shocks seem to have prevailed.

Table 2 clearly illustrates such difference by comparing food and energy CPI inflation versus non-food and energy CPI inflation across the different regimes in both countries. In the USA, food and energy inflation exceeds non-food and energy inflation in both high and low inflation regimes, when shocks to these items occur. Instead, in Argentina, inflation dynamics could hardly be explained by those shocks. The dimension of the inflationary phenomenon suggests that other forces, probably of domestic origin, must explain the very high inflation rates observed in those years and their further decline.

TABLE 2. INFLATION: FOOD AND ENERGY, AND OTHERS COMPONENTS IN ARGENTINA AND UNITED STATES, 1960-2007

Argentina			*United States*		
Regime	*Food and energy (%)*	*Others (%)*	*Regime*	*Food and energy (%)*	*Others (%)*
Moderate inflation 1961m01-1974m12	1.99	2.14	Low inflation 1960m01-1966m12	0.12	0.14
High inflation 1976m07-1982m06	6.11	6.04	Moderate inflation 1967m01-1972m12	0.28	0.34
Very high inflation 1982m07-1988m06	9.58	9.81	High inflation 1974m01-1981m12	0.51	0.45
Low inflation 1993m01-2001m12	0.02	0.04	Disinflation 1982m01-1990m12	0.26	0.33
Low-moderate inflation 2003m01-2006m12	0.54	0.72	Low inflation 1991m01-2007m12	0.22	0.16

3. INFLATION REGIMES AND COMOVEMENT

Inflation regimes can also be described by the pass-through of shocks to the inflation rate and also by the predominance of some sort of aggregate shock. For example, in a high inflation environment, such as it was the case of Argentina by the end of the 1980s, the behavior of money and prices should be mostly driven by inflation expectations. In this environment, a strong comovement in sectoral inflations should prevail. On the contrary, in low inflation environments, idiosyncratic price movements should predominate, with scarce trend comovement across sectoral inflation rates. This suggests that sectoral responses to shocks may differ, depending on the regime and also on the predominant type of shock.

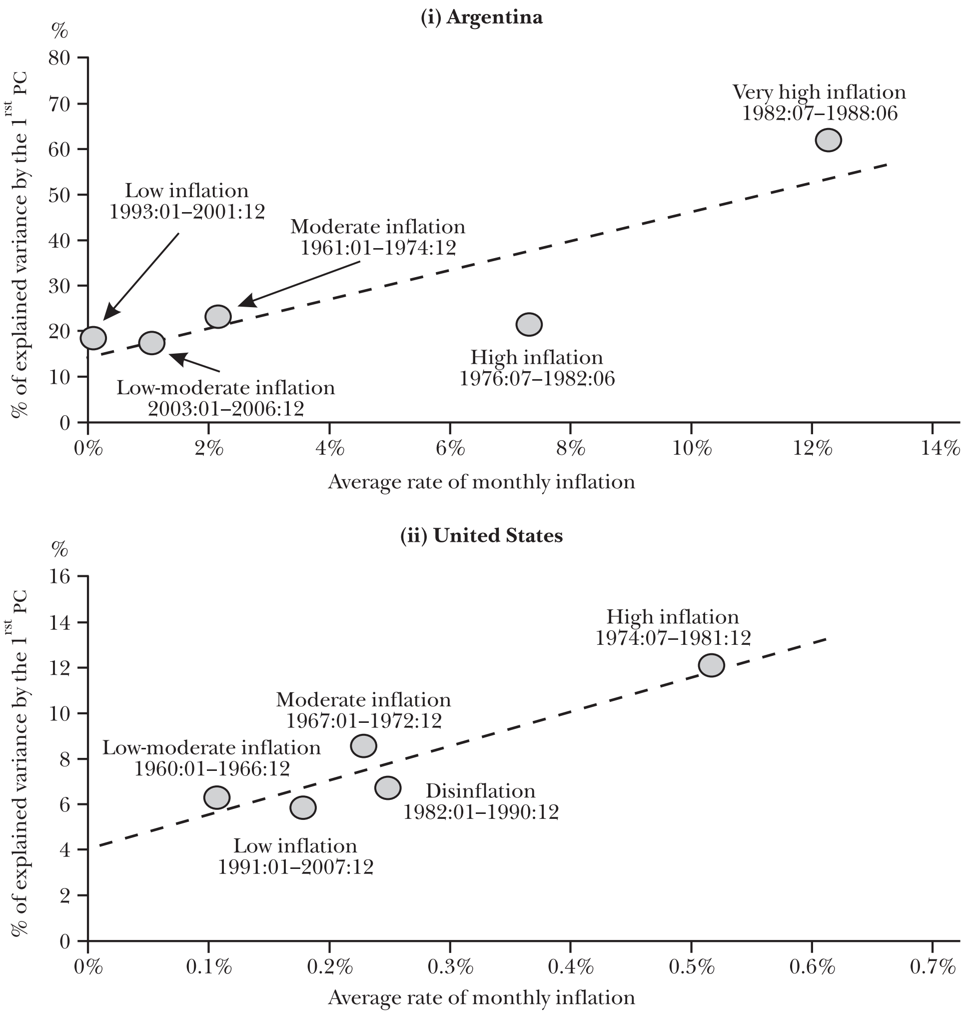
To look into these differences, we consider a measure of the joint response of sectoral inflations to aggregate shocks, given by the portion of the joint variance of sectoral inflation rates explained by the first principal component of CPI inflation.[4] A high portion of these variance explained by the first component indicates a high comovement in sectoral inflation rates. We expect the occurrence of aggregate shocks to induce a higher comovement, resulting in an increase in the variance explained by the first principal component. Our intuition suggests that the persistence of the comovement induced by the shocks may vary according to the inflationary environment.

The cross-plots in Figure 1 show the relation between trend inflation and the portion of variance explained by the first principal component of inflation for Argentina and the United States. Though the differences in the magnitude of trend inflation between Argentina and the United States under high inflation are quite significant, as it is also the case for the portion explained by the first principal component, a common feature of both economies is that as trend inflation increases, the portion of variance explained by the first principal component also increases, reflecting an growing comovement across sectoral inflation rates. Thus, it seems that in high inflation environments the comovement across sectoral inflations is high and tends to prevail over idiosyncratic movements.

To study the pass-through of aggregate shocks to the sectoral inflation rates and the degree of comovement they create under different environments, we construct three estimators: *i)* a recursive estimator whose

[4] See Appendix 1 for a detailed description of the sectoral CPI inflation series used for the cases of Argentina and the United States, and Appendix 2 for a description of the methodology employed to estimate the common shocks.

FIGURE 1. TREND INFLATION AND PROPORTION OF EXPLAINED VARIANCE BY THE FIRST PRINCIPAL COMPONENT OF INFLATION

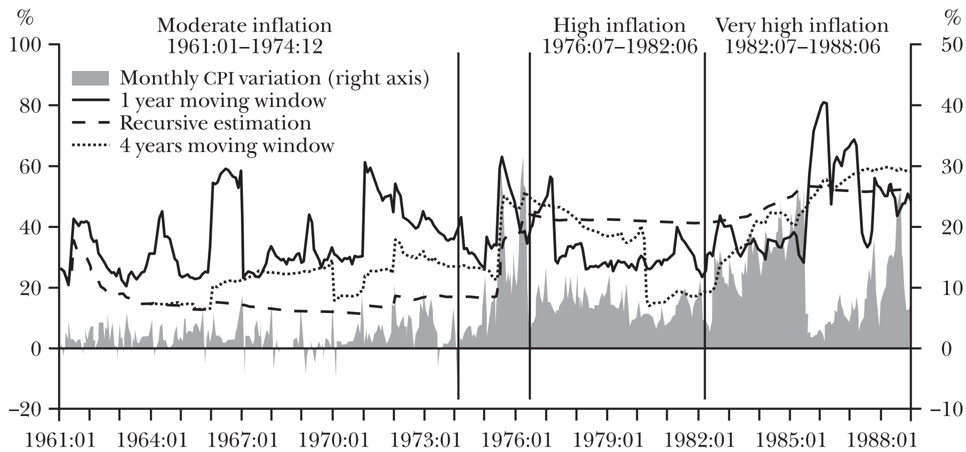


calculation starts a year before the initial observation of the sample which is recalculated as more observations are added, *ii)* a four-year rolling window and *iii)* a one-year rolling window.

Figures 2 to 5 show the evolution of the inflation rate in the different regimes, together with the three estimators of the common shocks.

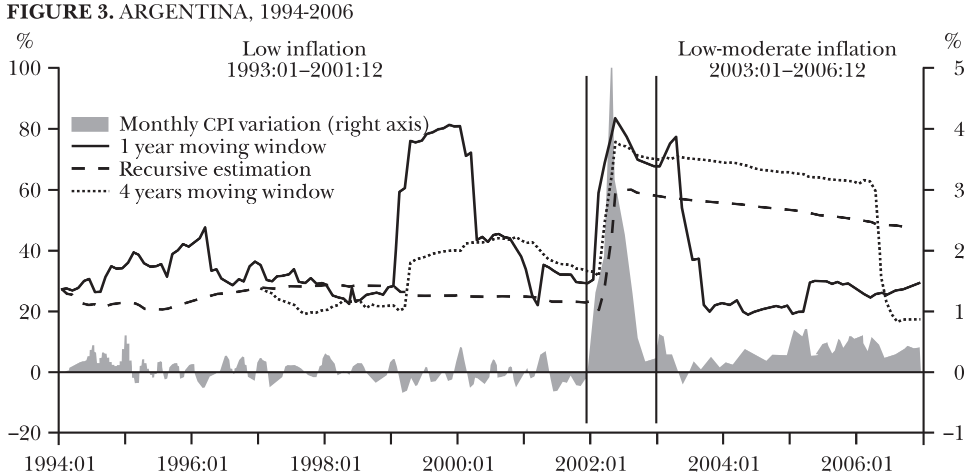
As can be seen from the Figures 2-5, the one-year rolling window allows identifying shocks of such magnitude as to generate a strong comovement, even temporarily. These shocks reflect in peaks in the variance

FIGURE 2. ARGENTINA, 1960-1988



explained by the first principal component, giving evidence of a generalized comovement in sectoral inflation rates. This seems to be consistent with the arguments of Sheshinski and Weiss (1977) and Dotsey et al. (1999), who suggest that sudden and significant changes in market conditions generate coordination in price adjustments.

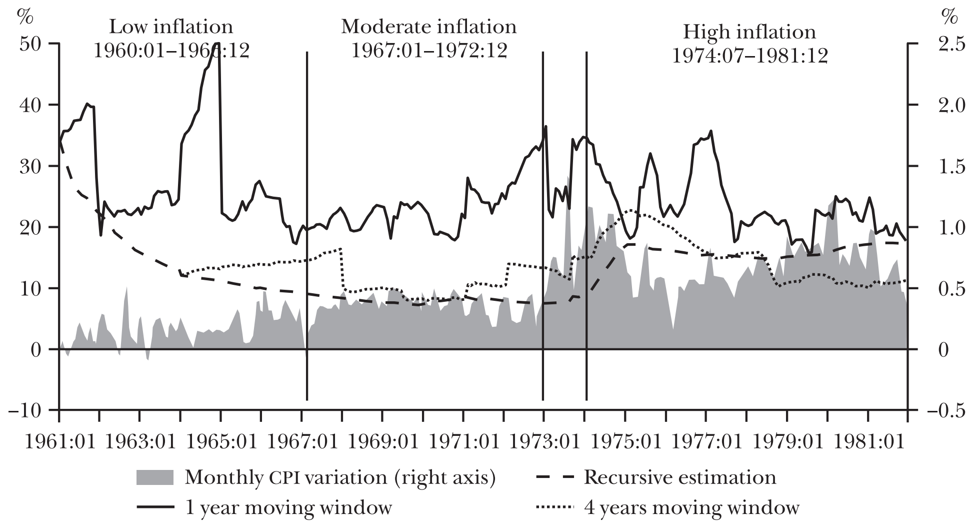
FIGURE 3. ARGENTINA, 1994-2006



When identifying the events related to these peaks, the sources of comovement are quite different between the two economies: In the United States, there is a clear predominance of shocks to food and energy prices as main source of inflation variability (see the peaks in 1973, 1979, 1987, 1991, 1999, 2001, 2004 and 2007).[5,6]

In Argentina the peaks are clearly related to depreciation episodes, usually preceded by periods or real appreciation of the currency as in 1961, 1964, 1966, 1969, 1971, and 1975.

FIGURE 4. UNITED STATES, 1961-1981



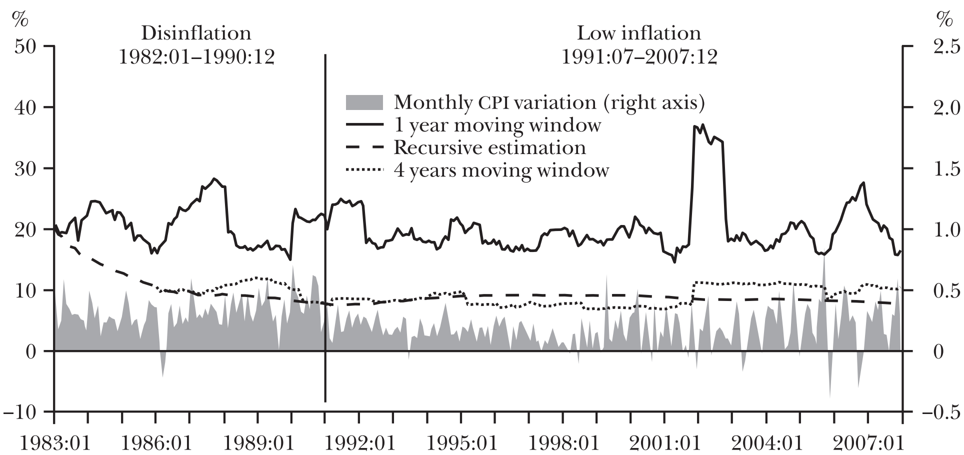
The recursive estimation and the four-year rolling window reveal the differences across regimes in terms of the persistence of the comovement induced by aggregate shocks on the sectoral inflation rates. In the United States the shocks to energy prices predominate as a source of inflation variability in both regimes (high and low inflation), but their impact under high inflation was clearly persistent, as shown by the recursive estimation of the variance explained by the first principal component. On the contrary, under low inflation, the oil price increase in 1999 and the subsequent shocks to energy and food prices seem to have had only a temporary effect on inflation. In other words, unlike the high inflation regime, in the recent low inflation regime these shocks have only caused a temporary comovement in sectoral inflation rates.

[5] See in this respect De Gregorio et al. (2007).

[6] A peak of great magnitude can also be observed in 1964, which could be associated to the beginning of the Vietnam War. The following peak, in 1971, corresponds to the moment when the United States announced the abandonment of the gold standard.

In the case of Argentina, we can clearly see how the transition towards a higher trend inflation comes together with an increasing persistence of the comovement among the sectoral inflation rates driven by aggregate shocks (see Figure 2). Likewise, in a low and stable inflation environment as from the adoption of the Convertibility regime, the aggregate shocks seem to have had a more transitory effect on inflation (see Figure 3).

FIGURE 5. UNITED STATES, 1991-2006



Shocks to the exchange rate prevailed in Argentina during the moderate and high inflation regimes. Their impact seems to have been quite transitory under the moderate inflation regime and more long-lasting under high inflation. In 1975, the *Rodrigazo* inflationary episode, which resulted in a change of regime in terms of the trend inflation (see Table 1), had a permanent effect on inflation dynamics in terms of the portion of the variance explained by the first principal component, which increased from 20% to over 40% remaining at around that level for a long period. An unstable money demand governed by inflation expectations and a persistent flight towards a reserve currency, gave the features of an inflationary process à la Cagan to the money-inflation dynamics over these years.[7] The increasing trend of inflation as from that moment was accompanied by an also growing comovement in sectoral inflations, as shown by the recursive estimation.

[7] See in this respect Basco, D'Amato and Garegnani (2009).

As illustrated in Figure 3, the transition towards a low inflation regime, with the adoption of a currency board, considerably reduced sectoral inflation comovement. Also it seems that in a low inflation environment, the effects of aggregate shocks became less persistent. In this regard, the impact of the devaluation episode of January 2002 was restricted and temporary, both on the CPI inflation rate and on the comovement across sectoral inflation rates, if compared to the effect of currency devaluations in the high inflation regimes.[8]

Summing up, previous results suggest that inflation regimes are different not only in terms of the prevalent trend inflation but also in terms the inflation dynamics induced by aggregate shocks: In high inflation environments the comovement generated by aggregate shocks is higher and tends to perpetuate. The transition from moderate towards high inflation regimes is not immediate. Rather, it seems to develop fairly slowly. Although these features seem to be common to both economies, the differences in the level of inflation among them are so important as to require a deeper insight into the causes of such differences. With this purpose, we go deeper in the next section in analyzing the sectoral responses to aggregate shocks.

4. COMOVEMENT AND SECTORAL PATTERS BEHIND INFLATION DYNAMICS

Price formation in each sector can be decomposed into a response to a common macro-economic shock, the first principal component of inflation, which is assumed to be driven by unobservable underlying forces (such as supply or demand shocks to which all sectors are exposed) and an idiosyncratic component that reflects sectors' heterogeneity in terms of demand, technology, climate factors, etc. Thus, each i sector' inflation dynamics can be written as

$$\pi_{it} = \lambda_i(L)U_t + \varepsilon_{it}, \tag{1}$$

where $U_t = (u_t, u_{t-1}, ..., u_{t-q})$ is a vector of the common shock and its relevant lags, $\lambda_i(L)$ is the response of sector i to the common shock and ε_{it} is the idiosyncratic component of sectoral inflation. Note that the sectoral responses to common shocks are not necessarily the same: The

[8] See in this respect Burstein et al. (2005), who investigate the causes of the limited pass-through of the currency devaluation in January 2002 to the CPI inflation.

higher the dispersion between the lag polynomials $\lambda_i(L)$, the higher the heterogeneity.

Likewise, the way in which a common shock passes through could also vary according to the inflation regime. That is, the macroeconomic environment could influence price responses to aggregate shocks. As shown in Figure 4, in a high inflation environment the sectoral responses to the common shock [in terms of Equation 1, the lag polynomials $\lambda_i(L)$] would be more homogeneous and more asymmetrically distributed, reflecting the prevalence of positive changes in prices, leading to a more generalized comovement across sectoral inflation rates and a higher trend inflation.

On the contrary, when inflation is low, the distribution of sectoral responses to aggregate shocks should be more heterogeneous and, if there are no sizable relative price shocks and/or a significant persistence, there would probably be no remarkable patterns in the aggregate inflation trend. Instead, in the presence of relative price shocks of some magnitude, the conventional adjustment mechanisms would operate, resulting in responses of different sign to the common shock across the groups of sectors, though without influencing the inflation trend (because of compensations).

While common shocks have a persistent or long-run effect on inflation, idiosyncratic innovations are usually temporary. These latter movements in prices are not of great concern from the macroeconomic policy point of view, which is expected to react to generalized movements in prices that persist over time. To identify the different sources of variability in inflation, we resort to frequency-domain analysis, a useful tool that allows breaking down time series into periodic contributions to their variance, providing a more natural description of their behavior at different time horizons or frequencies (e.g., short and long-run). In the bivariate case, frequency-domain analysis allows to compute the covariance at specific frequencies.[9]

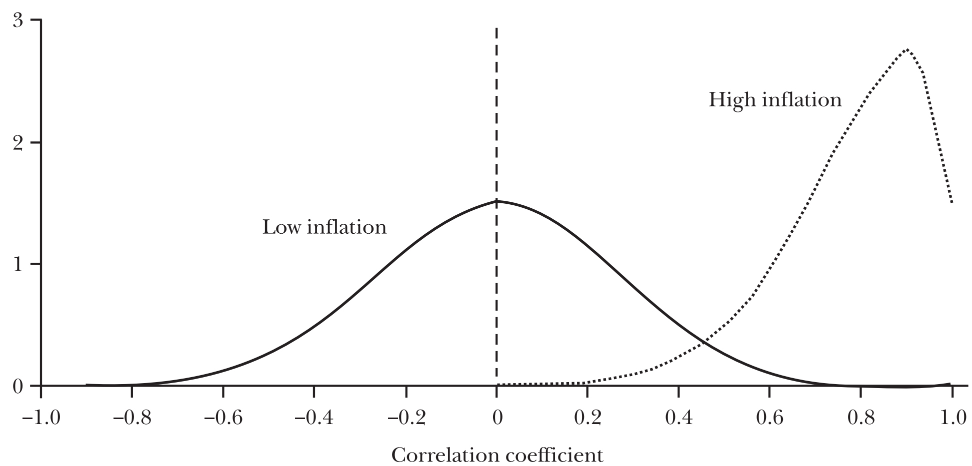
To find out to what extent sectoral responses to common shocks follow a specific pattern depending on the regime, we provide an approximate measure of the sectoral responses to the common shock, the polynomials $\lambda_i(L)$, by calculating the correlation coefficient between the first principal component of inflation and each individual inflation series at different time horizons. More specifically, we calculate correlation coefficients by frequency band according to

[9] Appendix 3 provides a more detailed description of this technique.

$$(2) \qquad \rho(\omega_1,\omega_2)=\frac{Cov(\tilde{\pi}_i(\omega_1,\omega_2);\tilde{U}(\omega_1,\omega_2))}{\sqrt{Var(\tilde{\pi}_i(\omega_1,\omega_2))}\sqrt{Var(\tilde{U}(\omega_1,\omega_2))}},$$

where $\tilde{\pi}_i(\omega_1,\omega_2)$ and $\tilde{U}(\omega_1,\omega_2)$ are frequency-band-specific time series extracted from data vectors, π_i is sector i inflation rate and U is the first principal component of inflation,[10] and $Cov(\circ)$ and $Var(\circ)$ are the covariance and the variance of these time series, respectively.

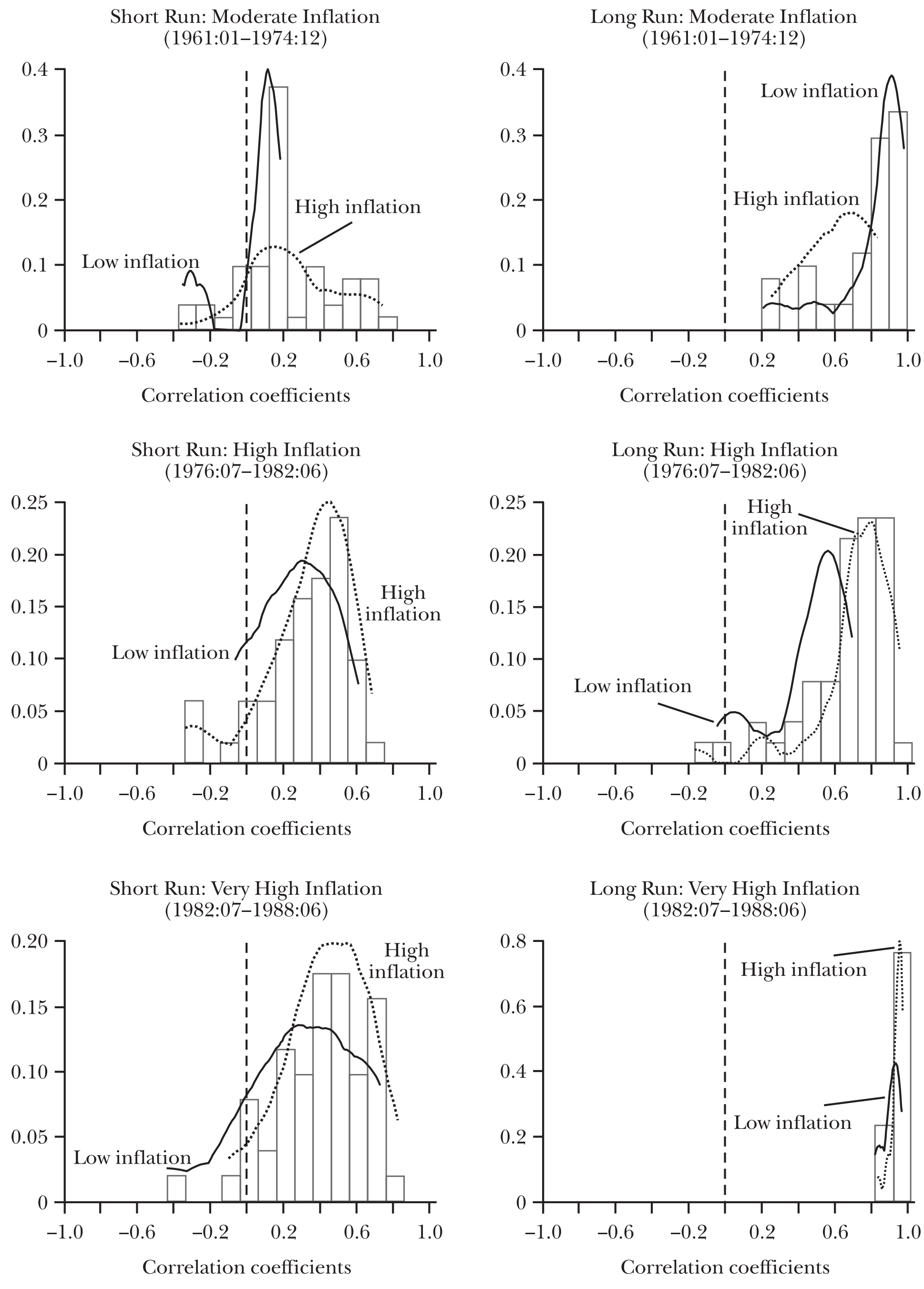
FIGURE 6. THEORETICAL FREQUENCIES DISTRIBUTION OF THE SECTORIAL INFLATION RESPONSES TO THE COMMON SHOCK

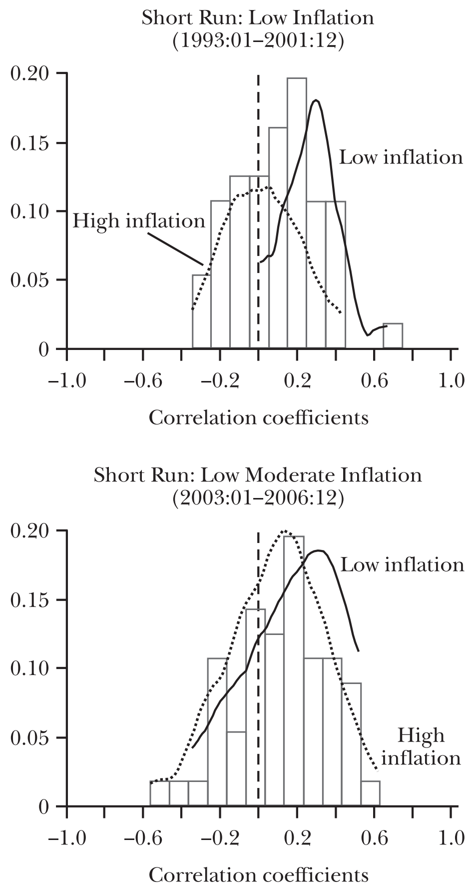


We consider two frequency bands: *Short-run* or high frequency (describing cycles shorter than three months) and *long-run* or low frequency (corresponding to cycles longer than two years). Figures 7 and 8 show the histograms of the estimated correlation coefficients between the first principal component of inflation and each individual time series in each of the regimes and for both countries. The shape of the histograms is informative about the strength of the comovement of the sectoral inflation rates with the common shock. On the one hand, the asymmetry of the distribution is an indication of comovement. If more frequency is concentrated on the right side of the histogram, sectors would be responding positively on average to the common shock. If it concentrates on the left side, then the opposite would be happening. If the histogram is centered, then sectoral responses would be offsetting themselves. On the other

[10] Appendix 4 describes in detail the filtering process in the frequency domain.

FIGURE 7. ARGENTINA – SECTORAL RESPONSES TO THE COMMON SHOCK, 1961-2001

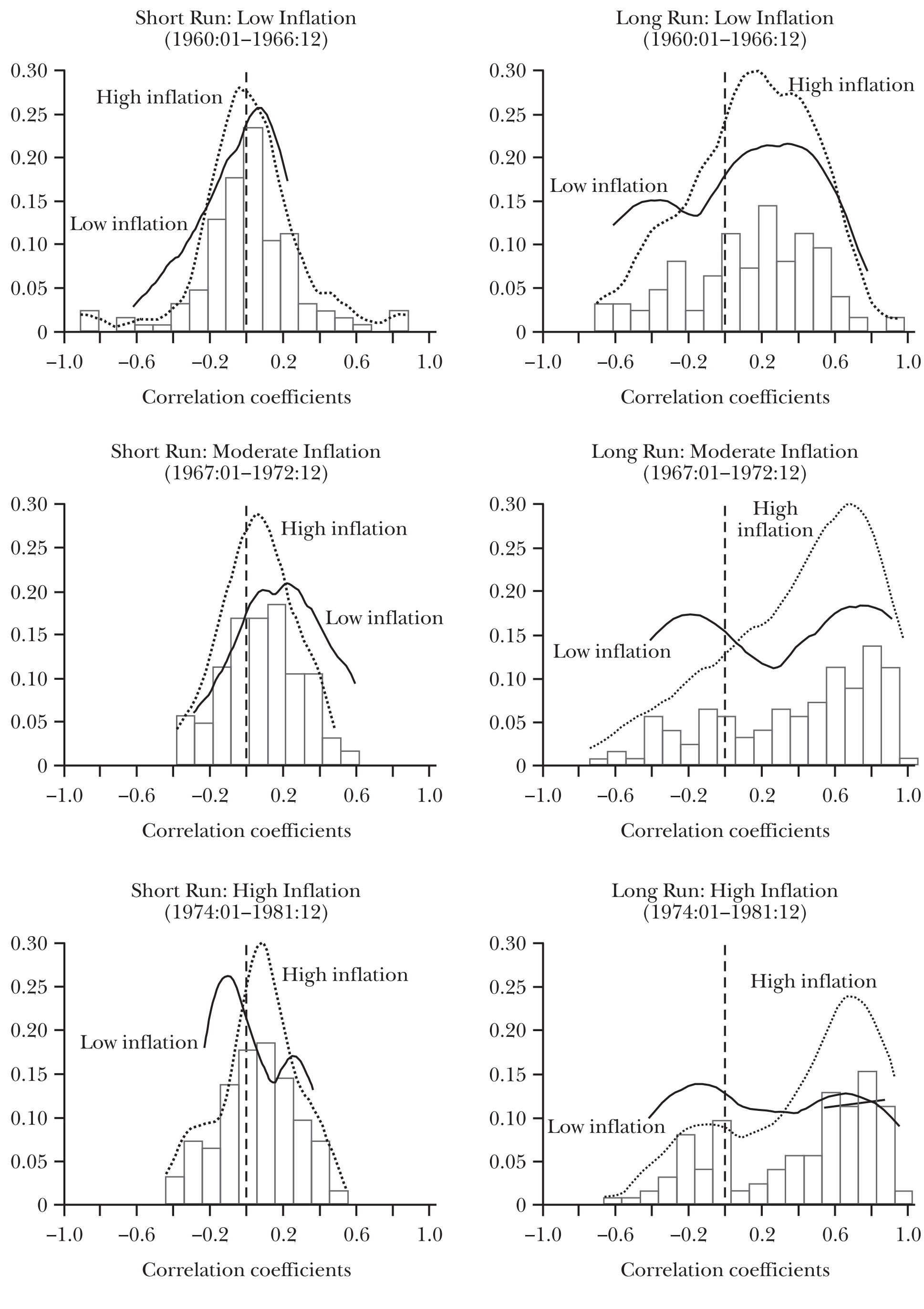


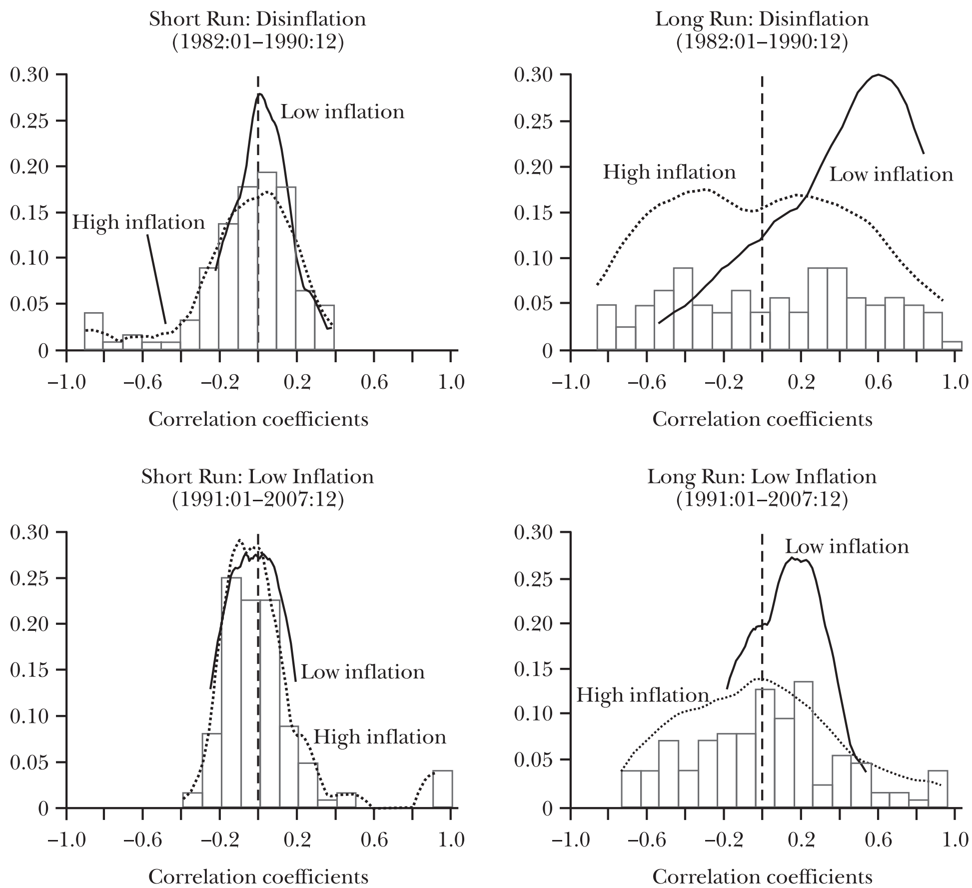


hand, the dispersion of the histogram indicates how generalized the comovement is. The lesser the dispersion, the more homogeneous the response of sectoral inflation rates to the aggregate shock.

Some features are common to both countries. In the short run the correlations are closer to zero on average, indicating a weak incidence of the common shock at this frequency. However, while in the case of the United States the distributions are centered in zero, in the Argentine case they are somewhat biased to the right. In this latter case, the aggregate shocks seem to induce a positive trend in sectoral inflation rates even in the short term. The higher inflation rates experienced by Argentina would explain such differences.

FIGURE 8. UNITED STATES – SECTORAL RESPONSES TO THE COMMON SHOCK, 1960-2007





As stated before, the particular characteristics of each regime are more clearly evident in the long run. In fact, at this frequency, the moderate to very high inflation regimes show a higher proportion of sectors comoving positively with the common shock. Likewise, in line with the evidence in the previous section, the higher the aggregate inflation rate, the sharper and more generalized the comovement. An extreme example in this regard is the very high inflation regime in the 1980s, when the distribution almost collapses in extreme values of correlation.

In turn, under the low inflation regimes (including the USA disinflation period), the short-run responses to shocks are even closer to zero on average (especially in the USA case), indicating an even lesser incidence of the common shocks on sectoral inflation rates. However, long-run responses have quite different patterns in both countries. While in the USA the sectoral responses are disperse and centered in zero, perfectly in line with what is expected in a low inflation period, Argentina departs strongly from that a priori, showing a positive and generalized comovement of sectoral inflation rates with the common shock.

The identification of sectoral patterns behind inflation dynamics helps to explain more accurately these features. As suggested above, shocks to the real exchange rate (RER) are an important source of CPI inflation variability for a small open like Argentina. In this regard, the distinction between tradable and non-tradable goods (whose relative prices may be considered a proxy of RER) seems to be adequate in this case. On the contrary, the distinction between the food and energy and non-food and energy seems to be more adequate for the United States, given the importance these shocks have historically had for the behavior of the headline inflation. Tables 3 and 4 show the long-run average responses for these groups of sectors in the different regimes and evaluate whether these responses are significantly different, using the Mann-Whitney rank-sum test. In addition, in Figures 7 and 8 we have overlapped to the histograms the estimation of the frequency distribution of the correlations with the common shocks for tradable versus non-tradable goods prices, in the case of Argentina, and food & energy versus non-food & energy components, in the case of the United States.[11]

As can be seen from Figures 7 and Table 3, in the Argentine case, the responses of tradable and non-tradable goods prices to common shocks are significantly different across all the regimes, thus confirming the importance of this relative price dynamics to explain the behavior of inflation in Argentina. Table 3 also reveals that mean responses to the aggregate shocks of the food and energy sectors versus the non-food and energy sectors are not significantly different for any of the regimes, what plays down the importance of this type of adjustment to explain the inflation dynamics in Argentina. This evidence is consistent with the poor performance exhibited by CPI inflation indices that exclude food and energy prices as indicators of core inflation for Argentina (see D'Amato et al., 2006). These findings reveal certain patterns in the importance of comovement vis-à-vis relative price adjustment to explain aggregate inflation dynamics across inflation regimes. Though we cannot precisely estimate how the relative importance of these two drivers of inflation dynamics varies

[11] To this effect, the Kernel non-parametric estimation technique is used.

TABLE 3. ARGENTINA: MANN-WHITNEY TEST FOR DIFFERENCES IN MEAN

	Argentina							
	Mean responses		*Statistic*	*p-value*	*Mean responses*		*Statistic*	*p-value*
	No tradables	*Tradables*			*Food and energy*	*Other*		
Moderate inflation 1961m01-1974m12	0.620	0.802	2.918[a]	0.004	0.714	0.786	1.752	0.080
High inflation 1976m07-1982m06	0.459	0.712	3.535[a]	0.000	0.574	0.695	1.773	0.076
Very high inflation 1982m07-1988m06	0.909	0.942	2.420[b]	0.016	0.918	0.942	1.900	0.058
Low inflation 1993m01-2001m12	0.640	0.595	−4.768[a]	0.000	0.600	0.615	0.190	0.850
Low-moderate inflation 2003m01-2006m12	0.695	0.660	−3.002[a]	0.003	0.583	0.703	1.841	0.086

[a] significant at the 1% level; [b] significant at the 5% level.

across regimes, our findings suggest that the relative importance of comovement increases with trend inflation. In one extreme, in a very high inflation environment (Argentina during the 1980s) the tradable-non tradable adjustment seems to be less significant and a strong comovement across the sectoral inflation rates is the prevailing feature. In the intermediate moderate-to-high inflation regimes in the 1960s and the first half of the 1970s, neither relative price adjustment nor comovement seems to prevail; both factors would be relevant to explain the dynamics that underlies the headline CPI. Under a low inflation context, such as the case of Argentina during the Convertibility regime, relative price adjustment prevails over comovement.

In the case of the United States, the histograms in Figures 8 and Table 4 also confirm that the distinction between food and energy, and non-food and energy is adequate for the last two periods of low inflation. The relative lowering of food prices during the disinflation period in the 1980s and their relative rise after the shocks to commodity prices experienced as from 1999 onwards, during the low inflation period of the 1990s-2000s would explain such developments, contrary to the low inflation period of the 1960s in which the responses seem to be heterogeneous without showing any specific sectoral pattern.

Another feature that is worth mentioning is the distinctive way in which the USA economy responded to similar supply shocks (i.e., aggregate relative price shocks) under low and high inflation. During the 1970s,

TABLE 4. USA: MANN-WHITNEY TEST FOR DIFFERENCES IN MEAN

	United States							
	Mean responses		*Statistic*	*p-value*	*Mean responses*		*Statistic*	*p-value*
	No tradables	*Tradables*			*Food and energy*	*Other*		
Low inflation 1960m01-1966m12	0.059	0.142	0.654	0.513	0.044	0.164	1.713	0.087
Moderate inflation 1967m01-1972m12	0.284	0.400	0.719	0.472	0.412	0.365	−0.379	0.704
High inflation 1974m01-1981m12	0.243	0.434	1.740	0.082	0.270	0.420	1.008	0.313
Disinflation 1982m01-1990m12	0.406	−0.013	−3.565[a]	0.000	0.034	0.073	0.515	0.607
Low inflation 1991m01-2007m12	0.121	−0.010	−2.021[b]	0.043	0.123	−0.036	−2.081[b]	0.037

[a] significant at the 1% level; [b] significant at the 5% level.

comovement in response to these common shocks seems to be a feature shared on average by both group of sectors. It is worth noting that, in this case, the mean responses of the two groups are not statistically significant. Additionally, sectoral responses do not differ significantly from those observed previous to the oil shock, indicating that a more generalized comovement across sectoral inflation rates was present before the occurrence of the oil shocks. In this sense, and in relation with the controversy about the determinants of high inflation in the USA in the 1970s and 1980s, this finding is more consistent with the explanation provided by De Long (1997) and Sargent (1999) than with that of Ball and Mankiw (1995). On the contrary, under the current low inflation regime, each group of sectors seems to respond differently and even in the opposite direction. More precisely, food and energy prices increased relatively (see the positive correlation with the common shocks of this group of sectors versus the negative covariation of the rest), giving evidence of the importance of the relative price adjustment behind inflation dynamics in the last period.

Summing up, the results obtained for the different inflation regimes in Argentina and the United States, suggest that the incidence of supply shocks has restricted to a reduced group of sectors in the last period (i.e., they have become less common). In the USA case, this is clear in the comparison between high and low inflation regimes, both subject to sizable shocks to oil and food prices. It is also clear in the case of Argentina, if we take into account the lower pass-through to domestic prices of the exchange rate devaluation of 2002 vis-à-vis previous episodes occurred in high inflation environments. This leads us to a second conclusion: a low inflation macroeconomic environment gives the conventional mechanisms of relative price adjustments more room to operate, i.e. the persistence of comovement across sectoral inflations induced by aggregate shocks depends to some extent on the inflationary context.

5. CONCLUSIONS

We study inflation dynamics in Argentina and the United States in the last 50 years. Both countries experienced low, moderate and high inflation. We find that inflation dynamics is not restricted to a generalized and persistent price comovement. Rather, it also reflects relative price adjustments which are persistent and do not only confine to short-run idiosyncratic noise.

Our results also indicate that the relative importance of relative price dynamics vis-à-vis generalized comovement between sectoral inflation rates depends on the monetary regime: In high inflation environments, when nominal impulses are an important source of inflation variability, comovement prevails over relative price adjustments. On the contrary, in a low inflation context, the opposite is true.

While aggregate shocks to inflation dynamics increase the comovement between sectoral inflation rates, their incidence varies according to the inflationary environment: Under high inflation, aggregate shocks induce a stronger comovement which tends to perpetuate. In turn, the transition from moderate inflation to high inflation is a slow process, i.e. price comovement increases as the trend inflation rises.

Likewise, the different nature of the aggregate shocks prevailing in each economy seems to impress distinct features to inflation dynamics. In Argentina, where there is a clear predominance of shocks to RER, the tradable-non tradable dynamics is a common feature of all regimes under study. In the United States, the different adjustment between energy and food, prices versus non-energy and food prices seems to be relevant. These distinctive features of inflation dynamics in terms of relative price adjustments should be taken into account when modeling for the purposes of the monetary policy. They should also be considered when selecting a core inflation measure for monetary policy objectives: an ex energy and food core measure seems to be relevant for the United States, but not so much for Argentina.

Finally, our results show that, under a low inflation environment, supply shocks tend to become more idiosyncratic, i.e., they tend to propagate less. This is clear in the case of Argentina, if we consider the lower pass-through of the 2002 exchange rate devaluation to CPI inflation vis-à-vis other devaluations occurred under high inflation contexts, but also for the United States, if we take into account the differentiated impact of shocks to energy and food under high and low inflation regimes. In this sense, a general conclusion is that high inflation environments tend to hinder relative price adjustments in response to aggregate shocks, because they induce a generalized comovement with a persistent incidence on inflation.

Appendix 1

Data

Data includes monthly inflation rates of the Consumer Price Index (CPI). In the case of Argentina, indexes are from the Instituto Nacional de Estadística y Censos (Indec) and correspond to the three digits CPI disaggregation. We excluded from sample regulated goods and services. This left 51 sub-indexes for medium, high and very high inflation regimes and 56 sub-indexes for the low and very low inflation regimes, because the consumption basket changed from one period to another. Aggregate inflation rate was calculated as the weighted sum of the remaining sectoral inflation rates.

In the case of the USA, data on seasonally adjusted price indexes for all components of consumption as measured in the NIPA accounts are taken from the Bureau of Economic Analysis web site. The data used allows for breakdowns at various levels of aggregation. The results, included below, focus on the so called third level of aggregation (124 sub indexes excluding regulated services and tax intensive items), although estimates were also preformed for the second level of aggregation (65 subindexes making the same exclusions) without significant changes in the results. When aggregation was performed, fixed rather time-varying weights are used. Shares used are based on average expenditures in each period considered.

Appendix 2

Principal Components and Common Shocks

Formally, as in Clark (2003), we assume a static representation of the dynamic factor model (see Stock and Watson, 2002). Inflation in each sector i is a function of a common and idiosyncratic component:

(A.1) $$\pi_{it} = \lambda_i(L)U_t + \varepsilon_{it} ,$$

where $U_t = (u_t, u_{t-1}, ..., u_{t-q})$ is a vector of the common factor component and its relevant lags, $\lambda_i(L)U_t$ is the common component, ε_{it} is the idiosyncratic component and $U_t \perp \varepsilon_{it}$.

Aggregate inflation rate is:

(A.2) $$\pi_t = \sum_{i=1}^{n} \theta_i \, \pi_{it} = \sum_{i=1}^{n} \theta_i \lambda_i(L)U_t + \sum_{i=1}^{n} \theta_i \varepsilon_{it} = CCOM_t + ICOM_t ,$$

where $CCOM_t$ and $ICOM_t$ are the common component and the aggregate idiosyncratic component of inflation, respectively, and θ_i is sector i's weight in the consumption basket. In the empirical application of Section 4 we estimate sectors' responses to common shocks according to (A.1) and calculate $CCOM_t$ based on (A.2).

Appendix 3

Frequency Domain Analysis

Frequency domain analysis allows decomposing the evolution of a time series in defined periodic contributions to their variance, providing a more natural description of their structure in terms of cyclical behavior at different time scales. So, frequency domain techniques appear to be specially suited to study a dynamic process like inflation, which, as explained, is the result of two defined sources of variability that affect inflation dynamics with different frequency, i.e. common and idiosyncratic shocks.

Formally, the total variance of a covariance stationary process X_t with mean $E(X_t) = \mu$ and j_{th} auto-covariance equal to $\Gamma(j) = E(X_t - \mu)(X_{t-j} - \mu)$ can be represented in the time domain as $X_t = \mu + \sum_{j=0}^{\infty} \varphi \varepsilon_{t-j}$, where ε_t is an

$i.i.d.$ process with mean 0 and variance σ_ε^2. Analogously, the total variance of X_t can be represented as a weighted sum of periodic trigonometric functions of frequency ω such that $X_t = \mu + \int_0^\pi \alpha(\omega)\cos(\omega t)d\omega + $ $+ \int_0^\pi \delta(\omega)\sin(\omega t)d\omega$. The weight each of those cyclical components has in explaining total variance of X_t it is usually summarized in what is known as spectrum.

The spectrum of X is the Fourier transform of its covariogram[12] and is given by:

(A.3) $$s(\omega) = \frac{1}{2\pi}\left\{\Gamma(0) + 2\sum_{j=1}^{\infty}\Gamma(j)\cos(\omega\, j)\right\},$$

The variance corresponding to a determinate frequency band $\omega_1 \leq |\,\omega\,| \leq \omega_2$ is given by $S(\omega_1,\omega_2) = 2\int_{\omega_1}^{\omega_2} s(\omega)\; d\omega$. Trivially, integrating the spectrum over all frequencies, that is, between $\omega_1 = 0$ and $\omega_2 = \pi$, yields the overall variance of the series. The portion of the variance at very high frequencies relates to temporary movements in time series and the portion at low frequencies relates to the permanent, trend component of their variability.[13]

In a classic but disappointing paper, Granger (1966) describes the typical shape of the spectrum of the majority of economic variables as one that concentrates the higher portion of variance at lower frequencies and whose height decreases smoothly as frequency increases, concluding that "possibly, the estimation of the power spectra alone is unlikely to be a productive technique." Although Granger's conclusions are in general true, we will show that there still is valuable information in the spectral decomposition of inflation processes.[14]

To have a better insight of the different distribution of the variance across frequencies and between regimes it is convenient to isolate the frequency distribution of variance from the change in the level of inflation.

[12] That is, the autocovariance generating function $g(z) \equiv \sum_{j=-\infty}^{\infty}\Gamma(j)z^j$ evaluated at $z = e^{-i\omega} = \cos(\omega) - i\sin(\omega)$ (for a formal proof see Hamilton, 1994).

[13] As a matter of fact, the height of the spectrum at frequency zero is well-known non-parametric measure of the persistence of a time-series.

[14] In fact, the height of the spectrum at the zero frequency is a non-parametric measure of the persistence of a time series.

The reason is simple: If the persistence parameters have not changed and the decrease in variance is only due to the fact that the innovation variance has gone down, i.e., lower mean inflation but no change in autoregressive behavior of the time series, the normalized spectrum should be the same for any two regimes, indicating that the variance distribution across frequencies has not changed.[15] This can be attained by calculating the *normalized spectrum*, simply dividing the spectrum by its variance:

(A.4) $$h(\omega) \equiv s(\omega) / \Gamma(0) .$$

This measure indicates the fraction of total variance that occurs at each frequency and, thus, integrating $h(\omega)$ over all frequencies results in a value of 1.

Appendix 4

Filters in the Frequency Domain

In this appendix we formally present the filtering procedure implemented to extract frequency band specific time series from data vectors.

Frequency Band Extraction Procedure

To filter in the frequency domain, we apply a Fourier transform of the series. Formally, let consider a vector $x = \left[x_1,\, x_2,\, x_3, \ldots,\, x_T\right]'$. For $s = 1, 2, 3, \ldots, T$ frequencies are defined as $\omega_s = 2\pi s / T$. The finite Fourier transform of x at frequency ω_s is then

$$\omega_s x = T_{t=1}^{-1/2T} x_t e^{(t-1)i\omega_s} ,$$

where

$$\omega_s = T^{-1/2} \left[1\, e^{i\omega_s}\;\; e^{2i\omega_s}\; \ldots\, e^{(T-1)i\omega_s}\right].$$

Letting $W = \left[\omega_0\; \omega_1\; \omega_2\; \ldots\, \omega_{T-1}\right]'$, it can be shown that W columns are orthonormal such that $W^{*}W = WW^{*} = I$ and W is a unitary matrix,

[15] The formal proof is as follows. The spectrum of a $MA(\infty)$ covariance stationary process like X_t can also be expressed as $s(\omega) = (1/2\pi)\varphi(e^{i\omega})\;\sigma_\varepsilon^2(e^{-i\omega})$, after replacing in (A.2) for covariance generating function evaluated at $e^{-i\omega}$ (see Hamilton, 1994). Dividing $s(\omega)$ by X_t variance, $\sigma_X^2 = \sigma_\varepsilon^2 \sum_{j=0}^{\infty} \varphi_j^2$, yields $h(\omega) \equiv s(\omega)/\sigma_X^2 = [\varphi(e^{i\omega})\;\,(e^{-i\omega})]/[2\pi \sum_{j=0}^{\infty} \varphi_j^2]$ that is independent of σ_ε^2.

where * indicates the Hermitian conjugate, that is, the transpose of the complex conjugate, and I is the identity matrix. This matrix times any data vector will give in result the Fourier transform of that vector. $\tilde{x} = Wx$ is the vector of the discrete Fourier transform of time series x at all fundamental frequencies ω_s, for $s = 0, 1, 2, ..., T-1$.

We can define A as a TxT matrix which has ones on the diagonal for frequencies that are to be included and zeros elsewhere. Fourier transform of a time series x at the $[\omega_s, \omega_r]$ frequency band is then

$$A(\omega_s, \omega_r)\hat{x} = A(\omega_s, \omega_r)Wx.$$

Finally, the complex data vector $A(\omega_s, \omega_r)\hat{x}$ is converted back to the time domain by applying the inverse Fourier transform. The frequency band $[\omega_s, \omega_r]$ inverse Fourier transform of vector x is

$$\tilde{x} = W^* A(\omega_s, \omega_r)Wx.$$

Computational issues

Frequency domain analysis applied to finite samples is frequently subject to the wrap-around effect. Because of the assumption that series are periodic, filters in the frequency domain treat the last observation as being identical to the observation preceding the first one. To deal with this, we padded with zeros the excess of each series up to a sufficiently large number of frequency ordinates. As to work with a number of elements T equal to a power of 2, which is necessary for the filter to work accurately, we selected a number of frequency ordinates equal to 576.

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Inflationary Dynamics and Persistence in Costa Rica: Period 1953-2009

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1. INTRODUCTION

There are various definitions of *inflation persistence* in the economic literature, however, for the purposes of this paper we adopt the definition suggested by Marques (2004), who sees it as the speed with which inflation returns to its long term equilibrium value after a disturbance.[1] High values of the inflation rate suggest high values of persistence after a disturbance, thus because inflation converges more slowly towards its underlying or long-term equilibrium, while low values of this coefficient show a rapid convergence of the variable to its equilibrium level (Álvarez, Dorta and Guerra, 2000).[2] This is consistent with the statistical definition of persistence attributable to Fuhrer (1995), who conceived it as the tendency of a

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[1] He quotes definitions of Batini (2002), Batini and Nelson (2002) and Willis (2003), Andrews and Chen (1994) and also Pivetta and Reis (2001), pointed out that inflation persistence defined similarly. D'Amato, Sotes and Garegnani (2007) also embrace this definition.

[2] That is, there is high (low) inflation persistence when they are very long (short) deviations of inflation from its steady state level, After the occurrence of a shock (Céspedes et al., 2003)

variable to stay away from its average level over an extended period of time, once it is disturbed.[3]

According to that definition it is possible to indicate that the persistence is conditional on the long-term equilibrium level of inflation that is assumed. Marques (2004) argues that it is not always appropriate to assume that this equilibrium level is constant over time, although it is exogenous and unaffected by the inflationary shock.

It is important to study the phenomenon of inflation persistence with regard to the economic environment and particularly to the field of action of the central banking. For economic policy in general it is relevant to understand the rigidities that underlie the persistence of inflation, because it helps to shape and guide the process of structural reform aimed at improving efficiency and economic welfare. In fact, bringing about changes in the indexation of prices and wages in the economy, from retrospective to prospective factors, liberalizing regulated markets and promoting competition in key economic sectors can result in the reduction of inflation persistence (IMF, 2009).

For the conduction of the monetary policy it is also important to estimate the level (extent) and sources of inflation persistence in the economy, because that can help into to design appropriate responses to inflationary shocks and also because it allows to improve macroeconomic modeling and inflation forecasting. When inflation persistence is high, the response of the monetary policy should be gradual and the horizon of inflation targets relatively long. This because the higher inflation persistence is associated to a greater *sacrifice ratio* (in terms of cost in product stabilizing inflation in the short term) and it is more difficult to anchor inflation expectations to the inflation target of the central bank.

However, it is also argued that inflation persistence is affected by endogenous factors, including changes in the behavior of the price fixing process in the economy resulting from policy changes and the credibility

[3] It should be noted that inflation persistence, thus defined, is different from the concept of inflation inertia. According to Lendvai (2004), inertia is the slow response of one variable to unexpected changes in economic conditions, so that past levels of the variable (or past expectations about its current level) have a direct influence on their level today. He adds that the persistence of a variable can be generated by various sources, being the only one inertia. Also, inflation persistence is considered different to inflation uncertainty, which is difficult to predict inflation because of its variability (measured from the standard deviation of forecast errors of inflation, generated by an econometric model for a certain period). Thus, a greater variance of inflation forecast errors implies higher inflation uncertainty and vice versa (Solera, 2002).

of monetary policy. When the central bank attaches great importance to achieving its inflation target, it counteracts inflationary shocks, so they come to have less impact and lower inflation persistence. In the other hand, if the central bank has a more flexible inflation target, and it is also concerned with other factors (such as growth or employment) after an inflationary shock, then the central bank has to face greater persistence (Hansson et al., 2009).

In accordance with the importance of this issue, the main objective of this paper is to study the dynamics of inflation and persistence in the case of Costa Rica. We identified relevant facts of the inflationary process in Costa Rica, modeled changes in the average rate of inflation over time, depending on the major internal and external inflationary shocks and changes in monetary policy strategy and finally we estimated the level of inflation persistence.

It should be noted that it is not objective of this paper to study the sources or causes of inflation persistence commonly mentioned in literature, such as the volatility of inflation itself, the degree of indexation of prices and wages in the economy and changes in the credibility of economic policy, including the changing nature of inflation targeting central bank policies.[4]

The document is structured as follows: The second section contains the most important conceptual issues. The third section briefly describes the methodology used. The fourth section includes a summary description of the evolution of inflation in Costa Rica. The fifth section contains the main empirical results and section six concludes.

2. CONCEPTUAL ISSUES

The issue of inflation persistence is discussed in the literature under two different approaches (Marques, 2004): a simple univariate time series representation of inflation, and a structural econometric, multivariate, approach of the behavior of this variable.

Under the univariate approach, it is usual to assume an autoregressive model of inflation, where the shocks on the residual component are

[4] The empirical study of the sources of inflation persistence in the country exceeds the objectives of this research, although a brief description of these factors, from the theoretical point of view, is provided in Annex 1 and in Annex 12. It also presents some measurements of inflation persistence sources in Costa Rica.

designed as a summary measure of all shocks that affect inflation in a given period.

The multivariate approach assumes a causality relation between inflation and its determining variables (usually the components of a Phillips curve[5] or variables in a structural VAR model), in which the shocks are structural in the sense that they are susceptible to economic interpretation, such as monetary policy shocks.

Following D'Amato et al. (2008), this paper adopted an univariate inflation approach.[6] The starting point assumes that this variable follows a stationary autoregressive process of order *p*:[7]

$$\pi_t = \alpha + \sum_{i=1}^{p} \beta_i \pi_{t-i} + \eta_t \ , \tag{1}$$

where π_t is the contemporary inflation rate; α, a constant term; β_i, the autoregressive coefficient of the inflation rate; and η_t, the random disturbance or shock.

Inflation persistence (ρ) is reflected in the sum of the significant autoregressive coefficients of order *p* in equation (1):

$$\rho = \sum_{i=1}^{p} \beta_i \ ; \ \forall\, i = 1, 2, ..., p. \tag{2}$$

Since it is assumed that inflation is stationary ($0 < \rho < 1$),[8] a shock would have a transient effect on inflation. As mentioned in the introductory

[5] Inflation expectations, real imbalances between actual and potential, real depreciation, among others.

[6] According to Marques (2004), this approach and its close substitute, which he calls low-frequency autocovariance of a series (the spectrum at zero frequency), seem able to deliver the best estimate of inflation persistence, compared with alternative measures, such as the *half-life* inflationary impact and the maximum autoregressive root. However, the univariate approach of the sum of the autoregressive coefficients is also point to certain limitations (Vladova and Pachedjiev, 2008): the likely bias of underestimation of the parameters of persistence when the latter is close to the unit, the choice of appropriate lag length, the likely overestimation of the persistence if not properly controlled or if structural changes are not considered variable in half time and the possibility of changes in persistence over time, especially over long periods.

[7] That is, it is assumed that inflation is a stationary series around its mean. Thus, a stationary representation of the behavior of inflation can be understood as the true inflation persistence (Fuhrer, 1995).

[8] Indeed $|\rho| < 1$, but according to Marques, to be a problem of interest it is suppose that ρ is not negative (if negative, a shock would have a contractionary transient impact on inflation).

section, if the effect of the shock takes a long time to disappear, inflation would be highly persistent, but if its effect is short-lived then it would exhibit low persistence.[9]

An important feature of a stationary time series is the property of reversion to the long term mean value after a shock. That is, if in the previous period the shock led to the series to be over (under) its average, in the current period it should decrease (increase) to converge to its mean. This is the basis for claiming that when evaluating the persistence of inflation, what really matters is the persistence of deviations of inflation from its mean, so, based on Marques (2004), D'Amato et al. rewrite the equation (1) as a correction mechanism to balance, as deviations of inflation from its mean value:

$$\pi_t - \mu = \sum_{i=1}^{p-1} \varphi_i \Delta(\pi_{t-i} - \mu) + \rho(\pi_{t-1} - \mu) + \eta_t \,, \tag{3}$$

where $\mu = \alpha/(1-\rho)$ is the unconditional inflation mean. Thus, under the stationary autoregressive inflation approach, the mean of the series plays the role of the long run equilibrium value of inflation to which this variable returns after a shock (Marques, 2004).

Since the inflation mean varies over time, assuming it is constant may erroneously lead to conclude that inflation is highly persistent when it is not and vice versa.[10] As we mention in the following methodological section, we deal with this problem by identifying structural breaks in the level of the series.

It is also important to note that the empirical use of the coefficient ρ as a measure of inflation persistence has the advantage of being simple to estimate and to test statistically, but according to Marques (2004),[11] it is easy to argue that this is also an abstract measure, which has difficulties of interpretation and comparison on a practical level.

An alternative measure of persistence that is easier to interpret, communicate and compare can be estimated using as a reference the value of

[9] According to Marques, it is possible to think that an integrated process has persistence unit (if the series is integrated of order one, $\rho = 1$ in that case a shock over the inflation would have permanent effects).

[10] Assuming a very flexible mean, it can be concluded that inflation is not persistent when in fact it is highly persistent.

[11] Unfortunately, according to the empirical literature it is not possible to clearly establish ranges of variation for this ratio, in which inflation persistence can be classify as *low, medium* or *high*.

ρ. This is called the *half-life* of an unexpected inflationary shock of unit magnitude, which is defined as the number of periods over which the effect of the shock value remains above 0.5 (Marques, 2004). The greater the number of periods required for half of the adjustment to takes place, the greater the degree of inflation persistence and vice versa. The total time it takes to complete the shock also gives an idea of the magnitude of the problem, because the more widespread it is, the higher the inflation persistence and vice versa.

For an autoregressive process of order one, the *half life(h)* can be computed as (Marques, 2004):

$$h = \ln(1/2)/\ln(\rho), \tag{4}$$

where *ln* denotes the natural logarithm.[12] However, it is more complex to calculate the *half-life,* for an autoregressive process of order *p*, so equation (4) is only an approximation to the *true* estimate of the concept. In this case, the *half-life* is usually estimated by simulating the effect on inflation of a unit shock on itself, this method is called an impulse response function (IRF) and it computes the number of periods that it takes to adjust the half of this shock.[13]

3. METHODOLOGY

Under the univariate time series approach adopted to study inflation persistence, we assume an autoregressive model of order *p* for the monthly change T (1,1) of the consumer price index (CPI) of Costa Rica, using as base period July of 2006 (July 2006 = 100).[14] However, for comparative purposes we also estimated the inflation persistence by using the definition of *half-life* of a shock of unit magnitude.

[12] Since $\rho^h = 1/2$ denotes the number of periods required for a unit shock to be reduced by half, applying the logarithmic transformation on both sides we have: $h\ln(\rho) = \ln(1/2)$. Solving for h it is possible to obtain the expression (4).

[13] It should be noted, however, that this alternative measure of persistence also has some disadvantages (Marques, 2004): may underestimate the persistence if the IRF declines on a swing; but monotonically decaying IRF still might not be appropriate to compare different series if one exhibits a more rapid initial decrease and a subsequent decrease slower than the other series and difficult to distinguish changes in persistence over time.

[14] Hereafter, the CPI monthly variation rate will be referenced as the monthly inflation rate; although, with the CPI high frequency data might be more appropriate named as price variation rate.

The total period of analysis covers from February 1953 to December 2009 (1953m02-2009m12). At the moment we started this, this period was the longest for which CPI official data were available from the National Institute of Statistics and Census (INEC) of Costa Rica.

Although the CPI monthly rates of change are more erratic, or have more *noise* that the inter-T(1,12), this are more informative about short-term movements in inflation, which are of interest under the approach chosen in this research. By contrast, inflation rate variations over 12 months (inflation) are more suited to analyze movements in the inflation trend, which is not the objective of this work, plus it can lead to significant overestimation of the persistence, as stated in Pincheira (2008).

3.1 Autoregressive Model of Order *p*

The methodology used in this research closely follows the research line of D'Amato et al. (2008). As a prerequisite it is important to verify that the monthly inflation rate series is stationary throughout the period of study. After that, it is necessary to cover the following stages:

i) First, determine the main structural breaks in the mean and in the autoregressive coefficient of monthly inflation. For this a preliminary qualitative analysis is carried out, which reviews the major economic events that shaped the history of inflation in Costa Rica since the early 50s. This is then complemented with a technical analysis to identify structural breaks in the inflation rate, through the study of the residuals coefficients of a recursive regression and then applying the Bai and Perron (1998 and 2003) multiple structural changes test.

The recursive analysis consists in the sequential estimation of model (1) for different sample sizes. In general, if the number of parameters of the model is $k+1$, the first sample used is of that size and then the remaining observations are added one by one until including the entire sample. In each aggregation of variables and model estimation, the predictions of the endogenous variable and the associated prediction error are calculated for the next period. This sequence of values was used to generate the coefficients and the recursive residuals. In general, if there is no structural change, the estimated parameters are kept constant and the residuals will not deviate significantly from zero when the sample increases gradually (Carrascal et al., 2001).

The Bai-Perron test allows to formalize hypotheses tests about the presence of structural breaks in stationary variables over the selected sample. The procedure offers a series of tests: the $SupF_T(K)$ test considers the null hypothesis (H_o) of no structural breaks versus the alternative hypothesis (H_A) of k breaks. The $SupF_T(l+1 / l)$ test the existence of l breaks (with l = 0.1 ...., and H_o) against the alternative of l+1 changes. The *UDmax* and *WDmax* tests prove the H_o absence of structural breaks against the alternative hypotheses H_A of the existence of an unknown number of breaks at a significance level of 1%. Both tests evaluate a F statistical for 1 to 5 breaks where the break points are selected by maximizing the total of the squared sum of residuals.[15] The selection and interpretation of the breaks are determined according to the criteria suggested by Bai and Perron: *sequential procedure supF, Bayesian information criterion* (BIC) and *Liu, Wu and Zidek* (LWZ).[16] Once the breaks are detected confidence intervals can be formulated that allow data and the errors have different distributions between the segments in which the test separates the sample, enabling to empirically compare the coincidence between the breaks detected and the actual behavior of a series.

ii) The second stage estimates the average non-constant rate of inflation (μ_t),using a model that takes into account the different subperiods in which structural changes were detected in the average or autoregressive component of this variable.

iii) The third stage calculated the deviations of the monthly inflation rate for the non-constant average value (estimated in the previous stage) in order to define a variable, $z_t = (\pi_t - \mu_t)$, that is used in estimates of inflation persistence (ρ), according to the following equation of correction of deviations of inflation (3).

$$z_t = \sum_{i=1}^{p-1} \varphi_i \Delta z_{t-i} + \rho z_{t-1} + \eta_t . \quad (5)$$

3.2 *Half-life* of an Inflationary Shock

The methodology for calculating the *half-life* of an inflationary shock

[15] The UDmax test equally weighted the five F statistics, while the WDmax statistical weights F so that the marginal p-values are equal across the number of breaks.

[16] The test program is implemented in GAUSS and was obtained from the website of Pierre Perron, Department of Economics, Boston University (http://people.bu.edu/perron/).

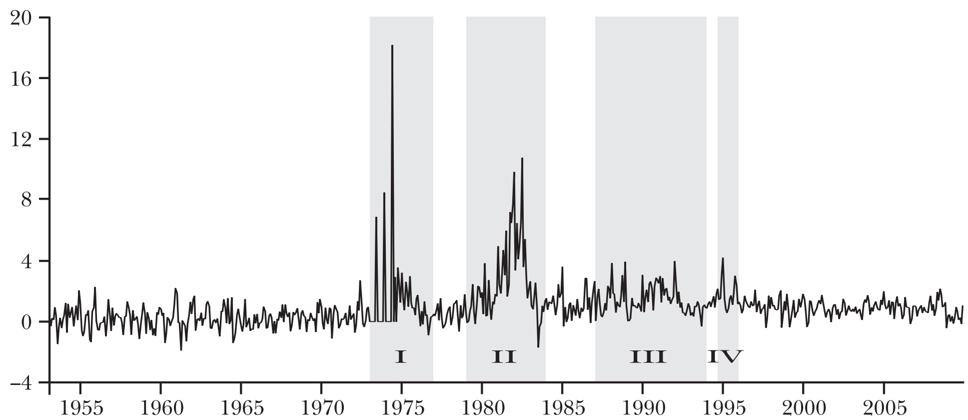
can also be performed by evaluating the stationarity of the monthly inflation rate in the period studied. Then an autoregressive model is estimated for this variable, whose initial optimal lag is determined with the FPE, AIC, LR and SC[17] criteria. This lag was subsequently adjusted according to the exclusion lag test applied sequentially to determine only those delays that are statistically significant.

Finally, after verification of the model stability and suitability of the residual of the regression, an impulse response function was estimated (IRF), by simulating the effect of a unitary shock on inflation itself and we computed the number of periods required for half of the adjustment to take place and for the rest of the adjustment to complete.

4. BRIEF HISTORY OF INFLATION IN COSTA RICA

During the 1953-2009 period inflation in Costa Rica recorded a monthly average of 0.9%. However, its behavior was highly volatile in some periods, as shown in Figure 1 and Table 1.

FIGURE 1. COSTA RICA: MONTHLY INFLATION RATE. PERIOD 1953M02–2009M12



SOURCE: Authors.

From 1953 to 1971 the monthly inflation rate was relatively low and stable, remaining at about 0.2% on average. This period was characterized by the absence of a formal process to define monetary policy rules by the

[17] Final prediction error (FPE), Akaike information criterion (AIC), sequential modified LR test statistic (LR) and Schwarz (SC).

TABLE 1. COSTA RICA: MONTHLY INFLATION RATES BY SUBPERIODS (PERCENTAGES)

Selected periods	*Mean*	*Standard deviation*
1953m02-1972m12	0.20	0.72
1977m01-1978m12	0.54	0.64
1984m01-1986m12	1.14	0.85
1994m01-1994m08	1.26	0.35
1996m01-2009m12	0.87	0.52
Periods to control		
I 1973m01-1976m12	1.39	3.02
II 1979m01-1983m12	2.54	2.51
III 1987m01-1993m12	1.42	0.91
IV 1994m09-1995m12	1.80	0.96

SOURCE: Authors.

monetary authority. Costa Rica's economy faced an external environment governed by new international monetary system and the adoption of the new exchange rate scheme called gold-dollar-standard. The exchange rate during this period was fixed and could be considered that served as anchor for monetary policy.

This relative inflation stability suffered its first major impact during the 1972-1982 period, when the monthly inflation average becomes higher and more variable. This period was characterized by global instability due to the first international oil prices crises in the mid 1970s, along with a break in the international monetary order. During these years Costa Rica experiencied an increase of capital inflows, which caused the typical problems related to the *Dutch disease:* appreciation of the currency affecting the competitiveness of exports, coupled with persistent fiscal imbalances. It is also necessary to highlight the effects as a result of the severe external debt problem that spanned most Latin American countries in the early 1980s, when average monthly inflation was 2.5% (Table 1).

During 1983-1990 inflationary problems were accentuated, dued to the exhaustion of the economic model in place since the sixties (Solera, 2002). This period is often categorized as the most inflationary one in the recent years, mainly due to adverse weather conditions, the abandonment of a fixed exchange rate (adopting a crawling peg exchange rate regime in 1983) when there was an acceleration of devaluation and higher interest rates. Additionally, the unfavorable behavior of international prices deepened the trade deficit. The average monthly inflation rate during this period was 1.3%, but with less variability than in the period described above.

Between 1991 and 2000 monthly inflation remained at 1.2% on average, a low level compared with that of previous periods, but high relative to international standards.[18] The fiscal deficit, associated to high public spending, was one of the main causes of inflation over this period, which led to an adjustment on the prices of public services, but also the accelerating pace of devaluation as well as the oil crises associated to the military conflict in the Persian Gulf and the rapid growth in money aggregates on the second half of 1994, due the intervention and posterior closure of the Banco Anglo Costarricense (see Solera, 2002) explain the relatively high inflation rates observed over this period.

With a strengthened institutional framework with clearer objectives in terms of defining an inflation goal by monetary authorities, the period 2001-2009 recorded an average monthly inflation rate of 0.8%. Of note during this period were the financial crisis of 2001, the introduction of a crawling band regime for the exchange rate adopted in October 16, 2006 and the recent financial crisis in mid-2008, when world production and the international prices of raw materials fell (such as oil and food), leading to a substantial fall in domestic inflation in 2009.[19]

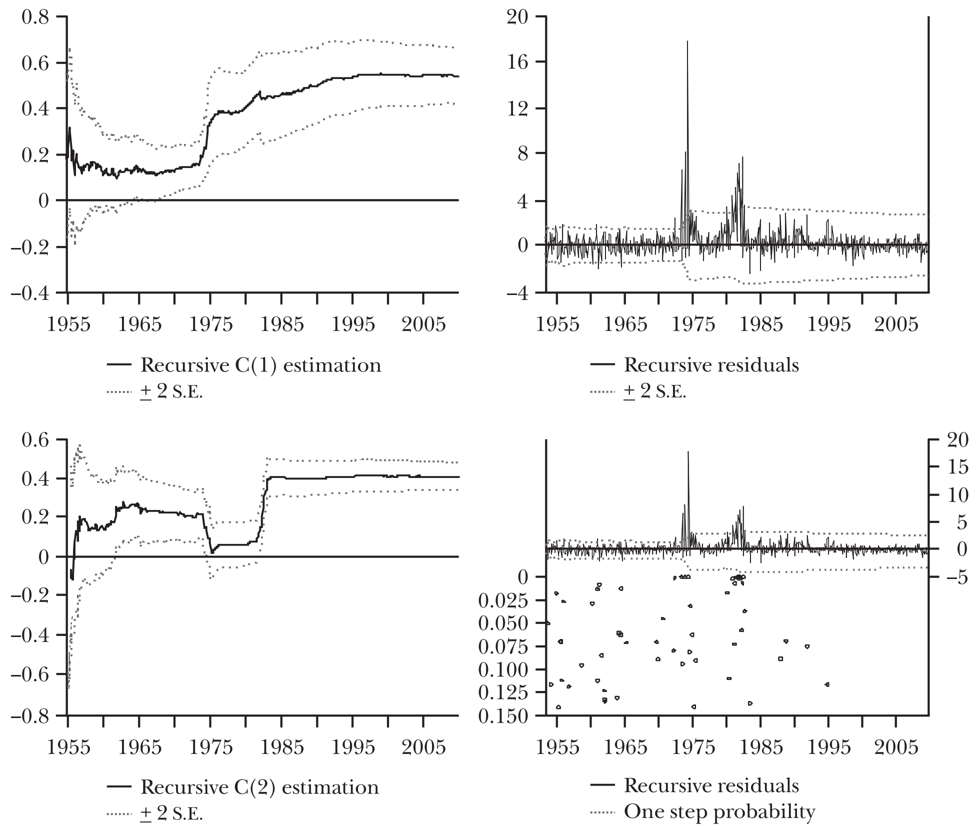
This brief characterization of the country's inflationary history helps to identify four subperiods (I to IV) of high inflation over the total period studied (Figure 2). So they must be taken into account to control the estimates of inflation persistence.

In short, these periods coincide with related shocks in international oil prices, the crisis of external debt and climate issues, and monetary and exchange rate issues typical of the Costa Rican economy. In general, they are periods that show a higher average monthly inflation and greater variability compared with other periods (Table 1).

[18] For example, the average monthly inflation rate of USA (main trade partner of Costa Rica) during this period was 0.21 per cent.

[19] The change in the CPI of December 2009 (4.0%) was 9.9 percentage points lower to that of December 2008 and the lowest since 1971. Many developed and developing economies also had disinflations because the slowdown or downturn and lower international prices of primary products (BCCR, 2010).

FIGURE 2. COSTA RICA: AUTOREGRESSIVE RECURSIVE ANALYSIS MODEL OF THE INFLATION RATE, PERIOD 1955–2009



SOURCE: Authors.

5. EMPIRICAL EVIDENCE

In this section we verify the stationarity of the monthly inflation rate and identify by technical means the main structural breaks in this variable, in order to estimate the non-constant average rate of inflation and the inflation persistence.

5.1 Degree of Integration Monthly Inflation

Table 2 contains the main results of the analysis of integration of the monthly inflation rate for the subperiods of mentioned in the previous section.

TABLE 2. COSTA RICA: ANALYSIS OF THE DEGREE OF INTEGRATION OF MONTHLY INFLATION, DICKEY FULLER F-STATISTIC, 1953-1997

Reference periods	*Constant*	*Trend*	*H_0: unitary root*
1953m02-1972m12	Not significant[a]	Not significant[a]	Rejected[a]
1977m01-1978m12	Not significant[a]	Not significant[a]	Rejected[b]
1984m01-1986m12	Significant[a]	Not significant[a]	Rejected[a]
1994m01-1994m08	Significant[a]	Significant[a]	Rejected[b]
1996m01-2009m12	Significant[a]	Not significant[a]	Rejected[a]

SOURCE: Authors.
[a] 1% significance. [b] 5% significance. [c] 10% significance.

It can be concluded that the monthly inflation rate has major breaks, but has no unit root, which is an important prerequisite to estimating inflation persistence; it ensures that the variable has no divergent or explosive behavior after the occurrence of a disruption, but has the property to revert to its mean.[20]

5.2 Recursive Analysis

To evaluate the presence of possible structural changes in the mean (constant) and in the autoregressive coefficient of monthly inflation, we estimate equation (1) recursively for the period 1953-2009.

As shown in the graphs on the left side of figure 2, there is evidence of instability of the estimated regression coefficients for both the coefficient associated with the constant, C(1), as for the autoregressive term, C(2). In the case of the constant, there is evidence of a break in the average inflation in the mid 1970s, while for the autoregressive coefficient breaks are seen in both the date as the early 1980s. Both structural changes in the monthly inflation coincide, in that order, with the first oil shock of the mid 1970s and the debt crisis of the early 1980s.

The analysis of the regression residuals stability in the first figure on the right side of Figure 2 shows that the errors are widely separated from zero and exceed the confidence band at 95% probability during the mid-1970s and early 1980s, which confirms the result mentioned above.

In the second figure on the right hand side, corresponding to one step ahead recursive residuals, the bottom shows the values of the probabilities

[20] According to the results of Dickey Fuller stationarity of monthly inflation is verified both in mean and variance.

for each of the points where the constancy of the coefficients can be rejected at various probability levels. It can be seen that the odds of record associated with the observations of the mid 1970s and early 1980s are zero.

In short, the recursive analysis concludes that no evidence of structural change in the monthly inflation series on those dates.

5.3 Evaluation of Multiple Breaks in the Inflation Rate (Bai-Perron test)

The above analysis is complemented with the study of the presence of multiple structural breaks in the monthly inflation rate, using the test developed by Bai and Perron (1998 and 2003). Two version of the test are used: breaks in the middle and breaks in the mean and the autoregressive coefficient for this variable.

As in D'Amato et al., we begin by testing the possibility of up to five structural breaks in mean inflation during the whole period, but only three are significant, according to the Bayesian information criterion (BIC), considered one of the most robust statistical tests of Bai-Perron. For this reason, applying the test again, restricting the number of breaks to three.

Both the *SupF* Sequential Procedure and again BIC confirm three significant structural breaks in mean inflation: May 1973, January 1983 and January 1997 (Table 3).

The dates of the first two structural breaks have been identified in the previous analysis (first oil shock and external debt crisis). The structural break January 1997 is a reflection of the sharp slowdown in inflation during the previous year (annual inflation in 1996 was nearly nine percentage points lower than in 1995), largely as a result of macroeconomic adjustment process and structural reforms in the Costa Rican economy in 1995-1996[21] (BCCR, 1997).

When testing breaks in the mean and in the autoregressive coefficients of monthly inflation rate, a Bai-Perron test for five breaks and then for three breaks suggest two significant structural changes at the discretion BIC: September 1974 and February 1996.

[21] In fact, restrictive economic policy pursued by the government in power in 1995-1996 resulted in a slower growth in domestic demand and lower inflationary pressures. Delgado (2000) states that heavily restrictive policies were the manifestation of political cycles in economic management.

TABLE 3. COSTA RICA: BAI-PERRON TEST FOR MULTIPLE STRUCTURAL BREAKS, 1953-2009

Change in mean (1953m02-2009m12)				
Specification				
z=1	q=1	p=0	h=100	m=3
Test				
SupFt(3)	UDmax	WDmax	SupF$_t$(3/2)	
35.71[a]	90.56[a]	90.56[a]	16.68[b]	
Number of selected breaks				
Sequencial	BIC	LWZ		
3	3	2		
T1	T2	T3		
1973m05	1983m01	1997m01		
Change in mean and recursive coefficients (1953m02-2009m12)				
Specifications				
z=2│3	q=2	p=0	h=136.6	m=3
Test				
SupF$_t$(3)	UDmax	WDmax	SupF$_t$(3│2)	
44.58[a]	92.42[a]	92.42[a]	31.00[a]	
Number of selected breaks				
Sequencial	BIC	LWZ		
3	2	1		
T1	T2			
1974m09	1996m02			

SOURCE: Authors.
[a] Significant at 1%. [b] Significant at 2.5%.

The first of them had been previously detected by the test for changes in means only and corresponds to the effect of the oil shock of the mid-seventies.

The second break is near the breakdown previously identified by the test in January 1997 and may reflect delayed effects of high monetary expansion in late 1994,[22] due to the closure and liquidation of the country's oldest bank, which required funding from the Central Bank of Costa Rica (BCCR) in an amount close to 1.5% of nominal GDP in that year (Azofeifa and Rojas, 2000). The following events during 1996 also could have explained the break (BCCR, 1996): persistence of high fiscal

[22] Total liquidity increased during the year at an annual rate of 23.1 per cent.

deficits,[23] high level of imported inflation (5.8% in 1995),[24] increase in the pass-through of exchange rate to prices, increase by 10% to 15% sales tax (in September 1995) and high inflation expectations for the following periods.[25] Mention should also be made of an institutional change occurred in 1995, when in November of that year the new Organic Law of the BCCR was passed, and the beginning of a period of disinflation in the economy relatively widespread.

5.4 Estimation of the Average Non-constant Inflation in the Whole Period

In this section we estimate a non-constant mean for the monthly inflation rate for the total period (1953m02-2009m12), which includes major structural breaks occurred during the period. To do so, we combine elements of qualitative analysis of Costa Rican inflation mentioned in Section 4 and the technical results provided by the recursive analysis and the test for multiple breaks of Bai Perron in sections 5.2 and 5.3. This allows to define a number of subperiods in the evolution of the monthly inflation rate, starting with an initial period of subinflation (0.2%), which comprises 1953m02 to 1973m04 and in which prevailed a fixed exchange rate. It also identify five subsequent periods (denoted $d1$ to $d5$), each delimited by the previously discussed major inflationary shocks (Figure 3):

- $d1$: 1973m05-1974m06. First shock in international oil prices.
- $d2$: 1974m07-1980m12. Transition period.
- $d3$: 1981m01-1983m01. External debt crisis, high fiscal expansion, balance of payments problems, high pass-through of devaluation to prices.

[23] For example, the fiscal gap in 1994 was estimated at 6.9% of GDP.

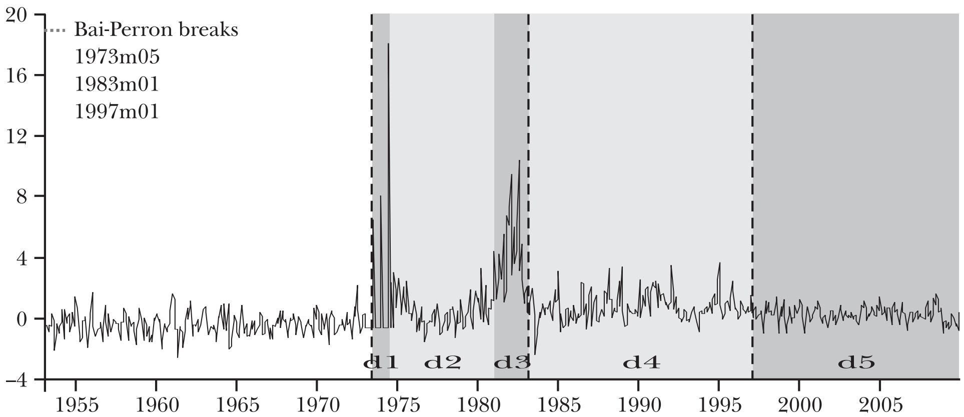
[24] In fact, in the period 1994-1996 several events were reported that affected the inflation rate in a group of Latin American countries, which were renegotiating their debts and stabilization programs focused on reducing inflation (Capistran and Ramos-Francia, 2007, pp. 7).

[25] Inflation expectations in 1995 were higher than 1994, mainly due to the following facts (BCCR, 1997): *i)* the year began with significant price increases, *ii)* the prospects of further devaluation, since the country had the resources of the PAE (Programa de Ajuste Estructural) III, *iii)* delay in the approval of the Tax Adjustment Act and the agreement with the International Monetary Fund; *iv)* persistence of high interest rates in the financial market.

– $d4$: 1983m02-1997m01. Introduction of a crawling peg regime, high pass-through, adverse weather conditions (Hurricane Jeanne), second shock in international oil prices (during the Persian Gulf War), the financing of losses due to the bankruptcy of BAC.

– $d5$: 1997m02-2009m12. Most recent period, which shows less variability in monthly inflation and includes amendments to the foreign exchange regime (crawling band was adopted in October 2006) and the international financial crisis contributed to lower domestic inflation 2009.

FIGURE 3. COSTA RICA: SUB PERIODS OF THE EVOLUTION OF THE MONTHLY INFLATION RATE, PERIOD 1953M02–2009M12



SOURCE: Authors.

Like Marques (2004) and D'Amato et al. variables dummy are considered that identify the average rate of inflation in each of the subperiods mentioned, which are incorporated in a regression whose dependent variable is the monthly inflation rate contemporary. The estimation of this regression is shown below.[26]

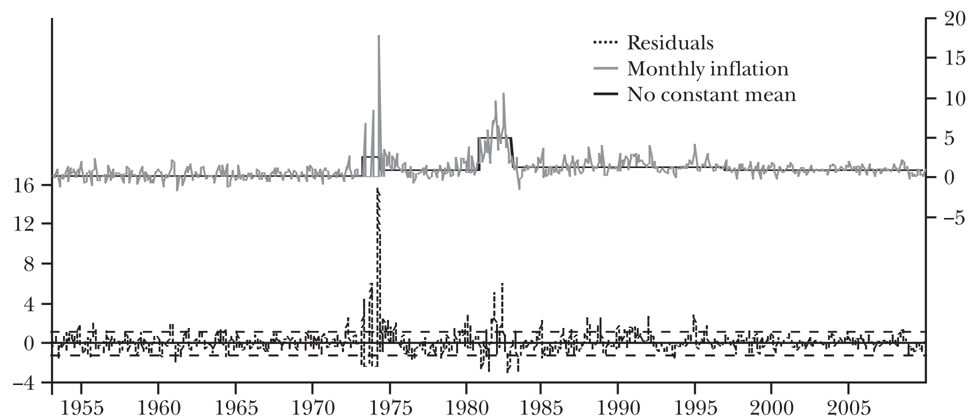
$$\underset{(HCSE)}{\pi_t} = \underset{(0.0449)}{0.2012} + \underset{(0.9828)}{2.1888}\,d_1 + \underset{(0.1765)}{0.7640}\,d_2 + \underset{(0.6320)}{4.4284}\,d_3 + \underset{(0.1090)}{1.1214}\,d_4 + \underset{(0.0680)}{0.6450}\,d_5 \tag{6}$$

[26] The model is estimated using ordinary least squares (OLS) with robust standard errors according to the covariance estimator of Newey and West (heteroskedasticity and autocorrelation consistent covariance-HAC-), which is consistent in the presence of heteroskedasticity and autocorrelation of unknown form (Annex 8.2).

The dummy variables ($d\,1$ to $d\,5$) correspond to the predetermined subperiod.[27.]

As expected, there is evidence of serial correlation in the residuals of the estimated equation for model (6). As in Marques (2004), lags of inflation were included in to overcome the problems of autocorrelation (Annex 3). Moreover, all coefficients maintained their significance and values did not change significantly, according to Wald test of coefficient restrictions (Annex 4). As stated by the author, these results can be seen as evidence that the time-varying (deterministic) mean implicit in (6) and represented by the stepped line at the top of Figure 4, is consistent with the data.

FIGURE 4. COSTA RICA: ESTIMATION OF THE AVERAGE NON-CONSTANT RATE OF MONTHLY INFLATION, PERIOD 1953M02–2009M12



SOURCE: Authors.

According to the model (6), the constant (0.20%) corresponds to the average monthly inflation in the early period, when fixed exchange rate and low inflation prevailed. However, the average inflation increases sharply during the first oil shock (2.39%),[28] the debt crises (4.63%) and the period in which significant internal and external shocks (adverse climatic factors, bankruptcy financing of BAC, high pass through and the Persian Gulf crisis, among others) were experienced (1.32%). During the transition period between the inflation shocks the average inflation reduces

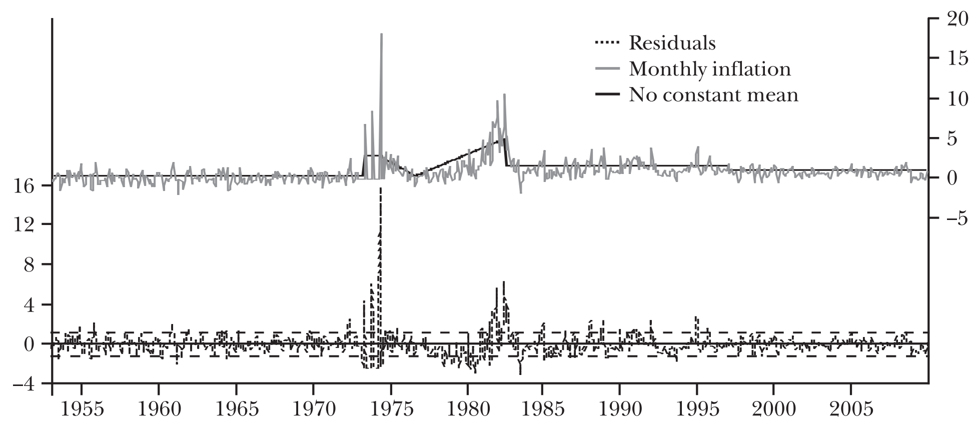
[27] Each dummy takes value one during the corresponding period and zero otherwise.

[28] The estimated mean value in each subperiod must be added the value of the finds of regression.

to 0.97%, while in the last period (1997 to 2008) the average monthly inflation was estimated at 0.85 per cent.[29]

Additionally, as suggested by the graphical analysis, we assessed the presence of deterministic trends in the transition period between high inflation of the mid-70s and the debt crisis in the early 80s. The first is a downward trend (t_1), covering the disinflation after the first oil shock (1974m07-1976m08) and the second is a growing trend (t_2),which accounts for the acceleration of inflation that led to the debt crisis of the early 80s (1976m09-1982m07) (Figure 5).

FIGURE 5. COSTA RICA: ESTIMATION OF THE NON-CONSTANT MEAN MONTHLY RATE OF INFLATION DETERMINISTIC TRENDS, PERIOD 1953M02–2009M12



SOURCE: Authors.

Lags of the inflation were again added to the calculation of variable mean to control for autocorrelation and the coefficients also maintained their significance, but Wald coefficients restriction tests revealed significant changes in mean values in most periods. Hence, we decided to keep results of the model (6) for purposes of calculating the time-varying average *(μ_t)*.

5.5 Estimated Inflation Persistence in the Total Period

As mentioned in Section 2, to evaluate the persistence of a time series what really matters is the persistence of deviations from the level of the se-

[29] For comparison this ratio amounts to 10.6% in annualized terms. However, it discourages the annualized monthly rates, to make the restrictive assumption that the rate will be maintained for a full year.

ries around their mean value, so we then calculated the deviations of the monthly inflation rate from μ_t, denoted as z, as shown in the model (5). In the econometric estimation of this model, the coefficient ρ is then the estimate of persistence when considering changes in average inflation (Table 4):[30]

TABLE 4. COSTA RICA: ESTIMATED INFLATION PERSISTENCE FOR CONSTANT MEAN AND CHANGES IN MEAN, PERIOD 1953M02-2009M12

	Constant mean	*Changes in mean*
Persistence (ρ)	0.78	0.18
NW-HAC[a]		(0.09)
Lags	1 a 2 y 6	1 y 3 a 5

SOURCE: Authors.
[a] Robust standard error as Newey y West covariance estimator (heteroskedasticity and autocorrelation consistent –HAC– covariances).

Under the assumption of a constant mean throughout the period, monthly inflation would be a highly persistent process (0.78),[31] with a significant lag up to six months. This result for Costa Rica is in line with international evidence for some Latin American countries (Annex 7). However, if it is recognized that there are changes in the mean of inflation, the estimated persistence is significantly reduced to 0.18, with a significant lag up to five months. This low rate of persistence may be, however, subject to the limitation mentioned in footnote 9, which refers to the possibility of changes in inflation persistence over time, especially when considering long periods. In particular, it can be influenced by the initial extended period of low inflation, in which no internal or external shocks of importance occurred and in which Costa Rica enjoyed great stability of prices, even higher than that observed in many developed and development (Delgado, 2000). For this reason, it is considered relevant to estimate inflation persistence over a more recent period that excludes the initial period and the subperiods following large external shocks and inflationary shocks of importance.

[30] The model was also estimated by OLS with robust standard errors as NW-HAC (Annex 5).

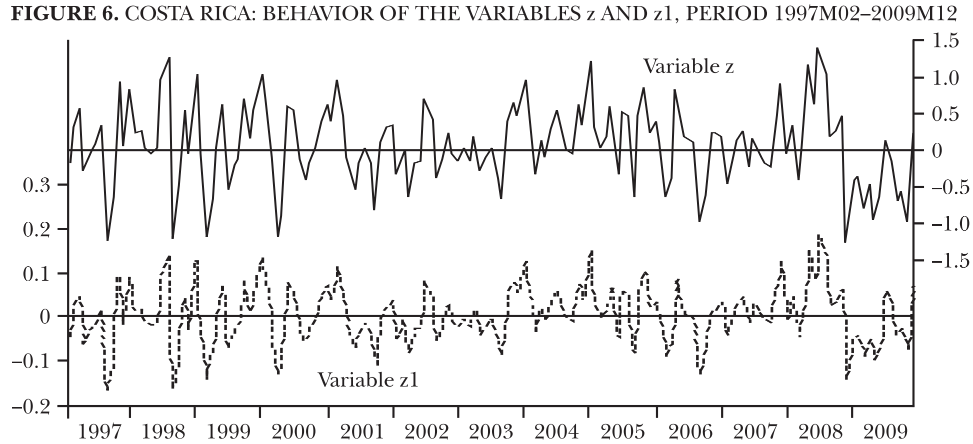
[31] To estimate the persistence failing to acknowledge changes in the average monthly inflation over the period, there are the autoregressive coefficients in the econometric estimation of equation (1) (Annex 6).

5.6 Estimation of Persistence in the Recent Subperiod

This section examines the persistence of inflation in the recent subperiod (1997m02-2009m12), both assuming that the average inflation rate (0.85%) represents the long-run equilibrium level of this variable in that period, such as using inflation targeting has been setting the BCCR at every opportunity as a characterization of the long-term level.[32]

As before, we begin by examining the requirement of stationarity of the deviations of the monthly inflation from its average level (variable *z*) and for the inflation of the BCCR from its average level (variable *z*1),[33] which is expected from the simple observation of the behavior of the series (Figure 6) and confirmed by the ADF test, Phillips-Perron and KPSS (Annex 8). This result is important because it confirms that the variables maintained the property of mean reversion.

FIGURE 6. COSTA RICA: BEHAVIOR OF THE VARIABLES z AND z1, PERIOD 1997M02–2009M12



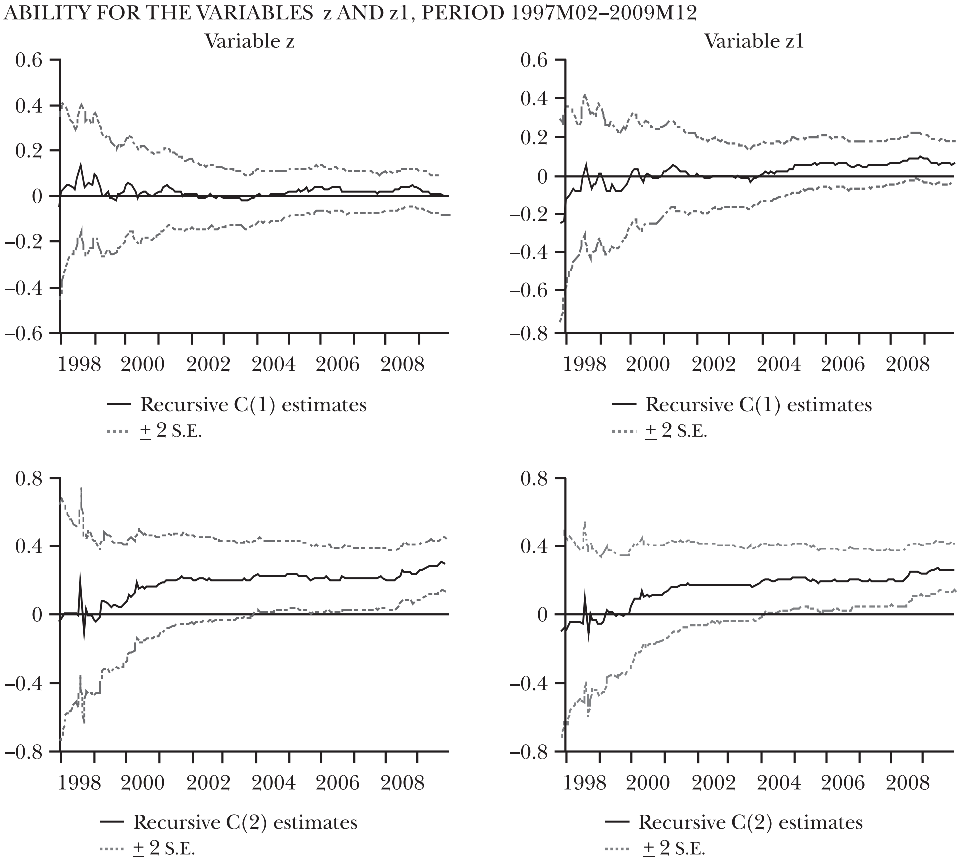
SOURCE: Authors.

[32] The use of inflation targeting central bank as a characterization of equilibrium level of long-term variable is a usual practice in inflation persistence estimates for countries with inflation targets. Although the BCCR does not operate under this monetary regime; in 2005 the BCCR authorities announced their will to adopt it in the future and for this has been preparing its monetary policy strategy, including the announcement and seeks forward-looking inflation targeting, consistent with the preparation of a medium-term macroeconomic program.

[33] To calculate the variable *z*1, monthly inflation rate is annualized and the inflation target has been established by the BCCR along this subperiod, which is expressed in annual price variations, is substracted. The monthly time series of the BCCR inflation target is taken from the work of Castrillo et al. (2008) and updated in this investigation.

According to the recursive analysis, to add data to estimate the coefficients does not produce significant variations and the confidence limits become narrower, ruling out the possibility of a structural change in the average or autoregressive coefficient of *z* and *z*1 in this subperiod (Figure 7).

FIGURE 7. COSTA RICA: ESTIMATED RECURSIVE COEFFICIENTS AND N-STEPS AHEAD PROBABILITY FOR THE VARIABLES z AND z1, PERIOD 1997M02–2009M12



SOURCE: Authors.

The main Bai-Perron statistical test suggests no breaks in the mean or the autoregressive coefficient of both variables when sequentially testing of up to five structural changes in these variables.

It is interesting to note that neither recursive coefficients nor the Bai-Perron test detected significant changes in the average or autoregressive component of *z* and *z*1 in connection with the adoption of the exchange rate band regime in October 2006. While after the adoption of this regime changes have been documented in the pass-through of the policy rate to other market interest rates (Durán and Esquivel, 2008) and changes in the pass-through of devaluation to prices (BCCR, 2009), these changes do not appear to have yet altered the data generating process of monthly inflation data as far the Bai-Perron test detected a significant structural break due to this new policy. The above evidence can be explained by the limited data available since the adoption of the new exchange rate system. Actually, there is structural change in the average inflation rate but not in the autoregressive coefficient, when the results are recalculated for the 2003m10-2009m12-subperiod, which takes into account the same number of observations before and after adoption of band exchange rate regime in October 2006 (Annex 9).

5.6.1 Autoregressive Model of Order p

Since there is no structural change in the average or autoregressive coefficient of variables (z) and ($z1$), the likelihood of spurious minimized results if one considers the constant mean of 0.85% implicit in the variable (z) is the inflation targets contemplated in $z1$ and the model (5) is directly used to estimate the persistence in this subperiod (table 5).[34]

The persistence of inflation in the recent subperiod is higher, estimated at between 0.31 and 0.42, with a maximum lag of 62 months in the case of the variable z and 19 months for the variable $z1$. Although this range of values is not considered high, the long lags show a slow rate of return of inflation to its average value or the value of long-run equilibrium

TABLE 5. COSTA RICA: ESTIMATION OF THE DEVIATIONS PERSISTENCE FROM DEVIATIONS OF INFLATION FROM ITS AVERAGE AND FROM THE INFLATION TARGET, PERIOD 1997M02-2009M12

	z variable	*z1 variable*
Persistence (ρ)	0,42	0.31
HCSE[a]	(0.08)	(0.08)
Lags	6,9,19,48,49,62	18,19

SOURCE: Authors.

[a] Robust standard error as Newey y West covariance estimator (heteroskedasticity and autocorrelation consistent –HAC– covariances).

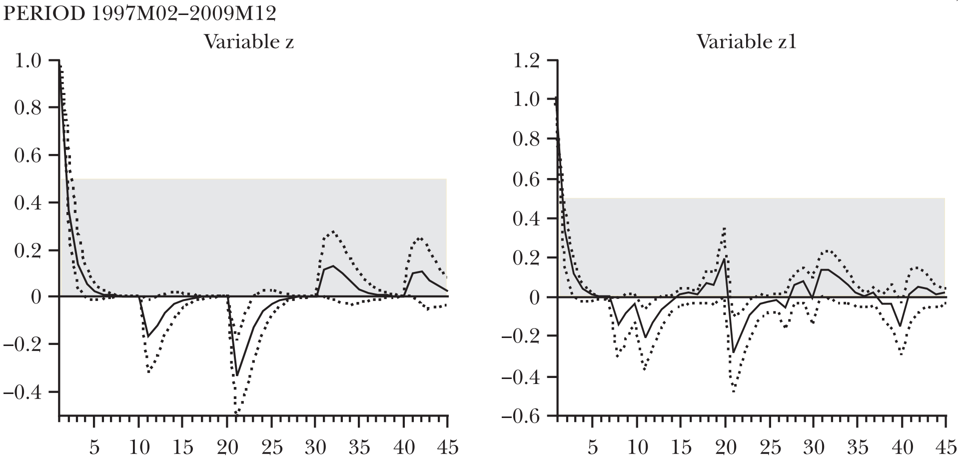
[34] OLS estimates with robust standard errors NW-SCC render have stationary, normal, homoscedasticity and not auto correlated. The models pass the specification test of Ramsey, recursive stability tests for the coefficient ρ and the test CUSUMQ (Annex 8.10).

after the occurrence of an inflationary shock, which points to inflation persistent in the last period analyzed.

5.6.2 Half-life *of an Inflationary Shock*

To complement the analysis and thus have stronger evidence, we also estimate inflation persistence according to the definition of *half-life* of an inflationary shock unit. This comes two autoregressive models: one for the variable z and one for the variable $z1$. According to the econometric tests, both models are stable and have normal, non-auto correlated errors.
The simulation of these unit shocks in the initial month ($t = 1$) shows the following impulse-response functions (figure 8):

FIGURE 8. COSTA RICA: IMPULSE-RESPONSE FUNCTION TO A UNIT INFLATIONARY SHOCK, PERIOD 1997M02–2009M12



SOURCE: Authors.

The *half-life* of both shocks is estimated at one month, as of the shock 50% is extinguished after that time. The total effect of the disruption is completed after 22 months for z and 40 months for $z1$ (table 6), affecting most persistent annualized monthly rates of change in this second case.

Although the *half-life* of a shock dissipates quickly, the fact that the shock takes a considerable time to extinguish in both models also indicates persistent inflation in the latter subperiod.

When using the MMPT to estimate the *half-life* , the inflation persistence is higher: 10 to 11 months and the shock takes about 33 months to exhaust (Annex 11), which could be due to the use of annual price changes and feedback effects implicit in the functional interrelations that

TABLE 6. COSTA RICA: ESTIMATION OF INFLATION PERSISTENCE ACCORDING TO DEFINITION OF *HALF-LIFE* OF A UNIT INFLATIONARY SHOCK, PERIOD 1997M02-2009M12

	Variable z	*Variable z1*
Half life (*h*)	1 month	1 month
Total adjust	22 months	40 months

SOURCE: Authors.

NOTES: The optimal lags for both models initially set from 1 to 20 months, according to final prediction error statistics (EPE), Akaike information criterion (AIC) and sequential modified LR test statistic (LR). The statistically significant lags finally reduced to 1, 10 and 20, in the case of the *z* model and 1, 7, 10, 19 and 20 for the *z*1 model, according to the sequential lag exclusion test.

make up the model. In any case, the results are not entirely comparable, because of the multivariate approach, the different sample size (data from 1991) and the frequency of the data (quarterly observations).[35]

6. CONCLUDING REMARKS

The purpose of this study was to estimate inflation persistence, understood as the speed with which the monthly inflation rate returns to its long run equilibrium value of long term after a shock for Costa Rica in the period 1953-2009. Under a univariate approach of inflation and a stationary autoregressive process for this variable, it is assumed that the equilibrium value is the average of the variable throughout the period.

According to the empirical evidence, if the average rate of inflation does not change in the whole period studied, inflation is highly persistent (0.78), which is consistent with the evidence for some countries in Latin America. However, recognizing that this value breaks depending on structural changes and internal and external inflationary shocks faced by the economy, the estimated inflation persistence in the total period (0.18) reduces significantly, although this result can be due to the initial extended period of low inflation.

When studying the most recent period (1997-2009), the estimate of inflation persistence is greater (it ranges between 0.31 and 0.42) and there is no evidence of structural changes in the average monthly inflation when crawling band regime was adopted in October 2006.

[35] In the Annex 8.12 there are indirect measures of inflation persistence available in the BCCR.

It is only possible to detect a structural break due to lower average inflation rate from November 2008 when considering the 2003m10-2009m12 period, although the estimate of inflation persistence does not change in statistical terms (0.47). This break is located just over two years after adoption of the band, so the contractionary impact on the average monthly inflation rate might be picking up both the lagged effect of improving the independence of monetary policy that has been gained over time, due to lower BCCR intervention on the foreign exchange market, and the impact of lower imported inflation on domestic prices in 2009 due to the economic contraction and the reduction of commodity prices in the international markets, following the global financial crisis.

By supplementing the analysis with the calculation of the alternative definition of inflation persistence as the *half-life* of a unit shock in the recent period (1997-2009), we find that 50% of the shock is completed quickly (one month after it happened), but the total adjustment takes considerable time to exhaust (22 to 40 months, according to the definition used), which also points to persistent inflation. However, if this shock is simulated in 2003m10-2009m12 period, the *half-life* does not change but the overall effect of the adjustment is considerably shorter (8 to 11 months). On the other hand, if the *half life* is calculated using the BCCR Macroeconomic Model for Projection (MMPT) data from 1991, 50% of the disruption is consumed after 11 months and the total effect takes 33 months to extinguish. These greater persistence effects would be due to feedback effects present in a multivariate approach and the use of annual price changes.

When we resorted to other evidence not directly comparable of inflation persistence available in the BCCR for different periods and calculation of alternative definitions of this phenomenon (*intrinsic persistence* and autoregressive coefficients), we obtain estimates in a wider range (0.53 to 0.93) and long periods of adjustment to inflationary shocks (22 to 33 months lag). We do not exclude, however, that these indirect measurements overestimate the degree of inflation persistence, given the use of annual price changes. In any case, as stated by Marques (2004), the reliability of any estimate of inflation persistence ultimately depends on how realistic is the long-term path of inflation assumed. In this regard, with data from February 1997 to December 2009, the univariate approach adopted in this paper as an estimated proxy for the path of inflation rate of 0.85% monthly average (10.6% annualized) and inflation target average around 10%.

Clearly, the main implication for monetary policy is that, given the dependence of current inflation not only on long run and short run determinants, but also on past inflationary shocks, the greater the cost of the disinflation for the economy and, therefore the longer should be the horizon of inflation targets to be defined.

On the other hand, the control of inflation becomes a more complex problem than simply handling a short-term policy rate, gaining significance also control the main sources of inflation persistence cited in the literature, such as the volatility of inflation itself, the mechanisms of price and wage indexation in the economy and changes in the credibility of monetary policy, including changes in the inflation target.

Finally, in a broader sense , economic policy in general may also help reduce inflation persistence, through actions aimed at promoting competition in key economic sectors and through the reformulation of pricing policies (valuation cost model and price adjustment patterns or rates of regulated goods and services, among others) and deregulation of markets.

Annex 1

Of the Main Theoretical Causes of Inflation Persistence

Commonly mentioned sources or causes of inflation persistence in the literature are:

- The volatility of inflation itself: Pincheira (2008) argues that the volatility of inflation itself contributes to the persistence, to the extent that its trend component is stochastic and present continuous variations.
- The degree of indexation of prices and wages in the economy: Álvarez et al. (2000) argues that indexation mechanisms allows to readjust items such as wages or production costs of firms pegging them to the consumer price index or the exchange rate, in order to protect prices and real wages structure in economies characterized by moderate inflation. However, this practice hinders the adjustment of prices to real shocks (inflation persistence helps) and increases the costs of reducing inflation. Also, De Gregorio (1992 and 1995) explains that inflation persistence stems from a bias in inflation expectations of economic agents, caused by the indexation of prices in the economy.

- Changes in the credibility of economic policy: Álvarez et al. (2000) cites the work of Calvo and Végh (1994), in which an adjustment program based on the exchange rate anchor has credibility problems that slows down the convergence of inflation to the target inflation rate. For its part, Pincheira (2008) mentions that in Cukierman and Leviatan (1992) persistence is explained as a problem of credibility of economic agents facing the monetary authority. According to these authors, the credibility problem ends up generating higher inflation expectations, plus the fact that the monetary authority has no control over inflation, which generates a slow stabilization process that results in persistent inflation.
- Frequent changes in the inflation target by the central bank: As noted by Marques (2004), assuming that in the medium and long term inflation is determined by monetary policy, then the long-term level of inflation corresponds to the inflation target the central bank. Thus, movements of the inflation target can be a source of inflation persistence (if the central bank changes its target, it might take time to learn about the new target, so that inflation will take longer to converge to the target compared to a fixed target).

Annex 2

Equation (6) Estimation

Dependent variable: INFLAMEN
Method: Least squares
Date: 03/01/10
Sample (adjusted): 1953m02-2009m12
Included observations: 685 after adjustments
Newey-West HAC standard errors & covariance (lag truncation = 6)

	Coefficient	*Standard error*	*t-Statistic*	*Probability*
C	0.201152	0.044858	4.484156	0.0000
d1	2.188848	0.982819	2.227111	0.0263
d2	0.763976	0.176535	4.327618	0.0000
d3	4.428448	0.631953	7.007562	0.0000
d4	1.121407	0.108985	10.28953	0.0000
d5	0.645041	0.068049	9.479128	0.0000

R^2	0.371533	Mean dependent variable	0.917584
Adjusted R^2	0.366891	S. D. dependent variable	1.443632
S.E. of regression	1.148671	Akaike info criterion	3.123835
Sum squared residue	893.2650	Schwartz criterion	3.163599
Log likelihood	−1060.790	Hannan-Quinn criterion	3.139224
F statistic	80.04473	Durbin-Watson statistic	1.807464
Prob (F statistic)	0.000000		

Annex 3

Equation (6) Estimation with Inflation's Lags

Dependent variable: π
Method: Least squares
Date: 03/01/10
Sample (adjusted): 1955m02-2009m12
Included observations: 659 after adjustments
Newey-West HAC standard errors & covariance (lag truncation = 6)

	Coefficient	*Standard error*	*t-Statistic*	*Probability*
π (−2)	0.068775	0.039476	1.742208	0.0819
π (−6)	0.299682	0.150851	1.986602	0.0474
π (−15)	−0.072482	0.038847	−1.865833	0.0625
π (−16)	−0.095905	0.041172	−2.329400	0.0201
π (−21)	−0.082722	0.031977	−2.586934	0.0099
π (−24)	0.089776	0.040958	2.191939	0.0287
C	0.145428	0.058244	2.496875	0.0128
d1	1.877183	0.799906	2.346754	0.0192
d2	0.584961	0.183127	3.194284	0.0015
d3	3.313143	0.677504	4.890219	0.0000
d4	0.939556	0.205768	4.566103	0.0000
d5	0.529849	0.120288	4.404833	0.0000

R^2	0.465249	Mean dependent variable	0.939120
Adjusted R^2	0.456157	S. D. dependent variable	1.458533
S.E. of regression	1.075605	Akaike info criterion	3.001686
Sum squared residue	748.5314	Schwartz criterion	3.083459
Log likelihood	−977.0554	Hannan-Quinn criterion	3.033384
F statistic	51.17354	Durbin-Watson statistic	1.860015
Prob (F statistic)	0.000000		

Date: 03/01/10
Sample: 1955m2-2009m12
Included observations: 659

Autocorrelation	*Partial correlation*		*AC*	*PAC*	*Q-Statistic*	*Probability*
		1	0.069	0.069	3.1923	0.074
		2	0.019	0.014	3.4246	0.180
		3	–0.001	–0.004	3.4260	0.330
		4	–0.079	–0.079	7.5380	0.110
		5	–0.065	–0.055	10.338	0.066
		6	–0.024	–0.014	10.725	0.097
		7	–0.032	–0.028	11.426	0.121
		8	–0.027	–0.028	11.898	0.156
		9	–0.011	–0.016	11.974	0.215
		10	0.012	0.009	12.078	0.280
		11	–0.014	–0.022	12.219	0.347
		12	0.002	–0.004	12.222	0.428
		13	–0.041	–0.048	13.382	0.419
		14	–0.033	–0.030	14.114	0.441
		15	0.008	0.010	14.162	0.513
		16	0.008	0.004	14.204	0.584
		17	–0.062	–0.072	16.777	0.470
		18	–0.031	–0.035	17.448	0.493
		19	0.024	0.026	17.834	0.534
		20	–0.060	–0.066	20.291	0.440
		21	0.032	0.026	20.989	0.460
		22	–0.025	–0.044	21.405	0.486
		23	–0.031	–0.031	22.054	0.517
		24	–0.017	–0.026	22.257	0.564
		25	0.019	0.013	22.501	0.607
		26	0.022	0.012	22.847	0.642
		27	0.025	0.009	23.262	0.671
		28	0.030	0.017	23.902	0.687
		29	0.019	0.011	24.147	0.722
		30	–0.006	–0.012	24.173	0.764
		31	–0.007	–0.016	24.207	0.802
		32	–0.019	–0.010	24.461	0.827
		33	–0.047	–0.044	26.017	0.801
		34	–0.026	–0.023	26.480	0.818
		35	–0.014	–0.016	26.620	0.845
		36	0.032	0.032	27.347	0.850

Annex 4

Wald Test of the Equation (6)

Null Hypothesis	*Probability*	*Decision*
H0: C(7)=0.20	0.3387	Do not reject H0
H0: C(8)= 2.19	0.6968	Do not reject H0
H0: C(9)=0.76	0.3283	Do not reject H0
H0: C(10)=4.43	0.0997	Do not reject H0
H0: C(11)=1.12	0.3768	Do not reject H0
H0: C(12)=0.65	0.3382	Do not reject H0

SOURCE: Authors.
NOTE: Chi square test.

Annex 5

Equation (5) Estimation

Dependent variable: Z
Method: Least squares
Date: 03/02/10
Sample (adjusted): 1953m08-2009m12
Included observations: 677 after adjustments
Newey-West HAC standard errors & covariance (lag truncation = 6)

	Coefficient	*Standard error*	*t-Statistic*	*Probability*
$\Delta Z(-1)$	−0.086894	0.035998	−2.413861	0.0161
$\Delta Z(-2)$				
$\Delta Z(-3)$	−0.071059	0.040377	−1.759892	0.0789
$\Delta Z(-4)$	−0.184949	0.076282	−2.424534	0.0156
$\Delta Z(-5)$	−0.257391	0.141215	−1.822691	0.0688
Z((−1)	0.177804	0.094053	1.890465	0.0591

R^2	0.098976	Mean dependent variable	−0.000403
Adjusted R^2	0.093613	S. D. dependent variable	1.149009
S.E. of regression	1.093906	Akaike info criterion	3.024746
Sum squared residue	804.1363	Schwartz criterion	3.058111
Log likelihood	−1018.876	Hannan-Quinn criterion	3.037663
Durbin-Watson statistic	1.941354		

Annex 6

Equation (1) Estimation

Dependent variable: π
Method: Least squares
Date: 03/02/10
Sample (adjusted): 1953m08-2009m12
Included observations: 677 after adjustments
Newey-West HAC standard errors & covariance (lag truncation = 6)

	Coefficient	*Standard error*	*t-Statistic*	*Probability*
C	0.201664	0.090765	2.221840	0.0266
π (–1)	0.198398	0.096122	2.064021	0.0394
π (–2)	0.175920	0.048674	3.614263	0.0003
π (–6)	0.408231	0.159779	2.554973	0.018

R^2	0.368892	Mean dependent variable	0.923530
Adjusted R^2	0.366079	S. D. dependent variable	1.448234
S.E. of regression	1.153072	Akaike info criterion	3.128628
Sum squared residue	894.8064	Schwartz criterion	3.155320
Log likelihood	–1055.041	Hannan-Quinn criterion	3.138962
F statistic	131.1261	Durbin-Watson statistic	2.003492
Prob (F statistic)	0.000000		

Annex 7

Inflation Persistence in Other Countries

Country	*Inflation persistence*[a]
Argentina	0.8542
Bolivia	0.8787
Brasil	0.8581
Chile	0.2899
Colombia	0.7874
Ecuador	0.8364
Mexico	0.8548
Peru	0.6657
Uruguay	0.8682
Venezuela	0.7666

SOURCE: Capistrán and Ramos-Francia (2007).
[a] Sum of the autoregressive coefficients (period 1980m01-2006m06).

Annex 8

Integration Analysis (recent periods)

INTEGRATION ANALYSIS OF THE MONTHLY INFLATION, PERIOD 1997M02-2009M12

Variable	*Option*	*ADF (P-value)*	*PP (P-value)*	*KPSS (LM-Stat)*
Z	CCCT	0.0000[a]	0.0000[a]	0.119230[b,c]
	CCST	0.0000[a]	0.0000[a]	0.140111[d]
	SCST	0.1152[a]	0.0001[a]	NA
D(Z)	CCCT	0.0000[a]	0.0001[a]	0.128210[b,c]
	CCST	0.0000[a]	0.0001[a]	0.225912[b]
	SCST	0.0000[a]	0.0000[a]	NA
Z1	CCCT	0.0000[a]	0.0000[a]	0.049261[c]
	CCST	0.0000[a]	0.0000[a]	0.149769[d]
	SCST	0.0000[a]	0.0000[a]	NA
D(Z1)	CCCT	0.0000[a]	0.0001[a]	0.126139[b,c]
	CCST	0.0000[a]	0.0001[a]	0.259787[d]
	SCST	0.0000[a]	0.0000[a]	NA

SOURCE: Authors.

NOTES: For ADF y PP, H_0: series has a unit root. For KPSS, H_0: series is stationary. NA stands for non-applicable.

[a] H_0 is rejected at the 1%, 5% and 10% significance level. [b] H_0 is rejected at the 10% significance level. [c] Critical values at 1%, 5%, 10%: 0.216; 0.146; 0.119, respectively. [d] Critical values at 1%, 5%, 10%: 0.739; 0.463; 0.347, respectively.

INTEGRATION ANALYSIS OF THE MONTHLY INFLATION, PERIOD 2003M10-2009M12

Variable	*Option*	*ADF (P-value)*	*PP (P-value)*	*KPSS (LM-Stat)*
Z	CCCT	0.0000[a]	0.0000[a]	0.096327[b,c]
	CCST	0.0000[a]	0.0000[a]	0.139136[d]
	SCST	0.0000[a]	0.0000[a]	NA
D(Z)	CCCT	0.0000[a]	0.0001[a]	0.027418[b,c]
	CCST	0.0000[a]	0.0001[a]	0.029775[b]
	SCST	0.0000[a]	0.0000[a]	NA
Z1	CCCT	0.0000[a]	0.0000[a]	0.076606[c]
	CCST	0.0000[a]	0.0000[a]	0.204467[d]
	SCST	0.0000[a]	0.0000[a]	NA
D(Z1)	CCCT	0.0000[a]	0.0001[a]	0.025414[b,c]
	CCST	0.0000[a]	0.0001[a]	0.26835[d]
	SCST	0.0000[a]	0.0000[a]	NA

SOURCE: Authors.

NOTES: For ADF y PP, H_0: series has a unit root. For KPSS, H_0: series is stationary. NA stands for non-applicable.

[a] H_0 is rejected at the 1%, 5% and 10% significance level. [b] H_0 is rejected at the 1%, 5% y 10% significance level. [c] H_0 is rejected at the 10% significance level. [d] Critical values at 1%, 5%, 10%: 0.216; 0.146; 0.119, respectively. [e] Critical values at 1%, 5%, 10%: 0.739; 0.463; 0.347, respectively.

Annex 9

Equation (5) Estimation on the Recent Period

VARIABLE Z

Dependent variable: Z
Method: Least squares
Date: 03/02/10
Sample (adjusted): 2002m05-2009m12
Included observations: 92 after adjustments
Newey-West HAC standard errors & covariance (lag truncation = 3)

	Coefficient	*Standard error*	*t-Statistic*	*Probability*
DZ(−6)	0.216157	0.065080	3.321420	0.013
DZ(−9)	0.145492	0.076912	1.891673	0.0619
DZ(−19)	0.230376	0.083233	2.767852	0.0069
DZ(−48)	0.169282	0.060851	2.781919	0.0067
DZ(−49)	0.102437	0.061974		0.1020
DZ(−62)	−0.126356	0.067888		0.0662
Z(−1)	0.418851	0.078728		0.0000

R^2	0.359942	Mean dependent variable	0.005219
Adjusted R^2	0.314761	S. D. dependent variable	0.497465
S.E. of regression	0.411797	Akaike info criterion	1.136466
Sum squared residue	14.41406	Schwartz criterion	1.328342
Log likelihood	−45.27745	Hannan-Quinn criterion	1.213909
Durbin-Watson statistic	2.082335		

VARIABLE Z1

Dependent variable: Z1
Method: Least squares
Date: 01/12/10
Sample (adjusted): 1998m09-2009m12
Included observations: 136 after adjustments
Newey-West HAC standard errors & covariance (lag truncation = 4)

	Coefficient	*Standard error*	*t-Statistic*	*Probability*
DZ1(−18)	0.175474	0.62916	2.789017	0.0061
DZ1(−19)	0.315224	0.056704	5.559140	0.0000
Z1(−1)	0.310072	0.080678	3.843335	0.0002

R^2	0.225359	Mean dependent variable	0.010541
Adjusted R^2	0.213710	S. D. dependent variable	0.068594
S.E. of regression	0.060824	Akaike info criterion	−2.739844
Sum squared residue	0.492046	Schwartz criterion	−2.675594
Log likelihood	189.3094	Hannan-Quinn criterion	−2.713734
Durbin-Watson statistic	1.848883		

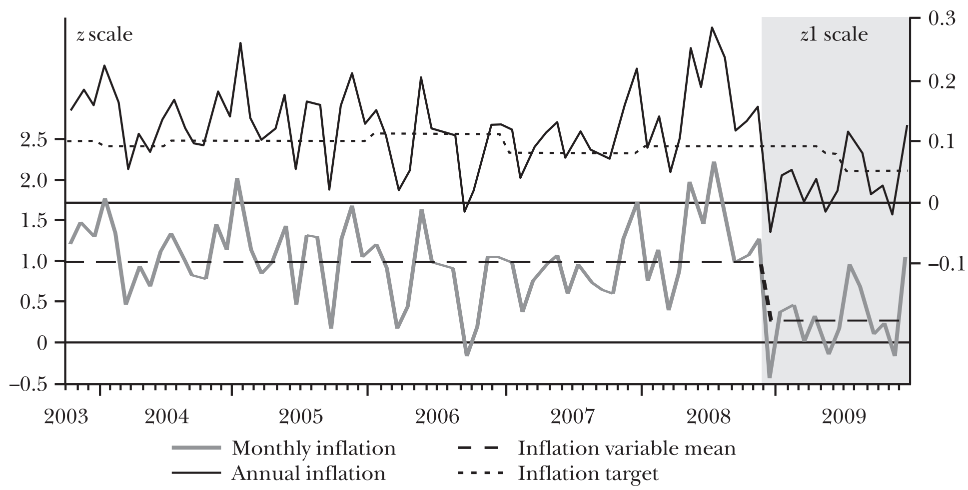
Annex 10

Inflationary Persistence in the Subperiod 2003m10-2009m12

In this annex we again test the hypothesis of structural change in the average monthly inflation after the adoption of the exchange rate band regime in October 2006. This takes into account the same number of observations before and after that date, so the new period of analysis is 2003m10-2009m12.

During this period π and $z1$ remain stationary (ADF test, PP and KPSS). Contrary to the results for other periods, recursive tests detected structural break in the mean and the autoregressive coefficient of π in mid-2008 and mid-2006 respectively, and in early 2006, both the mean and the coefficient autoregressive $z1$. Meanwhile, the BIC and statistical test LWZ Bai-Perron detect a break in mean inflation in November 2008 but not in the autoregressive coefficient (figure A.1).

FIGURE A.1. COSTA RICA: BEHAVIOR OF THE VARIABLES z=(π-μ) AND z1=(π_ANNUALIZED-TARGET), PERIOD 2003M10–2009M12



SOURCE: Authors.

This break is located a little after two years from the adoption of the crawling band regime, so that the contractionary impact on the monthly inflation rate could be picking up both the lagged effect of improving the independence of monetary policy that has been gained over time, due to lower BCCR intervention on the foreign exchange market,[36] as the impact of lower imported inflation on domestic prices in 2009 (due to problems with internal and external economic activity, following the international financial crisis), lower inflation expectations, nominal depreciation and lower pass-through to prices and improved supply of agricultural products (BCCR, 2010).

The variant monthly inflation average for the periods 2003m10-2008m11 and 2008m12-2009m12 is estimated at 1.0% and 0.27% respectively.[37] From this result, the variable z is redefined as inflation less this new average monthly variation in time. The variable $z1$ continues to define as before. With both variables, definitions of inflation persistence were recalculated (Table A.1).

The Wald coefficient restriction test, made on the basis of the evidence in table A.1, reveals that the estimated degree of persistence (coefficient

TABLE A.1. COSTA RICA: ESTIMATES OF INFLATION PERSISTENCE (PERIOD 2003M10-2009M12)

Variable z			*Variable z*[a]		
ρ [a]	*"Mean life"* [b]		ρ [a]	*"Mean life"* [b]	
	50% initial	*100% (total)*		*50% initial*	*100% (total)*
0.47 (0.12) 3/ Lag: 4,10,15,29,33	1 month	8 months	0,39 (0.10)[c] Lag: 18,19	1 month	11 months

SOURCE: Own elaboration.
[a] The OLS estimates, with robust standard errors NW-HAC, have stationary, normal, homoscedastic, and non-correlated residuals. Models passed the Ramsey specification test, recursive stability tests for the ρ coefficient and the CUSUMO test. [b] The autoregressive model for z is defined with 1, 4 and 6 significant lags, and for $z1$ with 1, 4, 6 and 8. Errors are distributed as a normal multivariate probability density, are homoscedastic and are not autocorrelated. [c] Robust standard errors according to the covariance Newey-West estimator (heteroskedasticity and autocorrelation consistent –HAC– covariances).

[36] In mid-November 2008 to mid-August 2009 the exchange rate was intermittently separating the *roof* of the exchange rate band and from that date keeps swinging freely inside without the intervention of the BCCR in market *wholesale* exchange (MONEX). This pointed to a lower variability of the money supply driven by the behavior of the exchange rate.

[37] The corresponding average inflation rates are annualized, in order, 12.8% and 3.3%. Estimates are as equivalent as in equation (6), using a variable dummy that takes a unit value during 2009m12-2008m12, and zero otherwise. As before, lags added to this equation is controlled for autocorrelation and coefficient restriction tests found no statistical changes in the estimated coefficients, which keeps its significance.

ρ) does not change in statistical terms between the subperiods studied (1997m02-2009m12 and 2003m10-2009m12) regardless of using the variable (z) or the variable ($z1$). Moreover, direct estimation of the *half-life* (50% of the initial shock) with (z) and ($z1$) indicates that the persistence does not change (remains invariant at 1 month) in the different subperiods, although the adjustment period for the remaining 50% of the shock to be extinguished reduces substantially in the 2003m10-2009m12.

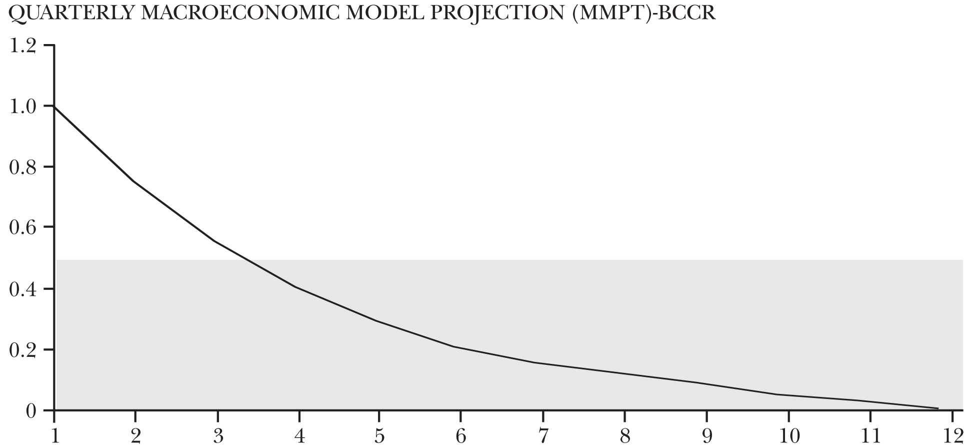
In short, structural change is detected in the average monthly inflation in November 2008, but the estimate of ρ does not change in statistical terms in this subperiod, although the adjustment period for the remaining 50% of the shock unit is extinguished is reduced, thereby reducing the persistence according to *half-life* definition.

Annex 11

***Half-Life* of an Inflationary Shock Using the MMPT Model**

When the effect of an inflationary shock unit is simulated using quarterly data from 1991, covering all the functional relationships implicit in the Macroeconomic Model for Quarterly Projection (MMPT)-BCCR (Muñoz and Tenorio, 2008), *half-life* of the disruption is estimated between 10 and

FIGURE A.2. COSTA RICA: IMPULSE-RESPONSE FUNCTION OF INFLATION TO A SHOCK ITSELF. QUARTERLY MACROECONOMIC MODEL PROJECTION (MMPT)-BCCR



SOURCE: Estimation of the Departamento de Investigación Económica, BCCR.

11 months and the other half of the disruption shows that takes about 33 months to extinguish (figure A.2).[38]

Although these results are not directly comparable with the estimate of *half-life* unit shock generated with VAR models for the variables (z) and ($z1$), given the difference in methodologies, sample size and data frequency, it should be noted that most of the estimated inflation persistence is due to feedback effects implicit in the functional interrelations that make up the MMPT. Moreover, these results are consistent with the above mentioned of the annual rates of change in the CPI tend to overestimate the degree of persistence.

Annex 12

Indirect Measures of Inflation Persistence Available in the BCCR

In the international empirical literature is usual to use new hybrid models of inflation in the short term Keynesian Phillips curve type, to show three sources of inflation persistence (Whelan, 2004):

- *Intrinsic persistence* (essential): occurs when firms partially index prices of their products at prices that prevailed in previous periods. Thus, inflation in the current period is influenced by past inflation in the model of the Phillips curve.
- *Expectations-based persistence* takes place when expectations are not rational and economic agents do not have perfect information about the economy and the functional relations between key macroeconomic variables. Then, when an unexpected inflation shock occurs, they do not know if this is temporary or permanent, so that in its attempt to determine its nature and the best way they could react, they use the history of inflation to predict future inflation. This effect is reflected in the coefficient of expectations in the Phillips curve.
- *Extrinsic persistence* (not essential): arises when companies do not react at the same time by changing their product prices to changes in economic conditions. This lack of synchrony in pricing can lead to inflation becoming persistent. This effect is reflected in the coefficient

[38] The estimate of the effect the disruption took place at the Economic Research Department of the BCCR.

associated with the output gap or the real marginal cost in the Phillips curve.

To estimate these sources of persistence and other alternative means of this concept, using semi-structural multivariate models (Phillips curve implied by the MMPT) and partial (own estimate of the Phillips curve, model of pass through, and fiscal model) and as simple univariate models (ARMA models) previously estimated in the BCCR and own estimates (Table A.2).

TABLE A.2. COSTA RICA: INERTIA AND ALTERNATIVE MEASURES OF INFLATION PERSISTENCE INDIRECT APPROACHES. UNIVARIATE AND MULTIVARIATE APPROACHES TO INFLATION

Models	*Approach*	*Period*	*Inflation measurements*	*Alternative measuremets*	
New hybrid Phillips curve (MMPT)[a]	Semiestructural multivariate	1993Q1–2009Q3	12-month acumulated (quarterly data)	0.32	Intrinsic persistence
				0.57	Expectations-based persistence
				0.19	Extrinsic persistence
New hybrid Phillips curve (own estimation)[b]	Parcial multivariate	1997Q1–2008Q4	12-month acumulated (quarterly data)	0.53	Intrinsic persistence
				0.53	Expectations-based persistence
				0.89	Extrinsic persistence
Pass-through (Castrillo and Laverde, 2008)[b]	Parcial multivariate	1991m12–2007m12	Semester ahead	0.82	Inflationary inertia
Fiscal treasury bill model (Durán and Rojas, 2007)	Parcial multivariate	1996m09–2007m04	12-month acumulated (quarterly data)	0.91	Autoregressive coefficient sum
ARMA (1.1) (Muñoz, 2088)	Univariate	1996m01–2008m12	12-month acumulated (quarterly data)	0.87	Autoregressive coefficient
ARMA (2.0) (Rodríguez, 2009)	Univariate	1996m01–2009m09	12-month acumulated (quarterly data)	0.93	Autoregressive coefficient sum

SOURCE: Authors.
[a] Preliminary estimates by GMM estimates used in the recent inflation report. Explanatory variables: inflation leads and lags, inflation expectations one year lagged output gap and imported inflation. [b] Estimated by GMM own. Explanatory variables: lagged inflation, one year ahead inflation expectations and lagged output gap. Instruments: lags of the inflation and oil prices.

Again we see that in fact the coefficients are not comparable, but can give a rough idea about the maximum range of variation of these indirect measures of inflation persistence, since the rates of change of inflation used overestimate this effect. The *intrinsic persistence* is estimated at between 0.32 and 0.53 and inflationary inertia 0.82. The autoregressive coefficients, in turn, are around 0.9. Considering the current samples are observed between 0.53 and 0.93, which contrasts with the direct estimate of inflation persistence (ranging between 0.31 and 0.42) in the recent period.

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How Persistent is Inflation in Argentina?: Inflation Regimes and Price Dynamics in the Last 50 Years

Laura D'Amato and María Lorena Garegnani*

1. INTRODUCTION

A key aspect of inflation dynamics for the monetary policy is persistence, which is merely a measure of the speed at which inflation returns to its trend value after a shock. If inflation is a very persistent process, shocks to this variable take much longer to revert, and causing a disinflation may be a highly costly process in terms of activity level.

The empirical evidence favored for a long time the perception of inflation as a highly persistent process, near to a random walk. The New Keynesian models on which the monetary policy modeling is currently based, settled on assumptions of monopolistic competition and price rigidity, generate an inflation dynamics which is, nevertheless, forward-looking. Since the empirical evidence suggested that inflation is highly persistent, there has been a tendency to include persistence when modeling inflation, in some cases, completely ad hoc.[1]

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[1] See Furher and Moore (1995), Galí and Gertler (1999), Furher (2006) and also Walsh (2003), for a very good review of the literature.

This discrepancy between data and theory has recently encouraged the production of abundant empirical evidence. This evidence, based on data including high and low inflation periods, indicates that persistence is not an inflation-inherent phenomenon but, on the contrary, it seems to vary in relation to trend inflation breaks. These breaks usually coincide with changes in the monetary regime.[2]

However, the concept of regime has remained fairly vague in the literature because it is an *unobservable* associated to institutional factors defining a framework for interactions between economic policy and private agents, influencing the creation of expectations and decision-making by such agents. We will try to identify regimes based on the results deriving from such interactions. In particular, it may be thought that trend inflation may be a proxy of the prevailing monetary regime.[3]

In this paper, we study aggregate inflation dynamics and, in particular, the phenomenon of inflation persistence in Argentina during the 1961-2006 period. We analyze the relation between changes in trend inflation and in its autoregressive component and monetary regime changes.

The assumption of a constant long-term value for trend inflation is undoubtedly implausible for an economy such as Argentina, which experienced moderate inflation in the 1960s and high inflation in the 1970s and 1980s, when monetary policy was strongly limited in its role of controlling inflation due to persistent fiscal imbalances entailing high fiscal dominance. This high inflation regime resulted, by the end of the 1980s, in a hyperinflationary episode after which Argentina adopted a currency board regime, known as Convertibility. During this period monetary policy was essentially passive and inflation dynamics was governed, to a large extent, by external factors. Inflation remained at reduced levels during such period, ending up in the abandonment of such regime in January 2002. After the abrupt peso devaluation, inflation accelerated, and reached a peak in April 2002, returning then to lower values, even though above the average levels observed during the Convertibility regime.

[2] See Marques (2004), Levin and Pigier (2004), Altissimo et al. (2006), and Angeloni et al. (2006), among others, for European economies, and Cogley and Sargent (2006) and Cogley and Sbordone (2007) for the United States.

[3] This is the approach taken by recent literature studying the effects of assuming a positive trend inflation under standard New Keynesian models. See to this respect Kiley (2006), Blake and Fernández-Corugedo (2006), and Ascari and Ropele (2007), among others.

2. INFLATION PERSISTENCE IN THE LITERATURE

Trend inflation can experience discrete breaks due to changes in the long-run determinants of inflation. There is agreement in monetary theory that the long-run value of inflation is closely related to money growth.[4] In this regard, the long-run values of inflation and money growth are not independent of the importance assigned by monetary policy to the goal of stabilizing inflation at a low and stable value. Therefore, the long-run values of inflation and money growth should not be expected to be constant but, rather dependent on the monetary regime.[5] In this respect, the empirical evidence indicates that, under regimes of fiscal dominance, trend inflation as well as money growth are high.[6] On the contrary, once monetary policy is less conditioned by fiscal policy and is able to fulfill its role of providing the economy with a nominal anchor, trend inflation tends to decline. Economies may also experience high inflation rates if there are incentives to monetary policy for exploiting the trade-off between growth and inflation persistently.

In spite of the fact that changes in trend inflation seem to be empirically relevant for inflation dynamics, the New Keynesian models used for monetary policy modeling, focused on short-run fluctuations of inflation and output, generally assume a zero inflation rate for the steady state, setting aside the possibility that long-run inflation may be positive and eventually variable over time.

At the same time, microeconomic models with nominal rigidities providing a theoretical basis for a Phillips curve (Taylor, 1980; Calvo, 1983, and Rotemberg, 1982) generate persistence in the price level, but not in inflation. This feature of these models is not aligned with the empirical evidence, which suggests that inflation is a highly persistent process. Therefore, authors such as Furher and Moore (1995) and Galí and Gertler (1999) propose to include an intrinsic component of persistence in inflation.

Recently, Cogley, Primicieri and Sargent (2007), Cogley and Sobordone (2007) and Sbordone (2006) have shown for the United States that

[4] See Walsh (2003) in this respect.

[5] According to Heymann and Leijonhufvud (1995) a policy regime can be characterized by the behavioral pattern of the interactions between policy makers and private agents, which supports the later expectations formation and decisions.

[6] See Heymann and Leijonhufvud (1995) and Walsh (2003) for a detailed discussion of the relation between monetary and fiscal policy.

inflation persistence may be explained by the presence of a trend inflation that is variable over time. Simultaneously, Benati (2006) and Altissimo et al. (2006) show, for a significant number of countries, that the degree of inflation persistence has varied over time and has been lower in periods when the monetary policy was able to stabilize inflation at reduced levels.

2.1 Inflation Persistence: Conventional Measures

Inflation persistence can be defined as the speed at which inflation returns to its long-run value after a shock.

The most widely used persistence measure in the literature is the one proposed by Andrews and Chen (1994).

Taking into account inflation as a stationary process AR(p)

$$\pi_t = \alpha + \sum_{i=1}^{p} \beta_i \pi_{t-i} + \eta_t \ . \tag{1}$$

Andrews and Chen propose as a persistence measure the sum of the autoregressive coefficients in (1)

$$\rho = \sum_{i=1}^{p} \beta_i \ . \tag{2}$$

Marques (2004) and Angeloni et al. (2006) emphasize the fact that the persistence concept is associated to the speed at which inflation returns to its long-run value after a shock. In this sense, Marques (2004) suggests that a proper representation of this process would be to rewrite (1) as an equilibrium correction mechanism in terms of deviation from its long-run value.

$$\pi_t - \mu = \sum_{i=1}^{p-1} \varphi_i \Delta(\pi_{t-i} - \mu) + \rho(\pi_{t-1} - \mu) + \eta_t \ , \tag{3}$$

where

$$\mu = \frac{\alpha}{1-\rho} \ , \tag{4}$$

is the unconditional mean of inflation. The higher the absolute value of ρ , the slower inflation returns to its equilibrium value. A critical issue to be determined prior to calculation of any persistence measure is whether it is appropriate to assume a constant long-run value for inflation.

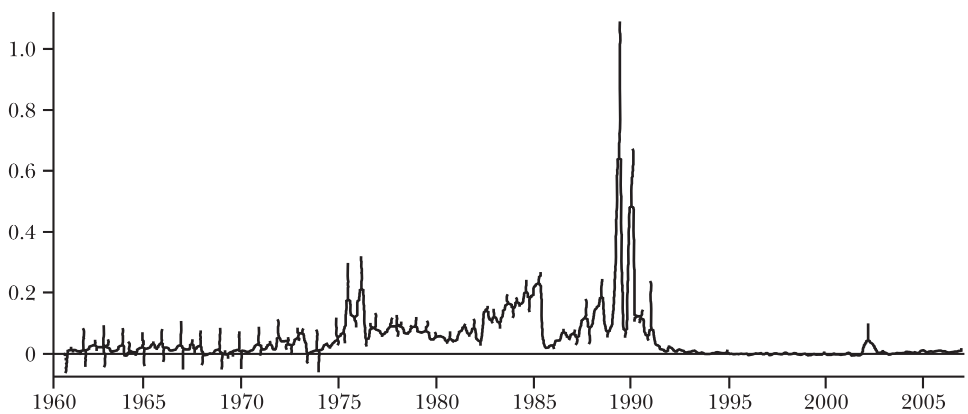
3. INFLATION PERSISTENCE AND MONETARY REGIMES

3.1 Inflation Dynamics in Argentina

As we previously mentioned, the assumption of a constant equilibrium value for the inflation rate is not reasonable in the case of Argentina. In this respect, Capistrán and Ramos-Francia (2006) provide evidence on inflation persistence for the ten largest countries of Latin America and find that, in the Argentine case, the degree of inflation persistence decreased between 1980m1 and 2007m2.

As shown in Figure 1, a simple visual inspection suggests that the trend inflation experienced substantial changes between 1961 and 2006.

FIGURE 1. MONTHLY INFLATION, 1961-2006 (%)



During the 1960s, inflation in Argentina remained at moderately high levels. Successive devaluation episodes imposed an increasing trend to inflation. After the inflationary outbreak known as *Rodrigazo*, in 1975, inflation increased substantially and did not return to its previous level. High inflation was a phenomenon widely spread in Latin America during the 1970s and 1980s. The monetary financing of fiscal imbalances was a common feature among the countries that went through hyperinflationary episodes such as Argentina.

Nevertheless, the Argentine case presents some particular features. Since mid-1970s, the public sector maintained high budget deficits. By the end of such decade, a crawling peg to the US dollar was adopted, a scheme that attempted to a convergence of domestic to international inflation. In those years, like in other economies in the region, Argentina started a process of trade and financial liberalization. The peso experienced a persistent real appreciation and the economy ran into sustained current account deficits. The sharp increase in the international interest rate in 1982 led to a severe debt crisis in the region, which seriously damaged Argentina. The peso was devaluated and the government took over a significant portion of private external debt, what deepened the already existent fiscal imbalances. In the following years, inflation accelerated significantly. In 1985, an attempt to stabilize inflation through a program known as Plan Austral resulted in a temporary reduction of the inflation rate. The program did not succeed and inflation accelerated afterwards, ending up in two hyperinflationary episodes in 1989 and 1990.

In April 1991, the adoption of a currency board regime and a hard peg to the US dollar by law, managed to anchor inflation expectations and caused a permanent reduction of the inflation rate that, for such decade, was on average near zero. The adoption of this policy scheme was accompanied by a drastic reform of the public sector including the privatization of the main public enterprises. The country gained access to international financial markets and, with better fiscal results at the beginning, the government replaced monetary financing with the issue of debt in international markets. This policy combination was successful in anchoring inflation expectations and stabilizing inflation at very low levels. However, the fiscal reform was incomplete. With an overvalued domestic currency, the country started to experience persistent current account deficits, increasing its external debt, both private and public. After the Asian crisis in 1997 and the Russian crisis in 1998, the economy entered a prolonged recession. The Brazilian devaluation of January 1999 led to a deepening of the recession. Increases in international interest rates led to a higher burden of interest payments in the fiscal accounts, while at the same time tax revenues decreased due to the recession. The government and the private sector's external debt increased over time and began to be perceived as unsustainable. Toward 2001, a financial and external crisis broke out, which resulted in the abandonment of the Convertibility regime and a devaluation of the Argentine peso, entailing a dramatic change in relative prices and resulting in inflation acceleration, which reached a peak in April 2002, to then decrease, even though at a slightly higher level than that prevailing under the Convertibility regime. By the end of 2004, when the economy started to recover on a sustained basis from the recession it had been immersed in for several years, inflation began to slightly accelerate up to the end of the sample.

3.2 Descriptive Analysis

The brief description of the historical inflation behavior in Argentina in the preceding Section suggests the presence of important structural breaks and disruptive episodes such as hyperinflations.

However, it is reasonable to expect that shocks to this variable have no permanent effect, to the extent that macroeconomic policy in general and monetary policy in particular acts providing the economy with some nominal anchor to stabilize inflation. In this sense, it is expected for unit root tests to reject the null hypothesis of a unit root for inflation when its time series properties are studied for a sufficiently long period of time. However, as stated in Section 2, it is possible for trend inflation to experience changes throughout long periods of time, if economies are subject to regime changes. In this case, no stationary behavior may be expected for this variable, but attributable to changes in its long-run value and not to the presence of a unit root.

In this section, we review the time series properties of inflation and assess the presence of breaks in its mean value. In the next section, we use different techniques to identify the presence of breaks both in the mean and in the autoregressive component of inflation, for the purpose of identifying and controlling for them in the calculation of measures of inflation persistence.

From Table 1, it can be seen that both the mean and volatility of inflation changed across the sample. In this respect, the descriptive statistics for the complete period are not informative about inflation behavior from 1961 to 2006. It is possible to identify a low inflation period from 1961

TABLE 1. DESCRIPTIVE ANALYSIS OF MONTHLY INFLATION, 1961-2006 (%)

Period	*Mean*	*Standard deviation*
1961m01-1975m05	0.021895	0.030503
1975m06-1976m05	0.181004	0.080249
1976m06-1979m12	0.077641	0.022908
1980m01-1989m03	0.103108	0.061452
1989m04-1990m03	0.443025	0.299911
1990m04-1991m02	0.113582	0.051173
1991m03-1992m12	0.020829	0.021575
1993m01-2006m12	0.004420	0.010522
1961m01-2006m12	0.051648	0.092957

to 1975m05, then a severe inflation episode, known as Rodrigazo, between 1975m06 and 1976m05, followed by a high inflation period from 1976m06 to 1979m12 and a very high inflation one between 1980m01 and 1989m03.

From 1989m04 to 1990m03 there were two hyperinflationary episodes, then there was a transition period between 1990m04 and 1991m02, followed by a disinflation period from 1991m03 to 1992m12 after the implementation of the Convertibility regime. Both, the *Rodrigazo* and the hyperinflation episodes as well as the transition and disinflation periods are considered in this analysis as temporary episodes of little interest for the study of a phenomenon such as persistence, and therefore, they are set aside or controlled when calculating measures of inflation persistence.

The rest of the sample, covering the 1993m01-2006m12 period, seems to be, from a statistical point of view, a low inflation period, briefly interrupted by an inflationary episode after the peso devaluation in January 2002. As can be seen in Figure 1 in the preceding section, the peak in inflation caused by the devaluation in January 2002 turns out to be insignificant if compared to the hyperinflation values. However, there was a monetary regime change in this period whose effects on inflation dynamics cannot be captured by the descriptive analysis. We will study it more in depth in the following sections.

In order to analyze the time series properties of inflation and assess the presence of breaks in its mean value, the Dickey-Fuller's test was used to evaluate the presence of a unit root, controlling for the significance of the constant and a deterministic trend (see Table 2). In all cases the presence of a unit root is rejected. These tests allow verifying that from 1961m01 to 1989m03 the inflation mean was significantly different from zero (positive). On the contrary, the null hypothesis of a mean equal to zero between 1993m01 and 2006m12 is not rejected. Besides, no statistically significant deterministic trend is identified in either period.

TABLE 2. DICKEY-FULLER TEST, 1961-2006

Period	*H_0: unit root*
1961m01-1989m03	–4.86[a]
1993m01-2006m12	–4.749[a]
1961m01-2006m12	–2.718[a]

[a] H_0 is rejected at 1% of significance.

These results suggest that even though inflation does not have a unit root, it can neither be considered a stationary process, to the extent that significant changes are identified in its mean value. In the following section, we complement the descriptive analysis with tests assessing the presence of structural breaks both in the mean and in the autoregressive component of inflation rate.

3.3 Assessing the Presence of Breaks in Trend Inflation

In the following two sections, the purpose is to identify the presence of breaks both in the mean and in the autoregressive component of inflation and to study their relation with the occurrence of changes in the monetary regime. This is done through a recursive analysis and by implementing the Bai-Perron test.

3.3.1 Recursive Analysis

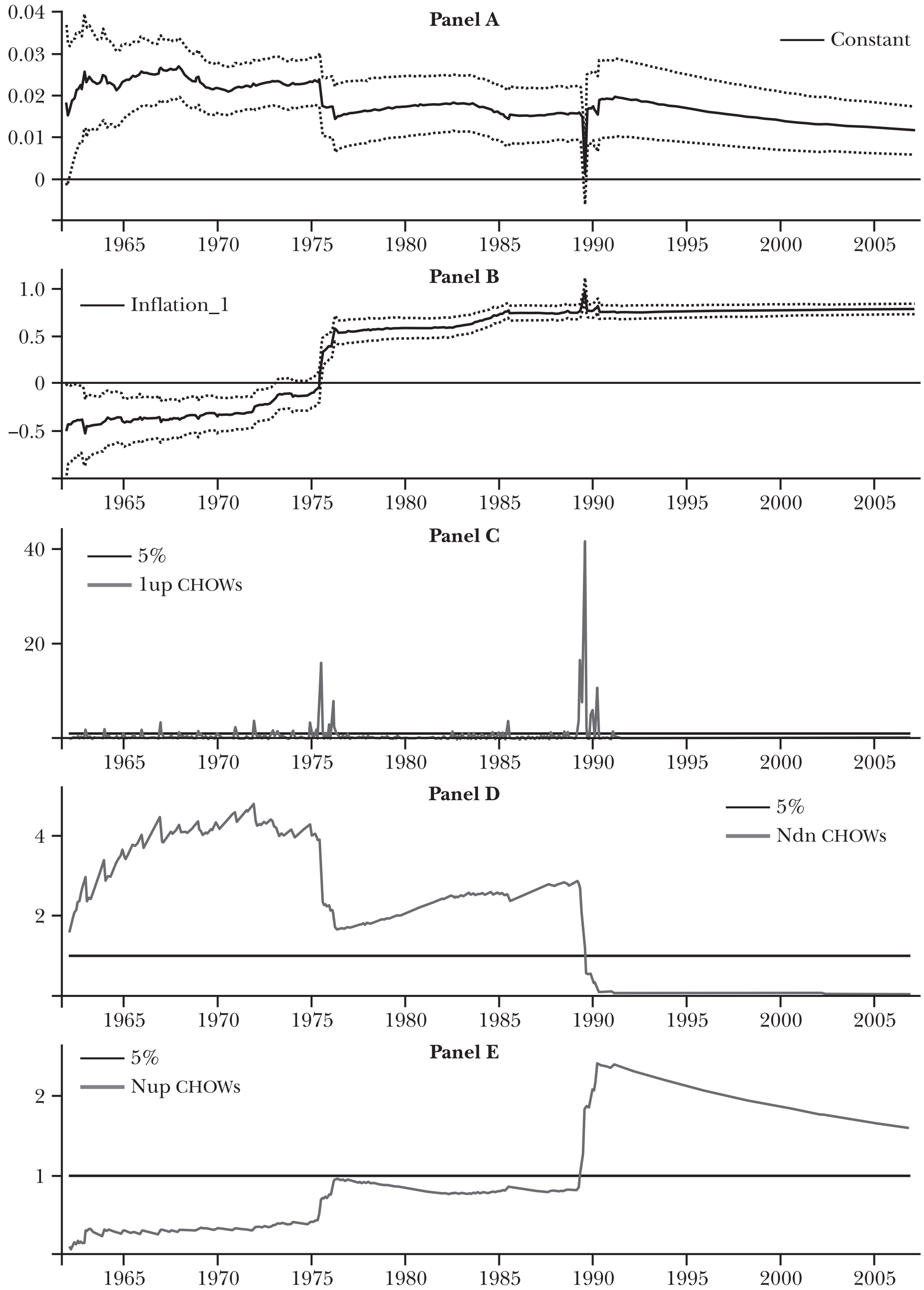
First, we recursively estimate Equation (1) and evaluate the presence of breaks both in the constant and in the autoregressive coefficient, using structural change tests. In Figure 2, panels A and B show that both coefficients, constant and autoregressive component, are outside the interval of ±2 times the previous standard deviations in the surroundings of the inflationary episode known as Rodrigazo, in 1975, and the hyperinflations. Chow tests, in Figure 2, panels C and E. (*forecast horizon* descendent, ascendant and one-step), confirm the presence of a break at the 5% critical value in the Rodrigazo episode and in the hyperinflation period.

To sum up, there is evidence of a change in inflation dynamics in the surroundings of the Rodrigazo inflationary episode and the hyperinflation episodes that ended up in the adoption of the Convertibility regime. Probably due to the magnitude of the hyperinflationary episodes, and to the volatility generated by them, it is not possible to identify a significant break in inflation dynamics after the abandonment of such regime. Therefore, we study such subperiod separately below.

3.3.2 Assessing the Presence of Multiple Breaks: The Bai-Perron Test

In order to evaluate the presence of multiple structural breaks in inflation dynamics we use the test developed by Bai and Perron (2003). In relation to the preceding analysis, the Bai-Perron methodology is more

FIGURE 2. RECURSIVE ANALYSIS, 1961m01-2006m12



general. It allows identifying the presence of multiple breaks, and proposes tests to evaluate the null hypothesis of no breaks vs. the presence of multiple breaks, as well as a procedure to assess the null hypothesis of n breaks versus $n + 1$ breaks. It also generates confidence intervals for dates of break, thus allowing data and errors to have different distributions among the segments into which the test separates the sample, or eventually imposes a common distribution. This flexibility is interesting in the Argentine case given the assumption of a non-constant variance throughout the period under study.

We conducted the test assessing the presence of breaks in the mean (3.A) and in the mean and autoregressive coefficient (3.B). Results are shown in Table 3.

We started by considering the possibility of up to five breaks in the mean (3.A) and in the mean and autoregressive coefficient (3.B). The four tests reported in Table 3 identify the presence of three breaks at the 1% level of significance. The different criteria proposed by Bai and Perron: SupF sequential procedure, Bayesian information criterion (BIC) and Liu, Wu and Zidek (LWZ) confirm that in the case of the mean, three breaks are identified: in November 1974, which may be associated to the inflationary episode known as the Rodrigazo, June 1982, associated to the debt crisis, and the adoption of the Convertibility regime in April 1991. Confidence intervals for breaks were calculated allowing for heteroskedasticity and serial correlation in the residuals.

When assessing changes in the mean and the autoregressive coefficient, the test identifies breaks in September 1974, August 1982 and July 1989. The first two are in the surroundings of those identified for changes in the mean, whereas the last one corresponds to the beginning of the first hyperinflationary episode.

4. INFLATION PERSISTENCE

Taking into account the previous descriptive analysis and considering the breaks identified both in trend inflation as well as in its autoregressive component in subsections 3.3.1 and 3.3.2, we construct a non-constant mean for inflation, to then estimate an autoregressive model according to Equation (3). Here, we follow Marques (2004) and use dummy variables to identify changes in trend inflation as suggested by the descriptive

TABLE 3. BAI-PERRON TEST (1961M01-2006M12)

A. Changes in Mean (α_1)

Tests			
SupF T(3)	*UDmax*	*WDmax*	*SupF T(2/3)*
100.2013	100.2013	135.3968	102.4602

Number of breaks		
Sequential	*BIC*	*LWZ*
3	3	2

Dates of breaks		
T_1	T_2	T_3
November 1974	June 1982	April 1991

Estimated parameters			
α^1	α^2	α^3	α^4
0.0209	0.0954	0.1928	0.0239

B. Changes in Mean (α_1) y autoregressive coefficient (β_1)

Tests			
SupF T(3)	*UDmax*	*WDmax*	*SupF T(2/3)*
143.5629	311.7505	311.7505	106.8836

Number of breaks		
Sequential	*BIC*	*LWZ*
3	3	2

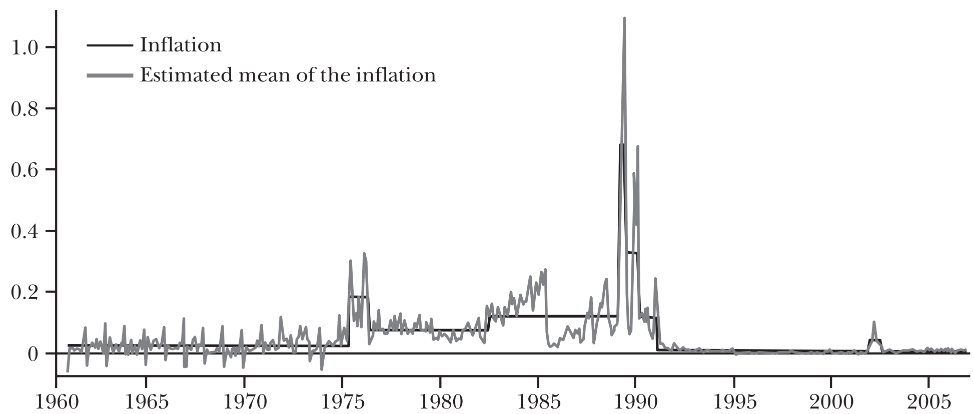
Dates of breaks		
T_1	T_2	T_3
September 1974	August 1982	July 1989

Estimated parameters			
α^1 ; β^1	α^2 ; β^2	α^3 ; β^3	α^4 ; β^4
–0.1192	0.0380	–0.0602	0.0141
0.0233	0.5911	1.5453	0.3778

analysis in previous sections. Thus, the inflation values estimated according to Equation (5) represent the trend inflation shown in Figure 3.[7]

$$\underset{(HCSE)}{\pi_t} = \underset{(0.0023)}{0.0219} + \underset{(0.0235)}{0.1591}\,d_1 + \underset{(0.0037)}{0.0499}\,d_2 + \underset{(0.008)}{0.0965}\,d_3 + \underset{(0.1463)}{0.6575}\,d_4 + \underset{(0.0805)}{0.3029}\,d_5 + \tag{5}$$
$$+ \underset{(0.0157)}{0.0917}\,d_6 - \underset{(0.0025)}{0.0171}\,d_7 + \underset{(0.008)}{0.0352}\,d_8$$

FIGURE 3. INFLATION AND ESTIMATED MEAN OF INFLATION, 1961-2006



According to equation (5) and to linear restrictions tests, a positive and statistically different from zero value (2.2% monthly) for trend inflation is obtained between January 1961 and May 1975, of 18.1% between June 1975 and May 1976, of 7.2% between June 1976 and July 1982 and of 11.7% between August 1982 and March 1989. During the two hyperinflationary periods, there is a 67.9% mean from April to September 1989 and 32.5% from August 1989 to March 1990, which goes down to 11.4% from April 1990 to February 1991. After the adoption of the Convertibility regime, the inflation rate decreased sharply, resulting statistically not different from zero until the end of the sample. However, during this last period and after the abandonment of the Convertibility regime in January 2002, inflation accelerated after the sharp peso devaluation, reaching a 10% monthly peak in April 2002, to then decelerate. Nevertheless, this inflation outbreak is small if compared to the Rodrigazo and the hyperinflationary episodes. When assessing the linear restriction of a different mean

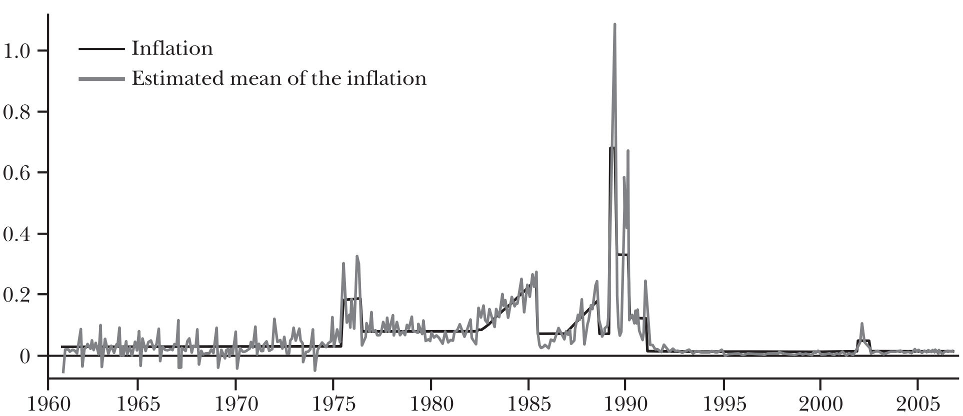
[7] Where d_1 corresponds to a dummy variable for the 1975m06-1976m05 period, d_2 for 1976m06-1982m07, d_3 for 1982m08-1989m03, d_4 for 1989m04-1989m07, d_5 for 1989m08-1990m03, d_6 for 1990m04-1991m02, d_7 for 1991m03-2006m12 and d_8 for 2002m01-2002m08.

from January to August 2002 with respect to the 1991-2006 period, we are close to rejecting the null hypothesis of equal means, and this suggests that this transition period may be considered an outlier within the low inflation period and, in this sense, it is reasonable to control for its presence, since it is a transitory episode. Section 4.1 studies separately and in depth the low inflation period, setting aside the disinflation period following the implementation of the Convertibility regime and when doing so, it is possible to detect changes in trend inflation after the adoption of a managed float regime.

In addition, the presence of positive deterministic trends in the high inflation period was evaluated. Equation (6) incorporates both trends to (5).[8]

$$
\begin{aligned}
(6)\quad \underset{(HCSE)}{\pi_t} = &\underset{(0.0023)}{0.0219} + \underset{(0.0235)}{0.1591}d_1 + \underset{(0.0037)}{0.0499}d_2 + \underset{(0.0061)}{0.0406}d_3 + \underset{(0.1465)}{0.6575}d_4 + \underset{(0.0805)}{0.3029}d_5 + \\
&+ \underset{(0.0157)}{0.0917}d_6 - \underset{(0.0025)}{0.0171}d_7 + \underset{(0.0082)}{0.0352}d_8 + \underset{(0.0003)}{0.0049}t_1 + \underset{(0.001)}{0.0055}t_2
\end{aligned}
$$

FIGURE 4. INFLATION AND TREND INFLATION, 1961-2006



Having obtained a non-constant mean for inflation (μ_t), according to (6), the following step is to calculate deviations of inflation with respect to such mean, which we will call z_t, to then estimate Equation (3) and calculate a persistence measure considering a non-constant mean. In Table 4, we compare the persistence measure obtained from the estimation of

[8] Where t_1 corresponds to a deterministic trend for 1982m07-1985m06 and t_2 for 1987m01-1988m08 periods.

equation (3) using a non-constant mean (μ_t) with respect to the measure obtained if a constant mean (μ) is assumed.

It can be seen from Table 4 that assuming a constant mean, inflation would be a highly persistent process (0.78). On the contrary, if we allow for a non constant mean, the degree of persistence reduces remarkably (0.31). Both persistence measures are statistically different, and this allows us to conclude that once breaks in the inflation mean are identified and controlled, inflation appears to be a rather less persistent process.

TABLE 4. INFLATION PERSISTENCE, 1961m01-2006m12

	No changes in mean	*Changes in mean*
ρ	0.78	0.31
HCSE	(0.156)	(0.106)
	(1 lag)	(1 lag)

A second issue to evaluate is if, associated to changes in the inflation mean, changes are also identified in the autoregressive component of the series. Both, the recursive analysis and the Bai-Perron tests presented in the preceding section, identify changes in the autoregressive coefficients of inflation associated to breaks in the mean. Recent evidence for other countries suggests that once inflation is reduced, its degree of persistence decreases.[9]

In order to calculate a persistence measure that takes into account the previously identified changes in inflation dynamics, we estimate an autoregressive model of z_t (inflation deviations from its non-constant mean estimated according to equation 6) including dummies multiplying the levels and differences of z_t: equation 7 shows the estimated model and Table 5 presents the persistence measures obtained as from such equation.[10]

$$\underset{(HSCE)}{z_t} = \underset{(0.009)}{0.051} z_{t-1} + \underset{(0.006)}{0.057} \Delta z_{t-1} + \underset{(0.080)}{0.171} d_{1'} z_{t-1} + \underset{(0.165)}{0.419} d_1 \Delta z_{t-1} + \underset{(0.016)}{0.064} d_{2'} z_{t-1} + \tag{7}$$

$$+ \underset{(0.104)}{0.214} d_{2'} \Delta z_{t-1} + \underset{(0.162)}{0.824} d_{3'} z_{t-1} + \underset{(0.172)}{0.676} d_{4'} \Delta z_{t-1} + \underset{(0.115)}{0.360} d_{5'} z_{t-1} + \underset{(0.095)}{0.283} d_{6'} \Delta z_{t-1}$$

[9] See in this respect Angeloni et al. (2006), and Capistrán and Ramos Francia (2006).

[10] In (7), d_1, corresponds to 1961m01-1975m05, d_1, as in (5) to 1975m06-1976m05, d_2, to 1976m06-1979m12, d_3, to 1980m01-1989m03, d_4, to 1989m04-1990m03, d_5, to 1991m03-1992m12 and d_6, to 1993m01-2006m12.

Results indicate that except for the Rodrigazo episode, inflation was not much persistent until the 1980s.

During the *high inflation* period, between 1980m01 and 1989m03, the inflation process is highly persistent (0.93), a value even greater than that obtained when a constant mean is assumed for the whole sample. Subsequent periods in Table 5 correspond to the two hyperinflationary episodes (1989m04-1990m03), transition (1990m04-1991m02) and the disinflation (1991m03-1992m12) following the implementation of the Convertibility regime. Even though we are not interested in measuring the degree of inflation persistence in such episodes, we had to control for them in the estimation to properly measure persistence in relevant periods. During the *low inflation* period, the degree of persistence is markedly reduced to 0.39.

TABLE 5. INFLATION PERSISTENCE, 1961m01-2006m12

1961m01-1975m05	0.2791
1975m06-1976m05	0.5277
1976m06-1979m12	0.3863
1980m01-1989m03	0.9323
1989m04-1990m03	0.7843
1990m04-1991m02	0.1077
1991m03-1992m12	0.4676
1993m01-2006m12	0.3910

To sum up, the preceding analysis indicates significant changes both in the inflation mean and its autoregressive component during the period under analysis. Controlling for these changes, we find that inflation was a little persistent process in the 1960s and part of the 1970s, and a highly persistent process in the high inflation period (near to a random walk). After the two hyperinflationary episodes Argentina underwent by the end of the 1980s, inflation persistence sharply declined once inflation became stable at significantly lower levels. There is also evidence that changes both in the mean and in the autoregressive component are related to the Rodrigazo episode and the adoption of such a peculiar regime as the Convertibility. The fact that inflation dynamics became close to the behavior of a random walk during the high inflation period seems to be consistent with the difficulties found by economic policy during such period to anchor inflation expectations and make inflation return to a long-run equilibrium value. Undergoing such a traumatic episode as hyperinflation seems to have generated the necessary adjustments, mainly on the fiscal side, so that an anchorage such as the currency board regime (Convertibility) managed to stabilize the inflation rate at very low levels. The change of regime entailed by the abandonment of such currency scheme cannot be captured when an atypical period such as hyperinflation is included; therefore, the 1993-2006 subperiod is analyzed separately in the following section.

4.1 A Detailed Analysis of the Low Inflation Period

As stressed in the previous section, the dramatic volatility entailed by the hyperinflationary episode restricts the possibility of identifying additional breaks in the inflation series and, in particular, the potential break associated to the abandonment of the currency board regime, and the adoption of a managed float regime in 2002. Therefore, in this section we analyze separately the low inflation period, where two potentially different subperiods could coexist given the change introduced in the monetary policy scheme in January 2002, since vast empirical evidence studying the relationship between money and prices suggests that inflation dynamics is not independent of the monetary scheme adopted by central bank authorities.[11]

In order to study the extent up to which the adoption of a managed float regime in January 2002, entailed changes in inflation dynamics, this subperiod is analyzed separately. The recursive analysis allows for the identification of a break both in the mean and in the autoregressive component of the AR(1) model coincidentally with the abandonment of the Convertibility regime in January 2002. The break in the autoregressive component suggests that the degree of persistence may have changed between both regimes.

These results are confirmed by the Bai-Perron test (see Table 6), identifying a break in January 2002 when we test breaks in trend inflation, and in May 2002 when we evaluate changes in the mean and in the autoregressive coefficients.

Upon identifying the presence of at least one break in trend inflation, we construct a non constant mean for such period. Equation (8) shows the results of the estimation.

[11] See in this respect, McCandless and Weber (1995), De Grawue and Polan (2002) and Gabrielli et al. (2004) and Basco et al. (2006) for the Argentine case.

FIGURE 5. RECURSIVE ANALYSIS, 1993m01-2006m12

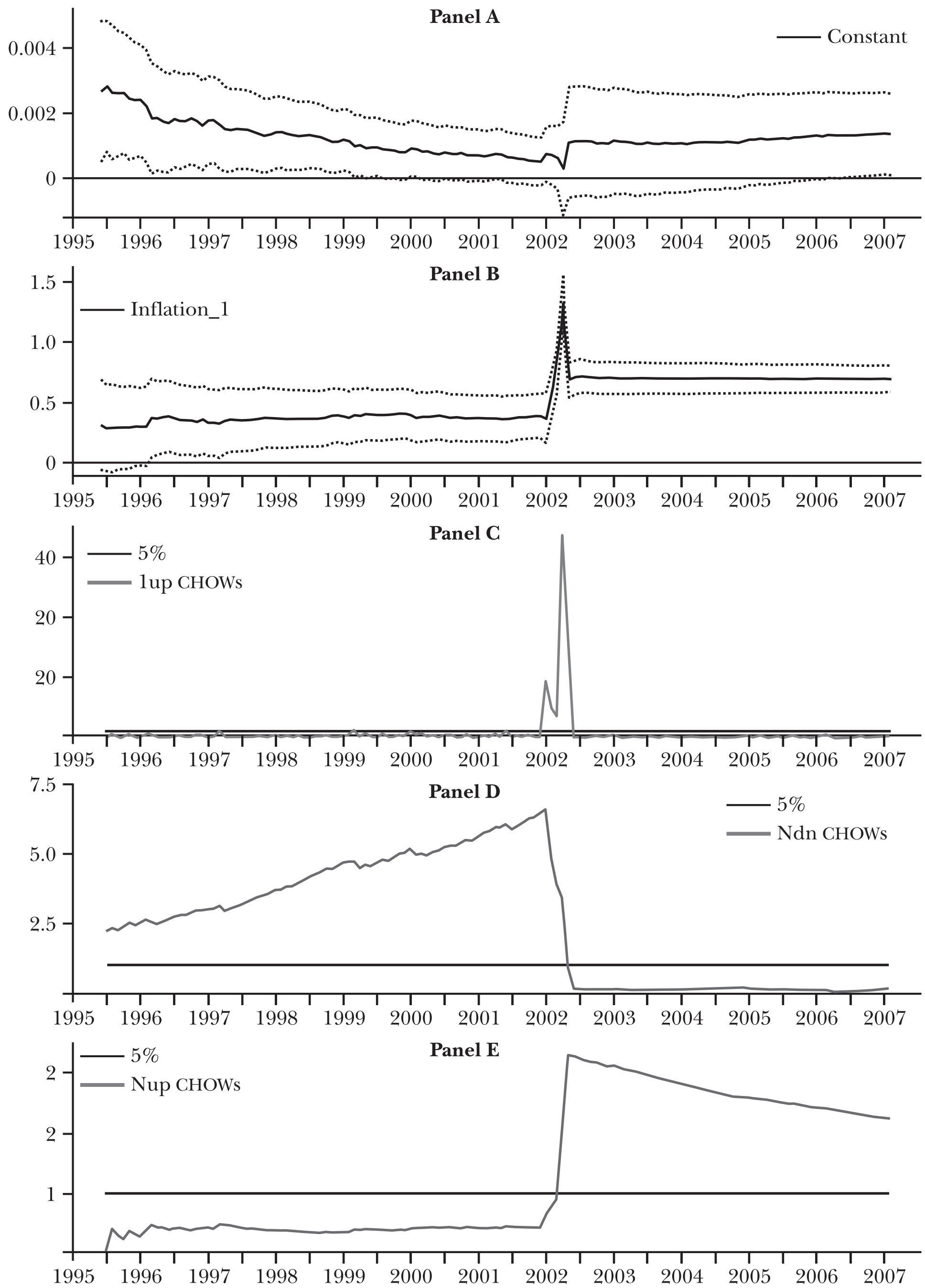


TABLE 6. BAI-PERRON TEST

A. Changes in Mean (α_1)

Tests		
SupF $_T$(1)	*UDmax*	*WDmax*
6.60	6.60	6.60

Number of breaks		
Sequencial	*BIC*	*LWZ*
1	1	1

Dates of breaks
T_1
January 2002

Estimated parameters	
α^1	α^2
0.0008	0.01

B. Changes in Mean (α_1) and Autoregressive Coefficients (β_1; β_2)

Tests		
SupF $_T$(1)	*UDmax*	*WDmax*
65.33	65.33	65.33

Number de breaks		
Sequencial	*BIC*	*LWZ*
1	1	1

Dates of break
T_1
May 2002

Estimated parameters	
α^1; $\beta^1{}_1$; $\beta^1{}_2$	α^2; $\beta^2{}_1$; $\beta^2{}_2$
0.0001	0.0029
1.1700	0.3060
–0.3160	0.2130

(8) $$\underset{(HCSE)}{\pi} = \underset{(0.0003)}{0.00087} + \underset{(0.0078)}{0.0362}\, d1 + \underset{(0.0006)}{0.0053}\, d2\ .$$

It can be seen that trend inflation was slightly different from zero during the Convertibility period. Then, during the crisis following the devaluation in January 2002, trend inflation rose to 3.6% monthly to then decline to a 0.5% mean rate, which is positive and statistically different from zero. Thus, upon considering the low inflation period, it is possible to identify a break that seems to be associated to the change of regime entailed by the abandonment of the Convertibility scheme. An atypical period is also identified in the months after the devaluation of January 2002, when inflation experienced a temporary jump. We also control for such period when calculating the inflation mean according to equation (8).[12]

Table 7 shows the results of calculating persistence measures for the 1993m1-2006m12 period using a constant mean and a non constant mean. A significant reduction in estimated persistence is observed when considering the breaks identified according to (8).

TABLE 7. INFLATION PERSISTENCE, 1993M01-2006M12

	Constant mean	*Non-constant mean*
ρ	0.69557	0.18291
HCSE	(0.207)	(0.082)
	(1 lag)	(1 lag)

Finally, when we try to identify the presence of changes in the autoregressive coefficients of inflation that might be associated to the regime change, we find a very low degree of persistence (0.15) during the Convertibility period, which is significantly increased (0.27), after adoption of the managed float regime (see 9).

(9) $$\underset{(HSCE)}{z_t} = \underset{(0.0688)}{0.1493}\, z_{t-1} + \underset{(0.1157)}{0.236}\, d_3 z_{t-1} + \underset{(0.0755)}{0.1437}\, d_3 \Delta z_{t-1} + \underset{(0.0003)}{0.0115}\, d_{951} + \\ + 02 \text{ crisis dummies}\ .$$

To sum up, the results obtained analyzing the low inflation period separately indicate a change in the inflation process both in terms of its mean value and its autoregressive component, thus observing a higher degree of persistence in the last subperiod of the managed float regime.

[12] In Equation 8 d_1 corresponds to a dummy variable for the 2002m01-2002m09 period and d_2 for the 2002m10-2006m12 period.

5. CONCLUSIONS

Recent empirical evidence has revealed that persistence may not be an inflation inherent characteristic of inflation and that inflation dynamics may change depending on the monetary regime prevailing in the economy. These studies also reveal the importance of considering the possibility that the long-run value of inflation may experience breaks. Besides, they show that upon reduction of inflation as a rather extended phenomenon among economies, its dynamics also seems to have changed and, in particular, inflation persistence has declined.

In the Argentine case, the presence of breaks in the long-run value of inflation is evident. Inflation was moderate in the 1960s, high in the 1970s and very high in the 1980s. During the last two periods fiscal dominance precluded monetary policy to control inflation. After two hyperinflationary episodes by the end of the 1980s, Argentina adopted a currency board regime (known as Convertibility regime) which managed to stabilize the inflation rate rather permanently at reduced levels. Under such regime, the monetary policy was passive and inflation dynamics was mainly governed by external factors. The Convertibility regime was abandoned after the peso devaluation at the beginning of 2002, when a floating exchange rate regime was adopted. The peso devaluation was followed by a brief inflation acceleration and then inflation reached again lower levels, even though somewhat higher than those prevailing throughout the Convertibility period.

We study inflation dynamics during the 1961-2006 period and, in particular, inflation persistence. Using recursive methods and the structural change tests developed by Bai and Perron, we identified breaks in trend inflation that coincide with regime changes: *i)* A high inflation regime after the 1975 inflationary episode, *ii)* a very high inflation regime after the 1982 debt crisis, *iii*) two hyperinflationary episodes (1989 and 1990), *iv)* a low inflation regime after the adoption of the Convertibility regime in 1991 and *v)* the abandonment of such regime in January 2002, when analyzing the low inflation period separately. Given the presence of changes in trend inflation, we calculate deviations from such mean that evolves according to discrete breaks. We then use this deviations to calculate inflation persistence measures. We find that inflation was a highly persistent process during the high inflation period, near to a random walk. On the contrary, upon inflation decline following the adoption of the currency board regime, persistence markedly decreased. After the implementation of a managed float scheme and controlling for the inflationary episode unleashed by the peso devaluation in 2002, we find that inflation shows again a more persistent behavior.

These results confirm the importance of evaluating the presence of structural breaks when modeling the inflation dynamics and, in particular, when attempting to estimate persistence. They also confirm that in the Argentine case persistence is not an intrinsic characteristic of inflation, but rather depends on the monetary regime.

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The Target of the Central Bank and Inflation Persistence in Colombia

Juan José Echavarría, Norberto Rodríguez and Luis Eduardo Rojas[*]

1. INTRODUCTION

A high level of inflation persistence forces the authorities to raise interest rates higher and for a more prolonged period in order to reduce inflation after a shock. This makes the process of disinflation more costly in terms of employment and GDP loss and might also lead to policy errors which, in the end, generate high levels of inflation. At the theoretical level, the existence of inflation persistence (the difference between inflation and its long term trend, when the latter is greater than zero) invalidates the so-called New Keynesian Phillips curve. Nevertheless, inflation analysis is useful for predicting its evolution.

In a recent paper, Echavarría, López, and Misas (Echavarría, López, and Misas, 2013) study the behavior of the Colombian inflation series. They find significant changes in the average and variance of the series for the periods 1991m01-2000m01 and 2000m02-2010m06, but not in a persistence indicator such as the sum of autoregressive coefficients. A similar result is found for the USA. Stock and Watson (2007) and Pivetta and Reis (2007), for example, argue that inflation persistence has not changed for decades in that country.[1]

[*] Banco de la República, Colombia. The points of view expressed in this document do not necessarily coincide with those of Banco de la República or its Board of Directors. Authors are grateful to Andrés González and Hernando Vargas for their comments.

[1] Stock and Watson (2007) define persistence as the major auto-regressive root and do not dismiss the possibility that the series has a unitary root, as in 1970-1983 and in 1984-2004. Based on a Bayesian model, Pivetta and Reis (2007) find that the major

How can the fact that inflation persistence has not fallen in the USA be explained when the literature shows important changes in monetary policy after 1982 under the Federal Reserve (Fed) presidencies of Volker and Greenspan (Clarida, Galí, and Gertler, 2000), and when empirical literature shows that statistical inflation persistence is reduced significantly under a credible monetary regime? Benati (2008), in effect, finds that inflation persistence has been low in countries that used the gold standard at some point, in countries who have adopted the euro as a common currency and in those countries which favor an inflation targeting regime, such as the United Kingdom, Canada and Australia.[2]

Colombia is a more paradoxical case. Mishkin (2007, pp. 299-300) suggests that during the 1990s the country did not seriously commit to reducing inflation below 20%-25% due to the fact that output stability was the central bank's primary objective. Inflation for 1991-1998 (22.7% on average) was similar to that of the 1980s (23.6%) and was systematically above the bank's target for 1991-1996 and again for 1998.

According to the author, an abrupt change occurred in October 2000 when the authorities officially adopted an inflation targeting regime. The recession of 1999 resulted in a 10% inflation rate, a level not seen since the 1970s, and the authorities took advantage of the circumstances to fundamentally reformulate monetary policy. Inflation targets for 2000, 2001 and 2002 were 10%, 8% and 6% respectively, which placed a higher emphasis on compliance with explicit targets and the transparency of the process. The interest rate was adopted as a policy instrument and a managed floating exchange rate was chosen.[3] Annualized monthly inflation was reduced from around 16% in mid-1998 to close to 2% for most of 2010.

Robalo Marques (2004) shows that an evaluation of persistence is conditional on assumptions about the behavior of long term inflation. Its value is different if long term inflation is a constant average, a stochastic

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autoregressive root is around one and is relatively constant for the period 1947-2001. However, as mentioned by Altissimo, Ehrmann, and Smets (2006), a review of the international empirical evidence suggests a high level of uncertainty about the level of persistence of the series: uncertainty about the precise value of the estimator, about the sensitivity of the periods and the methodological approach adopted, and uncertainty about the suitability of the distinct persistence measures. A review of the empirical literature for the USA and other countries is presented by Echavarría, López, and Misas (2013).

[2] Also see Levin and Piger (2004).

[3] See Hernández and Tolosa (2001); and Gómez, Uribe, and Vargas (2002).

trend or an explicit central bank target. This leads Echavarría, López, and Misas (2013) to explore an alternative path in the second part of their document. Following Cogley, Primiceri, and Sargent (2009), among others, the authors suggest that a gradual reduction of the inflation target could explain an unchanged persistence in the total inflation series. The authors estimate the persistence for the *inflation gap* $\pi_t - \pi_t^*$,[4] where π_t^* corresponds to the central bank target. However, unexpectedly, no significant changes in persistence under an inflation targeting regime are observed in this case either (even when the persistence value $\pi_t - \pi_t^*$ is low).

Vargas et al. (2009) suggests that the Banco de la República's target is an important determinant of expectatives formation by economic analysts, but this does not mean that the Bank is totally credible, and was less so in the first years of its independence. As such, this document assumes that the Banco de la República's inflation target is not entirely credible.[5]

Following Stock and Watson (2007) and Kang, Kim, and Morley (2009), an econometric model for 1979Q1-2010Q2 is estimated which breaks down the annualized quarterly inflation series among a stochastic trend (permanent component) and transitory component. In other words, transitory and permanent shocks are taken into account, the latter perhaps induced by variations in the central bank's target.

Following on from this introduction, Section 2 shows the model used, Section 3 evaluates total inflation persistence in Colombia and Section 4 the persistence of some items used by Banco de la República for its inflation forecasts.

[4] Cogley, Primiceri, and Sargent (2009) argue that the persistence for the inflation gap is relevant when trying to understand the velocity and effectiveness of central bank efforts to revert inflation to the target; whereas inflation is a relevant research subject when, for example, the impact of central bank decisions on bond prices in the market are considered.

[5] Svensson (1999) mentions the uncertainty of the model (e.g. uncertainty of the value of the natural interest rate or about the process of the smoothing of rates by the central bank) as an additional factor which creates persistence even though recent literature on the topic has concentrated on the uncertainty related to current and future central bank policies. In particular, see Erceg and Levin (2001) and Kozicky and Tinsley (2005).

2. THE MODEL

A model of unobserved inflation components which incorporates multiple regime changes is developed based on Kang, Kim, and Morley (2009).[6] The following three equations are considered:

$$\pi_t = \tau_t + C_t, \tag{1}$$

$$\tau_t = u_{S_t} + \tau_{t-1} + \eta_t, \tag{2}$$

$$C_t = \beta_{1,S_t} C_{t-1} + \beta_{2,S_t} C_{t-2} + \varepsilon_t, \tag{3}$$

$$\eta_t \sim N\left(0, \sigma^2_{\eta,S_t}\right);\ \varepsilon_t \sim N\left(0, \sigma^2_{\varepsilon,S_t}\right) \text{ para } s = 1, 2, 3,$$

where π_t corresponds to annualized quarterly inflation $(400{*}\ln(P_t/P_{t-4})$;[7] τ_t represents the permanent component of the series; and C_t the cyclical-transitory component, derived from an ARMA (p, q) process; C_t also corresponds to the inflation gap, defined as the difference between observed inflation and the permanent component.

η_t represents a permanent shock; ε_t a transitory shock; and s the current regime; $u_{S_t}, \beta_{1,S_t}, \beta_{2,S_t}$, σ^2_{η,S_t} and $\sigma^2_{\varepsilon,S_t}$ are model parameters, σ^2_{η,S_t} and $\sigma^2_{\varepsilon,S_t}$ quantify the volatility of the permanent and transitory shocks respectively. It is assumed that ε_t and η_t are independently distributed.[8]

Univariate inflation models have gained importance since, as suggested by Stock and Watson (2007), inflation is ever easier and also more difficult to predict: easier as its volatility has decreased; more difficult because of the ever lessening additional explicative power of other variables such as the output gap or international prices. In the same vein, Atkeson and Ohanian (2001) show that starting in 1984 the predictive capacity of the Phillips curve in the USA is even less than a simple forecast which equalizes expected inflation in the following 12 months with the simple average of inflation during the preceding year.

[6] The routine available in Gauss at <http://www.bepress.com/snde/vol13/iss4/art1/> was used as a base.

[7] Seasonally adjusted. The series is slightly different from that used by Echavarría, López, and Misas (2013). These authors work with annualized monthly inflation (1,200 * $\ln(P_t/P_{t-1})$) (adjusted) in the first part of the document and with annual inflation (100 * $\ln(P_t/P_{t-12})$) in the second part.

[8] This might not be entirely appropriate when the central bank revises its targets in response to changes in perceptions on the structure of the economy. (Cogley, Primiceri, and Sargent, 2009).

Stock and Watson (2007) encounter a significant reduction from 1960-1983 to 1984-2004 in the coefficient which relates the output gap with future inflation (see also Roberts, 2004). As such, while Stock and Watson (1999) affirm that the inflation projections produced by economic activity indexes have been more accurate than those based on other macroeconomic variables, including interest rates, the quantity of money or the price of primary goods. A decade later Stock (2010) only finds a relation between inflation and the output gap *in strong recessionary periods.*

The model proposed by Kang, Kim, and Morley (2009) is similar to that developed by Stock and Watson (2006) but assumes a process of unobserved components with abrupt changes (rather than stochastic volatility). This is consistent with that proposed by Levin and Piger (2004) and Benati (2008), confirmed in this document, which posits that persistence variations are associated with relatively abrupt changes to the monetary regime. Moreover, the use of a model with regime change and with the impulse-response function to measure persistence makes our results relatively comparable to those of Echavarría, López, and Misas (2013).[9]

The authors transform the unobservable component model in its ARIMA representation to calculate a scalar measurement of persistence and find the accumulated impulse-response function. The expected long term response in the presence of projection error of the distinct regimes is found in this way. Due to the structure of the unobserved components, inflation persistence depends on the relative importance of permanent and transitory shocks, as well as propagation of the ARMA model in the case of transitory shocks. The model allows for discreet changes in inflation persistence between regimes.

The impulse-response function obtained allows for the discrimination between a process with unit roots subject mostly to permanent variations and a stationary process which is mostly subject to transitory variations. Additionally, the resulting impulse-response function allows the differentiation of persistence levels in processes with unit roots (Kang, Kim, and Morley, 2009).

The number of potential regimes was arbitrarily set at three, with which the expected changes were possibly captured starting from: *1)* the Constitution of 1991 and *2)* the adoption of an inflation targeting scheme

[9] Andrews and Chen (1994), and Pivetta and Reis (2007) suggest using the sum of autoregressive coefficients or the impulse-response function as the best measures of statistical persistence.

at the end of 1999. The model parameters and change points of each regime were estimated through an adjustment maximization process. Turning points were found determining the three periods 1979Q1-1988Q4, 1989Q1-1999Q3 and 1999Q4-2010Q2, which are relatively close to those found by Echavarría, López, and Misas (2013).[10]

To make regime identification easy, it is assumed that they are *terminal* (they are never revisited once they have been abandoned) and that the last regime is *absorbent* (it is never abandoned once reached). The model is robust and open to the possibility posited by Sims (2001) that the regime change responds to the presence of heteroskedasticity and not to changes in the conditional mean.

3. PERSISTENCE OF TOTAL INFLATION

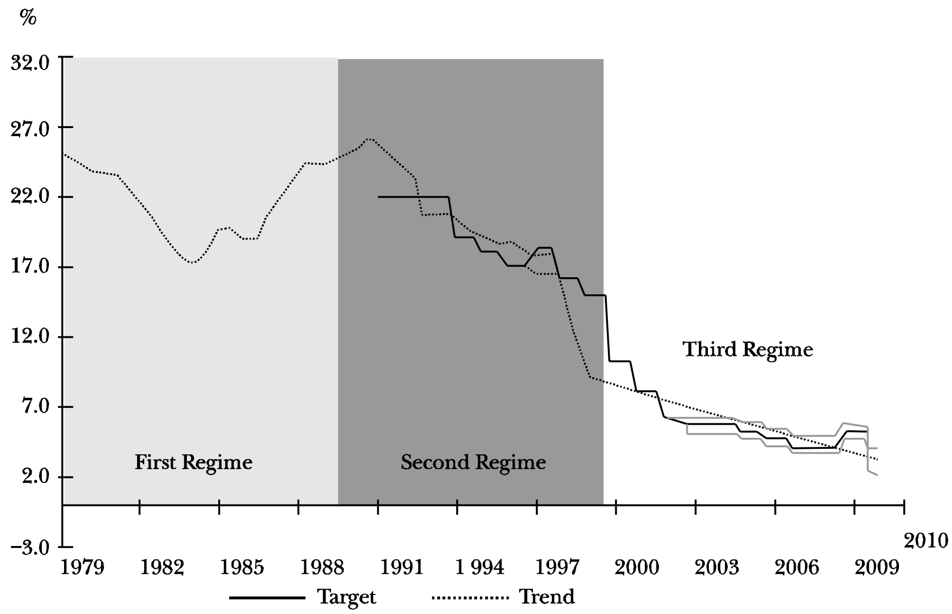
Figure 1 compares the evolution of the permanent component of inflation (τ) with the target set by the Board of Directors of Banco de la República. The Bank established *precise targets* for the period 1991-2002 and *target ranges* for later years. Additionally, a *long term target range* of 3%, plus or minus one percentage point was announced in 2001. A medium range figure, which is relevant in some minimum wage contract negotiations, was also announced. According to the bank's law, this tends to lead to meeting inflation target established in November of the previous year in December of the following year.

The long term estimated trend follows the inflation targets set by the Bank but does not coincide exactly. It was above target between 1994Q1 and 1996Q3 and below target between 1996Q4 and 2001Q1. It was close to the upper limit of the range between 2004Q1 and 2007Q2 but fell more rapidly between this time and the end of the series.

The implicit inflation *target* before 1991 is also shown. This fell from 25.3% in 1979Q1 to 17.5% in 1984Q2 and went up from a minimum of 18.6% in 1983Q1 to 26.5% in 1990Q4. As suggested by Dornbusch and Fischer (1991), no government deemed a reduction in inflation as a priority objective between 1971 and 1990, and the agents learned to live with it. The authors cite Colombia and Portugal as the only two countries where

[10] Kang, Kim, and Morley (2009) make a significant effort to determine the years which accompany regime changes. Comparison with the results of the work of Echavarría, López, and Misas (2013) was important to us and we therefore emphasised this objective less.

FIGURE 1. LONG RANGE TREND AND CENTRAL BANK TARGETS, 1979-2010 (PERCENTAGE)



moderate inflation became a *way of life* for more than 12 years. The *implicit* inflation target was high because the authorities surely considered it very costly to reduce inflation.[11] The sacrifice ratio was not observed to rise when the inflation target is high (Cogley and Sbordone, 2006).

Table 1 shows the estimated parameters for the maximum likelihood for the three regimes, taking into consideration an AR(2) process for the transitory component,[12] and Figure 2 shows the annualized quarterly inflation ($400^*\ln(P_t/P_{t-4})$) and reproduces the permanent component (τ_t) again for the three regimes. Each regime can be described in general terms as follows:

– First regime (1979-1989): characterized by high volatility of permanent and transitory shocks, with transitory shocks of short duration (close to one quarter).

– Second regime (1989-1999): shows a lesser variance of shocks with respect to the first regime, with a higher reduction for the variance of

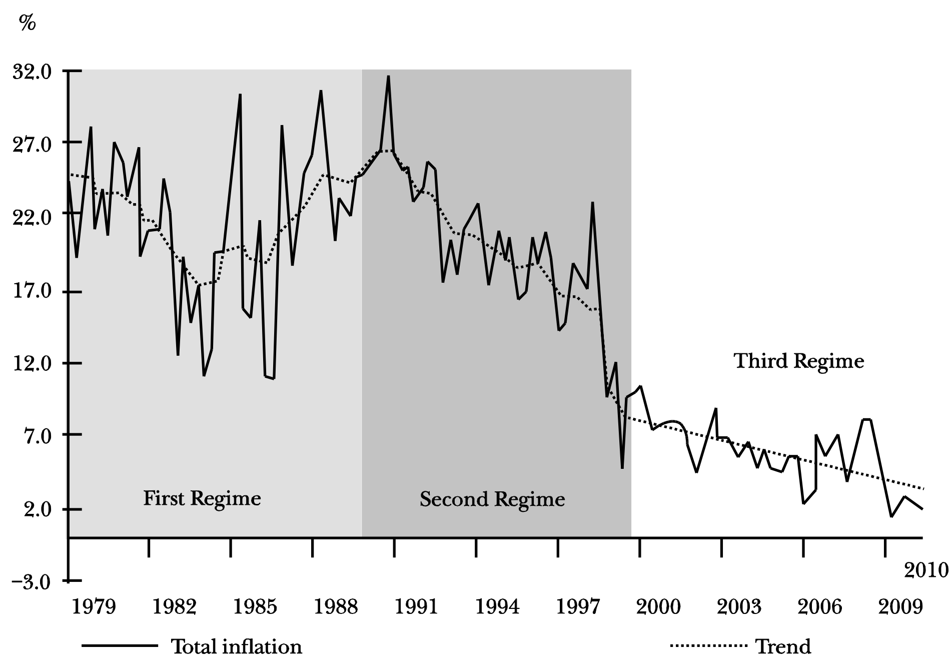
[11] Ocampo (2004), pp. 87-88.

[12] As in Kang, Kim, and Morley (2009) for the USA, an AR(2) process is sufficient to record the behavior of the transitory component.

transitory shocks. The permanent component τ_t shows a negative u_2 trend and a significant magnitude (a reduction of 28 basis points of annualized quarterly inflation each quarter).

– Third regime (1999-2010): permanent shocks show a variance close to zero, and therefore the inflation shocks are principally transitory. These transitory shocks also last longer than in the two previous regimes. The trend is practically deterministic.

FIGURE 2. LONG TERM TREND AND OBSERVED INFLATION, 1979-2010 (PERCENTAGE)



It is possible that inflation persistence could decline even further in the future because the disinflation process ended and Banco de la República has announced an inflation target for the next few years which coincides with the long term target set in 2001 (3% ± 1 basis point). Variations in the inflation target have led to highly persistent inflationary behavior in the past (Cogley, Primiceri and Sargent, 2009).

As can be seen in Table 1, the variance of permanent shocks (σ^2_{η,S_t}) was higher in 1989-1999 (2.26) than in 1979-1989 (2.02), and much higher in these two periods than in 1999-2010 (close to zero). On the other hand, the variance of transitory shocks ($\sigma^2_{\varepsilon,S_t}$) has gradually decreased from very high levels in 1979-1989 (19.50) to intermediate levels in 1990-1999 (5.71) and even lower levels for 2000-2010 (2.57). In sum, the big *gain* in 1999-2010 was the large reduction in permanent shocks while a gradual reduction of transitory shocks began in 1989. The relation between standard deviations $\sigma^2_{\eta,S_t} / \sigma^2_{\varepsilon,S_t}$ rose from 0.32 to 0.62 between period 1 (1979-1989) and 2 (1989-1999), and fell to zero for period 3 (1999-2010).

TABLE 1. TOTAL INFLATION, MAXIMUM LIKELIHOOD ESTIMATORS (TO 90% DEGREE OF CONFIDENCE)

	S = 1 (1979Q1-1989Q4)	*S = 2 (1989Q1-1999Q3)*	*S = 3 (1999Q4-2010Q2)*
$u_{s,t}$	−0.05	−0.28	−0.13
	(−0.053, −0.036)	(−0.29, −0.27)	(−0.14, −0.12)
$\beta_{1,S}$	0.12	0.11	0.53
	(0.08, 0.15)	(−0.04, 0.19)	(0.40, 0.70)
$\beta_{2,S}$	−0.16	0.05	−0.07
	(−0.19, −0.14)	(−0.03, 0.11)	(−0.23, 0.07)
$\sigma^2_{\eta,S}$	2.02	2.26	0.00
	(1.83, 2.30)	(2.00, 2.70)	(0.00, 0.01)
$\sigma^2_{\varepsilon,S}$	19.50	5.71	2.57
	(18.60, 20.31)	(4.70, 6.44)	(2.00, 3.16)
$\sigma^2_{\eta,S} / \sigma^2_{\varepsilon,S}$	0.32	0.62	0.00

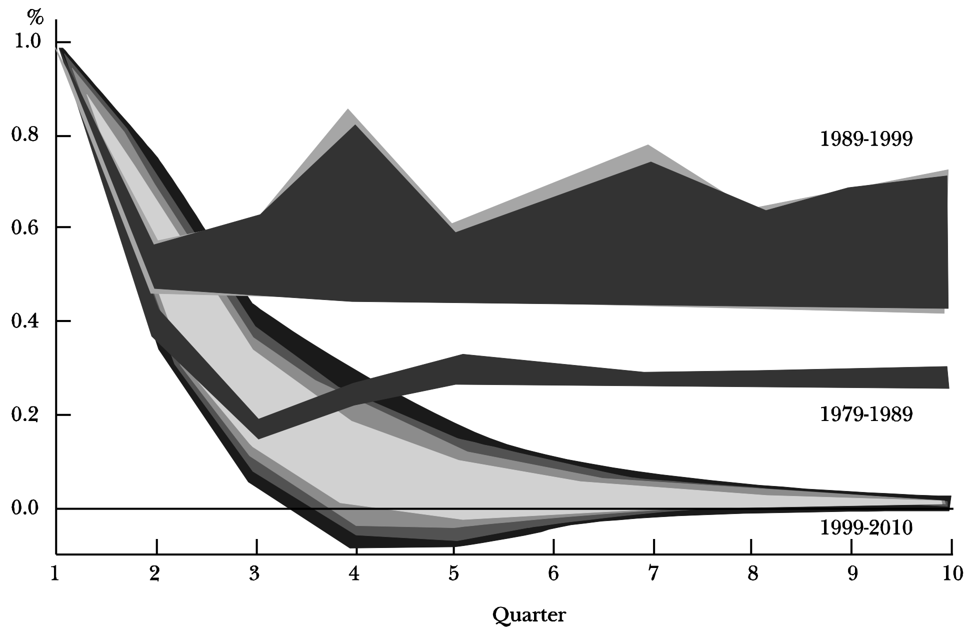
The results also shed light on the possible characteristics of the Phillips curve in Colombia. The coefficients β_1 and β_2 are associated with the variables C_{t-1} and C_{t-2} in equation (3), and show the inertia of the *gap* (cyclical or transitory component). The shock decreases to less than half during the next three quarters. In other words, the empirical evidence seems to partially confirm the validity of the New Keynesian Phillips curve where the inflation *gap* is not very persistent.[13]

Nevertheless, the enormous importance of the target (and of the credibility of the agents) in inflation determination leads to the New Keynesian Phillips curve being an adequate explanation of only a small amount of the variations in total inflation. Thus, as stated by Woodford (2005), pp. 3 "... expectations about policy matter, but at least under current conditions, very little *else* matters."

Figure 3 shows the impulse-response function for inflation and the different confidence intervals for a standardized typical shock equal to one. Intervals of 99%, 95%, 90%, 80% and 60% are shown, obtained via the so-called bootstrap re-sampling method with 2,000 repetitions (Shumway

[13] See Cogley and Sbordone (2008) and Mankiw (2001). For a review of the literature see Echavarría, López, and Misas (2013), Section 2.

FIGURE 3. IMPULSE-RESPONSE FUNCTIONS FOR THE THREE REGIMES (PERCENTAGE POINTS)



and Stoffer, 2006). The standard shock comprises a permanent shock component and another transitory one with a relative importance proportional to its variances.

Inflation persistence is defined as a function of the level observed for the impulse-response function after an initial shock, and in function of the number of quarters it takes for the shock to disappear. When these two characteristics are taken into consideration it can be concluded that inflation persistence increased in Colombia between 1979-1989 and 1989-1999, and declined to its lowest levels from 1999-2010.

If a 60% degree of confidence is used (darker area) it is observed that for the period 1979-1989 the initial shock of 1 is reduced to 0.4 after one quarter and to a little over 0.2 for the following quarters; but the shock does not entirely disappear in the 10 quarters shown on the Figure. The initial shock is only reduced to 0.5 in the period 1989-1999 and it remains at this level. The behavior is not very different for quarters 1-3 in 1979-1989 and in 1999-2010, but is for the other quarters: the average value of the series continues to fall gradually for 1999-2010, and remains at zero starting in the 5th quarter.

As mentioned previously, the impulse-response function obtained allows discrimination between a process with a unit root mostly subject to permanent variations and a stationary process that mostly adheres to transitory variations. It also allows the differentiation of persistence between two processes with unit roots. Thus, the behavior of the inflation series for the period 1999-2010 is better represented by a stationary process because the shock disappears, while the other two series can be thought of as non-stationary because the shock does not disappear. The series is observed to be more persistent in 1989-1999 than in 1979-1989 because the values observed for the impulse-response function are systematically higher. Both are non-stationary because the shock does not disappear.

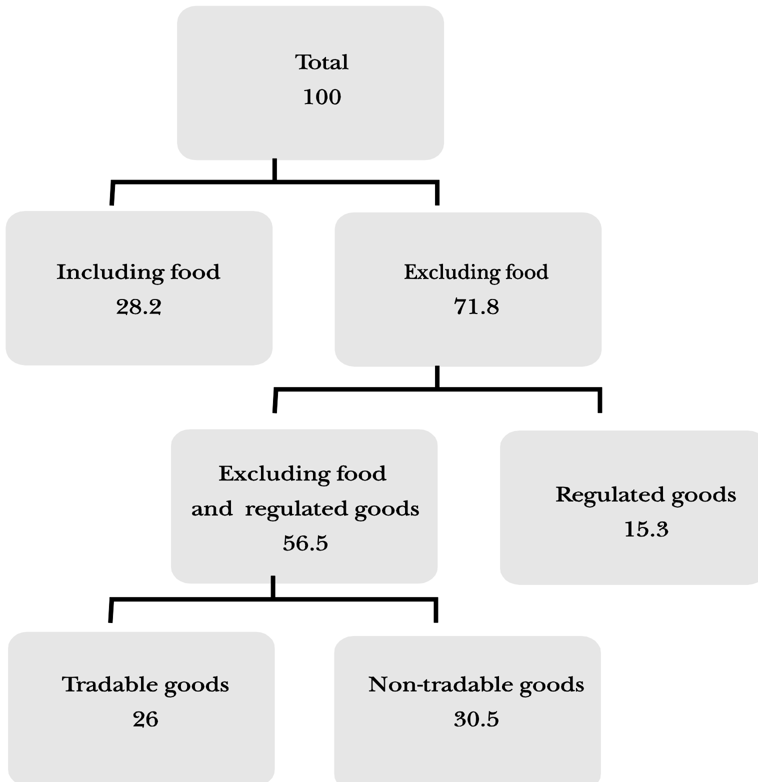
4. PERSISTENCE OF THE DIFFERENT COMPONENTS OF TOTAL INFLATION

Forecasts for inflation prepared by Banco de la República's technical team frequently consider product sub-groups. In particular, as seen in Figure 4, the so-called *transmission mechanism model* uses different behavioral equations of inflation for the total, for food and for the total excluding food. In turn, inflation excluding food can be broken down into the total excluding both food and regulated goods and the total including regulated goods. Finally, inflation excluding food and regulated goods is divided into inflation of tradable goods and non-tradable goods (Hamann, 2004). The figure shows the weight of each product group within the basket of goods. Tradable goods (26.0%), non-tradable goods (30.5%), and regulated goods (15.3%) explain the weight of the total excluding foods (71.8%), while foods represent 28.2 percent.

Figure 5 compares the behavior of the permanent and observed components of total inflation (once again), inflation excluding food, inflation of tradable goods and non-tradable goods. The shaded areas indicate periods of important change *for total inflation.* Tables 2-4 show the estimated results for each group of products.

A change in the behavior of the series can be seen in the majority of cases for 1989 and in 1999, with the exception of inflation of tradable goods, whose behavior changes only one time starting in 1989. Additionally, an almost horizontal line close to 4% is seen for non-tradable goods from 2000.

FIGURE 4. PRODUCT GROUPS IN THE TRANSMISSION MECHANISM MODEL



Tables 2-4 show that the variance in the permanent component ($\sigma^2_{\tau,S}$) falls to zero during 1999-2010 for the four groups of products, and that in 1979-1989 (specially) and in 1989-1999 it was particularly high for non-tradable goods and for the total excluding foods.

Meanwhile, the variance of the transitory component ($\sigma^2_{\varepsilon,S}$) is larger for total inflation than for its components, and only shows a continuous decline for total inflation. It does not decrease between 1989-1999 and 1999-2010 for inflation excluding foods and for non-tradable goods, and it does not exhibit a decline between 1979-1989 and 1989-1999 for tradable goods and non-tradable goods.

The coefficients β_1 and β_2 are associated with the variables C_{t-1} and C_{t-2} in equation (3), and capture the inertia of the gap (cyclical or transitory

TABLE 2. INFLATION EXCLUDING FOODS, MAXIMUM LIKELIHOOD (90% DEGREE OF CONFIDENCE)

	S = 1 (1979Q1-1989Q4)	*S = 2 (1989Q1-1999Q3)*	*S = 3 (1999Q4-2010Q2)*
$u_{s,t}$	−0.02	−0.26	−0.12
	(−0.031, −0.011)	(−0.27, −0.24)	(−0.13, −0.10)
$\beta_{1,S}$	−0.3	0.57	0.46
	(−0.77, −0.14)	(0.23, 0.82)	(0.26, 0.67)
$\beta_{2,S}$	−0.39	−0.07	−0.01
	(−0.68, −0.30)	(−0.35, 0.19)	(−0.22, 0.22)
$\sigma^2_{\eta,S}$	3.5	1.84	0.00
	(2.93, 5.89)	(1.46, 2.60)	(0.00, 0.01)
$\sigma^2_{\varepsilon,S}$	4.76	1.71	2.02
	(1.71, 6.02)	(0.69, 2.46)	(1.45,2.71)
$\sigma^2_{\eta,S} / \sigma^2_{\varepsilon,S}$	0.86	1.04	0.00

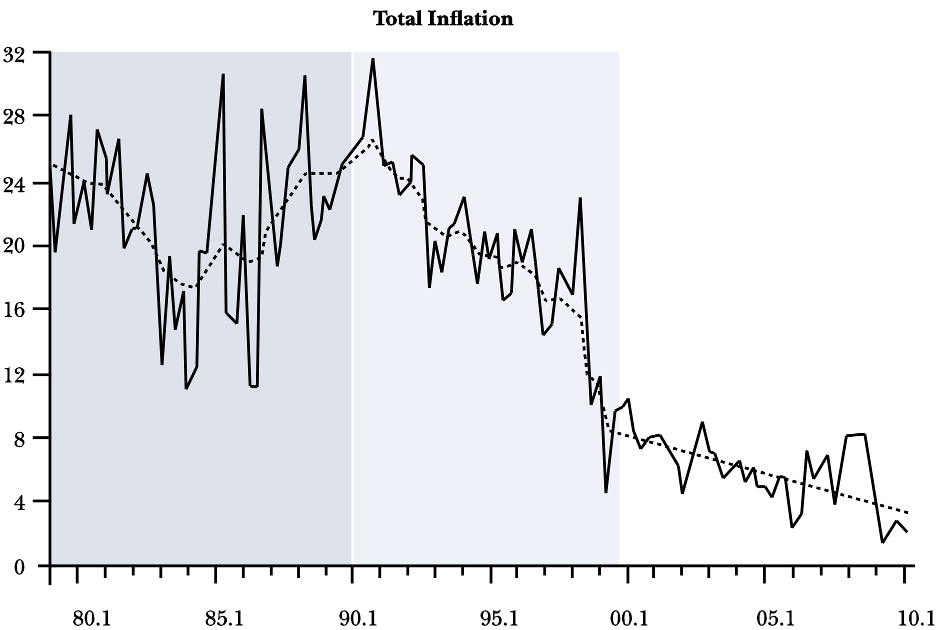
component). The shock is reduced to less than half during the first quarter in the case of the total excluding foods, in two quarters for tradable goods, and in a practically immediate fashion for non-tradable goods. This signifies that the persistence of the gap is relatively similar to that of total inflation (see above) for tradable goods, and less than that of total inflation for the total excluding foods and for non-tradable goods.

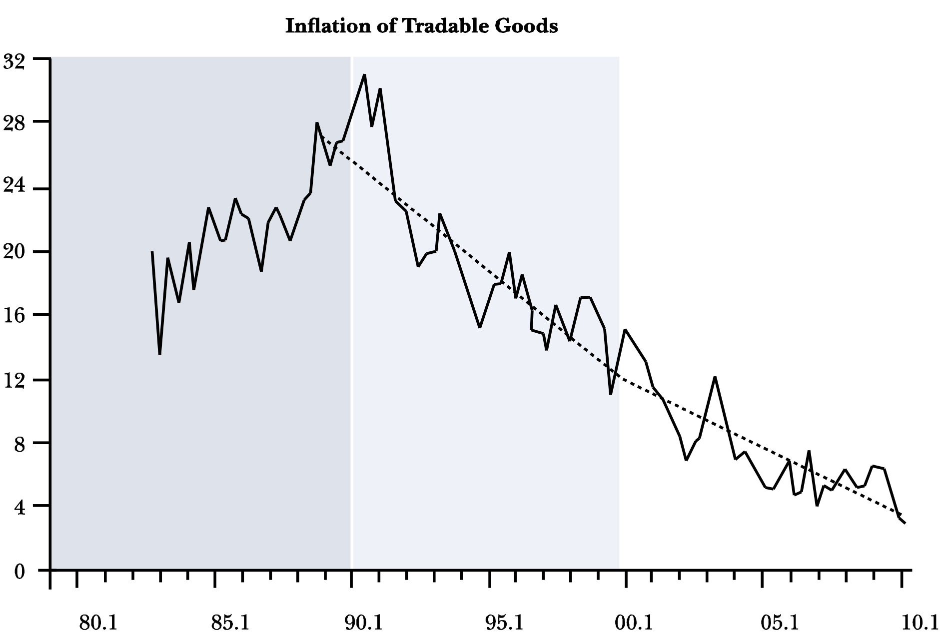
Finally, Figure 6 shows the impulse-response functions for the four product categories with 60% and 90% degrees of confidence. Only comparisons for 60% (darker area) are considered. The most noteworthy fact resides in that during 1999-2010 the shocks disappear at some time for all the product groups: toward month two for non-tradable goods, toward month four for the total, toward month five for the total excluding food and toward month ten for tradable goods.

TABLE 3. INFLATION OF TRADABLE GOODS, MAXIMUM LIKELIHOOD (90% DEGREE OF CONFIDENCE)

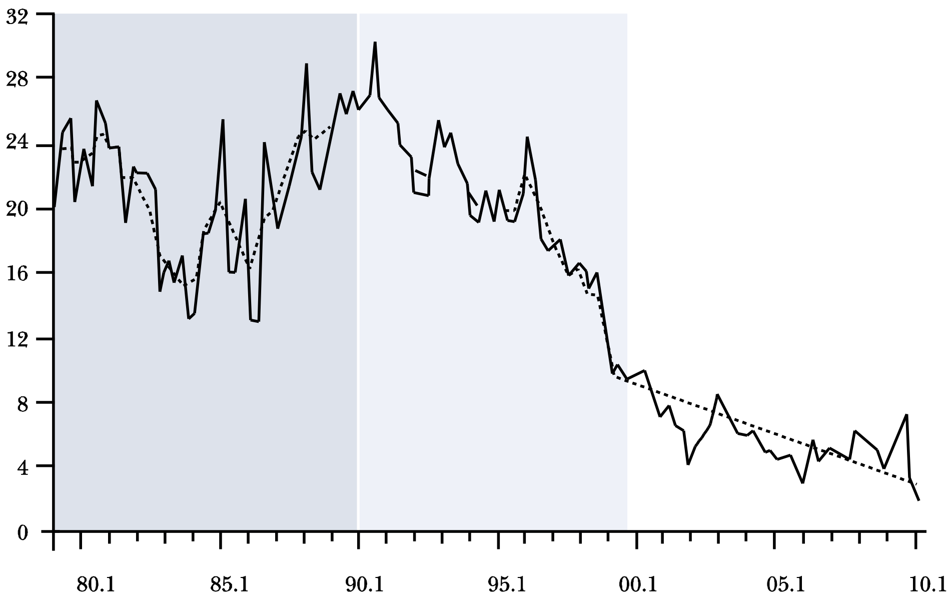
	S = 1 (1979Q1-1989Q4)	*S = 2 (1989Q1-1999Q3)*	*S = 3 (1999Q4-2010Q2)*
$u_{s,t}$	0.27	−0.41	−0.25
	(0.25,0.29)	(−0.42, −0.40)	(−0.27, −0.24)
$\beta_{1,S}$	−1.33	0.68	0.65
	(−1.38, −1.28)	(0.56, 0.82)	(0.50, 0.84)
$\beta_{2,S}$	−0.72	0.04	0.03
	(−0.75, −0.68)	(−0.10, 0.15)	(−0.17, 0.20)
$\sigma^2_{\eta,S}$	2.68	0.00	0.00
	(2.16, 3.24)	(0.00, 0.01)	(0.00, 0.01)
$\sigma^2_{\varepsilon,S}$	0.00	3.79	2.49
	(0.00,0.01)	(3.18, 4.37)	(1.95,3.09)
$\sigma^2_{\eta,S} / \sigma^2_{\varepsilon,S}$	0.00	0.00	0.00

FIGURE 5. INFLATION AND TREND FOR DIFFERENT PRODUCT GROUPS





Inflation Excluding Foods



Inflation of Non-tradable Goods

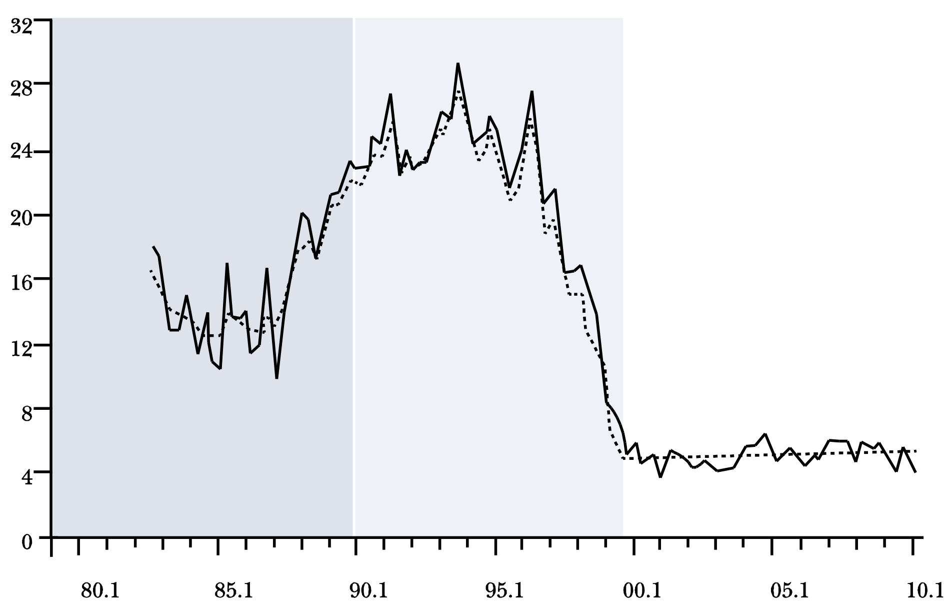
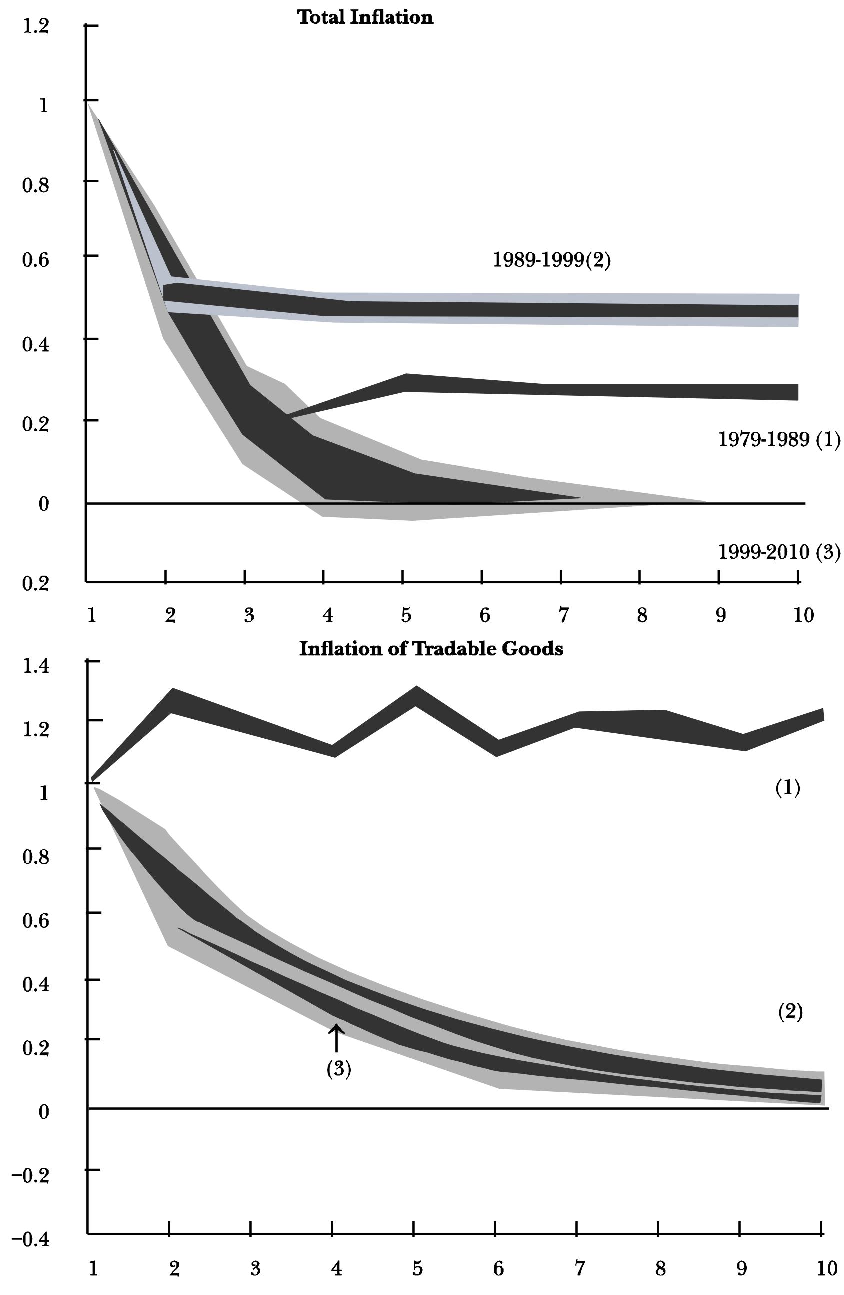
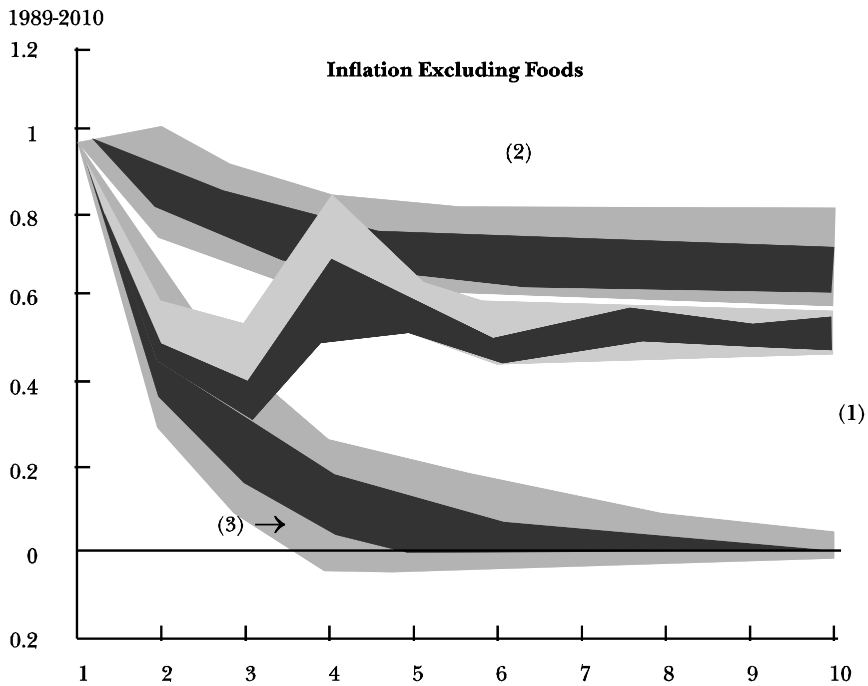


FIGURE 6. IMPULSE-RESPONDE FUNCTION FOR DIFFERENT PRODUCT GROUPS,



NOTE: The different colors correspond to 60% (dark) and 90% degree of confidence.


1989-2010
Inflation Excluding Foods
1.2
1
0.8
0.6
0.4
0.2
0
0.2
(2)
(1)
(3)
1
2
3
4
5
6
7
8
9
10

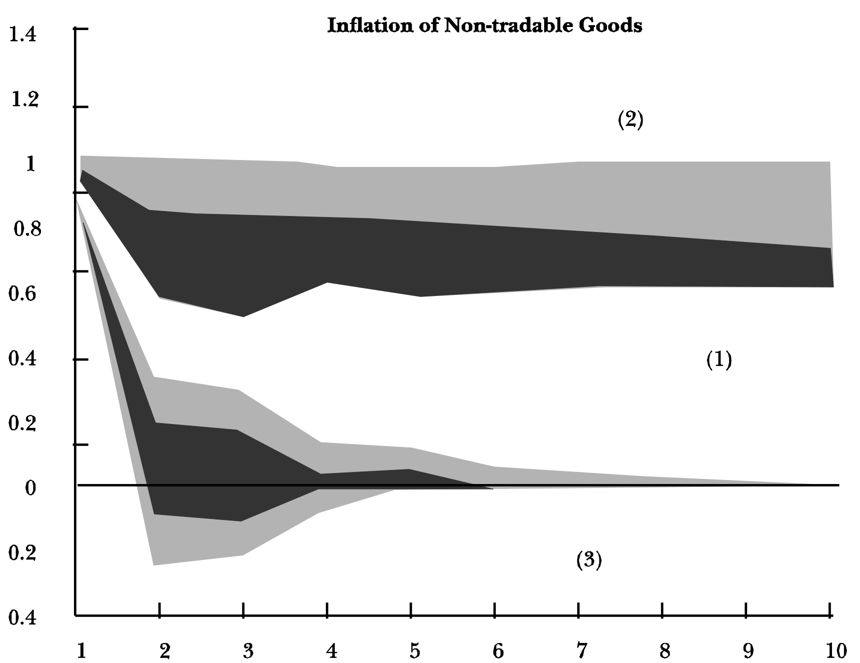

Inflation of Non-tradable Goods
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0.2
0.4
(2)
(1)
(3)
1
2
3
4
5
6
7
8
9
10

TABLE 4. INFLATION OF NON-TRADABLE GOODS, MAXIMUM PROBABILITY (90% DEGREE OF CONFIDENCE)

	S = 1 (1979Q1-1989Q4)	*S = 2 (1989Q1-1999Q3)*	*S = 3 (1999Q4-2010Q2)*
$u_{s,t}$	0.05	−0.20	0.00
	(0.02,0.08)	(−0.70, −0.14)	(−0.03, −0.02)
$\beta_{1,S}$	−1.01	0.94	0.04
	(−1.18, −0.26)	(0.60, 1.9)	(−0.26, 0.31)
$\beta_{2,S}$	−0.78	−0.01	−0.01
	(−0.98, −0.30)	(−0.98, 0.20)	(−0.26, 0.25)
$\sigma^2_{\eta,S}$	3.91	3.31	0.00
	(2.69, 4.74)	(0.01, 4.37)	(0.00, 0.01)
$\sigma^2_{\varepsilon,S}$	0.46	0.87	2.50
	(0.01,2.27)	(0.01, 5.08)	(1.71,3.40)
$\sigma^2_{\eta,S} / \sigma^2_{\varepsilon,S}$	2.92	1.95	0.00

On the other hand, in three of the four panels greater persistence is observed in 1989-1999 than in 1979-1989 and much larger than in 2000-2010. The case of tradable goods is the exception, with an enormous level of persistence in 1979-1989, possibly due to the semi-fixed exchange rate regime that existed in that period. This suggests that the most important exchange rate modification occurred in 1989 when the *crawling-peg* was abandoned (in place since 1967) and not in 1999 when the *exchange rate band* was abandoned.

The persistence of inflation excluding foods was higher than that of total inflation in 1979-1989 and in 1989-1999, with relatively similar patterns in 1999-2010. Furthermore, no single pattern was observed when comparing persistence for tradable goods and non-tradable goods. Inflation of non-tradable goods is very persistent in 1979-1989 and in 1989-1999, but not very persistent in 1999-2010, while inflation of tradable goods was relatively persistent in the three periods (especially in 1979-1989 during the crawling-peg regime); it slowly declined to zero in 1979-1989 and in 1989-1999.

5. CONCLUSIONS

The sum of the autoregressive coefficients for the total inflation series, an indicator of persistence, did not fall in Colombia with the adoption of an inflation targeting regime (Echavarría, López, and Misas, 2013), possibly due to the influence of the Central Bank's highly persistent target. Nevertheless, the inflation target was not entirely credible, and it is because of this that it is important to consider a model which allows estimation of the long term path of inflation anticipated byagents.

Stock and Watson (2006) proposed a model with such characteristics and the model used in this document follows their general recommendations. Following Kang, Kim, and Morley (2009), a model of the unobserved components of inflation with a change of regime is estimated for 1979Q1-2010Q2. (in place of stochastic volatility) and is more in accordance with the idea that changes in the monetary regime produce relatively abrupt variations in the pattern of inflation.

The long term estimated trend follows the inflation targets set by the Bank but does not coincide exactly with them. Inflation persistence, as defined by the terms of the impulse-response function, also grew in Colombia during 1979-1989 and 1989-1999 and diminished to its lowest levels in 1999-2010 due to the adoption of an inflation targeting regime. It is possible that inflation persistence will decline even further in the future as the disinflation process has come to an end and Banco de la República has announced an inflation target for the next few years which coincides with the long term target set in 2001 (3% ±1 point).

This work revindicates the value of the so-called New Keynesian Phillips curve because the inflation *gap* is not very persistent. Nevertheless, the enormous importance of the target (and the credibility of the agents) in the determination of inflation makes the New Keynesian Phillips curve an adequate explanation for only a small portion of the variations in total inflation.

This paper compares the behavior of inflation for different product groups. The shocks disappear at one time or another for all of them in 1999-2010: toward month two for non-tradable goods, toward month four for the total, toward month five for the total excluding foods and toward month ten for tradable goods. It also suggests that the most important exchange rate modification occurred in 1989 when the *crawling-peg* was abandoned (in place since 1967) and not in 1999 when the *exchange rate band* was abandoned.

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The Statistical Persistence of Inflation in Colombia

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1. INTRODUCTION

Inflation persistence is an analogue concept to that of inertia in physics: the more inertia has a body, the greater the force required for its motion to return to its pre shock state (Fuhrer, 2009). In the same way, the greater the inflation persistence, the larger the decrease in GDP and employment required for inflation to return to its previous level. A high degree of persistence means authorities have to act in advance to stave off the lasting effects of shocks, as well as raise interest rates further and for longer periods in order to reduce inflation. Low persistence, on the other hand, allows for modest responses to cost shocks and the adoption of fast disinflationary policies.[1]

Furthermore, variations in inflation persistence can explain changes in the capacity of the yield curve to predict the business cycle, implying that high inflation persistence leads to greater reductions in GDP when contractionary monetary policy is adopted.[2] Finally, similar levels of persistence facilitate monetary integration between countries because they mean common shocks have similar effects (Franta, Saza, and Smidkova, 2007).

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[1] See Altissimo, Ehrmann and Smets (2006) and Rudd (2005).

[2] Bordo and Haubrich (2004) and Kang, Kim and Morley (2009).

Statistical, or *reduced*, *persistence* is related to certain empirical regularities of inflation and occurs when inflation remains far from its mean after a shock,[3] while structural persistence includes *structural* economic factors which produce statistical persistence. A large body of recent research on inflation persistence has been focused on the relation between statistical persistence and the economic –structural factors determining them.

Proper measurement of *statistical persistence* is a first step towards understanding the phenomenon. It also allows authorities to make accurate forecasts of future inflation, an important factor in an inflation targeting scheme (named inflation-forecast targeting by Svensson, 2005). A high level of uncertainty regarding statistical persistence would make it recommendable to avoid any abrupt changes in economic policy instruments (Brainard, 1967) unless this was going to adversely affect inflation expectations.

However, the discussion on persistence must go beyond this and question the economic reasons producing the patterns observed in statistical persistence. Can a microfounded Phillips curve produce inflation persistence when there are rational expectations? What is the relative importance of the Phillips curve and the Taylor rule for explaining persistence? And how important is central bank credibility and the evolution of inflation targets? What monetary policy characteristics produce persistence?

Section 2 of this paper analyzes the *structural* factors possibly associated with statistical persistence. Section 3 discusses methodological aspects related to its measurement and presents a brief summary of international empirical evidence. Section 4 applies different methodologies to the case of Colombia. In particular, it evaluates the level of integration and the sum of autoregressive coefficients in determined subperiods using a Markov-Switching methodology, estimating the degree persistence changes over time for the spread between observed inflation and the inflation target. Section 5 gives the conclusions.

2. *STRUCTURAL* FACTORS. A RESEARCH PROGRAM FOR COLOMBIA

Although the main objective of this paper is the measurement of statistical persistence (sections 3 and 4), it is still important to show the economic

[3] When the series is stationary. If the series were not stationary then the shock would be permanent. See 3.1.

factors which determine it. As mentioned previously, a large amount of recent research on inflation persistence has referred to the relation between *statistical persistence* and *structural persistence*. The questions posed suggest a long term research program for Colombia.

2.1 Structural Factors Explaining Persistence

Before beginning it is important to emphasize the difficulties involved in evaluating the relative importance of different *structural* factors, given that they interact with general equilibrium and their relative importance can depend on the monetary regime (Angeloni et al., 2005). Such factors could also be surrounded by wide ranging uncertainty, in which case it might be necessary to evaluate the costs and benefits of employing the *incorrect* model.[4]

If we start from the version of the economy shown in equations (1) to (4) with two alternative Phillips curve models:

New Keynesian Phillips curve

(1) $$\pi_t = \beta E_t \pi_{t+1} + \phi_x x_t + u_t \quad \text{with } \beta \approx 1.$$

Hybrid Phillips curve

(2) $$\pi_t = (1-\beta)\pi_{t-1} + \beta E_t \pi_{t+1} + \phi_x x_t + u_t.$$

IS

(3) $$x_t = \sigma_{x-1} x_{t-1} + (1-\sigma_{x-1}) E_t x_{t+1} - \sigma_r (R_t - E_t \pi_{t+1}) + \varepsilon_t.$$

Taylor rule

(4) $$R_t = \rho(L) R_{t-1} + (1-\rho)\left[r^* - (\tau_\pi - 1)\pi^* + \tau_\pi \pi_t + \tau_x x_t\right],$$

where π_t is the inflation rate; β, the discount factor; x_t, the output gap; u_t and ε_t correspond to supply (i.e., an international oil price shock) and demand shocks; R_t is the nominal interest rate and r the real interest rate; ρ is a smoothing parameter in the fixing of nominal interest rates by the central bank; super index * indicates the variable's target, which in literature mostly coincides with its *natural* equilibrium or long-term steady-state.[5]

[4] For the case of the Phillips curve see Sbordone (2007).

[5] More precisely, in several cases it concerns the deviation between the variable and its stationary position. See section 2.3.1.

Equation (1) corresponds to the so-called New Keynesian Phillips curve with rational agents that intertemporally maximize, and with a random proportion $(1-\theta)$ of firms who can adjust prices in each period (Calvo, 1983).[6] It is also assumed that there is a constant relation between real marginal costs and output gap, that the markup is constant throughout the cycle and that steady-state inflation equals zero $(\pi^* = 0)$.

As will be seen, there is no inflation persistence (or it is very low) when the Phillips curve is as in (1), indicating that price rigidities (implicit in Calvo's model) do not explain inflation persistence.[7] The alternative Phillips curve represented in equation (2) is known as *hybrid* and adds lagged inflation π_{t-1}. Empirical evidence places significant weight on this variable, even though it is not easy to explain its inclusion in theoretical models where agents have rational expectations.

Equation (3) corresponds to the curve IS and (4) to a Taylor rule with interest rate smoothing by the Central Bank (Clarida, Galí and Gertler, 2000). The so-called Taylor principle $(\tau_\pi > 1)$ is a necessary condition for the system's stability. It means that when inflation grows the authorities must raise nominal interest rates more than proportionally. This guarantees an increase in the real interest rate, a decrease in the output gap (in the IS) and a reduction of inflation (in the Phillips curve) to its previous level. The Taylor principle guarantees that the inflation series is $I(0)$ given that the authorities make it return to its previous level and the shock dissipates after some time.[8]

What is the relation between the parameters of equations (1)-(4) and *statistical persistence*? In order to understand the effect of some of the main parameters in the above system Fuhrer (2009) reduces them to a *minimum* model shown by equations (5)-(7):

Phillips curve

$$\pi_t = \pi_{t-1} + \phi_x x_t , \tag{5}$$

[6] Empirical evidence tends to support Calvo's model above other rigid price models such as Taylor's (1979). See Angeloni et al. (2005).

[7] Formally, Calvo's model sustains that $p_t = \theta p_{t-1} + (1-\theta) p_t^*$, where p_t^* is the optimum price fixed by firms which are able to re-optimize. There are rigid prices, with p_{t-1} on the right hand side.

[8] Formally, the *Taylor principle* guarantees the existence of a unique stationary equilibrium in the system (Walsh, 2004, pp. 247). In their classic paper, Clarida, Galí, and Gertler (2000) suggest that the Taylor principle was not followed in the US during pre-Volcker administrations but was applied in the Volcker-Greenspan administrations.

IS

(6) $$x_t = -\sigma_r r_t,$$

Taylor rule

(7) $$r_t = \tau_\pi \pi_t.$$

Inflation expectations and supply shocks in the Phillips curve disappear in this *minimum* model, as do lagged GDP and demand shocks in the IS, while it is assumed that the authorities' only objective is to control inflation with $\pi^* = 0$. Substituting (6) and (7) in (5) gives $\pi_t = \pi_{t-1} + \phi_x(-\sigma_r)(\tau_\pi \pi_t)$. From which one can deduce:

(8) $$\pi_t = a\pi_{t-1} \quad \text{with } a = \frac{1}{1+\tau_\pi \sigma_r \phi_x}.$$

Equation (8) shows that inflation persistence is low for high values of τ_π, σ_r y ϕ_x. Furthermore, the particular shape of the Phillips curve (5) suggests that variable π_{t-1} is important in explaining persistence (see below). Intuitively, in order for inflation persistence to be low the authorities must raise interest rates in the event of an inflation shock (*Taylor principle*, $\tau_\pi > 1$),[9] this increase in interest rates reduces the output gap in (6), which depends on σ_x in the IS curve, and this fall in x then reduces inflation in the Phillips curve through parameter ϕ_x.

The previous model allows identification of some of the main characteristics which lead to inflation persistence. Fuhrer (1995) sets forth a slightly more complex model which requires numerical solutions, although some of its results are similar to those of the simplified model. The exercise also shows the evolution of the output gap and the sacrifice ratio for different scenarios.[10] The sacrifice ration (SR) is defined as the cost society must pay in terms of GDP loss –unemployment in order to reduce inflation by one point.

[9] Besides, Section 2.5 argues that a low value of τ_π (i.e. a high value of τ_x) leads to higher persistence through expectations when these are not rational. An active central bank, overly concerned about the output gap can delay agents' process of learning and increase inflation persistence. Beeche and Osterholm (2009) suggest some of the reasons that could lead the authorities to high τ_x. The relative weight of new members with this vision on the Central Bank's Board, political pressure or empirical evidence on the high costs of reducing inflation.

[10] See also the calibration exercises presented by Beechey and Osterholm (2009).

The author compares the level of persistence produced by the Phillips curves (1) and (2). The Taylor rule with and without interest rate smoothing and the Taylor rule when parameter τ_x is increased (parameter τ_π is reduced). In addition, the numerical exercises assume that $\tau_\pi = 1.5$ y $\tau_x = 0.5$, a standard assumption in Taylor rule empirical evaluations. It also gives equal weight to π_{t-1} and $E_t\pi_{t+1}$ in the *hybrid* Phillips curve. Its shows that the Phillips curve plays an important role and that it is impossible to explain the persistence of equations' system without including π_{t-1} in said curve.

The author also shows that the New Keynesian Phillips curve (1) leads to immediate disinflation, without persistence, and to disinflation with a little persistence when there is simultaneous smoothing of nominal interest rates in Taylor rule. This therefore suggests that monetary policy persistence (rate smoothing) is not sufficient to explain high values of inflation persistence.

Little inflation persistence is observed for the New Keynesian Phillips curve with rational expectations (1) because expectations are totally flexible and π_t can be modified immediately in response to changes in output gap. Such flexibility is also observed in *stock* type models, useful for explaining the behavior of the US dollar or shares on the stock Exchange, in which future expectations play an important role. On the other hand, when the output gap changes and the Phillips curve is *hybrid*, π_t cannot fluctuate freely because it partly depends on π_{t-1}, a variable which has already happened.

Price and wage rigidities increase the *impact* of monetary policy on production, but do not explain inflation persistence or the persistent effects of monetary policy on production. Mankiw (2001) makes an analogy with the relation between the behavior of capital stock and capital investment in growth models. In Calvo's (1983) model, higher θ, corresponding to greater price rigidity only produces lower ϕ_x.[11] Thus, in a less steep Phillips curve: when there are few opportunities for changing prices, firms cease to be interested in current demand and focus their attention more on future inflation as a determinant of current inflation.

[11] Fulfilling that $\phi_x = \frac{(1-\theta)(1-\theta\beta)}{\theta}$. Higher θ, corresponding to greater rigidity, produces a lower value ϕ_x. Sbordone (2007) shows that the coefficient ϕ_x declines even further when there are *strategic complementarities* among firms. Cogley and Sbordone (2005) also consider the case where capital cannot be reassigned instantaneously among firms.

Second, disinflation overshooting is produced when the Phillips curve is as in (1) and, even further, when there is smoothing of interest rates in Taylor rule. If the Central Bank raises interest rates in order to reduce inflation a negative gap is produced in (1) with $\pi_t < E_t\pi_{t+1}$ (not exactly a disinflation). The only way to avoid this is if inflation jumps downwards immediately and then reaches its long term level (0%) from below. Disinflation produces *bonanzas* in some subperiods. In such case there is a negative correlation between inflation and output gap, a paradoxical result, because disinflation produces *bonanzas* in some subperiods.[12]

The costs of disinflation are null or very low for Phillips curve (1), with a sacrifice ratio (SR) equal to zero if there is no interest rate smoothing,[13] and 0.7 when smoothing exists. On the other hand, the *hybrid* Phillips curve gives sacrifice ratios of 2.0 and 4.1 (with and without rate smoothing, respectively), closer to those observed in reality. Ball (1993) for instance finds a sacrifice ratio of 2.93 in Germany and 2.39 in the United States.[14]

A large amount of recent discussion on the topic analyzes the importance of the different components on the right hand side of equation (2). What is the role of output gap x_t (*inherited* or *intrinsic* persistence), or that of inflation expectations ($E_t\pi_{t+1}$), of π_{t-1} (*intrinsic* persistence), and supply shocks (persistence in the *error*)? The main conclusion is that the *hybrid* Phillips curve plays the determining role.

Finally, Fuhrer (2009) puts forward a general dynamic and stochastic equilibrium model with which it is possible to obtain more accurate conclusions, many of them coinciding with those given by the previous exercises. Among these are:

[12] The phenomenon of *disinflationary overshooting* is produced by the assumption of rational expectations and does not occur when expectations exhibit persistence. One way to understand the negative relation between inflation and output gap is as follows: lagging equation (1) with the assumption that $\beta = 1$ and adding π_t on both sides would give that $\pi_t = \pi_{t-1} - kx_{t-1} - E_{t-1}\pi_t + \pi_t$. This implies that: $\pi_t - \pi_{t-1} = -kx_{t-1} + \varepsilon_t$, where $\varepsilon_t = \pi_1 - E_{t-1}\pi_t$. Thus, the negative output gap will lead to growing inflation. Ball (1992) and Mankiw (2001) explain it simply. If announced disinflation is credible, firms who can adjust their prices will reduce the size of increases, even before money supply dynamics are reduced. Real balances (M/P) and output will grow.

[13] Calvo's model assumes rational expectations and includes a Phillips curve as in (1). It shows that the authorities can keep inflation under control, without costs, sustaining output close to its potential.

[14] Although it is much lower in France (0.75) or the UK (0.79). See also Cecchetti and Ric (2001). Gómez (2002) finds an average sacrifice ratio of 1.34 for Colombia during the 1990s.

- As mentioned above, inflationary inertia is shown to have a close relation with the presence of variable π_{t-1} in the Phillips curve (*intrinsic* persistence). Inflation falls immediately and inflationary inertia is minimal when $\phi_{\pi-1} = 1 - \beta = 0$ in (2).
- *Inherited* persistence, stemming from x_t in the Phillips curve is unlikely to play an important role. The pattern of inflation is relatively similar when ϕ_x varies from 0.10 to 0.25.[15] Furthermore, the volatility of supply shocks u_t decreases the persistence generated by x_t.[16] Finally, the persistence of x_t *has not decreased* over time, making it difficult to explain the reductions in inflation persistence (under discussion) from the behavior of x_t (Fuhrer, 2009, p. 39).
- The pattern of inflation is relatively similar when the variance of u_t changes (the supply shock in the Phillips curve) from 0.5 to 0.1, or when parameter σ_{x-1} changes in the IS curve from 0.5 to zero.
- The characteristics of monetary policy difficulty explain observed inflation persistence (see Section 3.2). Not even a value of τ_π equal to five in the Taylor rule manages to reduce inflation persistence slightly.

2.2 Including π_{t-1} in the Phillips curve

It is difficult to explain inflation's high *statistical persistence* (an ongoing debate) or obtain a successful empirical adjustment in the Phillips curve if π_{t-1} is not included. Thus, for the *tripod* model (Gordon, 1997), in which the oil price is added to the equation (2), including π_{t-1} raises the coefficient R^2 from 0.24 to 0.74 during the period 1966Q1-1984Q4, from 0.79 in the period 1985Q1-2008Q4, from 0.39 to 0.77 in 1996Q1 to 1984Q4, and from 0.16 to 0.72 in 1985Q1 to 2008Q4 (Fuhrer, 2009). In the same direction, Rudd and Whelan (2005) find that only a small percentage of

[15] Besides, some authors such as Williams (2006) and Mishkin (2007) state that ϕ_x has declined over time. Meanwhile, Dupuis (2004) and Linde (2005) find relatively stable parameters in the Phillips curve.

[16] Even with high persistence of x_t (i.e. between 0.9 and 0.95) and a high ϕ_x parameter (i.e. close to 0.01), inflation persistence is below 0.3 when the variance of supply shocks is high. Persistence values in real activity are in any case very high. The first-order autocorrelation coefficient varies between 0.80 and 0.92 for different subperiods, while that of the output gap varies between 0.80 and 0.92. The sum of autoregressive coefficients fluctuates between 0.78 and 0.96 (different periods) for the real marginal cost, and between 0.77 and 0.97 for the output gap.

the good adjustment of the *hybrid* Phillips curve comes from future inflation expectations or the output gap. Meanwhile, Estrella and Fuhrer (2002) conclude that that models including π_{t-1} tend to be more stable over time than those only using inflation expectations.[17]

Based on models which allow some *irrationality*, Smets (2004) and Galí and Gertler (2000) find a weight of 0.52 and 0.25 for π_{t-1}, respectively, while Paloviita (2004) finds that π_{t-1} significantly contributes to explaining π_t when the Organisation for Economic Co-operation and Development (OECD) inflation expectations are used as a proxy for expectations.

It is not necessary to assume adaptive expectations in order to explain the importance of π_{t-1} in the Phillips curve. For some authors the importance of π_{t-1} is spurious because it detaches from Calvo's model with rational expectations but with inflation targets different from zero or with non-random hazard functions, while for others it obeys the central bank's learning processes and lack of credibility. Empirical works show that the importance of π_{t-1} in the Phillips curve is low when inflation expectations are anchored (Altissimo, Ehrmann and Smets, 2006). For the same reason the impact of shocks other than Mishkin's (2007) output gap would seem to be lower nowadays.

2.3 Modifications to Calvo's Model (with Rational Expectations)

2.3.1 Inflation Target Different to Zero

For some authors it is not necessary to sacrifice the hypothesis of rational expectations or the policy implications caused by a microfounded Phillips curve (1). It is enough to eliminate the assumption that the inflation target is equal to zero in order to produce the alternative Phillips curve shown in (9).[18]

$$(9) \qquad \hat{\tilde{\pi}}_t = \phi_{\pi_{-1},t}\left(\hat{\tilde{\pi}}_{t-1} - \hat{g}_t^{\pi^*}\right) + \phi_{x,t}\hat{x}_t + \phi_{\pi_{+1},t}\tilde{E}_t\hat{\tilde{\pi}}_{t+1} + b_{\pi_{+j}}\tilde{E}_t\sum_{j=2}^{\infty}\phi_t^{j-1}\hat{\tilde{\pi}}_{+j} + u_t\,.$$

where π^* is the inflation target (or trend inflation), $\tilde{\pi}_t = \dfrac{\pi_t}{\pi^*}$ is the relation between inflation and the target, equal to one in its steady-state, and

[17] See also Rudebusch (2002).
[18] See Cogley and Sbordone (2006) and Cecchetti et al. (2007).

$\hat{g}_t^{\pi^*} = \frac{\pi_t^*}{\pi_{t-1}^*}$ corresponds to the target growth rate; finally $\hat{\pi}_t = \ln\left(\frac{\pi_t}{\pi_t^*}\right)$. The New Keynesian equation (1) coincides with (9) when $\pi_t^* = 0$ or when $\phi_{\pi_{-1},t} = 1$ (complete indexation). The assumption of an inflation target equal to zero is even less appropriate for a country like Colombia than for the US or Europe. As figure 1 shows, inflation targets in Colombia have been high and have decreased only gradually.

Equation (9) has three radically different characteristics from equation (1). First, the coefficients are now variable over time, even for parameters that are mainly constant in Calvo's model. Second, parameter $\phi_{x,t}$ is low (the sacrifice ratio) when the inflation target is high. In other words, a high inflation target makes reducing inflation more costly and could cause the authorities not to do so. Finally, the expected value for future inflation in (9) could be correlated with π_{t-1}, meaning the *successful* inclusion of the latter variable in empirical calculations could be erroneous (it obeys omitted variables). In fact, Altissimo, Ehrmann and Smets (2006) and Cogley and Sbordone (2006) show that *intrinsic* persistence (due to π_{t-1}) is reduced when long-term values for inflation are included. Given all the aforementioned, the microfounded Phillips curve (1) could be a good approach for designing optimum monetary policy.

2.3.2 Functions of Hazard Variables

Calvo's model assumes that changes in prices are random, but Gooodfriend and King (1999) and Wolman (1999) work with a more realistic assumption according to which the probability of changes in prices is higher when they have remained unchanged for a long period of time. Woodford (2007) shows that this case leads to the following equation for the Phillips curve:

$$\pi_t - \gamma\pi_{t-1} = \beta E\left[\pi_{t+1} - \gamma\pi_t\right] + \phi_x E_t\left[\left(1 - L^{-1}\right)^{-1} x_t\right]. \tag{10}$$

Where $0 < \gamma < 1$ in the case of a growing hazard function ($\gamma = 0$ in Calvo's model). Again, the relevance of variable π_{t-1} is spurious, and optimum monetary policy coincides with that derived from the microfounded Phillips curve (1).[19]

[19] Notwithstanding, Rudd and Whelan (2006) state that the expected sign for π_{t-1} is negative in this model, the opposite of that obtained in empirical calculations.

2.4 Learning Processes

The assumption of adaptive expectations would adequately explain the existence of π_{t-1} in the Phillips curve in the way originally set forth in the inflation models suggested by Friedman (1968) and Phelps (1967), although it seems insufficient in light of Lucas's so-called criticism (Mankiw, 2001). In any case, several recent empirical studies have been forced to abandon the assumption of perfect rationalism.

Christiano, Eichenbaum, and Evans (2005), for instance, assume that firms which do not re-optimize in Calvo's (1983) model, index their prices to the preceding period's inflation. Formally, firms which do not re-optimize remain constant $p_t(i)-\gamma p_{t-1}$, where γ corresponds to the indexation level of such prices, where $p_t(i)$ is the logarithm of the good's price *i*, and p_{t-1} is the logarithm of the aggregate level of prices in *t−1*.This therefore leads to the following hybrid Phillips curve $\pi_1-\gamma\pi_{t-1}=\phi_x x_t+\beta E_t\left[\pi_{t+1}-\gamma\pi_t\right]$ (Woodford, 2007, pp. 204). The authors' assumption appears inconvenient in light of empirical evidence because agents are not changing prices all time.[20]

Meanwhile, Galí and Gertler (2000) justify including π_{t-1} in the Phillips curve by assuming that firms which randomly decide to re-optimize their prices in Calvo's (1983) model follow a rule of thumb, with prices representing average weighted optimum prices fixed in the preceding period plus an adjustment for past inflation.

Small deviations from the rational expectations assumption can drastically change the model's results. Angeloni et al. (2005) show two examples: imperfect information on the shock's characteristics (e.g., temporary versus permanent) can produce persistence and a gradual response from agents; something similar happens when there are agents' learning processes and the authorities hamper them by preferring a high value of τ_x (or a low value of τ_π) in the Taylor rule.[21] Collard and Dellas (2004), Erceg and Levin (2001), and Milani (2005) include learning dynamics with transitory differences in the rational expectations model. Again, as in previous cases, the importance of coefficient π_{t-1} in empirical estimations of the Phillips curve is spurious and results from the correlation between lagged inflation and *irrational- subjective* forecasts for inflation.

[20] See Woodford (2007) and Sbordone (2007). Regarding price fixing schemes see Blinder (1991) for the US and Julio, Zárate, and Hernández (2010) and Zárate (2010) for Colombia.

[21] See also Orphanides and Wiliams (2005).

2.5 Central Bank Credibility

Svensson (1999) mentions the uncertainty of the model (e.g., uncertainty concerning the natural interest rate or the process of interest rate smoothing by the central bank) as an additional factor which creates persistence, although recent literature on the subject has focused its efforts on the uncertainty related to current and future central bank policies.

The previous models assume that agents who take pricing decisions know the central bank is determined to decrease demand in order to reduce the rate of inflation and will remain committed to this. If agents expect real short-term interest rates to be high today and in the future, the long-term interest rate will be high and this will lead to a reduction in aggregate demand and inflation.

Thus, Fuhrer (1995) considers the inertia stemming from the imperfect credibility of the central bank as a third persistence factor, besides the inertia resulting from price and wage pacts or a slow adjustment in expectations. Agents basically do not believe the central bank will implement the monetary policy required to reduce inflation. Erceg and Levin (2001), for instance, show that agents' learning of central bank inflation targets can explain the gradual disinflation observed in the Volcker era. Mishkin (2007) associates the trend inflation observed before Volcker with unanchored long-term inflation expectations.

If persistence originates in the price and wage fixing process, the central bank will have to accept the costs of disinflation if it fosters it. On the other hand, if persistence originates in central bank credibility, it must decide how and when to increase its credibility. Central bank communication could be a main determining factor in said expectations and the way agents learn (Woodford, 2005).

3. *STATISTICAL PERSISTENCE.* METHODOLOGY AND INTERNATIONAL EMPIRICAL EVIDENCE

Literature on persistence measurement is usually divided into two large groups. The first group researches the level of integration of the series, while the second considers the evolution of different persistence measurements in autoregressive models for $I(0)$ series. Section 3.1 suggests that the sum of autoregressive coefficients and the impulse-response functions represent the *best* measurements in $I(0)$ series. Section 3.2 shows international empirical evidence for different indicators. Inflation persistence falls when the monetary regime (i.e. the gold standard or inflation targeting scheme) manages to anchor inflation expectations, although it is still being debated whether persistence levels in all developed nations are lower today than in the past.

3.1 Measurement Methodologies

For inflationary process $\pi_t = a\pi_{t-1} + \varepsilon_t$, in which ε_t represents a shock during period *t*, fulfills that $\pi_1 = \varepsilon_t + a\varepsilon_{t-1} + a^2\varepsilon_{t-2} + a^3\varepsilon_{t-3} + \dots$. A high *a* coefficient equals more persistence because it reflects a higher relative impact of past shocks on π_t. Furthermore, when the series has unit root $(a = 1)$ inflation variance is unlimited and persistence is infinite because all past shocks affect current inflation $(\pi_t = \sum_{i=0}^{\infty} \varepsilon_{t-i})$.

One the first steps in determining *statistical persistence* consists of establishing the level of integration of the inflation series, an area where the results of international literature have not been conclusive. A large amount of such literature finds that long term series are *I*(1), even though the unit root is rejected more frequently when short and recent periods are studied. An *I*(1) series which then becomes *I*(0) indicates that the inflationary process has become less persistent because the shock now disappears at some moment in time.

For some authors, the unit root observed in long term series (under discussion) is not due so much to inflation persistence as to the persistence of the targets implied or fixed by the central bank. Stock and Watson (2006), for instance, propose breaking down observed inflation into its permanent and transitory components, each one of these with its own variance changing over time. Meanwhile, the permanent component is associated with implicit or explicit inflation targets.[22]

For others, the series are neither *I*(1) nor *I*(0), but present intermediate levels of fractional integration.[23] This also explains the divergent results observed in practice when only two extreme possibilities are consid-

[22] The model is relatively similar to an integrated moving average process. See also Cecchetti et al. (2007).

[23] A stochastic process characterized by the presence of a fractional difference operator. Fractional integration, more commonly known as long memory, can make a series seem stationary although it has high autocorrelations which are too large to be identified by a parsimonious ARMA model. See Baillie, Chung and Tieslau (1996), Baum, Barkuolas, and Caglayan (2010) and Kumar and Okimoto (2007).

ered. It might also explain why inflation series in the US is $I(1)$ when using an AR(12) model, and $I(0)$ when using AR(3) and AR(6) models (Kumar and Okimoto, 2007).[24] Nevertheless, it is not easy to differentiate long memory processes with fractional integration from those in which the average changes (Altissimo, Ehrmann and Smets, 2006).[25]

Only when the series is not $I(1)$ does it make sense to ask questions about the levels and variations in indicators such as the autocorrelation coefficient, the largest autoregressive root, average life, the sum of autoregressive coefficients or the impulse-response function. Literature tends to favor the sum of autoregressive coefficients and the impulse-response function as persistence indicators, both of which are used in the empirical evaluation of Colombia's case shown in section 4.

Although the trend is to favor the sum of coefficients, it does not seem advantageous to ignore information provided by other roots or lags. All else being equal, an AR(2) process with 0.9 and 0.8 roots is more persistent than an AR(2) process with 0.9 and 0.1 roots.[26] The impulse-response function is also popular because it can discriminate between a process with a unit root subject to permanent variations and one subject to transitory variations (something that does not occur, for instance, with the maximum autoregressive root).[27] The two best indicators are related: the sum of autoregressive coefficients is the indicator recommended by Andrews and Chen (1994), partly because it is similar to the long term impulse-response function in the event of a unit shock. Average life has been widely used for evaluating purchasing power parity (PPP), but presents innumerable problems as a persistence indicator due, among other reasons, to the fact that there is no broad body of study on the statistical characteristics of its distribution.

[24] Rose (1988) is one of the few studies which find that the integration series is I(0) during the post war period (to be more specific the author actually studies the 1947-1986 period).

[25] Besides, Hassler and Wolters (2010) argue that in the presence of fractional integration the augmented Dickey Fuller test (1979) fails for rejecting the hypothesis that the series is I(1). Furthermore, if fractional integration exists it is possible that unit root tests and AR based persistence measurements lead to diverging conclusions (Kumar and Okimoto, 2007).

[26] See Andrews and Chen (1994). The sum of autoregressive coefficients is not without problems either. The sum is higher when inflation rises rapidly to high levels and abruptly returns to zero than when inflation initially increases slightly and returns slowly to zero. The latter process should appear more persistent (Pivetta and Reiss, 2007, pp. 3).

[27] See Kang, Kim and Morley (2009).

Stock and Watson (2006) propose a different measure of inflation persistence[28] based on coefficient R^2 of forecasts for different terms from the model employed. For example, for 1960-2006 they find that coefficient R^2 in their transitory and permanent component model shifted from 90% in the 1970s and 1980s to around 50% from the 1980s until the end of the sample, suggesting lower persistence. For four quarters onwards coefficient R^2 increased from 50%-75% in the former period to 15% in the latter, and for eight quarters onwards from 20%-35% to 10 percent.

3.2 International Empirical Evidence

Literature on persistence measurement can be divided into two main groups. The first researches the levels of integration in the series, while the second studies the evolution of different persistence measures from valid autoregressive models for $I(0)$ series. The following paragraphs discuss the case of the US with occasional references to other developed countries and Latin America. Review of international empirical evidence suggests a large degree of uncertainty regarding the level of persistence in the series. There is uncertainty concerning the precise value of estimators, the sensitivity of adopted periods and methodological approaches, and uncertainty over the advantages of different measures of persistence (Altissimo, Ehrmann and Smets, 2006). Different levels of persistence are frequently obtained for different price indexes during the same period and the statistical properties of the series mean persistence grows with the level of aggregation.[29]

3.2.1 Level of Inflation Integration

Original post war inflation series (i.e., without considering structural breaks) seem to have a unit root. Fuhrer (2009), for instance, shows that the augmented Dickey Fuller test (ADF) does not allow rejection of the unit root hypothesis in 1966-2008 for any of the three price indexes used.[30] Meanwhile, based on the confidence interval for the largest unit

[28] The non-parametric persistence indicator proposed by Robalo Marques (2004) is not considered here. This indicator is not affected by the model's misspecification problems.

[29] Idiosyncratic shocks to a series' subcomponents tend to cancel each other out; besides, the persistence of aggregate series gives greater weight to the most persistent subcomponent. See Altissimo, Ehrmann and Smerts (2006) and Angeloni et al. (2005).

[30] Results are not so clear when using the Phillips-Perron test (1988).

root, Stock and Watson (2006) do not reject the unit root hypothesis for the 1960-1983 or 1984-2004 periods. Using a similar methodology (including Bayesian *priors*) Pivetta and Reis (2007) do it neither, for whom inflation in the US can be associated to a constant unit root process. Levin and Piger (2004), Table 1, find that three out of the four price series studied for the US are $I(1)$ between 1984 and 2003.[31] The unit root hypothesis is not rejected either by the relatively recent Works of Bai and Ng (2004) and Henry and Shields (2004), as well as a broad sub-group of papers outlined in Murray, Nikolsko-Rzhevskyy and Papell (2008), Table 1.

Similarly, for the 1980m01-2006m06 period, Capistrán and Ramos-Francia (2007) find that the inflation series is $I(1)$ in seven of the ten major Latin American countries, only rejecting by 5% the unit root hypothesis for Chile, Peru and Venezuela.

As mentioned above, for some authors the series are not $I(1)$ or $I(0)$, but instead possess intermediate levels of fractional integration. Baillie, Chung and Tieslau (1996), for instance, simultaneously apply the tests suggested by Phillips and Perron (1988) and by Kwiatkowski et al. (1992) in the 1948-1990 period in the US They find that it is possible to reject both the hypothesis that the series is $I(1)$ as well as that it is $I(0)$ for eight out of the 10 countries studied (excluding Germany and Japan).

Kumar and Okimoto (2007) and Baum, Barkuolas and Caglayan (2010) also find it appropriate to consider methodologies that allow fractional integration levels to be considered. Meanwhile, Kumar and Okimoto (2007) discover a permanent reduction in the level of integration (degree of persistence) in the US since the mid-1980s as well as in other G7 countries except Italy.

3.2.2 Level of Integration of the Series Including Structural Changes

After including structural changes in the series for 1984-2003, Levin and Piger (2004) reject the unit root hypothesis in all four of the inflation indexes studied, with an inflation shock which in most cases disappears within a few quarters. This result is in contrast to the unit root found for three of these when structural changes are not considered (see above). The authors note that structural changes occur in the inflation mean and not in the autoregressive coefficients.

[31] Altissimo, Ehrmann and Smets (2006) combine the evidence presented by Levin and Piger (2004) with other works and arrive at similar conclusions.

TABLE 1. UNIT ROOT TESTS AT 10%, 1960-2010

				ERS				*NG-PERON*								
		AIC lags		*DF_GLS*		*PT*		*MZA*		*MCB*		*MSB*		*MPT*		*KPSS (Newey-West)*
Variable	*Model*	*MAIC*	*ADF*	*AIC*	*MAIC*	*AIC*	*MAIC*	*AIC*	*MAIC*	*AIC*	*MAIC*	*AIC*	*MAIC*	*AIC*	*MAIC*	
							Period: 1960m8-2010m6									
		12		−3.563	−3.563	4.05	4.05	−23.32	−23.32	−3.39	−3.39	0.145	0.145	4.04	4.04	0.628
PI	CT	12		Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:
				−1.61	−1.61	6.89	6.89	−14.2	−14.2	−2.62	−2.62	0.18	0.18	0.18	0.18	0.12
		12	−3.28	−3.038	−3.038	1.603	1.603	−18.00	−18.00	−2.90	−2.90	0.161	0.161	1.706	1.706	0.75
PI	C	12	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:
			2.56	1.61	1.61	4.48	4.48	−5.7	−5.7	−1.62	−1.62	0.27	0.27	4.45	4.45	0.34
							Period: 1980m1-2009m12									
		12	−2.77	−2.76	−2.76	7.12	7.12	−12.73	−12.73	−2.52	−2.52	0.197	0.197	7.16	7.16	0.388
PI	CT	12	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:
			]3.13	−2.59	−2.59	6.88	6.88	−14.2	−14.2	−2.62	−2.62	0.19	0.19	6.67	6.67	0.12
							Period: 1990m1-2010m6									
		12	−3.45	−3.47	−3.47	4.40	4.40	−20.57	−20.57	−3.20	−3.20	0.16	0.16	4.48	4.48	0.36
PI	CT	12	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:	Vc:
			3.13	−2.63	−2.63	6.86	6.86	−14.2	−14.2	−2.62	−2.62	0.19	0.19	6.67	6.67	0.12

Using information for 1948-1999, Kim (2000) presents evidence that the inflation series in the US shifted from being $I(0)$ before 1973 to $I(1)$ in later years. Using information for the 1959-2000 period, Leyburne et al. (2003) show evidence that inflation moved from having a unit root before 1982 to being stationary in the following years.

Persistence also falls significantly in Latin America when structural breaks are included in the analysis, and the series now becomes $I(0)$ in nine out of the ten countries studied by Capistrán and Ramos-Francia (2007). Paradoxically, it is not possible to reject the unit root hypothesis for Colombia, not even when structural breaks are considered. The authors attribute this result to the significant seasonal variations in monthly data, but they do not reject the unit root hypothesis either when this factor is explicitly included.

3.2.3 Sum of Autoregressive Coefficients

Just as occurred with the level of integration, persistence measurements for series $I(0)$ decrease slightly when structural changes are considered. Altissimo, Ehrmann and Smets (2006), Table 3.1, for instance, compare the sum of autoregressive coefficients for studies with long time series, whose average is close to 0.9, with those of other studies which consider short time periods or changes in the mean, whose average is close to 0.6.

On the other hand, persistence seems to be low when there is a well-established monetary anchor. Thus, Benati (2008) finds that inflation persistence has been low under the gold standard, with the adoption of the euro by some countries in the European Community and the adoption of inflation targeting regimes in the UK, Canada and Australia.

However, there is great controversy over the existence (or not) of lower inflation persistence during recent decades, presumably as a consequence of changes in monetary policy. On the one hand, Brainard and Perry (2000), Taylor (2000) and Kim, Nelson and Piger (2001) find that inflation persistence in the Volcker-Greenspan era has been substantially lower than during previous decades. Similar results are obtained by Evans and Wachtel (1993) and Kang, Kim ad Morley (2009) based Markov-switching estimates. Fuhrer (2009) and Mishkin (2007) also find significant decreases in the sum of autoregressive coefficients during recent periods.[32] Ravenna (2000) documents a strong fall in persistence for the post-1990 period in Canada.

Nonetheless, a large body of other work reaches opposite conclusions. Benatti (2008), Tables 7 and 8, present perhaps the most exhaustive research on the behavior of inflation persistence in the US since the colonial period. The author does not find any significant change in the sum of autoregressive coefficients between the period named *high inflation* and the post-Volcker period of stabilization.[33] For 12 industrialized countries in the 1984-2003 period (and four price indexes) Levin and Piger (2004) find important changes in the average, but not in the sum of autoregressive coefficients. O'Reilly and Whelan (2004) do not discover significant changes for the euro zone as a whole, concluding that the sum of autoregressive coefficients is around one,[34] while Batini (2002) does not find significant changes in persistence when different European countries are studied. As mentioned above, the major autoregressive root estimates made by Pivetta and Reiss (2007) and Stock and Watson (2006) do not identify any significant changes either.

For the ten main Latin American countries, Capistrán and Ramos Francia (2007) find that the sum of autoregressive coefficients are high between January 1980 and June 2006 in Uruguay and Venezuela, at medium levels in Argentina, Brazil, Colombia, and Ecuador and low in Chile, Mexico and Peru (with mixed results in Bolivia). Nevertheless, once again some of the results change when mean changes are taken into account, in this case persistence levels are relatively low (as compared to historic levels) in at least five out of the ten countries analyzed (Argentina, Brazil, Ecuador, Mexico and Peru); no significant declines are found in Chile, Colombia and Venezuela; with increases in Uruguay and mixed results in

[32] According to Fuhrer (2009), for the consumer price index the indicator shifted from 0.89 in 1966-2008 to values close to zero in 1995-2008 (the decline is lower for the GNP deflator and even less for indicators on core inflation). Evidence for significant changes in persistence for other indicators is also found. The average autocorrelation coefficient rose from 0.5 in the 1970s to 0.8 in 1975-1995, and values close to zero during recent years. Autocorrelograms show important reductions, with values oscillating between 0.75 and 0.5 for the first three lags in the 1966-1984 period, and values around 0.3 in 1995-2008 (decreases in persistence are not so clear when core inflation is considered).

[33] No important changes are found in persistence for the GNP deflator, the GNP deflator or the so-called PCE; the only significant change is that observed in the consumer price index.

[34] The authors do not find significant changes in the sum or the mean of coefficients once they correct the parameter stability test proposed by Andrews (1993).

Bolivia. Idiosyncratic factors dominate, particularly in Bolivia and Mexico, and slightly in Chile, Peru and Uruguay.[35]

According to the authors, Colombia has one of the highest autocorrelation coefficients for inflation in levels, both for the period as a whole (0.91), 1980-1989 (0.90), 1990-1999 (0.92) and 2000-2006 (0.85). The results are relatively more favorable (less persistence) when the sum of autoregressive coefficients is studied, giving values of 0.79 (whole period), 0.59 (1980-1989), 0.62 (1990-1999) and 0.67 (2000-2006) when breaks are not considered, and 0.58 (whole sample), 0.58 (1980-1989), 0.58 (1990-1999) and 0.68 (2000-2006) after including breaks.

3.2.4 Markov-switching

The Markov-switching methodology or regime switching model recognizes that the temporary series is state-dependent, i.e. its average, variance and historic relation depends on the economy's regime or state, said state being generated by a first order Markov process. The advantage of this methodology for studying inflation persistence as compared to other traditional models is that it allows endogenous recognition of regime changes in the behavior of the autoregressive process over time. In this case, persistence is defined as state-dependent and is measured using the sum of the autoregressive coefficients associated to each state.

Furthermore, applying the Markov-switching model to inflation allows analysis of persistence or the expected duration of inflation in each regime, as well as the frequency of change of private agents' rational expectations, assuming that these form their expectations following simple rules. If inflation is highly persistent, the rule employed by private agents for forming their inflation expectations would therefore not change frequently. The assumption of relatively sudden changes is particularly relevant given that inflation persistence is possibly linked to monetary regime changes and the central bank's reputation.[36] Murray, Nikolsko-Rzhevskyy and Papell (2008) employ Markov-switching methodology and find that

[35] In any case *common* factors explain between 15% and 30% (depending on the methodology) of persistence variations in the different countries. The authors suggest that during the 1980s fiscal dominance was relatively common in all the region's countries. The favorable behavior of inflation in the last decade possibly obeyed the impact of globalization and appropriate policies (Rogoff, 2003).

[36] See Cogley and Sbordone (2005), Benati (2008) and Kang, Kim and Morley (2009).

inflation has a unit root in most years between 1967 and 1981, while it is stationary before 1967 and after 1981.[37]

3.2.5 Inflation Targets

Robalo Marques (2004) emphasizes that any persistence indicator is conditional to the assumption made on medium and long term inflation, which can also vary over time. In the same way, a large body of recent literature tends to assign an important role to the high persistence of the inflation target as a determinant of persistence in observed inflation (Altissimo, Ehrmann and Smets, 2006).

As mentioned above, Stock and Watson (2006) consider that observed inflation results from the sum of a permanent component, modeled as a random walk, with unit root and associated with the inflation target implicit in the US as well as a transitory component. The authors find that the reduction in inflation variance observed during recent years is due to the reduction of the variance of this permanent component. In the same way, Cogley, Primiceri and Sarget (2009) find a significant reduction in the persistence of $\pi - \pi^*$, π^* being the inflation target, and Kang, Kim and Morley (2009) find that $\pi - \pi^*$ is stationary during the whole 1959Q1-2006Q2 period.

4. STATISTICAL PERSISTENCE IN COLOMBIA

As mentioned above, measuring statistical persistence is the first step in an analysis of inflation dynamics and should serve as the basis for later study on the behavior and dynamics of the *structural* variables which determine it. Questions on the IS, the Taylor rule and the Phillips curve (mainly) will be addressed by the authors in the future.

In this context, an analysis of the series' order of integration is of central importance. If inflation is integrated by first-order $I(1)$, it is said to be extremely persistent, because all shocks to it are permanent and there is no return to its previous behavior. If inflation is stationary, $I(0)$, all shocks dissipate and it is possible to determine the time necessary for it to revert to its mean. In such case it is advantageous to use the two *best* persistence indicators, the sum of autoregressive coefficients and the impulse-response function. Finally, as mentioned previously, it is not only im-

[37] Evans and Wachtel (1993) also.

portant to consider the dynamics of inflation but also those of differential $\pi - \pi_t^*$.

Sections 4.1 and 4.2 evaluate the order of integration of overall inflation in Colombia[38] during the periods: *i)* 1960m08-2010m06, *ii)* 1980m01-2010m06, and *iii)* 1990m06-2010m06. Evidence of the stationary behavior of the series in the latter period allows it to be examined to ascertain if it is governed (or not) by a Markov-switching autoregressive process, i.e. if the nature of inflation differs during said period. There are two regimes: the *previous regime*, between 1990m01 and 2000m01, and the *current regime* between 2000m02 and 2010m06. The behavior of the sum of autoregressive coefficients and the impulse-response function in each of these periods is researched. Section 4.3 studies the performance of the spread between inflation and its target ($\pi - \pi_t^*$, instead of π_t), constructing a persistence measurement which changes over time based on the combination of a Kalman filter and a non-linear optimization procedure.

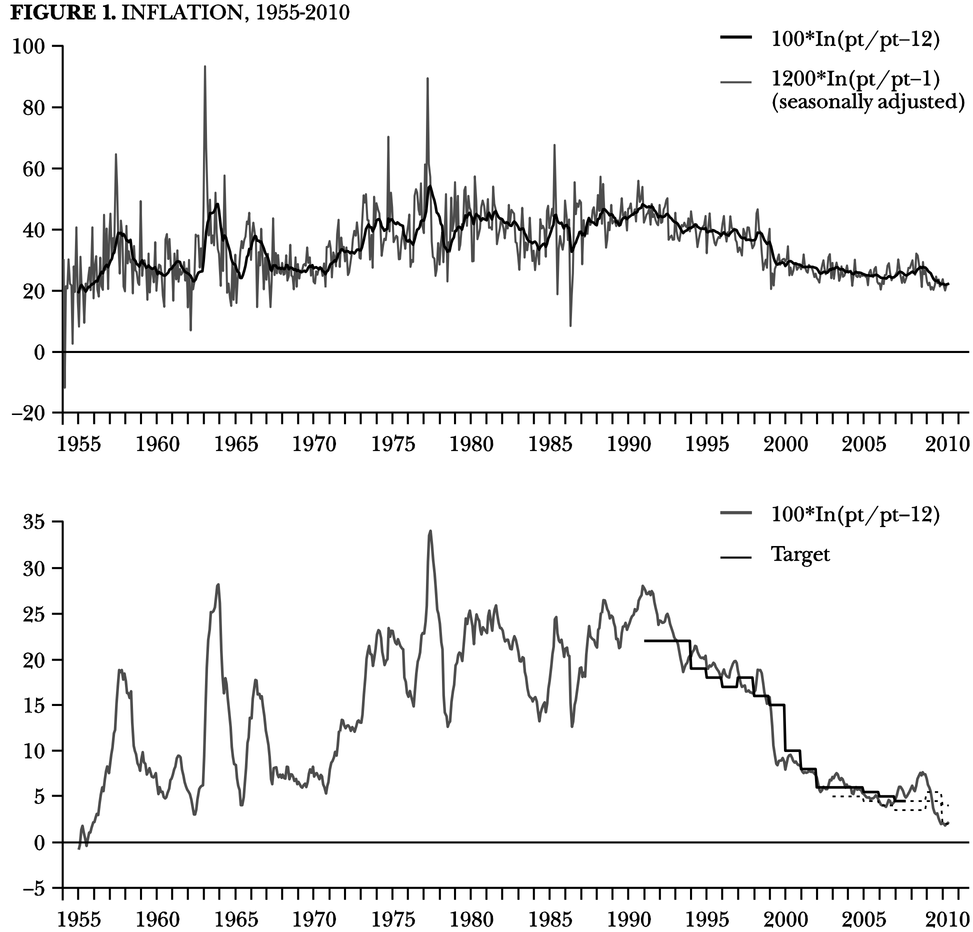
4.1 Series Order of Integration Test

The top of Figure 1 shows the evolution of annualized monthly inflation, defined by $1{,}200^*\ln(P_t / P_{t-1})$ and month-on-month annual inflation defined by $100^*1n(P_t / P_{t-12})$. As would be expected the former series exhibits greater volatility because the latter smooth shocks that dissipate in less than one year. The bottom of the figure again shows annual inflation and the inflation target set by the central bank each year. According to the bank's law, it aims to meet in December the inflation target established in November of the preceding year. Thus, the target set for 1991 was 22% but was not met because inflation observed in December of that year was 23.8%. The Executive Board established *punctual targets* during the period between 1991 and 2002, and *target ranges* in later years. Furthermore, since 2001 it announced a long term target range of 3% plus or minus 1 percentage point.

With the aim of examining the degree of integration of the inflation series, this paper employs unit root tests developed by Ng and Perron (2001), Elliot, Rothenberg and Stock (1996), and Hobijin, Franses and

[38] Employing annualized monthly inflation $1{,}200^*1n(P_t / P_{t-1})$ where P_t is the seasonally adjusted CPI. Seasonal adjustment is made using the X11 procedure. This series differs from that used in economic policy discussions in Colombia, defined as $100^*1n(P_t / P_{t-12})$, which smooths shocks lasting less than 12 moths and therefore shows greater persistence (Payaa, Duarteb and Holdene, 2010).

FIGURE 1. INFLATION, 1955-2010



Ooms (2004), who modified conventional tests in order to improve performance and power. Conventional tests such as that of Dickey-Fuller and augmented Dickey-Fuller (Dickey and Fuller, 1979), present particularly delicate problems when dealing with the case presented here.

Ng and Perron (2001) underline two main problems in conventional test construction.[39] The first concerns low explicative power when the autoregressive polynomial is smaller but very close to one. A correction for this problem is obtained with the ADF-GSL and Point Optimal tests proposed by Elliot, Rothenberg and Stock (1996) –ERS– who, using simulations based

[39] Taken from Betancourt, Misas and Bonilla (2008).

on finite samples, found a greater power as compared to traditional tests. The second problem occurs when the moving average polynomial of the first difference or the residuals has a large negative root, which induces a higher probability of rejecting the unit root hypothesis. In this regard, Ng and Perron (2001) propose modifications to the Phillips and Perron (1988) and ERS Point Optimal (1996) tests[40] and develop modified Akaike's information criterion (MAIC) to determine the optimal number of lags. Finally, there is the unit root test proposed by Kwiatkowski et al. (1992), KPSS, whose null hypothesis sets out series stationary. The test has been generalized for highly autoregressive processes by Hobijin, Franses and Ooms (2004), introducing automatic lag selection from a broadband in the Newey and West (1994) fashion.

Series testing is carried out for the periods: *i)* 1960m8-2010m6, *ii)* 1980m1-2010m6, and *iii)* 1990m1-2010m6. Table 1 shows results of the tests for unit root existence of Elliott, Rothenberg and Stock (1996), ADF-GSL and Point Optimal, Ng and Perron (2001) MZA, MZB, MSB and modified KPSS (1998), to a 10% level of significance. The maximum number of lags used is 12 in the first two periods and five in the last, which guarantees correlation absence of the residuals in each period. Lags were determined according to Akaike (AIC) and modified Akaike's (MAIC) selection criterion, after considering 18 lags in the first two sub periods and 12 lags in the last. The intercept, and the intercept and trend in auxiliary regressions are considered.

According to the results of Table 1 there is no conclusive evidence on the order of integration for the inflation series during the reference period. This is also open to debate for the US series (see section 3.2). Based on the results of the ADF test, which is high powered under the alternative hypothesis, and the ERS-DFGLS and MZA, and Ng and Perrron's MZB tests, in this paper annualized inflation is considered stationary $I(0)$ for the period between January 1990 and June 2010. Furthermore, as mentioned above, it is difficult to believe that an inflation targeting regime can move away permanently from its long-term level.[41]

[40] The Phillips and Perron (1988) tests transform DF statistics in order to make them compatible with the presence of autocorrelation and heteroskedasticity in disturbance terms, without altering test distribution.

[41] Section 3.2 mentioned that Stock and Watson (2006) and Cogley, Primiceri and Sargent(2009), among others, consider a different strategy. According to these authors, the inflation series can be $I(1)$ (several statistical tests do not allow reject this hypothesis for the US) thanks to the influence of long-term targets implicitly or explicitly adopted by the

It should be remembered that, the fact that a series is $I(0)$ implies that all shocks dissipate over time. An $I(1)$ variable will be persistent, meaning that shocks affecting it will be long lasting and prevent the series from returning to a previously defined level. It has been observed recently that macroeconomic variables –such as the rate of inflation– can have stationary or non-stationary characteristics within specific periods. Thus, some series can shift from $I(0)$ to $I(1)$ behaviors or vice versa. An important number of papers show that the current monetary regime has a significant impact on the properties of inflation persistence. This seems to have been the case for the inflation targeting scheme adopted by the monetary authority in Colombia.

4.2 Regime Switching Model (Markov-switching)

Given the stationarity of the annualized inflation series in the 1990-2010 period, this Section analyzes if the behavior of inflation during this period is regime-dependent. In particular, taking into account the adoption of an inflation targeting regime in Colombia in 1999 (Vargas, 2007), the possible existence of two regimes or natural states for inflation is studied.[42] The *current regime* could be characterized by a credible inflation target with expectations anchored to the targets, something which did not happen in the *previous regime*. The persistence index would therefore be expected to be lower in the *current regime*. The exercise uses the sum of autoregressive coefficients as an indicator of persistence.

Krolzig (1997) and Hamilton (1994) are followed in order to estimate the core inflation generation process in Colombia from 1990 to 2010 through a Markov regime switching model. It is found that the model shows inflation in Colombia as a process governed by two regimes or natural states, which switch among themselves according to a first order Markov process, i.e., the probability of being in a particular state or regime only depends on the state during the preceding period. The methodology explains inflation through an autoregressive scheme which allows parameters to change with the states.

The Markov-switching method employed asserts that all parameters depend on unobservable variable S_t, called state variable. This variable

central bank. For this reason the authors suggest analyzing statistical properties of the *spread* between inflation and the long term target.

[42] For details on the characteristics of monetary policy during the 1990s see Hernández and Tolosa (2001).

characterizes the state or regime during period t, and takes values 1, 2,..., K; K being the number of regimes included in the model. Each of the states describes a determined inflationary behavior. For instance, if $K = 2$, a state or regime will have a situation of low inflation and low volatility, while the other describes a situation of high inflation and high volatility. In this way the Markov-switching model employed allows each regime to be characterized by a determined average, variance and level of persistence.

The results of different statistical tests show that the specification best describing the process of changing inflation regimes in Colombia is that found in the MSIAH model.[43] This acronym is taken from Krolzig (1997) and means that both intercept (I), as well as autoregressive parameters (A) and the variance-covariance matrix (H) are regime dependent. Thus, it is considered that inflation follows a state-dependent autoregressive process in all the parameters included in equation (11).

(11) $$\pi_t = \mu_{S(t)} + \phi_{1_{S(t)}} \pi_{t-1} + \ldots + \phi_{p_{S(t)}} \pi_{t-p} + \varepsilon_t .$$

Where π_t is inflation and $S_t \in \{0,1\}$ is an unobserved discrete variable representing the state of the economy. The behavior of this variable defines regime 1 or *current* when $S_t = 0$ and regime 2 or *previous* when $S_t = 1$. The end of shock ε_t follows a normal distribution with state-dependent variance:

(12) $$\varepsilon_t \sim N\left(0, \sigma_{S_t}^2\right).$$

That is, variance depends on the natural state of the economy:

(13) $$\begin{gathered} \sigma_{S_t}^2 = \sigma_0^2\left(1 - S_t\right) + \sigma_1^2 S_t , \\ \sigma_0^2 > 0, \quad \sigma_1^2 > 0. \end{gathered}$$

Similar behavior is observed in the different autoregressive parameters of model:

(14) $$\varphi_{jS_t} = \varphi_{j0}\left(1 - S_t\right) + \varphi_{j1} S_t , \qquad j = 1, \ldots, p$$

Equations (15) and (16) show regime switch or state transition probabilities.

[43] Markov Switching Intercept Autoregressive Parameters Heteroscadasticity

(15) $$P\left[s_t = 0 \middle| s_{t-1} = 0\right] = p \quad P\left[s_t = 1 \middle| s_{t-1} = 1\right] = q$$

(16) $$P\left[s_t = 1 \middle| s_{t-1} = 0\right] = 1 - p \quad P\left[s_t = 0 \middle| s_{t-1} = 1\right] = 1 - q$$

Persistence will be determined by the sum of the autoregressive coefficients in each regime:

(17) $$\alpha_{S(t)} = \sum_{i=1}^{p} \phi_{i_{S(t)}}$$

Table 2 shows the results of MSIAH model estimates for total inflation in Colombia during the 1990m01-2010m06 period when considering two natural states. Regime 1, or *current*, corresponds to the period between 2000m02 and 2010m06 and is characterized by low and slightly volatile

TABLE 2. MSIAH ESTIMATE: INFLATION

Current Regime_1 $(S_t = 0)$

	Coefficient	*Standard*	*t statistics*
Constant	11.035	2.063	5.34
Infla_1	0.332	0.083	4.02
Infla_2	0.061	0.075	0.82
Infla_3	−0.126	0.072	−1.76
Infla_4	−0.040	0.069	−0.58
Trend	−0.038	0.008	−4.75

Standard error: 1.936
Confidence interval for the variance: $I = [3.46, 5.10]$
Sum of autoregressive coefficients: 0.2267

Previous Regime_2 $(S_t = 1)$

	Coefficient	*Standard*	*t statistics*
Constant	16.75	3.339	5.02
Infla_1	0.425	0.100	4.25
Infla_2	−0.056	0.111	−0.51
Infla_3	0.234	0.113	2.10
Infla_4	−0.267	0.103	−2.59
Trend	−0.059	0.012	−4.61

Standard error: 3.68
$\sigma^2_{Regime2} \notin I$
p-values
Difference of intercepts: 0.120
Difference of trend: 0.116
Difference of sum of coefficients: 0.552

inflation, while regime 2, or *previous*, comprising the period between 1990m01 and 2000m01 is characterized by high and very volatile inflation.

In order to verify the existence of statistical changes in the model's parameters for each regime, tests are made on the difference of: *i)* intercepts, *ii)* coefficients associated to the deterministic trend and *iii)* level of inflation persistence or sum of the model's autoregressive coefficients. At a level of 12% significance the tests indicate that each natural state presents statistically different trend intercepts and parameters. The results also show the *previous regime* exhibits higher volatility and that the variance associated to the *previous regime* does not belong to the variance interval estimated for the *current regime*.

However, no differences in persistence between the two states are found. The sum of autoregressive coefficients decreases from 0.336 in the previous regime (1990m01-2000m01) to 0.226 in the current regime (2000m02 and 2010m06), but this difference is not statistically significant, with a *p*-value of 0.552 for the difference.

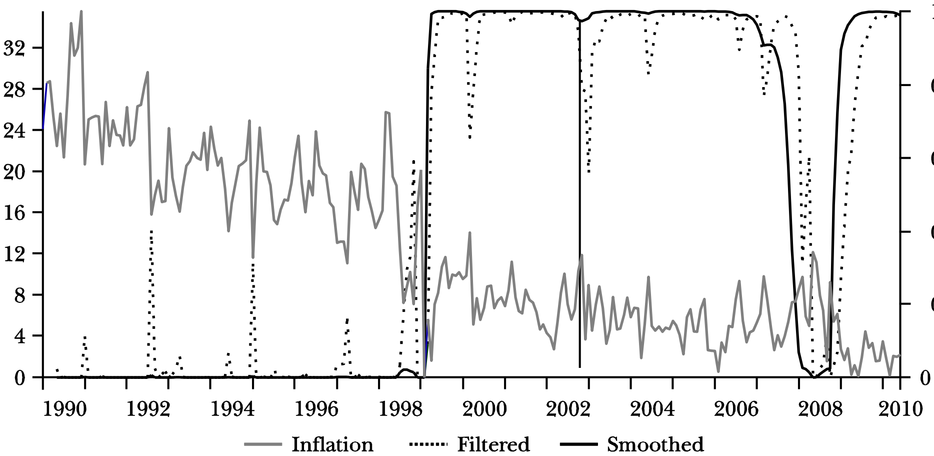
Finally, Table 3 shows the Markov transition matrix, illustrating that the two regimes are absorbent: after having entered a particular regime there is a very low probability of exiting it. In fact, the probability of remaining in the *previous regime* once already in it is 0.9824, and that of remaining in the *current regime* is 0.9905.

TABLE 3. TRANSITION MATRIX

	Current-regime 1	*Previous-regime 2*
Current-regime 1	0.9905	0.0095
Previous-regime 2	0.0176	0.9824

Nevertheless, the high probability of remaining in the current regime is no guarantee of not returning to the past. Figure 2 represents the probability that inflation during a determined period of time t is governed by the *current regime*. It can be seen that during the months from November 2007 to October 2008 inflation temporarily changed to the *previous regime*, characterized by high inflation and volatility. During said period Colombia's economy was affected by an international shock in the prices of foods and energy, which could have had serious consequences for inflation. Luckily, the response of the authorities and a new fall in international prices mitigated its impact and returned the economy to the regime of low inflation and volatility achieved since 2000.

FIGURE 2. PROBABILITY OF REGIME ONE, OR CURRENT, 1990-2010

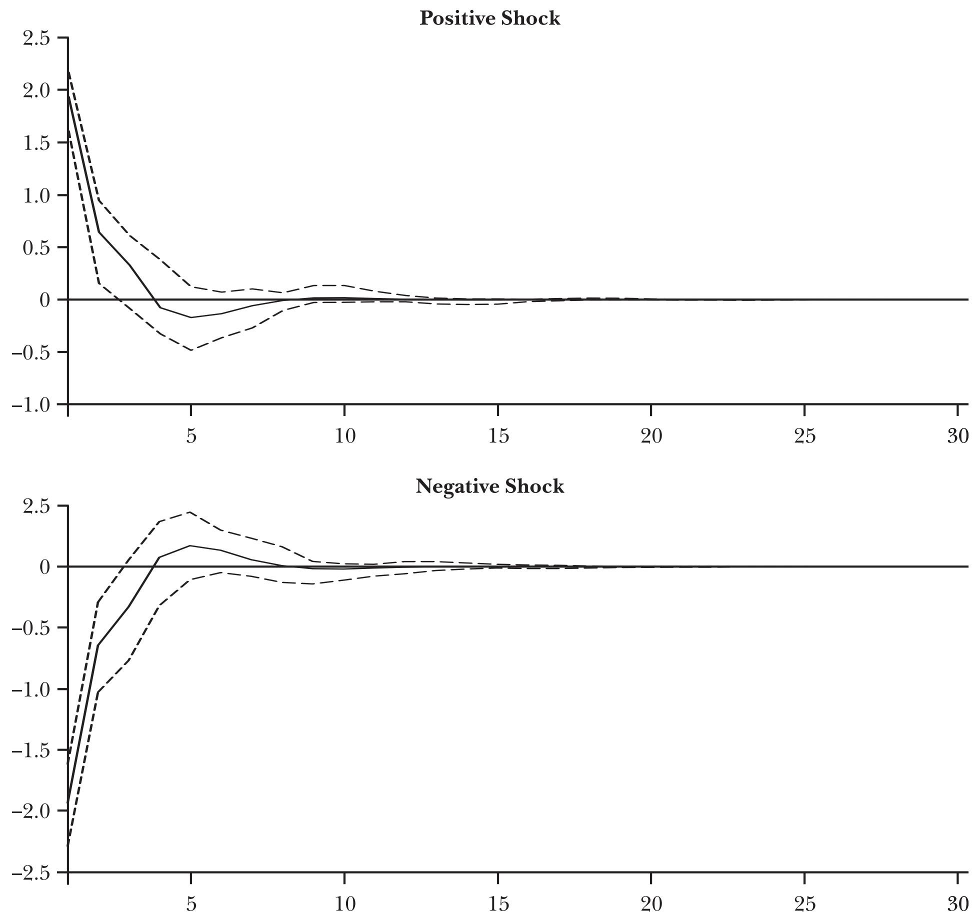


The functions shown in Figures 3 and 4 suggest that a positive shock on inflation dissipates in four months under the *current regime* and in five months under the *previous regime*. In other words, as mentioned above, when the sum of autoregressive coefficients is compared inflation persistence seems to have declined very slightly in Colombia during the last two decades. Furthermore, the non-asymmetrical behavior between states in the event of positive and negative shocks is due to the fact that the system in each regime is lineal and the transition matrix has an absorbent main diagonal.

Although inflation persistence has fallen only slightly during the last two decades (previous section), this could result from the fact that central bank inflation targets were highly persistent in both periods (lower part of Figure 1). For this reason, following, among others, Cogley, Primiceri and Sargent (2009), this Section analyzes persistence of the variable $\pi_t - \pi_t^*$ (instead of π_t), where π_t^* is the inflation target established by the central bank each year. The variable π_t^* also corresponds to the long-term trend when the central bank's targets are totally credible. As mentioned above, Stock and Watson (2006) propose an alternative strategy in which the long-term stochastic trend is estimated (and a stationary component), associating this trend with what agents estimate to be the implicit and explicit target of the central bank (see footnote 41).

A model allowing changes in persistence to be observed over time is employed as shown in equation (18).

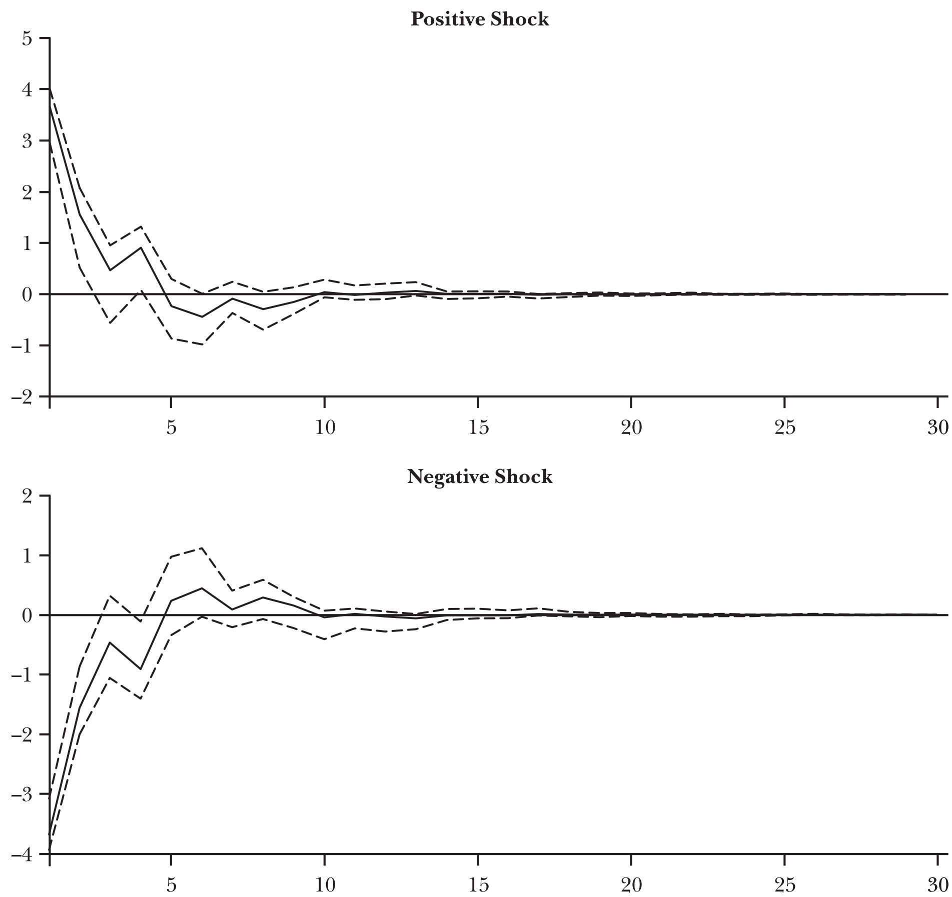
FIGURE 3. IMPULSE-RESPONSE ANALYSIS. TOTAL INFLATION. CURRENT REGIME



$$\pi_t = \pi_t^* + \rho_t \pi_t \left(\pi_{t-1} - \pi_{t-1}^*\right) + u_t + \sum_{i=1}^{11} \theta_i u_{t-1} \,, \qquad (18)$$

where ρ_t is the series persistence parameter changing over time and π_{t-1}^* is the inflation target from the preceding period. In this case annual inflation π_t is defined as $100^*\ln(P_t/P_{t-12})$, more comparable with the annual inflation target set by the central bank than the annualized monthly inflation employed in the previous exercises. However, the end of the Section presents some comments allowing persistence values in both exercises to be compared. Modeling through a first order autoregressive process in this case introduces an MA(11) structure in the disturbance term.

FIGURE 4. IMPULSE-RESPONSE ANALYSIS. ANNUALIZED TOTAL INFLATION. PREVIOUS REGIME



In addition, equation (19) shows the law of evolution for parameter ρ_t:

(19) $$\rho_t = \rho_{t-1} + w_t .$$

Equations (18) and (19) show a state-space representation formulated from measurement and transition equations (20) and (21):

(20) $$\pi_t = H_t'\xi_t + A_t ,$$

(21) $$\xi_t = F\xi_{t-1} + v_t .$$

With R and Q in (24) and (25) being the variance-covariance matrices of the measurement and transition equation, and ξ_0 the initial state vector, which must satisfy $E[v_t, \xi_0] = 0$.

Equations (20) and (21) correspond to the measurement and transition equations of the state-space representation in matrix form, and equations (22) and (23) to the corresponding variance-covariance matrices.

$$(22)\quad \pi_t = \begin{bmatrix} \pi_{t-1} & -\pi^*_{t-1} & 1 & \theta_1 & \theta_2 & \theta_3 & \theta_4 & \theta_5 & \theta_6 & \theta_7 & \theta_8 & \theta_9 & \theta_{10} & \theta_{11} \end{bmatrix} \begin{bmatrix} \rho_t \\ u_t \\ u_{t-1} \\ u_{t-2} \\ u_{t-3} \\ u_{t-5} \\ u_{t-6} \\ u_{t-7} \\ u_{t-8} \\ u_{t-9} \\ u_{t-10} \\ u_{t-11} \end{bmatrix} + \begin{bmatrix} \pi^*_t \end{bmatrix}$$

$$(23)\quad \begin{bmatrix} \rho_t \\ u_t \\ u_{t-1} \\ u_{t-2} \\ u_{t-3} \\ u_{t-4} \\ u_{t-5} \\ u_{t-6} \\ u_{t-7} \\ u_{t-8} \\ u_{t-9} \\ u_{t-10} \\ u_{t-11} \end{bmatrix} = \begin{bmatrix} 1 & 0 & \dots & & & & \dots & & & & \dots & & 0 \\ 0 & 0 & \dots & & & & \dots & & & & \dots & & 0 \\ 0 & 1 & 0 & & & & \dots & & & & \dots & & 0 \\ 0 & & 1 & 0 & & & & & & & \dots & & 0 \\ 0 & & 0 & 1 & 0 & & & & & & \dots & & 0 \\ 0 & & \dots & 0 & 1 & 0 & \dots & & & & \dots & & 0 \\ 0 & & \dots & & 0 & 1 & 0 & & & & \dots & & 0 \\ 0 & & \dots & & & 0 & 1 & 0 & & & \dots & & 0 \\ 0 & & \dots & & & & 0 & 1 & 0 & & \dots & & 0 \\ 0 & & \dots & & & & & 0 & 1 & 0 & \dots & & 0 \\ 0 & & \dots & & & & & & 0 & 1 & 0 & & 0 \\ 0 & & \dots & & & & & & & 0 & 1 & 0 & 0 \\ 0 & & \dots & & & & \dots & & & & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \rho_{t-1} \\ u_{t-1} \\ u_{t-2} \\ u_{t-3} \\ u_{t-4} \\ u_{t-5} \\ u_{t-6} \\ u_{t-7} \\ u_{t-8} \\ u_{t-9} \\ u_{t-10} \\ u_{t-11} \\ u_{t-12} \end{bmatrix} + \begin{bmatrix} \eta_\rho \\ u_t \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$(24)\qquad R = 0$$

$$Q=\begin{bmatrix} \sigma_w^2 & 0 & & \cdots & 0 \\ 0 & \sigma_u^2 & 0 & & 0 \\ & 0 & 0 & & 0 \\ \vdots & & 0 & 0 & 0 \\ & & & 0 & 0 \\ 0 & 0 & & 0 & 0 \end{bmatrix}_{13\times 13} \tag{25}$$

The estimation process is carried out through the work of both an optimization algorithm and a Kalman filter on the previously shown representation, a procedure which enables estimation of unobserved variables and parameters such as coefficient ρ_t (persistence). Table 4 shows the results of state-space representation estimates for equations (22) and (23).

The results can be seen in Figure 5.[44] Parameter ρ_t increased in the 1992-1995 period, rising from levels below 0.72 to values above one by the end of the period, and remaining stable at *high* levels between 1999 and 2007 (0.88 on average). After a sharp but short lasting fall during some months of 2008, it increased in the second half of the year to its highest level for the period as a whole. The increase observed at the end of the exercise corresponds to the increase in inflation which took place during the referred period as a consequence of the supply shock caused by increases in international prices of foodstuffs.

The results are consistent with those in the preceding section, in that the value of ρ_t does not seem to have fallen significantly with the adoption of an inflation targeting regime. On the other hand, they tended to increase worryingly during all of 2009 and part of 2010. Although our exercise ends in March 2010, a preliminary study with new information seems to suggest that persistence has again declined to past levels, partly because the authorities responded to the external shocks by considerably raising their reference interest rates and because the international shock weakened during the remainder of the year. Inflation reached surprisingly low levels for the rest of 2010 and might end the year at below 2.7%.

Values of *persistence* ρ_t obtained in this Section for $\pi_t - \pi_t^*$ are not directly comparable with those in the preceding Section, partly because different inflation series are employed. This Section uses the series $100^*\ln(P_t/P_{t-12})$ which allows a direct comparison with the central bank's

[44] It is important to point out that the path of persistence is strong in initial parameter values and the state vector.

annual inflation targets, while the preceding Section employs the series 1,200*ln(P_t/P_{t-1}) (see footnote 38).

Nevertheless, as would be expected, and as Robalo Marques (2004) suggests, the persistence obtained when medium-term inflation is *discounted* (this Section) should be much lower than when it is not *discounted* (preceding Section).[45] This also occurs in our case if it is taken into account that series 1,200*ln(P_t/P_{t-1}) can be expressed as: $\pi_t = \ln(p_t/p_{t-1}) + \ln(p_{t-1}/p_{t-2}) + \ldots + \ln(p_{t-11}/p_{t-12}) = \pi_t^{month} + \pi_{t-1}^{month} + \ldots + \pi_{t-11}^{month}$. For this reason the original model can be written as:

$$(26)\quad \pi_t^{month} = \left(\pi_t^* - \rho\pi_{t-1}^*\right) + (\rho_t - 1)\pi_{t-1}^{month} + (\rho_t - 1)\pi_{t-2}^{month} + \ldots + (\rho_t - 1)\pi_{t-11}^{month} + (\rho_t - 1)\pi_{t-12}^{month} + u_t$$

Equation (26) corresponds to an AR(12) with trend given by $\pi_t^* - \rho_t\pi_{t-1}^*$, with stationary component $\rho_t\pi_{t-12}^{month}$, and persistence $(\rho_t - 1)\pi_{t-j}^{month}$. The sum of coefficients will therefore be $13\rho_t - 12$, whose minimum occurs when $\rho = 0.92$, a value relatively close to those shown in Figure 5.

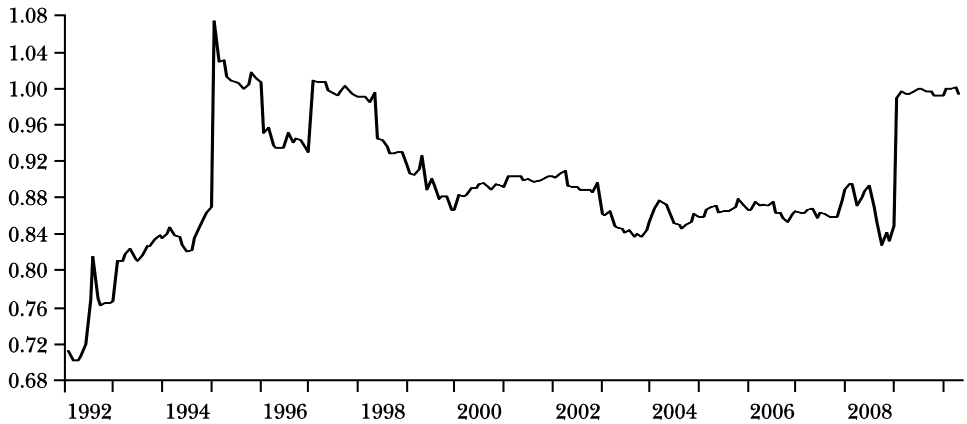
TABLE 4. STATE-SPACE REPRESENTATION ESTIMATE

Optimization Process Results		
Parameter	*Estimate*	*Gradient function*
θ_1	0.7367	0.00128
θ_2	0.6311	−0.00016
θ_3	0.7135	−0.00061
θ_4	0.5445	−0.00134
θ_5	0.4131	−0.00087
θ_6	0.5095	0.000009
θ_7	0.5214	−0.00017
θ_8	0.5621	0.00077
θ_9	0.7133	−0.00041
θ_{10}	0.6786	0.00034
θ_{11}	0.5465	0.00076
θ_u^2	0.00020	0.00164
θ_w^2	0.1548	−0.00064

Objective function value: −429.67

[45] Special thanks to Luis Eduardo Rojas for his suggestions regarding this exercise.

FIGURE 5. PERSISTENCE EVOLUTION, 1992-2008



5. POLICY IMPLICATIONS AND CONCLUSIONS

Reduced or statistical measurement of persistence is an essential step for understanding the *structural* factors governing it. One of this paper's first findings is that the annual inflation series is stationary around a deterministic trend during the period from January 1990 to June 2010. This implies that the shocks to inflation dissipated over time.

Second, employing a Markov-switching method for an autoregressive process finds two natural states. Inflation was high and very volatile in the 1990m01-2000m01 period (*previous state*), while inflation was low and less volatile during the 2000m01-2010m06 period (*current state*). This suggests that the inflation targeting scheme adopted at the end of the 1990s had an impact on some of the characteristics of inflation.

Nevertheless, there is no statistically significant reduction in persistence. Although the sum of autoregressive coefficients declined from 0.336 during the *previous regime* to 0.226 in the *current regime*, such difference is not statistically significant. In the same way, impulse-response functions for each period show that the positive shock disappears in five months during the *previous regime* and in four months in the *current regime*, while the negative shock disappears in one month in both regimes.

Third, there is little room for complacency among economic authorities given the return of inflation persistence from 2007-2008 during the *previous regime* characterized by high and volatile inflation. Fortunately, international prices of foods declined rapidly and the authorities reacted quickly and strongly.

Fourth, and in line with previous results, no significant decline in persistence is seen since 1999 when working with the spread between observed inflation and the target.

A large amount of recent research on inflation persistence has been focused on the relation between *statistical persistence* and *structural persistence*, which suggests a long-term research program for Colombia. Inflation persistence is closely related to parameters τ_π in the Taylor rule, σ_r in the IS and ϕ_x in the Phillips curve, but above all to the existence (or not) of lagged inflation π_{t-1} in the Phillips curve. This has perhaps been the central debate in macroeconomics for the last 30 years and it continues to be so.

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Is Inflation Persistence Over?

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1. INTRODUCTION

One of the most important characteristics of the dynamics of inflation is its degree of persistence. It is related to how quickly inflation reverts to its initial level after a shock. As Mishkin (2007) points out, if inflation is persistent, it increases the costs of monetary policy (in terms of product or unemployment) to keep inflation under control.[1]

In the last years, both industrial and emerging economies have experienced important changes in the degree of their inflationary persistence. As Cechetti et al. show (2007) both the volatility and level of inflation has decreased in industrial economies. In these economies the decades of 1960 and 1970 were considered periods of high and persistent inflation, while the more recent decades, 1990 and 2000, have low levels of inflation as well as low persistence.

Contrary to industrial countries, emerging economies have experienced high levels of inflations for a longer period. Some of these countries, such as Brazil, Argentina, Bolivia, Peru, Mexico, Israel, Poland and Turkey, have had periods of *hyperinflation* in the last thirty years.[2] Only recently, in the decade of 1990, the levels of inflation have started to decrease in these countries. This, in part, is due to the important changes in

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[1] In a more formal way, we can define inflation persistence as the propensity of inflation to converge slowly towards its long run equilibrium following a shock that has taken inflation away from this equilibrium.

[2] Sometimes is hard to define if an inflationary process experienced by a country is a *hyperinflation* episode. That is why we have decided to use it in italics.

the conduct of their macroeconomic policies.[3] However, it is not clear if the decrease of the level of inflation has been accompanied by a reduction of their inflationary persistence.[4]

Our objective in this paper is to analyze empirically the inflation persistence of several industrial and emerging countries in the recent past. We selected a very representative group of 23 industrial and 17 emerging economies. We want to answer the following questions: Is inflation persistence low for both industrial and emerging economies? Has persistence been stable throughout our sample period for all countries? Is inflation persistence in countries that have experienced *hyperinflation* in the recent past higher[5] than the ones observed in the other countries?

Our results show that inflation persistence is low and has been stable for both industrial and emerging economies in general. We observe that persistence seems to be lower in industrial economies relative to emerging ones. We also show that even economies that had experience *hyperinflation* in the near past have low inflation persistence nowadays, albeit apparently higher than the ones observed in the other countries of our sample. One explanation for this is that inflationary memory can be still alive among the economic agents.

To obtain our results we estimate several reduced form inflation dynamics. We estimate the following types of models: models with lags of inflation with and without GDP gap; new Keynesian Phillips curves with foreign exchange rates; and models that are reduced-form inflation dynamics of structural models that incorporate some form of wage rigidity

[3] As examples of some macroeconomic policies we can list: inflation targeting adoption, reduction of budget deficits, improvement of financial regulation, trade liberalization and flexible exchange rate policies among others.

[4] See Stock and Watson (2003) for a brief analysis of monetary policy in some industrial countries in the last years.

[5] Our sample of emerging economies is Argentina, Brazil, Bolivia, Chile, Colombia, Czech Republic, Hungary, Israel, Korea, Mexico, Peru, Philippines, Poland, South Africa, Slovak Republic, Thailand, and Turkey. Our sample of industrial countries is: Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States. Various factors can explain persistence: persistence may be inherited from persistent fluctuations in the determinants of inflation, like marginal cost or output gap (this is called extrinsic persistence); the dependence of inflation on its own past, also called intrinsic persistence and persistence due to the formation of inflation expectations. Each one of this persistence can be associated with one of the three terms of a new Keynesian Phillips curve.

in the spirit of Blanchard and Galí (2005). Our sample period starts in the first quarter of 1995. We have quarterly data and use headline consumer inflation as our[6] measure of inflation.

This finding of a low and stable persistence parameter for a great number of different countries may be somewhat surprising considering the obvious relevance of Lucas (1976) critique for our exercise. However, it is consistent with recent evidence for the United States as Rudebusch (2005) shows. Rudebusch estimates a new Keynesian Phillips curve to show that the parameters of reduced form regression will tend to be relatively stable even in the presence of realistic changes in monetary policy rules.

For many of the countries we considered, substantial shifts in monetary policy have occurred over the past two decades. In the case of European countries the introduction of the euro is a very important milestone. In the case of emerging economies, we can cite more sound macroeconomic policies including, for many of them, the choice of inflation targeting as a framework for monetary policies. Therefore, one of our key approaches was to allow for the possibility of structural breaks in the inflation dynamics in order to avoid spurious estimates of degree of persistence.

We observe that there is very little instability in the parameters of inflation persistence for most of the economies we study. We did several tests of stability and also recursive least squares estimation. Our full sample estimation of the persistence parameter is in general far away from 1 and stable as the results from unknown break points are consistent with the null hypothesis of no change over time in the persistence of inflation. Overall, our results are in accordance with a stable reduced-form representation for inflation and a low level of inflation persistence.

Our results are consistent with a vast literature that shows that inflation persistence has decreased, such as: Dossche and Everaert (2005), Taylor (1999), Altissimo et al. (2006), Benati (2008) and Batini (2002). Our paper, however, contributes to the literature by looking at a greater and more diversified group of countries, including several emerging ones, by

[6] Various factors can explain persistence: persistence may be inherited from persistent fluctuations in the determinants of inflation, like marginal cost or output gap (this is called extrinsic persistence); the dependence of inflation on its own past, also called intrinsic persistence and persistence due to the formation of inflation expectations. Each one of this persistence can be associated with one of the three terms of a new Keynesian Phillips curve.

considering a more recent period and by estimating various inflation dynamics specifications.

Other papers look at how inflation persistence has evolved over a longer period of time also estimating reduced form inflation processes. For example, Mishkin (2007) studies inflation persistence in the United States in the last 40 years using autoregressive models and decomposing inflation in cycle and trend as in Stock and Watson (2006). Mishkin confirms the results of Stock and Watson (2006), showing that inflation persistence is decreasing worldwide since the 1990s, compared with persistence[7] observed in the 1960s and 1970s.

Nason (2006) describes the dynamics of inflation in the United States with several different models of inflation and confirms the results of Mishkin (2007) and Stock and Watson (2006) that inflation persistence is decreasing in the United States in the last years. Rudd and Whelan (2005) estimate a new Keynesian hybrid Phillips curve with lags in inflation and show that inflation in the United States is much more forward looking than backward looking, that shows that inflation persistence is decreasing. Fuhrer (2005) also models inflation using a hybrid Keynesian Phillips curve. He separates persistence in two types: one related to the dynamics of the output gap and the other to marginal cost and that depends on lags of inflation. Fuhrer shows that the more relevant part of inflation in the last years is due to intrinsic inflation and not to output gap.

An important explanatory factor behind this low level and stability of inflation persistence in the recent past is the anchoring of inflation expectations of economic agents. By conducting monetary policies such that inflation expectations of economic agents are anchored, the central banks can ensure that actual inflation does not deviate for too long and in a very persistent way from its medium term objective. We believe that long-term inflation expectations have been successively anchored in the recent years and, as a result, inflation expectations are much less dependent on past inflation. Also, actual inflation developments are less persistent.

The rest of the paper is the following. Section 2 describes the data. Section 3 presents the empirical analysis. Section 4 concludes.

[7] Stock and Watson (2006) show the inflation dynamic in the United States is well described by several latent factors, such as cycle and trend, both with stochastic volatility. Cycle is a stationary process while trend in non-stationary. Inflation persistence is described as a trend. The authors show that persistence in inflation has decrease substantially in the United States in the last decade.

2. DATA

Our data is quarterly and starts in the first quarter of 1995. It is composed by 40 countries: 23 industrial and 17 emerging. Our data source was International Financial Statistics from International Monetary Fund. Our measure of inflation is headline CPI inflation. We also use as exogenous the following variables: the nominal foreign exchange rate and the GDP gap, that is the difference between nominal GDP and potential GDP obtained through Hodrick-Prescott filtering.

For the purpose of our analysis, we separate our sample of countries in three groups: one group is comprised of industrial countries (Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States), emerging countries that did not experienced *hyperinflation* in the recent past (Chile, Colombia, Czech Republic, Hungary, Korea, Philippines, South Africa, Slovak Republic and Thailand), and emerging economies that have had *hyperinflation*, such as Argentina, Brazil, Bolivia, Peru, Mexico, Turkey, Israel and Poland.

Table 1 shows descriptive statistics of inflation for our economies: emerging (total), emerging with *hyperinflation* experience and industrial economies. We can see that average quarterly inflation in emerging market (EM) economies was 1.84% and average standard deviation was 0.018. As far as GDP gap is concerned, average GDP gap is 0.14 per cent.

TABLE 1. DESCRIPTIVE STATISTICS – INFLATION AND OUTPUT GAP (in percentages)

	Emerging Market Countries		*Non - Emerging Market Countries*
	Total	*"Hyperinflation" Experience*	*Total*
Average inflation	1.84	2.32	0.54
Average standard deviation	0.018	0.022	0.006
Maximum inflation	19.43	19.43	5.55
Minimum inflation	−4.10	−1.42	−3.99
Average output gap	−0.14	−0.30	−0.01

SOURCE: IMF.

Table 1 column 2 shows descriptive statistics of inflation for the group of emerging economies that has had some *hyperinflation* episode in the last thirty years. We can see that average inflation was 2.32% and average standard deviation was 0.022. Average output gap was −0.30% in this subgroup. Column 3 shows us that in non-emerging countries of our sample, average inflation was only 0.54%. Average output gap, in other hand, was greater: –0.01%.

It is clear from Table 1 that inflation is higher in emerging economies that have had *hyperinflation* in the recent past. The average inflation in these economies was one percentual point higher than average inflation in the emerging economies that did not experience *hyperinflation* and 1.78 percentual points higher than industrial economies that also did not experience *hyperinflation.* Not only average, but also volatility is much higher than non-emerging countries and also non-hyperinflation ones.

In the next section, we will present our empirical analysis based on the estimation of reduced form inflation dynamics for these groups of countries.

3. EMPIRICAL ANALYSIS

3.1 Traditional Models of Inflation

The overall degree of inflation persistence can be measured in several ways. The results reported in this section are based on the methods that are most frequently used in the literature. In order to show how fast inflation returns back to its mean following a disturbance, or its persistence, we measure the dependence of inflation on its past values.

The most obvious way of measuring inflation persistence is to regress inflation on several of its lags as in equation (1) and then calculate the sum of coefficients on lagged inflation. If the sum of coefficients is close to one, then shocks to inflation have long lived effects on inflation. The higher the sum of the coefficients of inflation lags, the longer it takes for inflation to return back to its mean. In other words, inflation behaves like a random walk so that when inflation goes up it stays up. If the sum of coefficients is well below 1 then a shock to inflation has only temporary effect on inflation and inflation soon reverts to its trend level.

$$\pi_t = \beta_0 + \beta_1 \pi_{t-1} + \sum_{k=2}^{L} \phi_k \pi_{t-k} + \varepsilon_t, \; E[\varepsilon_t] = 0 \;\; \mathrm{var}(\varepsilon_t) = \sigma_\varepsilon^2, \tag{1}$$

where π_t is headline consumer inflation.

To the extent that lagged inflation captures true persistence in the price setting process the model implies that rapid reductions of inflation can only be produced at the cost of substantial increase in unemployment or decrease in product. Hence, the model points to a gradualist approach as providing the best way to effect a large reduction in inflation.

An equivalent approach for analyzing persistence (and the one we will follow in this paper) is to estimate ρ in equation (2) as O'Reilly and Whelan (2005) show.

$$\pi_t = \beta_0 + \rho\pi_{t-1} + \sum_{k=2}^{L}\phi_k \Delta\pi_{t-k} + \varepsilon_t,\ E[\varepsilon_t] = 0\ \operatorname{var}(\varepsilon_t) = \sigma_\varepsilon^2. \tag{2}$$

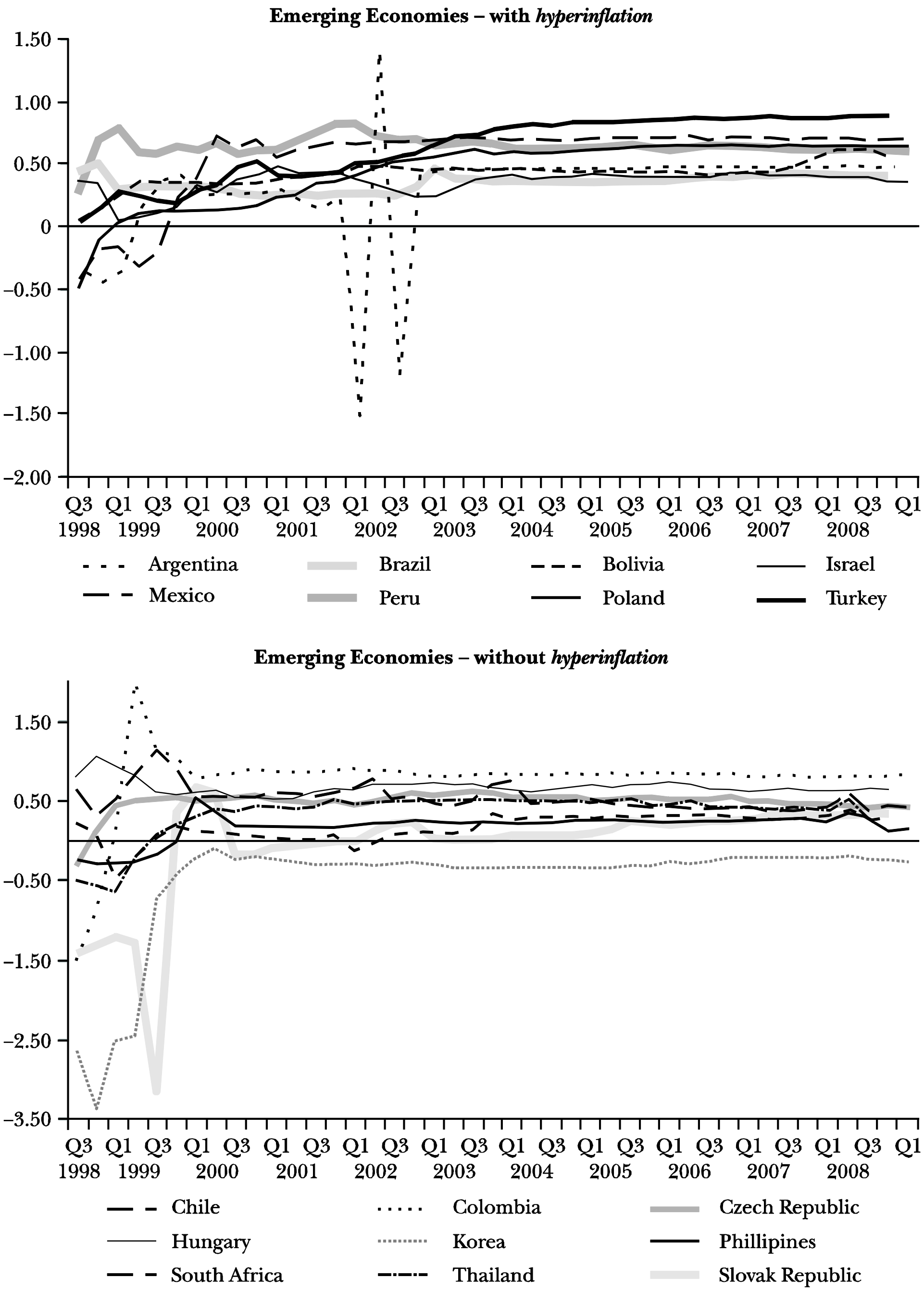
There are a number of good reasons for focusing on ρ as our main measure of inflation persistence. For example, in this model, ρ is a crucial determinant of the response to shocks over time. It can also be shown that $1/(1 - \rho)$ gives the infinite-horizon cumulative impulse response to shocks. Moreover, an advantage of focusing on the estimate of ρ rather than on sum of coefficients is that the first one remains pertinent even when the underlying process contains a unit root or is explosive.

We chose the number of lags of first difference of headline consumer inflation in (2) so as the residuals do not present serial correlation, using Lagrange Multiplier (LM) test to identify serial correlation. We also checked for heteroskedasticity with White and Breush-Pagan. If there is evidence of heteroskedasticity, we correct it with the Newey-West robust errors. We did a Wald test of $\rho = 1$ for all estimations of the traditional models and we rejected $\rho = 1$ for all estimations. We also compared the average of the persistence coefficient of inflation of the three groups by doing Wald tests in a system of equations estimated with ordinary least squares (OLS) in which each equation is the same one we estimated individually.

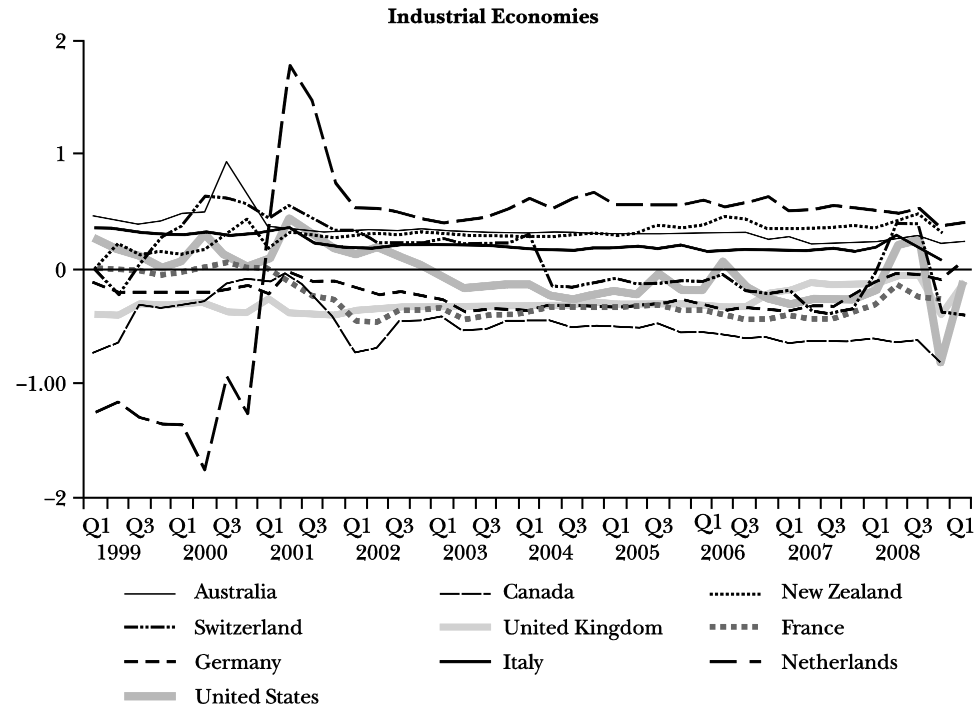
It is also crucial from an econometric point of view to allow for structural breaks in the dynamics of inflation. Otherwise, we could be estimating biased and inconsistent coefficients. We test for breaks using different methods, such as Andrews-Quandt and Chow. We found indication of structural breaks for some countries: Argentina, Austria, Greece and Poland. We then choose some possible breakpoints with the Chow test. We changed the specification including dummies as regressors or interacting them with the lag of inflation regressors. Our results did not change with these new specifications.

In figure 1, we show the recursive least squares estimations for the inflation persistence coefficient (ρ) in (2): emerging countries that have had high inflation episodes and those that had not and 10 (from 23) industrial countries. Inflation persistence for all countries seems to be stable, especially after 2003. Emerging countries appear to have inflation persistence

FIGURE 1. STABILITY OF PERSISTENCE PARAMETERS MODELING INFLATION AS AN ARMA



PROCESS, 1998-2009



that fluctuates around 0.5 while industrial countries persistence appears to fluctuate around zero.

Table 2 (column 1) shows the estimated ρ for this specification. The average persistence coefficient was 0.15, and Turkey has the largest one: 0.879. Emerging market economies seem to have, on average, greater coefficients: 0.45 compared to 0.07 of the industrial economies. Also, *hyperinflation* EM countries seem to have even larger persistence. Considering only these countries increases persistence coefficient to 0.59. The average persistence of EM economies that do not experience hyperinflation also seems to be greater than industrial countries (0.33 compared to 0.07).[8]

We repeated the estimation above including in equation (2) the output gap calculated using Hodrick-Prescot filter.[9] The results are very similar

[8] We compared the average of persistence coefficient of the three groups by doing Wald tests in a system of equations estimated with OLS in which each equation is the same one we estimated individually.

[9] Again, we tested for serial correlation, heteroskedasticity, structural breaks and

to the ones described above (see Table 2 column 2). Again, economies that had *hyperinflation* episodes in the recent past showed greater average as well as greater volatility of inflation persistence.

If inflation has indeed become less persistent because monetary policy has anchored inflation expectations more solidly the monetary authorities may find they have less need to induce large swings in economic activity to control inflation. This is a key benefit of establishing a strong nominal anchor. If this is correct, cyclical movements in interest rates need not be as great as it was necessary when expectations are anchored. To try the capture this possibility we will estimate in the following section new Keynesian models of inflation that incorporate inflation expectations.

3.2 New Keynesian Models Estimation

The most important implication of the pure new Keynesian model of inflation is that there is no intrinsic persistence in inflation in the sense that there is no structural dependence of inflation on its own lagged values. Instead, inflation is determined in a completely forward-looking manner. One implication of this model in contrast to traditional ones is that it is much easier to quickly reduce inflation in this model than in the traditional one. In fact, according to the new Keynesian model, inflation can be costless controlled by a credible commitment to keep output close to its potential.

It has been shown that in economies where central banks have adopted explicit inflation objectives, long-term inflation expectations are not related to past inflation. In this context, central bank transparency is crucial. In such a setting, agents will try to disentangle persistent shifts in inflation objective from transitory disturbances and will manage to do so more quickly the more transparent and credible the central bank is.[10]

Due to the difficulty of fitting the data with new Keynesian pure forward-looking model, a vast literature that incorporates lags of inflation in

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compared the statistical differences of averages of the inflation persistence coefficient of different groups. We did once more a Wald test of $\rho = 1$ for all estimations of the traditional models with GDP gap. We rejected $\rho = 1$ for all estimations.

[10] The most popular formulation of the new Keynesian framework is based on Calvo (1983) model of price random adjustment. The model assumes that in each period a random fraction of firms reset their price while all other firms keep their prices unchanged. Calvo assumes an imperfectly competitive market structure as well. These two hypotheses generate the basic new Keynesian model of inflation.

TABLE 2. ESTIMATED INFLATION PERSISTENCE PARAMETERS

	Ecuation (2)	*Ecuation (2)*	*Ecuation (3)*	*Ecuation (4)*	*Ecuation (5)*
	AR(ρ)	*Including output gap*	*NKPC*	*NKPC including output gap (–1)*	*Galí and Gertler with unemploy-ment*
Argentina	0.479	0.428	0.296	0.412	0.539
Austria	0.123	–0.149	–0.018	0.146	–0.102
Australia	0.250	0.282	0.018	0.125	0.065
Belgium	–0.265	–0.397	0.198	–0.051	0.118
Bolivia	0.581	0.596	–0.026	0.070	–
Brazil	0.416	0.426	0.441	0.509	0.503
Canada	–0.805	–0.883	0.021	0.067	0.157
Chile	0.435	0.288	0.073	0.101	–
Colombia	0.825	0.782	0.408	0.481	0.445
Czech Republic	0.404	0.508	–0.079	–0.221	0.124
Denmark	–0.199	–0.184	0.147	0.140	0.229
Finland	–0.038	–0.095	–0.126	0.600	0.050
France	–0.250	–0.357	0.147	–0.150	0.317
Germany	0.068	–0.057	–0.188	0.148	0.036
Greece	0.393	–1.431	–	–	–
Hungary	0.657	0.656	0.641	0.596	0.714
Iceland	0.577	0.568	–0.387	–0.270	–
Ireland	0.297	0.141	–	–	0.601
Israel	0.366	0.381	0.158	–0.071	–
Italy	0.095	–0.046	0.481	0.399	–
Japan	–0.343	–0.473	0.370	0.292	0.323
Korea	–0.284	–0.416	–1.008	–0.464	–0.641
Luxembourg	0.177	0.068	–0.049	0.406	0.036
Mexico	0.404	0.783	0.534	0.455	–
Netherlands	0.409	–0.082	–0.523	1.124	–0.739
Norway	–0.504	–0.599	0.173	0.119	0.187
New Zealand	0.319	0.123	0.260	0.347	0.263
Peru	0.601	0.617	0.229	0.245	–
Phillipines	0.136	0.183	0.158	0.138	–
Poland	0.661	0.659	0.616	0.591	0.547
Portugal	–0.340	–0.101	–1.058	–0.397	–
South Africa	0.290	–0.071	–0.099	–0.134	0.397
Slovak Republic	0.347	0.007	–0.127	–0.116	–0.180
Spain	–0.385	–0.394	–0.906	0.103	2.921
Sweden	0.115	–0.040	0.045	0.112	–0.304
Switzerland	–0.383	–0.436	–0.934	–0.834	–0.396
Thailand	0.134	–0.263	0.316	0.312	0.350
Turkey	0.879	0.864	–0.177	0.100	0.224
United Kingdom	–0.110	–0.250	0.170	0.224	0.437
United States	–0.817	–1.337	0.166	0.154	0.172

the new Keynesian Phillips curve (NKPC) has emerged.[11] For many, this class of models represents a sort of common-sense middle ground that preserves the insights of standard rational expectations models while allowing for better empirical fit by dealing directly with a well known deficiency of the pure forward looking model of inflation. As a result this class of models has been widely used in applied monetary policy analysis.

The structural equation for inflation that we estimate is in the spirit of hybrid new Keynesian Phillips curve as in (3). These models add a dependence of inflation on its lagged values to otherwise purely forward looking models. Such models are often considered as a compromise between the need for rigorous micro foundations of the sort underlying the pure new-Keynesian Phillips curve and the need to fit the data empirically.

$$(3) \qquad \pi_t = \rho\pi_{t-1} + (1-\rho)E_t\left[\pi_{t+1}\right] + \beta_2 h_{t-1} + \gamma X_{t-1} + \varepsilon_t,\ E\left[\varepsilon_t\right] = 0\ \operatorname{var}\left(\varepsilon_t\right) = \sigma_\varepsilon^2,$$

where h_t is output gap and X_t is foreign exchange rate.

The parameter that measures inflation persistence is ρ. We estimated equation (3) above, using lags of consumer headline inflation as instruments. We also checked for serial correlation with LM test and for heteroskedasticity with White test. In the presence of serial correlation, we included more lags of regressors, until there is no more evidence of serial correlation. In the presence of heteroskedasticity, we corrected with Newey-West robust matrix. We, again, compared the statistical differences of averages of the inflation persistence coefficient of different groups.

Table 2 column 3 shows the estimated ρ. The average persistence estimator was 0.009, and the standard deviation was 0.43. The country with the highest average was Hungary while the one with the lowest was Portugal. Considering our three groups, emerging economies that did not experience *hyperinflation* had an average persistence estimator of 0.03. Within the industrial economies group, the average coefficient was –0.095. The country with the highest persistence was Italy.

Considering countries that experienced *hyperinflation*, the highest persistence was from Poland (0.62) while the one with the lowest was Turkey (–0.18). The average of this group was 0.26.

In figure 2, we show the recursive least squares estimations for the inflation persistence coefficient (ρ) in NKPC. Again, emerging market economies

[11] See Fuhrer and Moore (1995), Galí and Gertler (1999) and Christiano et al. (2005) for some theoretical models that justify the inclusion of lags of inflation in the new Keynesian Phillips curves.

appear to have higher levels of persistence. And countries that had a *hyperinflation* history have an even higher persistence level.

As we can see these results do not differ from the estimation of the more traditional models presented in section 3.1. Once again, higher inflation in the past implies higher persistence of inflation in the present.

In the next section, we will include wage rigidity in the new Keynesian framework in line with Blanchard and Galí (2005). The objective is to see if there is a change in estimated persistence due to these rigidities.

3.3 New Keynesian Models Estimation with Wage Rigidities

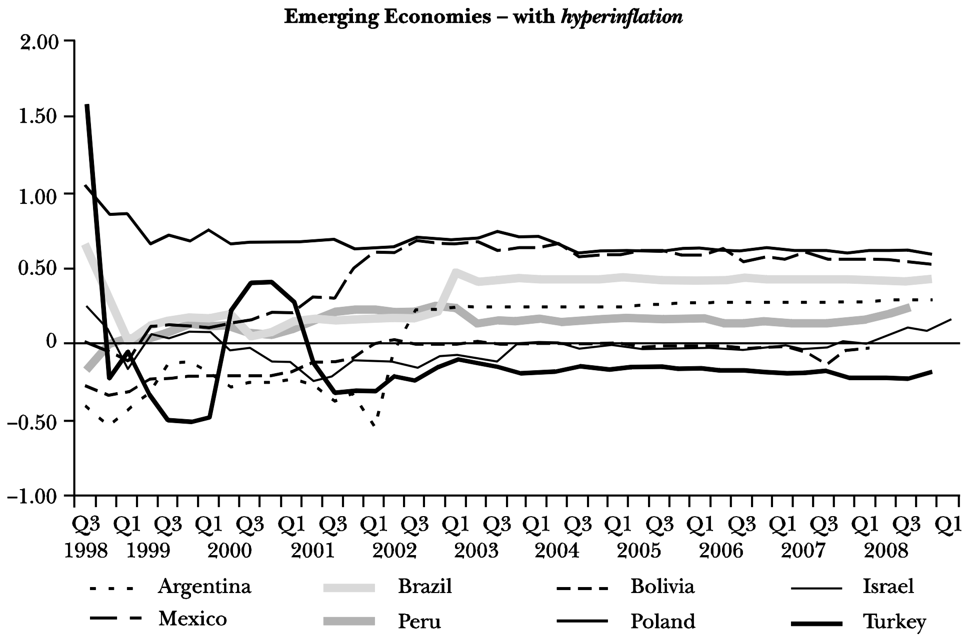
Blanchard and Galí (2005) incorporate wage rigidities in the structural model of inflation. The reduced form equation that results from their structural model is equation (4) below. Note that this equation is very similar to the hybrid new Keynesian Phillips curves specification used in many empirical and policy analysis applications and that allows for both backward looking and forward looking inflation terms (with coefficients whose sum is close to one). In our model the relative weight of lagged inflation is tightly linked to the degree of real wage rigidities. The novelty is the inclusion of the first difference of lagged output gap. This is the result of wage rigidity and makes the divine coincidence –where the central bank stabilizing inflation also stabilizes the welfare relevant gap– not possible anymore. The ρ coefficient continues to measure inflation persistence. Galí and Blanchard show that this coefficient is an increasing function of wage rigidity.

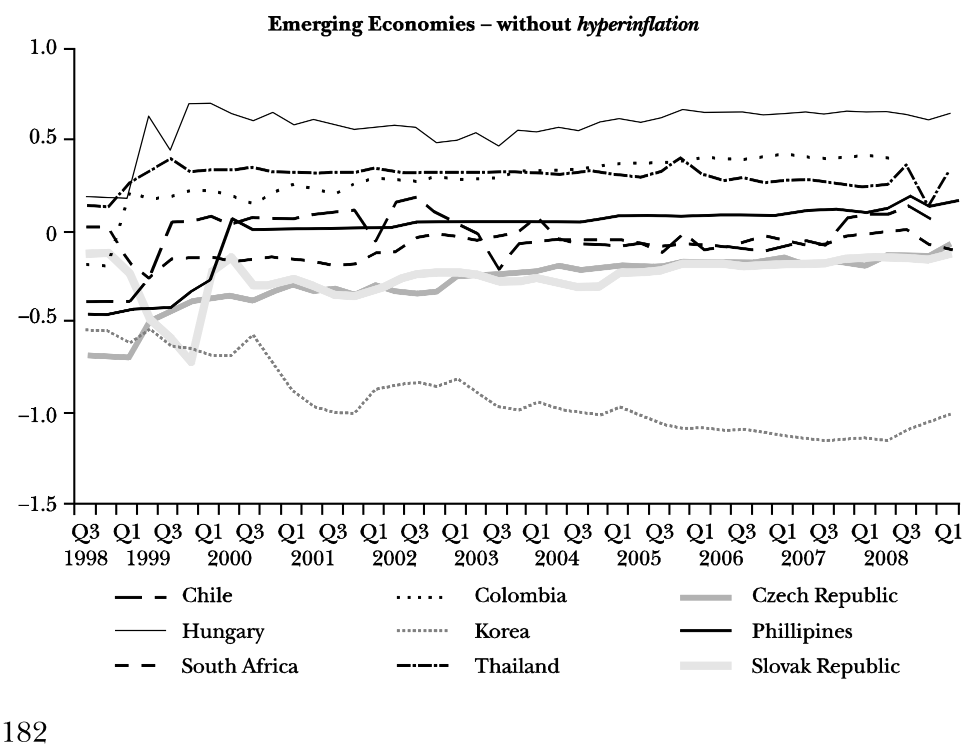
$$(4) \qquad \pi_t = \rho\pi_{t-1} + (1-\rho)E_t[\pi_{t+1}] + \beta_1 h_{t-1} + \beta_2 \Delta h_{t-1} + \varepsilon_t, \ E[\varepsilon_t] = 0 \ \text{var}(\varepsilon_t) = \sigma_\varepsilon^2.$$

Table 2 (column 4) shows the estimated ρ for this specification. The average persistence coefficient was 0.16 and Netherlands has the highest one: 1.124. Emerging market economies that experienced *hyperinflation* in the recent past seem to have greater coefficients on average: 0.289 compared to 0.134 of the industrial economies.

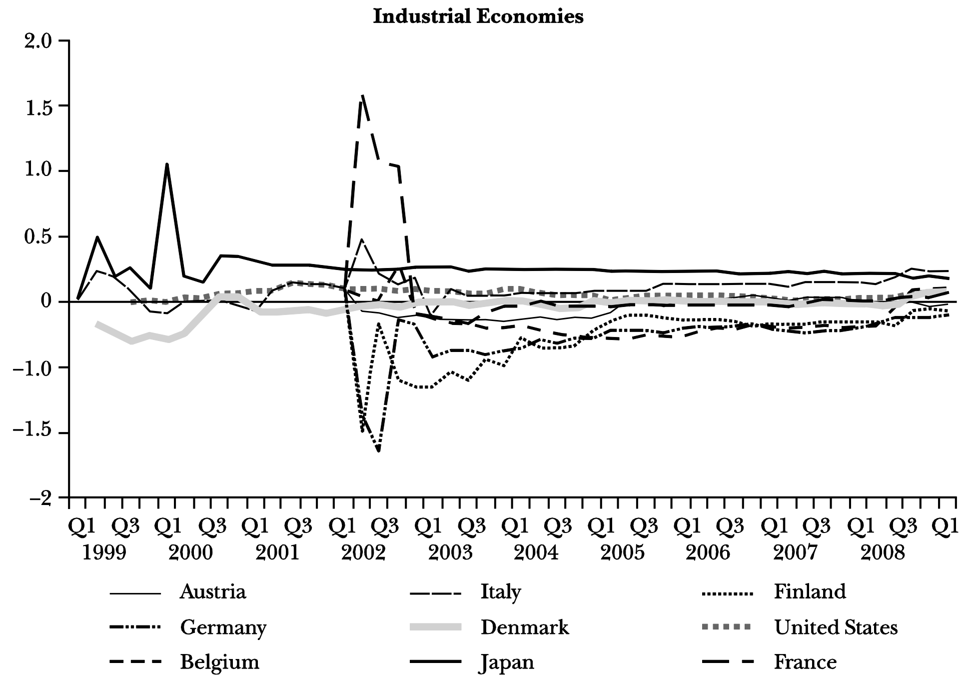
For all estimations we tested for structural breaks using Andrews-Quandt Chow and recursive least squares. No breaks were observed in the estimated processes. We did once more a Wald test of $\rho = 1$ for all estimations. We rejected $\rho = 1$ for almost all economies with the exception of Netherlands. We, again, compared the statistical differences of averages of the inflation persistence coefficient of different groups with a system of equations approach.

FIGURE 2. STABILITY OF PERSISTENCE PARAMETERS MODELING INFLATION AS A NEW





KEYNESIAN PHILLIPS CURVE, 1998-2009



Another implication of Blanchard and Galí (2005) model is the relation between inflation and unemployment as in equation (5). As Mishkin (2007) points out, when researchers estimate this equation they typically find that the coefficients on the unemployment gap have declined in the absolute value since the 1980s often by a marked amount. In other word, the evidence suggests that the Phillips curve has flattened.

$$\pi_t = \rho\pi_{t-1} + (1-\rho)E_t[\pi_{t+1}] + \beta_1 u_{t-1} + \varepsilon_t,\ E[\varepsilon_t]=0\ \text{var}(\varepsilon_t)=\sigma_\varepsilon^2. \tag{5}$$

Table 2 (column 5) shows the estimated ρ for this specification. The average persistence coefficient was 0.246 and Spain has the highest one: 2.921. Emerging market economies that experienced *hyperinflation* in the recent past once again seem to have greater coefficients on average: 0.453 compared to 0.23 of the industrial economies.

For all estimations we test for structural breaks using Andrews-Quandt, Chow and recursive least squares. We did not observe any break in any of the processes we estimated. Wald tests rejected ρ = 1 for almost all economies with the exception of Ireland and Spain.

As we can see, once again the results for both models of wage rigidities are similar to the ones of traditional and hybrid new Keynesian models. There is clear evidence that persistence is higher and more volatile in emerging economies that had *hyperinflation* than in the rest of our sample.

4. CONCLUSION

We analyzed inflation persistence in several industrial and emerging countries in the recent past by estimating various reduced-form models of inflation. Our results show that inflation persistence is low and stable, albeit lower for the former than for the latter. We also show that even countries that experienced *hyperinflation* in the recent past showed low levels of persistence but still have higher levels than the other countries in our sample. Overall, our results are consistent with a stable reduced-form representation for inflation and a low level of inflation persistence worldwide.

In interpreting our results, we must first recognize that all of them are based on reduced form relations. Thus, they are about correlations and not necessarily about true structural relations. Explanatory variables in our inflation estimations are themselves influenced by changes in economic conditions. So, changes in the underlying monetary policy regime are likely to be a source changes in reduced-form inflation dynamics. This problem is especially acute for structural relations involving expectations or other factors that are not directly observable and so cannot be included in reduced form regressions. In such cases, we cannot use the reduced form equations to disentangle the effects of such unobserved factors which themselves may be driven by changes in monetary policy from that of other influences.

Mishkin (2007) makes it clear that inflation expectations must be a key driving force behind inflation. This dependence has long been implicit in traditional Phillips curve analysis but now expectations are explicit and are also a central feature of new Keynesian Phillips curves in which current period inflation is a function of expectations next period and output gap.

Anchoring of inflation expectations must be related to monetary policy. During the past years most central banks have increased their commitment to price stability in both words and action. The Federal Reserve, the European Central Bank and several central banks of emerging economies have been committed to keep inflation under control. The result has been low and stable inflations but also, as we report in this paper, low and stable inflation persistence.

The pursuit of more aggressive monetary policy to control inflation and the achievement of anchored inflation help explain in part our results. With expectations of inflation anchored the sacrifice ratio becomes lower and monetary policy much more effective to improve the welfare of the economy.

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Price Formation

Introduction

Enrique López E.

This section of the book contains four papers focusing on the study of price formation in the microeconomic environment. A better understanding of how prices are set has important implications for structural economic policy and monetary policy. In the structural area, if price rigidities originate from imperfect competition, an appropriate policy could include a structural reform component to improve competition in goods and services markets at the producer and consumer levels. This would reduce price rigidity and facilitate the adjustment of prices to economic conditions.

As for monetary policy, a better understanding of monetary policy should lead to greater insight into the optimum inflation target. In this regard several possibilities can be mentioned: *i)* if downward rigidities prevail over upward rigidities it will justify a higher inflation target in order to facilitate an adjustment in relative prices; *ii)* knowledge of a possible sectorial heterogeneity in price persistence may mean it is necessary to redefine the price index employed by the monetary authority; and *iii)* the enhancement of central bank analysis and forecasting models as a consequence of the improved specifications that would be obtained for the price and wage equations they include.

The papers use two analysis instruments that can complement each other: direct surveys of producers and frequency and duration estimates employing so-called microdata taken from consumer price indexes (CPI) or retail points of sale.

In the first type of work, Misas, López and Parra employ information from a survey in which they asked Colombian business owners directly about how they set the prices of their main products. The answers and their tabulation allow calculation of the frequency of price changes and the implicit measures of their duration. Information can also be extracted from the survey regarding the frequency of price changes and their duration. Nevertheless, the main advantage of this type of survey is that it provides the opportunity to explore the reasons behind business owners pricing decisions. Thus, if there are also results on pricing patterns obtained from price index microdata, potential synergies can be exploited by examining the same phenomenon from different angles.

The most important results of the Misas *et al.* paper are:

i) Most sales by Colombian companies are made in the domestic market with long-term customers.

ii) The majority of Colombian companies employ time-dependent rules when the economy is stable. This is true for companies experiencing low levels of competition in their market. Meanwhile, during periods of economic turmoil, companies follow state-dependent rules.

iii) Colombian companies consider the current and expected behavior of inflation as well as other variables related to the production process as equally important when reviewing prices.

iv) The inflation target of Banco de la República and the minimum wage it sets each year are considered important factors when reviewing prices.

v) Companies that review their prices at fixed time intervals mostly do so on a monthly or quarterly basis.

vi) Companies experiencing low levels of competition review their prices every three months, while companies facing high levels of competition do so monthly.

vii) Colombian companies follow price setting strategies based on costs plus a profit margin as well as on competitor prices.

viii) With respect to the second stage of price setting, the results suggest that 38% percent of Colombian companies change prices once a year, while 75% of companies do so up to two times per year.

ix) Cost shocks are more important for explaining price increases than decreases, while demand shocks are more important in explaining price decreases.

x) Pricing practices changed throughout the five years before the survey was carried out. The main explanation for such changes is the greater variability recorded in input prices.

xi) Price changes are less frequent than price reviews. Furthermore, under normal economic conditions, the most flexible companies are those following state-dependent rules, while the least flexible follow time dependent rules.

xii) A cost based pricing hypothesis is the main explanation for why companies do not change their prices more frequently.

The work of Fernández Bujanda is aimed at studying the frequency of consumer price changes in Venezuela using data from the CPI of the Metropolitan Area of Caracas. The paper estimates the duration of prices using direct and indirect methods. According to the author, the former calculates how long a price takes to change using the distribution of durations, which can be calculated with information contained in the group of panel data. The second method calculates the duration with the frequency that prices change each month. The main finding of Fernández's research refers to the speed of price changes in Venezuela. It finds that the average time of price variations in such country is 2.6 months with a median of 1.9 months. It also shows that there is heterogeneity in price durations among sectors: prices of services such as education and health tend to be more rigid than those of other sectors.

The work of Ysusi calculates the degree of nominal consumer price rigidities for different sectors of the Mexican economy. To achieve this it presents a breakdown of data on the frequencies, implicit durations and sizes of each sector calculated for a CPI microdata set. The study covers the period from July 2002 to December 2009 when Banco de México adopted an inflation targeting regime. It is important to mentioning that inflation was at historically low levels and was relatively stable during this time period. The study's most important results show that in Mexico there exists a considerable heterogeneity in the price setting behavior across different sectors and over time. It also finds that the percentage of firms changing prices varies when there are inflation shocks.

One feature that characterizes the work of Borraz and Zipitría is the database employed. The latter contains daily prices of 117 articles captured at grocery stores in Uruguay's main cities during the period April 2007 to December 2010. This rich database allows the authors to carry out some specific exercises. They begin by studying price rigidities, calculating the average probability of daily fluctuations in prices and their average duration measured in months. They find that retail prices in Uruguay change frequently. Prices are less rigid than in the USA and Brazil, but more rigid than in the UK and Chile. The median duration of prices in Uruguay is two and a half months. Meanwhile, an examination of the existence of seasonality finds no evidence of a seasonal pattern in price adjustments. With only a few exceptions, they do not find that the likelihood of price adjustment correlates positively with expected inflation either. The availability of daily data allows the authors to analyze companies' price adjustment decisions by day of the month. It is shown that the probability of price fluctuations on the first day of the month is nine times higher than on any other day. Finally, when estimating the hazard rate in order to study if the likelihood of price fluctuations depends on time, they find that the synchronization of price changes is very high. This evidence seems to indicate use of a state-dependent model for price changes.

Price Setting in Retailing: the Case of Uruguay

Fernando Borraz and Leandro Zipitría*

1. INTRODUCTION

In recent years there has been a large increase in the empirical literature of price behavior. As new and detailed datasets become available we observe an important number of studies on the microeconomic fundamentals of price setting of firms –mainly retailers– and their impact on inflation. This analysis allows a better understanding of the behavior, dispersion and volatility of prices.

In this paper, we use a rich and unique dataset of 30 million daily prices in grocery stores and supermarkets across the country to analyze

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stylized facts about consumer price behavior. Our findings are as follows: *i)* The median duration of prices is two and one-half months. Therefore, retail prices in Uruguay are less sticky than in the United States (USA) and Brazil, but stickier than in Chile and the UK. *ii)* We do not find evidence of a seasonal pattern in the likelihood of price adjustments. *iii)* The frequency of price adjustment is only correlated with expected inflation for the personal care product category. However, for the food category we find that firms change the percentage points of the adjustment and not their frequency. *iv)* The probability of price change on the first day of the month is nine times higher than on any another day. *v)* The probability of a price change is not constant over time. *vi)* There exists a high synchronization of price changes in our database, either at the city level or chain level. Overall, our analysis seems to be consistent with time dependent models, although the high synchronization of price changes on the first day of the month awaits a better theoretical formalization.

1.1 A Brief Review of the Empirical Literature

Although there are different theoretical models that explain these issues in the macroeconomic literature –such as menu cost models, sticky price, sticky information models, and time or state-dependent pricing strategies–, the stylized facts pointed out in the literature avoid a unique formalization. Klenow and Malin (2010) provide an up-to-date and concise overview of the empirical evidence, and confront the data with different theoretical models. They stress ten facts of the microeconomic behavior of prices. The primary facts are that prices do change at least once a year; that the main instrument for downward price adjustment is sales; that most markets have a stickier reference price; that goods prices differ in their frequency of adjustment and their changes are asynchronous between them; that there exist microeconomic forces which explain the behavior of prices that differ from aggregate inflation and, finally, that prices adjust mainly when wages change.

Gopinath and Rigobon (2008) study the stickiness of traded goods using micro data on US import and export prices at-the-dock for the period 1994-2005. They find long price duration of traded goods –10.6 months for imports, and 12.8 months for exports–; great heterogeneity in price stickiness across goods at the disaggregated level; a declining probability of price adjustment over time for imports; and a rather low exchange rate pass-through into US import prices.

Nakamura and Steinsson (2008) use the Consumer Price Index (CPI) and the Producer Price Index (PPI) from the Bureau of Labor Statistics (BLS) in the USA for the period 1988-2005 to study price stickiness. Their results show that there is a duration of regular prices of between 8 and 11 months, after excluding price sales; that temporary sales are an important source of price flexibility –mainly downward price flexibility–; that, excluding sales, roughly one-third of price changes are price decreases; that price increases function strongly as covariates with inflation, but price decreases do not; and that price changes are highly seasonal –mainly in the first quarter. Finally, they find that the hazard function of price changes, which estimates the probability of a price change after *t* periods without changing, is slightly downward sloping, which implies that the probability of a price change occurring decreases the longer the time span since the last change.

Some of these conclusions are relativized by Klenow and Kryvtsov (2008). Using monthly price information from the BLS for the period 1988-2004, they find that prices change quite frequently, every 3.7 months if sales are included and up to 7.2 months if excluded. They compare their results with those of other papers for the USA and conclude that different methodologies on how to include or not include sales and how to take into account prices of substituted goods, change the estimated rigidity of prices. Price changes are quite large, up to an average of 10% a year in their sample. Also, they find a large number of small price changes: nearly 44% of price changes are smaller than 5% in absolute value, with 12% being smaller than 1%. The distribution of the size of price changes is similar between price increases and decreases. Hazard rate estimates for a given item are quite flat, after taking into account the mix of heterogeneous hazard rates for different goods, that is, survival bias.

Ellis (2009) studies the behavior of prices using weekly data for the UK. He finds low price rigidities in the UK retailing industry. Prices change frequently (the mean duration is about two weeks) even after discarding promotions and sales. When analyzing the sign of the price change in price reversals –that is, price changes that later reverted to the original price–, he finds that there is a prevalence of price decreases, which is consistent with sales. Also the range of price changes is very wide: there are some products that display large changes in prices, and a large number that show small changes. Lastly, he finds that all products have declining hazard functions, as do Nakamura and Steinnson (2008).

Studies for Latin America are scarce due to the lack of available scan data, and they have concentrated on micro CPI data. Barros et al. (2009) and Medina et al. (2007) analyze price formation in Brazil and Chile, respectively. They show that the frequency of adjustment is different from the one obtained using macro data. They estimate median duration of four and three months for Brazil and Chile, respectively. Because their data is monthly, they cannot capture price changes within a month. Also, the CPI data must deal with a higher measurement error than does scan data. Chaumont et al. (2010) study price setting behavior in Chile using weekly scan data. They find significant heterogeneity in price behavior by supermarkets. One salient finding is the relative price flexibility of Chilean supermarkets in their database; price duration is about 1.3 weeks, even lower than in the UK, see Ellis (2009). In contrast to Nakamura (2008), they find that nearly 35% of price changes are idiosyncratic to product or chain shocks, and 65% of prices changes are common shocks that affect all products in a category and all stores in the country at the same time. The only paper that compares price rigidities across Latin American countries is that of Cavallo (2010). He uses scraped online data from Argentina, Brazil, Chile, Colombia, and Uruguay. He finds price stickiness in Chile and relative price flexibility in Brazil.

To the best of our knowledge, our paper is the first to analyze price behavior of retailers in a small open economy using daily price data from across all country regions. The objective of this study is to describe stylized facts of price formation in Uruguay and to compare them with those of the existing literature. The paper is organized as follows: The next section provides a detailed description of the database. After that, we present the main findings of the analysis, and offer a brief comparison with the available evidence. Then, we discuss the implication of our findings for the existing theoretical literature. Finally, the last section shows the study's main conclusions.

2. DATA

We analyze a micro dataset with a daily frequency compiled by the General Directorate of Commerce (DGC, by its Spanish acronym) which includes more than 300 grocery stores all over the country and 155 products (see Annex 1 for a map with the cities covered in the dataset). The product brands were chosen to be the most representative of the product being described, and they were selected as the best selling brand in each category. The products in the sample represent at least 12.6% of the goods and services in the CPI basket (see Annex 2).

The DGC is the authority responsible for the enforcement of the Consumer Protection Law at the Ministry of Economy and Finance. In 2006 a new tax law was passed by the legislature which changed the tax base and rates of the value added tax (VAT). The basic rate was reduced from 23% to 22% and its minimum rate (staple foods, hotel rooms in high season, certain health related services and electricity for public consumption) from 14% to 10%. In addition, exemptions were eliminated (e.g. health sector, passengers transport, sales of new homes). A tax on intermediate consumption of goods (COFIS) at a 3% rate was eliminated. The tax reform also reduced the asymmetries between sectors of activity regarding the employer contribution to social security and introduced a personal income tax.

As the Ministry of Economy and Finance is concerned about incomplete pass-through from tax reduction to consumer prices, it publishes an open public dataset of prices in different grocery stores and supermarkets in order to inform consumers. In this regard, the DGC issued Resolution Number 061/006 which mandates that grocery stores and supermarkets must report the daily prices for a list of products if they fulfill the following two conditions: *i)* they sell more than 70% of the products listed in Annex 2 of said Resolution, and *ii)* they have more than four grocery stores under the same name, or have more than three cashiers in a store. The information sent by each supermarket is a sworn statement, which means that they are subject to penalties in case of misreport.

The DGC makes the information public through a webpage that publishes the average monthly prices of each product for each store in the defined basket (see http://www.precios.gub.uy/publico/). This information is available within the first ten days of the next month. It should be noted that there is no further use for the information; e.g. no price control, nor are any further policies implemented to control supermarkets or producers. The idea is to give consumers adequate information about prices so they can do their shopping at the cheapest store.

The products that are to be reported to the DGC were initially established per the results of a survey distributed to the main supermarket chains inquiring about their annual sales for each item and brand. After discarding supermarkets' own brands, the three highest-selling brands were chosen to be reported for each item. Most items had to be homogenized in order to be comparable, and each supermarket must always report the same item. For example, bottled sparkling water of the Salus brand is reported in its 2.25 liters variety by all stores. If this specific variety is not available at a store, then no price is reported.

Each item is defined by its universal product code (UPC) with the exception of meat, eggs, ham, some types of cheese, and bread. In some instances, as in the case of meat and various types of cheese, general definitions were set, but because of the nature of the products, the items could not be homogenized. In the case of bread, most grocery stores buy frozen bread and bake it, rather than produce it at the store. Grocery stores differ in the kinds of bread they sell, so in some cases the reported bread does not coincide with the definition, and grocery stores prorate the price submitted to the DGC; i.e. if the store sells bread that is 450 grams per unit, and the requested bread is 225 grams, it submits half the price of its own bread.

Each month, the DGC issues a brief report with general details of the price evolution. This report counts the number of products that increase or decrease their prices. The prices used for these calculations are the simple average market prices for each product.

The database records began in March 2007, and the new tax base was put into place in July 2007. A few months later, new products were added to the database, after a push of inflation in basic consumer products in 2008. The government made "voluntary sectoral price agreements" with producers in the salad oil, rice and meat markets. Additionally, in the second semester of 2010, newer goods were added to the dataset in order to expand its representation.

Within two days of the end of the month, each supermarket uploads its price information to the DGC. After that, it begins a process of *price consistency checking*. This process starts by calculating the average price for each item in the basket. Each price 40% greater or less than the average price is selected. Then, the supermarket is contacted in order to check whether the submitted price is right. If there is no answer from the supermarket, or if the supermarket confirms the price submitted, the price is posted online as reported. If the supermarket corrects the price, which is an exception, the price is corrected in the database and posted online.

Our database contains daily prices from April 2007 to December 2010 on 155 items. From the database, we eliminated: *i)* those items that were not correctly categorized (marked as "XXX" and "0"); *ii)* ham, as different products mistakenly share the same UPC; and *iii)* one brand of cheap ham

"Leonesa" and meat that also share the same UPC. The complete list of products can be found in Annex 2. We also eliminated March 2007 observations, because they were preliminary and had not been posted online. Finally, we eliminated those products –and supermarkets– for which there are no observations for more than half of the period.

We end up with data for 117 products in 303 grocery stores from 45 cities in the 19 Uruguayan departments (see Annex 1). These cities represent 80% of the total population of Uruguay. The capital city, Montevideo, with 45% of the population contains 60% of the supermarkets in the sample.

Table 1 summarizes the total number of price observations (30 million) according to four product categories: *food, soft drinks, alcohol,* and *personal care and cleaning items* (named *personal*). Food is the main category, followed by products of personal cleaning, and lastly beverages.

TABLE 1. NUMBER OF DAILY PRICE OBSERVATIONS BY CATEGORY, APRIL 2007 TO DECEMBER 2010

Category	*Number of observations*	*Percentage of total*
Food	20,380,541	66
Soft drinks	1,814,628	6
Alcohol	1,486,176	5
Personal	7,038,089	23
Total	*30,719,434*	*100*

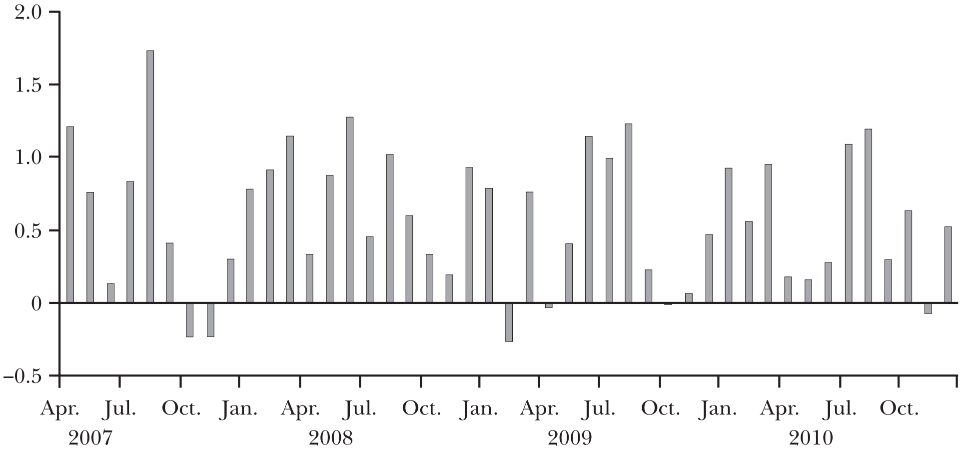
SOURCE: Own elaboration from data of the Uruguayan Ministry of Economy and Finance.

Finally, as our results could be driven by differences in the overall inflation in the sample, we plot the monthly variation of prices. This period is characterized by inflation pushes (the median monthly inflation rate is 0.56%), as the government was worried that inflation would reach a high level in the medium term.

3. RESULTS

This section shows the main results of the analysis, and it is divided into six facts. The first section reviews the frequency of price adjustment. The second section studies the existence of seasonality in the pricing adjustment of supermarkets. In the third, we study the nexus between individual price changes and expected overall inflation. The fourth section analyzes price changes by day of the month, which is new in the literature. The

FIGURE 1. MONTHLY INFLATION RATE, 2007-1010 (%)



SOURCE: Instituto Nacional de Estadística.

fifth computes the joint hazard rate of price changes. Lastly, we study the synchronization of prices at the chain and city level.

3.1 Frequency of Price Adjustments

As is standard in the literature, we first study the rigidity of prices by computing the median probability of daily price changes and the median duration of prices in months, and by contrasting the results of price increases and decreases. It should be noted that we study the whole sample and do not differentiate between sales and the absence of sales. From a theoretical point of view, if there is a price decrease because of a sale this shows evidence of price flexibility and we do not want to eliminate such an observation (see Klenow and Kryvtsov, 2008).

The median daily price change for the whole sample is a non-trivial 1.3%. This implies a medium price change every 75 days, or every two and one-half months, on average, which is considerably lower than the estimates of Nakamura and Steinsson (2008) and Nakamura (2008), but greater than the results of Chaumont et al. (2010) for Chile and Ellis (2009) by about two weeks. This result is slightly less than the median durations of three and four months found by Barros et al. (2009) and Medina et al. (2007) for Brazil and Chile, respectively.

We offer two explanations for this behavior: First, this is a period of relatively high inflation, so one could expect prices to change more quickly: the median monthly inflation in the period in Uruguay was 0.56%.

Second, as our database has daily prices, we can calculate price changes more accurately than in previous studies that use weekly or monthly data. In this case, we can detect earlier price changes and our measure of price rigidity would be more sensitive to them. This would result in less price stickiness for our database.

In line with Nakamura and Steinsson (2008), 40% of the price changes are price decreases. Table 2 presents the median probability of price changes, the percentage of price decreases and the median monthly duration by product category.

TABLE 2. PRICE VARIATION AND DURATION BY CATEGORY

Category	*Median probability of daily variation*	*Percentage decrease*	*Monthly duration*
Food	0.013	40.6	2.5
Soft drinks	0.010	33.3	3.2
Alcohol	0.009	30.0	3.5
Personal	0.017	42.0	1.9
Total	*0.013*	*40.4*	*2.5*

SOURCE: Own elaboration from data of the Uruguayan Ministry of Economy and Finance.

Our results show that the personal cleaning category is that which changes price most frequently, and that the alcohol category is the opposite. There is a significant variation in price stickiness across product categories, ranging from 1.9 months for personal to 3.5 months for alcohol.

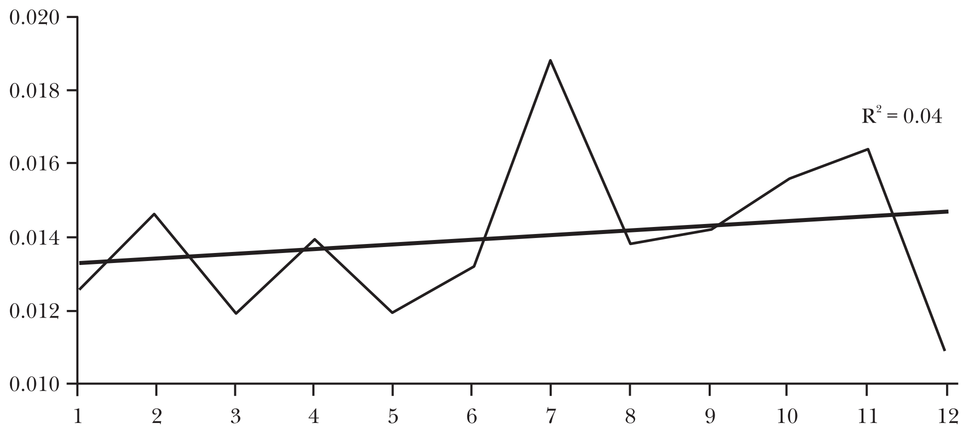
In Annex 3 we present a detailed analysis of this result for each product in the sample. There is a high variability of results across products. For example, we find products that change prices quite frequently, such as cheese "Disnapt" and "Cerros del Este," for which prices change five and two times a month, respectively. Other products change prices more slowly, like brown eggs "El Ecologito" and salt "Torrevieja," whose prices can remain the same up to five months.

3.2 Seasonality of Price Changes

Secondly, we study the existence of a seasonal adjustment pattern of prices. Nakamura and Steinsson (2008) find that price changes in the USA are highly seasonal, and are concentrated in the first quarter and then decrease. This seasonality of Nakamura and Steinsson (2008) is consistent with their price rigidity calculation of about eihht months. In contrast, Ellis (2009) finds no monthly seasonality in his study, a result in line with his finding of just two weeks of price rigidity. As we find price duration of two and one-half months, we should expect to find no seasonality in the data.

Figure 2 shows that there is not a clear pattern of seasonality in the price adjustment of firms.

FIGURE 2. PROBABILITY OF PRICE CHANGE BY MONTH



SOURCE: Own elaboration from data of the Ministry of Economy and Finance.

Additionally, we do not find a seasonal pattern in price changes looking at data on a quarterly basis. The percentage of daily price changes in the first quarter is 1.28%, 1.29% in the second, 1.58% in the third, and 1.49% in the fourth quarter. The greatest price change seems to be concentrated in the third quarter. Next, we look at the seasonal behavior of prices by categories (see Table 3).

All categories but personal have the greatest number of price changes in the third quarter, although there is no clear tendency in the data. Therefore, we cannot conclude that seasonality exists in the speed of price adjustments.

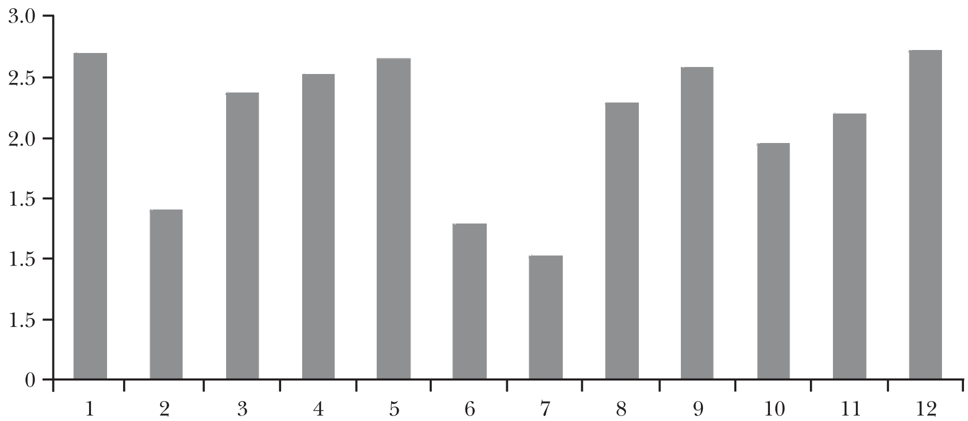
TABLE 3. SEASONAL PROBABILITY OF PRICE CHANGE BY PRODUCT CATEGORY AND QUARTER

Quarter / Category	*Food*	*Soft Drinks*	*Alcohol*	*Personal*
1	0.013	0.008	0.006	0.013
2	0.012	0.009	0.008	0.017
3	0.016	0.012	0.010	0.018
4	0.015	0.010	0.009	0.019

SOURCE: Own elaboration from data of the Uruguayan Ministry of Economy and Finance.

Next, we study whether seasonality exists in the level of the price adjustments. Figure 3 shows the rate of price growth conditional on price change by month. Again, we do not observe a clear pattern of seasonality. It should be stated that in Uruguay workers receive an extra half month's wages in June and December. Also, during December's New Year festivities, supermarkets' sales generally receive a boost.[1] In summary, we do not find demand driven seasonal price changes in the data.

FIGURE 3. PRICES GROWTH RATE GIVING PRICE CHANGE BY MONTH (%)



SOURCE: Own elaboration from data of the Ministry of Economy and Finance.

3.3 Individual Price Changes and Inflation Perceptions

One interesting issue is whether price changes and inflation expectations move together. Ellis (2009) suggests a positive relationship between the frequency of price changes in his sample and the inflation perception surveyed by Bank of England. Table 4 shows the result of an ordinary least square (OLS) regression estimation where the dependent variable is the median probability of price change and the exploratory variables are expected inflation and indicator variables for the July 2007 tax reform. The expected inflation variable is the median forecast from a survey of experts performed by the Central Bank of Uruguay. We include an indicator variable before and after the tax reform to capture anticipated effects of the reform.

[1] In Uruguay, supermarkets' sales usually soar the day before they close. The 1st and 6th of January, the 1st of May, and the 25th of December are usually the days that supermarkets do not open.

The regression shows no correlation between changes in prices and inflation perception. One would suggest that if prices tend to be stickier, then the inflation expectations should not be of inflation acceleration. It is interesting to point out that we only observe correlation between inflation and the percent variation in individual prices when considering price decreases. The tax reform indicator variables suggest that firms anticipated the reform and changed prices before the implementation of the reform in July 2007.

TABLE 4. INDIVIDUAL PRICE CHANGES AND INFLATION PERCEPTIONS: OLS REGRESSION, APRIL, 2007 TO DECEMBER, 2010

	Dependent variable			
	Probability of price change	*Price change in percentage*		
Variables		*All*	*Increases*	*Decreases*
Expected yearly inflation	0.001	−0.024	0.449	−0.640[a]
	(0.001)	(0.412)	(0.369)	(0.194)
Tax reform indicator variable, May 2007	0.008[c]	3.052[c]	3.659[b]	−1.043
	(0.004)	(1.792)	(1.604)	(0.844)
Tax reform indicator variable, June 2007	0.012[b]	−4.102[b]	2.500	−0.288
	(0.004)	(1.790)	(1.602)	(0.843)
Tax reform indicator variable, July 2007	0.011[b]	−1.371	−4.849[a]	2.740[a]
	(0.004)	(1.789)	(1.602)	(0.843)
Tax reform indicator variable, August 2007	−0.018[a]	3.396[c]	−0.550	−1.401
	(0.004)	(1.793)	(1.605)	(0.845)
Tax reform indicator variable, September 2007	−0.009[a]	−0.390	0.183	0.479
	(0.003)	(1.293)	(1.158)	(0.609)
Constant	−0.001	1.520	5.090[b]	−4.304[a]
	(0.007)	(2.780)	(2.488)	(1.309)
Observations	45	45	45	45
R-squared	0.733	0.229	0.405	0.399

SOURCE: Own elaboration from data of the Uruguayan Ministry of Economics and Finance and the Central Bank of Uruguay.

NOTES: Standard errors in parentheses. [a] $p<0.01$, [b] $p<0.05$, [c] $p<0.1$.

For a better understanding of the relation between individual daily prices and inflation, we estimate the previous equation by product category. Table 5 shows the results of the coefficient on expected inflation.

Interestingly, results indicate that there is a positive association between probability of price changes and expected inflation only for the *personal* product category. For the other product categories, the correlation is zero. This means that expectations about future inflation do not influence the price strategies of firms in those markets. We do find an association between changes in prices and the average rate of price decreases in the *food* product category.

TABLE 5. INDIVIDUAL PRICE CHANGES AND INFLATION PERCEPTIONS: OLS REGRESSION BY PRODUCT CATEGORY, APRIL 2007 TO DECEMBER 2010

	Dependent variable			
	Probability of price change	*Price change in percentage*		
Category		*All*	*Increases*	*Decreases*
	Coefficient - Standard Error on Expected Yearly Inflation			
Food	0.001	–0.168	0.700	–0.771[a]
	(0.001)	(0.522)	(0.456)	(0.221)
Soft drinks	–0.001	–1.644[c]	–1.678	0.393
	(0.001)	(0.924)	(1.997)	(0.513)
Alcohol	0.003	0.298	0.256	–0.064
	(0.002)	(0.790)	(0.781)	(0.552)
Personal	0.003[b]	0.839	0.195	–0.602
	(0.001)	(0.527)	(0.477)	(0.361)
Observations	45	45	45	45

SOURCE: Own elaboration from data of the Uruguayan Ministry of Economics and Finance and the Central Bank of Uruguay.

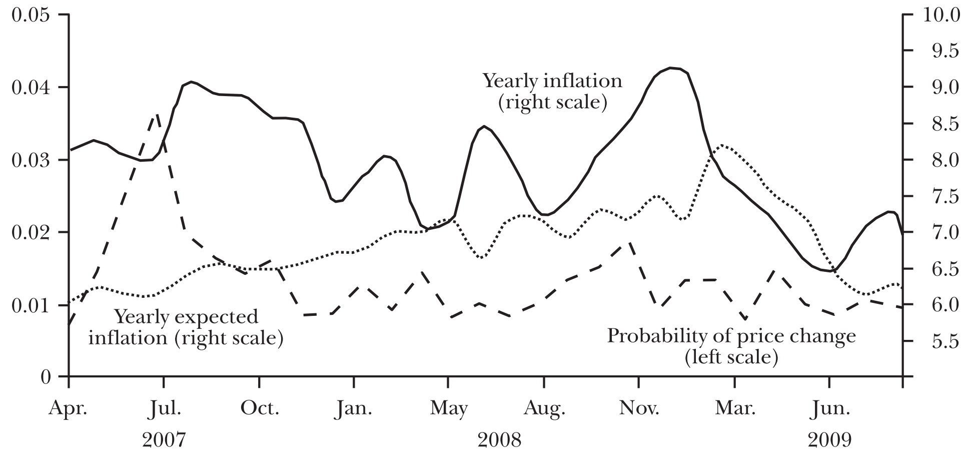
NOTES: Standard errors in parentheses. [a] $p<0.01$, [b] $p<0.05$, [c] $p<0.1$.

To provide more evidence for this topic Figure 4 plots the probability of price adjustment (left scale), and the inflation and expected inflation rate (left scale). We observe no association between price changes and inflation perceptions.

3.4 Prices Changes by Day of the Month

Given the fact that we have daily data we can analyze the pricing decision of firms by day of the month. Figure 5a shows the probability of a price change by day of the month. Interestingly, the probability of price

FIGURE 4. PROBABILITY OF PRICE CHANGE, INFLATION AND EXPECTED INFLATION, 2007-2009



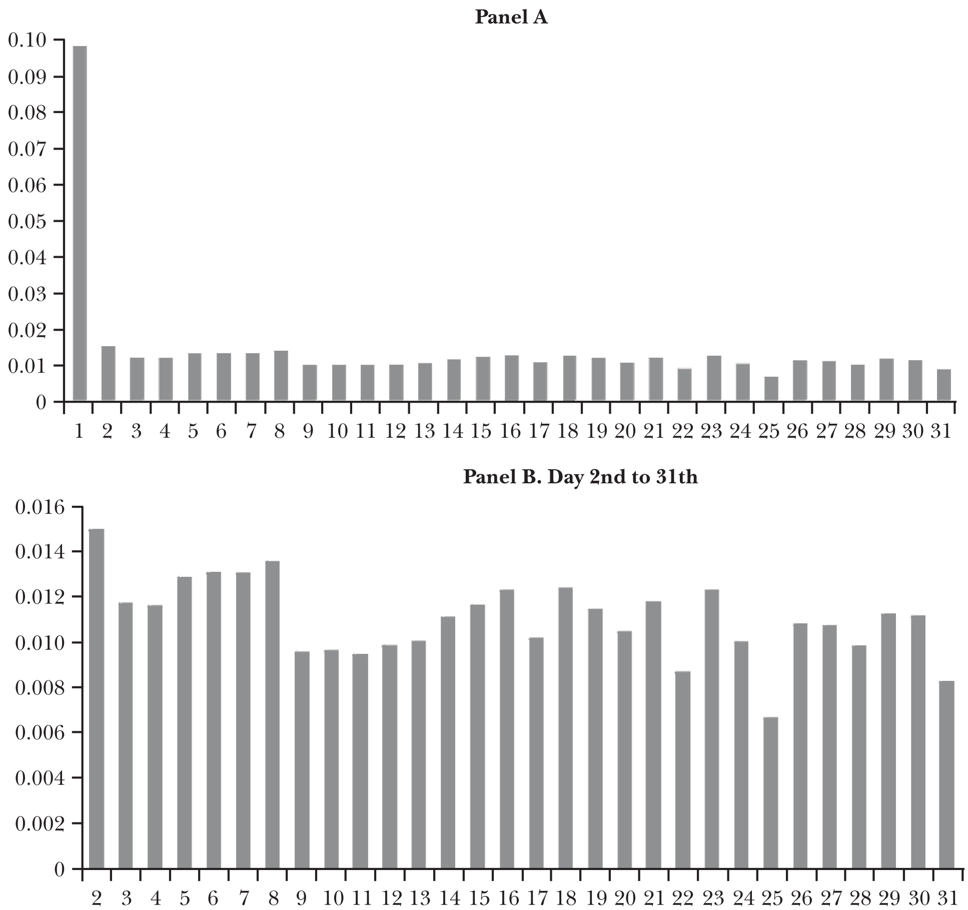
SOURCE: Own elaboration from data of the Ministry of Economy and Finance and the Central Bank of Uruguay.

change on the first day of the month is nine times higher than on any other day.

Figure 5b plots the daily probability of a price change from the second day to the last day of the month. In this case, we do not observe a clear pattern in the data.

Figure 6 shows that price increases and decreases also are concentrated on the first day of the month. Also, Figure 7 shows that the fact that price changes are concentrated on the first day of the month is a general result valid to all product categories. This is one of the most remarkable findings of our paper, since to the best of our knowledge no other study analyzes the distribution of price changes by day of the month. One supermarket manager told us that this pricing behavior is related to producers, which tend to adjust their prices the first day of the month. In this case, the observed behavior could be a response to cost increases by supermarkets. This pattern is the same for price increases and price decreases. As price decreases are associated with sales, this implies that supermarkets tend to follow a pattern of price changes that concentrates most of them in one day, which may indicate the existence of menu costs associated with pricing behavior or some other rigidity that prevents the supermarkets from changing prices.

FIGURE 5. PROBABILITY OF PRICE CHANGES BY DAY

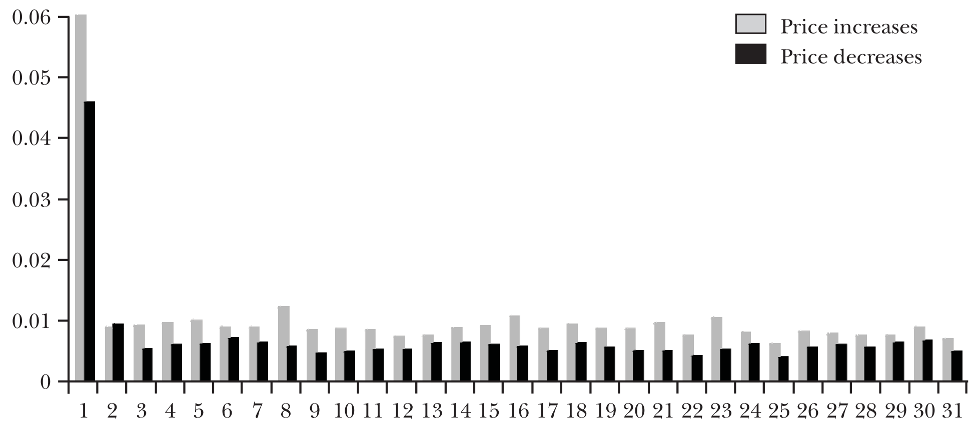


SOURCE: Own elaboration from data of the Ministry of Economy and Finance.

3.5 Hazard Rate Estimates

In order to study whether price changes are time dependent we estimate the hazard rate. The hazard rate at moment t is calculated as the quotient of the number of prices that change in t, given that they do not change until that moment, over the number of prices that have not changed until moment t. As the greatest price duration is half a year (see Annex 3) we calculate the hazard function up to two hundred days. Figure 8 shows the smoothed hazard rates. We observe a non-constant over time hazard rate. This result is consistent with Nakamura (2008) and Ellis (2009),

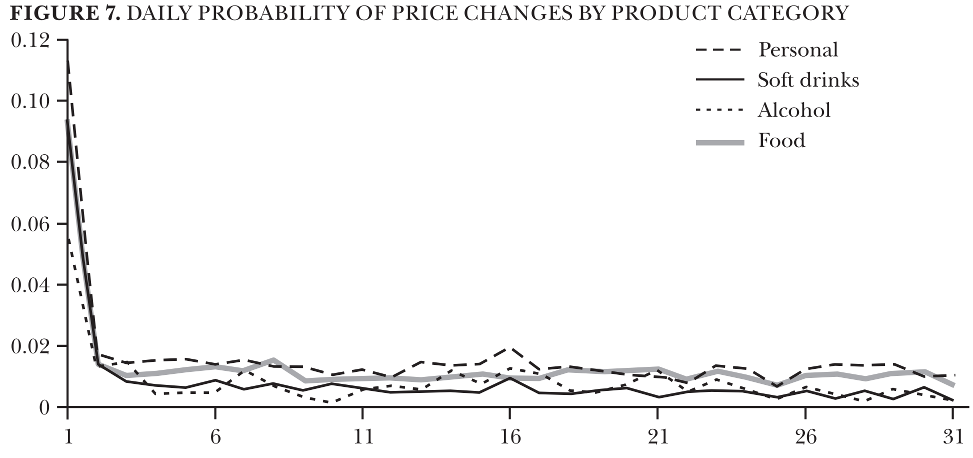
FIGURE 6. PROBABILITY OF PRICE INCREASES AND DECREASES BY DAY OF THE MONTH



SOURCE: Own elaboration from data of the Ministry of Economy and Finance.

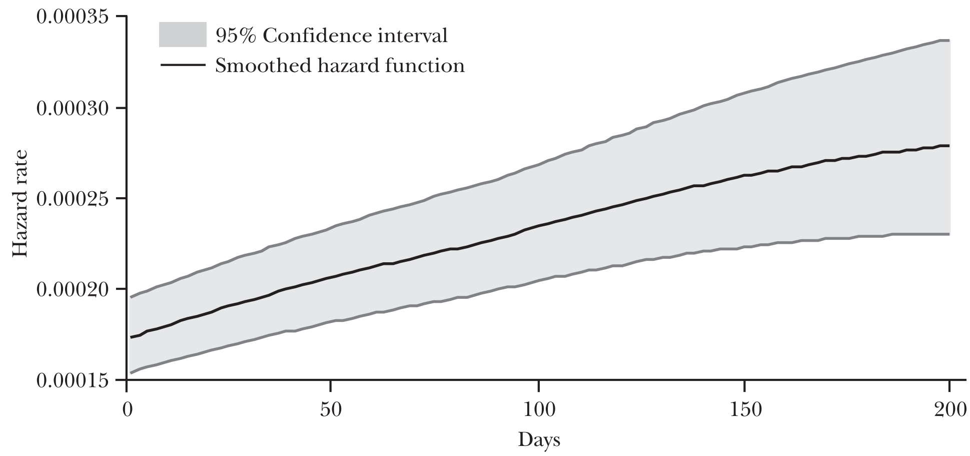
although they find hazard rates to be decreasing, and we find increasing rates. The upward-sloping hazard rate is consistent with state-dependent pricing. This fact invalidates the modeling of a constant probability of price change, and implies that supermarkets do not follow a time dependent strategy for price setting. In turn, this result is in line with our finding of no seasonality in price changes.

FIGURE 7. DAILY PROBABILITY OF PRICE CHANGES BY PRODUCT CATEGORY



SOURCE: Own elaboration from data of the Ministry of Economy and Finance and the Central Bank of Uruguay.

FIGURE 8. SMOOTHED HAZARD ESTIMATE



SOURCE: Own elaboration from data of the Ministry of Economy and Finance, and the Central Bank.

3.6 Price Synchronization

Finally, we estimate price synchronization in two ways: across firms that belong to the same chain, and across firms in each city. To estimate price synchronization we calculate the Fisher and Konieczny (2000) estimator (FK). Table 6 indicates that price changes across supermarkets of the same chain[2] are highly synchronized.

For this result two remarks are in order. First, our database consists of daily observations and we find that prices change on average after about

TABLE 6. PRICE SYNCHRONIZATION ACROSS SUPERMARKETS THAT BELONGS TO THE SAME CHAIN

Chain	*Fisher and Konieczny indicator*
Devoto	0.94
Tienda Inglesa	0.92
Macromercado Mayorista	0.96
El Dorado	0.92
Multiahorro	0.91
Disco	0.96
Ta Ta	0.84

SOURCE: Own elaboration from data of the Uruguayan Ministry of Economy and Finance.

[2] We estimate the FK indicator just for the major chains: those that have more than five stores and also more than three cashiers per store on average.

two and one-half months. Second, we also find that price changes are concentrated on the first day of the month. Therefore, our database has a great deal of synchronized 'no price changes' and as a consequence a high FK. To control for this effect, we also estimate the FK synchronization indicator, conditional on price change (see table 7).

TABLE 7. ADJUSTED PRICE SYNCHRONIZATION SUPERMARKETS CHAINS THAT BELONGS TO THE SAME CHAIN CONDITIONAL ON PRICE CHANGE

Chain	*Synchronization indicator*
Devoto	0.54
Tienda Inglesa	0.56
Macromercado Mayorista	0.75
El Dorado	0.51
Multiahorro	0.56
Disco	0.61
Ta Ta	0.36

SOURCE: Own elaboration from data of the Uruguayan Ministry of Economy and Finance.

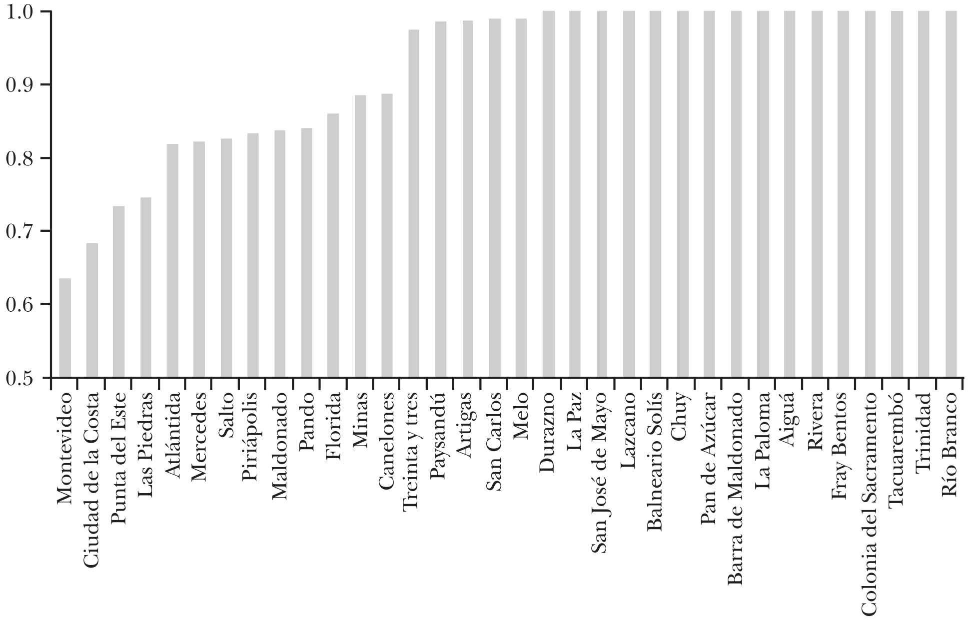
In this case, the synchronization estimates are lower than before, but the main result of high synchronization of price adjustments in supermarkets that belong to the same chain remains. This result is in contrast to that of Chaumont et al. (2010), who finds much lower price synchronization for Chile.

Additionally, we estimate the FK synchronization indicator across the cities in our sample. Figure 9 shows the FK estimator for each city. As it can be seen, synchronization is by itself large, with a minimum of 0.63 for Montevideo –which has the greatest number of supermarkets– and one for a large number of cities which have few supermarkets.

4. CONTRASTING THE RESULTS WITH THEORY

In this section we compare the results of the analysis with the main theoretical predictions of menu costs, time-dependent and state-dependent theories. We discuss each stylized fact found in the previous analysis and review how it fits the theoretical explanations. Table 8 presents a brief summary of the analysis, in a similar vein to Table 14 of Klenow and Malin (2010).

FIGURE 9. FISHER AND KONIECZNY SYNCHRONIZATION INDICATOR BY CITY



SOURCE: Own elaboration from data of the Ministry of Economy and Finance.

As can be shown from the Table 8, the empirical evidence seems to point to state-dependent models as the main explanation of the inflation phenomena in Uruguay. The flexibility of prices remains a disputed issue in the empirical literature; as we have considered sales in our database, the relative flexibility could be less if we take them out.

In contrast to the empirical literature, we have found a high synchronization of prices even at the chain and city level. This result could be

TABLE 8. STYLIZED FACTS AND MODEL FEATURES

Fact	*Consistent Features*	*Inconsistent Features*
Price change are somewhat flexible	Small menu cost	Large menu cost
No seasonality of price changes	State dependent models	Time dependent models
Price change mainly the first day of the month	Time dependent models	State dependent models – common shocks
Upward-slopping hazard rates	State dependent models	Time dependent models
Price changes are highly synchronized	State dependent models –common shocks– strategic complementarities	Big idiosyncratic shocks

driven by the particularity of our database which consists of daily observations. In the same vein, we have discovered that prices tend to change on the first day of the month. Additionally, this result is not surprising considering the fact that Uruguay is a highly centralized country. This result reflects that common shocks may be an important part of price adjustment policies of firms.

We think that this result could not be explained in full using macro models. As all the items in our database are the highest-selling brands, and most markets are oligopolies –even the supermarket industry– price setting behavior needs to be analyzed using micro modeling. As for the matter of prices changing mostly on the first day of the month, we think that this could serve as a reference point for price setting of firms. This particular day, in turn, could reduce menu costs in the event of price changes.

5. CONCLUSIONS

We present evidence on price formation at the retail level in Uruguay. We use a rich and unique dataset of 30 million daily prices in grocery stores and supermarkets across the country to analyze the behavior of consumer prices in Uruguay. We find that retail prices in Uruguay change frequently. Prices are less sticky than in the USA and Brazil but stickier than in the UK and Chile. The median duration of prices in Uruguay is two and one-half months.

We do not find evidence of a seasonal pattern in the adjustment of prices. The probability of price changes varies positively with expected inflation only for the personal care product category. However, for the food category we find an association between price changes and the percentage rate of price decreases. Also, the probability of price changes on the first day of the month is nine times higher than on any other day of the month, and the probability of price adjustments is not constant over time. Finally, we find very high synchronization of price changes.

This evidence seems to point to a state-dependent model of price changes. Nonetheless, the high synchronization of price changes is a newer element in the empirical literature, which could be the result of analyzing daily data. Lastly, the high concentration of price changes on the first day of the month needs further theoretical analysis, as one possible interpretation could be that this day serves as a reference point for price adjustment.

Annex 1

URUGUAY: CITIES INCLUDED IN THIS STUDY

Annex 2

LIST OF PRODUCTS

Product	*Brand*	*Specification*	*Share in CPI (%)*	*Category*
Beer	Patricia	0.96 l	0.3	Alcohol
Beer	Pilsen	0.96 l	0.3	Alcohol
Common red wine	Roses	1 l	0.34	Alcohol
Common red wine	Santa Teresa Clásico	1 l	0.34	Alcohol
Common red wine	Tango	1 l	0.34	Alcohol
Beef “peceto”	No brand	1 kg	0.90	Food
Beef “nalga”	Boneless - no brand	1 kg	0.43	Food
Beef “nalga”	With bone - no brand	1 kg	0.43	Food
Beef “aguja” meat	Boneless - no brand	1 kg	0.86	Food
Beef “aguja” meat	With bone - no brand	1 kg	0.86	Food
Beef “paleta”	With bone - no brand	1 kg	n/i	Food
Beef "rueda"	With bone - no brand	1 kg	n/i	Food
Ground beef	Up to 20% Fat	1 kg	0.29	Food
Ground beef	Up to 5% Fat	1 kg	0.29	Food
Bread	No brand	1 Unit Aprox. 0.215 kg	1.21	Food
Brown eggs	El Ecologito	1/2 Dozen	0.34	Food
Brown eggs	El Jefe	1/2 Dozen	0.34	Food
Brown eggs	Prodhin	1/2 Dozen	0.34	Food
Butter	Calcar	0.2 kg	0.15	Food
Butter	Conaprole sin sal	0.2 kg	0.15	Food
Butter	Lacterma	0.2 kg	0.15	Food
Cacao	Copacabana	0.5 kg	0.04	Food
Cacao	Vascolet	0.5 kg	0.04	Food
Cheese Colonia	Cerros del Este	1 kg	0.23	Food
Cheese Colonia	Dispnat	1 kg	0.23	Food
Chicken	Avícola del Oeste	1 kg	0.64	Food
Chicken	Tenent	1 kg	0.64	Food
Coffee (non-instant)	Águila	0.25 kg	0.10	Food
Coffee (non-instant)	Chana	0.25 kg	0.10	Food
Caramel spread	Conaprole	1 kg	0.14	Food
Caramel spread	Los Nietitos	1 kg	0.14	Food
Caramel spread	Manjar	1 kg	0.14	Food
Flour	Canuelas	1 kg	0.16	Food
Flour	Cololo	1 kg	0.16	Food
Flour	Puritas	1 kg	0.16	Food
Frankfurters (short)	Cattivelli	8 Units - Aprox. 0.340 kg	0.26	Food
Frankfurters (short)	Ottonello	8 Units - Aprox. 0.330 kg	0.26	Food
Frankfurters (short)	Schneck	8 Units - Aprox. 0.330 kg	0.26	Food
Grated cheese	Conaprole	0.08 kg	0.15	Food
Grated cheese	El Trébol	0.08 kg	0.15	Food
Grated cheese	Milky	0.08 kg	0.15	Food
Semolina noodles	Adria	0.5 kg	n/i	Food
Semolina noodles	Las Acacias	0.5 kg	n/i	Food
Ham	Centenario	1 kg	0.21	Food
Ham	La Constancia	1 kg	0.21	Food

Product	*Brand*	*Specification*	*Share in CPI (%)*	*Category*
Ham	Schneck	1 kg	0.21	Food
Margarine	Danica dorada	0.2 kg	0.02	Food
Margarine	Doriana nueva	0.25 kg	0.02	Food
Margarine	Primor	0.25 kg	0.02	Food
Mayonnaise	Fanacoa	0.5 kg	0.09	Food
Mayonnaise	Hellmans	0.5 kg	0.09	Food
Mayonnaise	Uruguay	0.5 kg	0.09	Food
Noodles	Cololo	0.5 kg	0.3	Food
Peach jam	Dulciora	0.5 kg	0.17	Food
Peach jam	Limay	0.5 kg	0.17	Food
Peach jam	Los Nietitos	0.5 kg	0.17	Food
Canned peas	Arcor	0.35 kg	0.05	Food
Canned peas	El Hogar	0.35 kg	0.05	Food
Canned peas	Trofeo	0.35 kg	0.05	Food
Quince jam	Los Nietitos	0.4 kg	n/i	Food
Rice	Aruba type Patna	1 kg	0.20	Food
Rice	Blue Patna	1 kg	0.20	Food
Rice	Green Chef	1 kg	0.20	Food
Rice	Pony	1 kg	0.20	Food
Rice	Vidarroz	1 kg	0.20	Food
Crackers	El Trigal	0.15 kg	0.17	Food
Crackers	Famosa	0.14 kg	0.17	Food
Crackers	Maestro Cubano	0.12 kg	0.17	Food
Salt	Sek	0.5 kg	0.05	Food
Salt	Torrevieja	0.5 kg	0.05	Food
Salt	Urusal	0.5 kg	0.05	Food
Semolina pasta	Adria	0.5 kg	n/i	Food
Semolina pasta	Las Acacias - franja celeste	0.5 kg	n/i	Food
Soybean oil	Condesa	0.9 l	n/i	Food
Sugar	Azucarlito	1 kg	0.25	Food
Sugar	Bella Union	1 kg	0.25	Food
Sunflower oil	Optimo	0.9 l	0.25	Food
Sunflower oil	Uruguay	0.9 l	0.25	Food
Tea	Hornimans	Box 10 units	0.09	Food
Tea	La Virginia	Box 10 units	0.09	Food
Tea	Lipton	Box 10 units	0.09	Food
Tomato paste	Conaprole	1 l	0.08	Food
Tomato paste	De Ley	1 l	0.08	Food
Tomato paste	Qualitas	1 l	0.08	Food
Yerba mate	Canarias	1 kg	0.34	Food
Yerba mate	Del Cebador	1 kg	0.34	Food
Yerba mate	Sara	1 kg	0.34	Food
Yogurt	Conaprole	0.5 kg	0.06	Food
Yogurt	Parmalat (Skim)	0.5 kg	0.06	Food
Sodium hypoclorite	Agua Jane	1 l	0.08	Personal
Sodium hypoclorite	Sello Rojo	1 l	0.08	Personal
Sodium hypoclorite	Solucion Cristal	1 l	0.08	Personal
Diswashing detergent	Deterjane	1.25 l	0.20	Personal
Diswashing detergent	Hurra Nevex Limon	1.25 l	0.20	Personal

Product	*Brand*	*Specification*	*Share in CPI (%)*	*Category*
Laundry soap	Drive	0.8 kg	n/i	Personal
Laundry soap	Nevex	0.8 kg	n/i	Personal
Laundry soap	Skip - Paquete azul	0.8 kg	n/i	Personal
Laundry soap in bar	Bull Dog	0.3 k - 1 unit	0.45	Personal
Laundry soap in bar	Nevex	0.2 k - 1 unit	0.45	Personal
Shampoo	Fructis	0.35 l	n/i	Personal
Shampoo	Sedal	0.35 l	n/i	Personal
Shampoo	Suave	0.93 l	n/i	Personal
Soap	Astral	0.125 kg	0.16	Personal
Soap	Palmolive	0.125 kg	0.16	Personal
Soap	Suave	0.125 kg	0.16	Personal
Toilet paper	Higienol Export	4 unit - 25 m each	0.24	Personal
Toilet paper	Personal	4 unit - 25 m each	0.24	Personal
Toilet paper	Sin Fin	4 unit - 25 m each	0.24	Personal
Toothpaste	Closeup Triple	0.09 kg	0.49	Personal
Toothpaste	Colgate Total	0.09 kg	0.49	Personal
Toothpaste	Kolynos	0.09 kg	0.49	Personal
Cola	Coca Cola	1.5 l	1.94	Soft drinks
Cola	Nix	1.5 l	1.94	Soft drinks
Cola	Pepsi	1.5 l	1.94	Soft drinks
Sparkling water	Matutina	2 l	0.70	Soft drinks
Sparkling water	Nativa	2 l	0.70	Soft drinks
Sparkling water	Salus	2.25 l	0.70	Soft drinks

SOURCE: Own elaboration from data of the Uruguayan Ministry of Economy and Finance.
NOTE: n/i means not included in the CPI. k: kilogram, l: liter and m: meter.

Annex 3

PROBABILITY OF PRICE CHANGES AND DURATION BY PRODUCT

Product	*Brand*	*Probability of daily variation*	*Monthly price duration*	*Percentage decrease*
Beer	Patricia	0.008	3.9	20.4
Beer	Pilsen	0.009	3.5	23.2
Common red wine	Roses	0.008	4.0	22.1
Common red wine	Santa Teresa Clásico	0.012	2.7	38.3
Common red wine	Tango	0.011	2.9	39.4
Beef “peceto”	No brand	0.026	1.2	40.3
Beef “nalga”	Boneless - no brand	0.027	1.2	43.1
Beef “nalga”	With bone - no brand	0.015	2.2	34.2
Beef “aguja” meat	Boneless - no brand	0.018	1.8	34.7
Beef “aguja” meat	With bone - no brand	0.027	1.2	40.1
Beef “paleta”	With bone - no brand	0.028	1.2	39.9
Beef “rueda”	With bone - no brand	0.013	2.5	34.2
Ground beef	Up to 20% fat	0.022	1.5	37.5
Ground beef	Up to 5% fat	0.019	1.7	36.6

Product	Brand	Probability of daily variation	Monthly price duration	Percentage decrease
Bread	No brand	0.011	2.9	28.6
Brown eggs	El Ecologito	0.007	5.0	24.7
Brown eggs	El Jefe	0.008	4.2	29.5
Brown eggs	Prodhin	0.012	2.8	33.8
Butter	Calcar	0.018	1.8	41.8
Butter	Conaprole sin sal	0.016	2.0	32.3
Butter	Lacterma	0.007	4.7	43.2
Cacao	Copacabana	0.011	2.9	34.4
Cacao	Vascolet	0.019	1.7	40.7
Cheese Colonia	Cerros del Este	0.068	0.5	45.0
Cheese Colonia	Dispnat	0.145	0.2	48.4
Chicken	Avícola del Oeste	0.041	0.8	42.8
Chicken	Tenent	0.039	0.8	44.6
Coffee (non-instant)	Águila	0.009	3.7	34.0
Coffee (non-instant)	Chana	0.007	4.6	42.6
Caramel spread	Conaprole	0.013	2.5	33.3
Caramel spread	Los Nietitos	0.013	2.6	40.0
Caramel spread	Manjar	0.013	2.6	31.4
Flour	Canuelas	0.027	1.2	43.7
Flour	Cololo	0.024	1.4	39.6
Flour	Puritas	0.015	2.2	36.3
Frankfurters (short)	Cattivelli	0.010	3.2	45.7
Frankfurters (short)	Ottonello	0.012	2.7	42.4
Frankfurters (short)	Schneck	0.015	2.1	36.1
Grated cheese	Conaprole	0.009	3.8	25.1
Grated cheese	El Trébol	0.009	3.5	36.9
Grated cheese	Milky	0.007	4.4	30.0
Semolina noodles	Adria	0.015	2.2	36.6
Semolina noodles	Las Acacias	0.019	1.7	40.2
Ham	Centenario	0.008	4.2	29.0
Ham	La Constancia	0.034	1.0	46.1
Ham	Schneck	0.015	2.2	35.8
Margarine	Danica dorada	0.012	2.7	39.0
Margarine	Doriana nueva	0.013	2.6	42.6
Margarine	Primor	0.016	2.1	41.2
Mayonnaise	Fanacoa	0.011	3.0	39.5
Mayonnaise	Hellmans	0.021	1.5	41.9
Mayonnaise	Uruguay	0.024	1.3	42.3
Noodles	Cololo	0.017	1.9	38.8
Peach jam	Dulciora	0.012	2.6	35.9
Peach jam	Limay	0.008	4.1	30.4
Peach jam	Los Nietitos	0.011	3.0	37.9
Canned peas	Arcor	0.010	3.3	42.9
Canned peas	El Hogar	0.009	3.5	25.3
Canned peas	Trofeo	0.017	1.9	44.4
Quince jam	Los Nietitos	0.011	2.9	38.6
Rice	Aruba tipo Patna	0.018	1.8	43.4
Rice	Blue Patna	0.024	1.4	41.4

Product	*Brand*	*Probability of daily variation*	*Monthly price duration*	*Percentage decrease*
Rice	Green Chef	0.027	1.2	42.6
Rice	Pony	0.009	3.5	41.1
Rice	Vidarroz	0.012	2.7	49.3
Crackers	El Trigal	0.009	3.6	32.4
Crackers	Famosa	0.010	3.2	29.5
Crackers	Maestro Cubano	0.012	2.6	41.1
Salt	Sek	0.011	3.1	41.9
Salt	Torrevieja	0.007	4.7	30.4
Salt	Urusal	0.012	2.7	41.7
Semolina pasta	Adria	0.015	2.2	35.6
Semolina pasta	Las Acacias	0.018	1.9	41.1
Soybean oil	Condesa	0.029	1.1	56.2
Sugar	Azucarlito	0.017	1.9	35.3
Sugar	Bella Union	0.017	2.0	34.7
Sunflower oil	Óptimo	0.033	1.0	42.1
Sunflower oil	Uruguay	0.032	1.0	40.9
Tea	Hornimans	0.009	3.5	46.5
Tea	La Virginia	0.010	3.2	46.8
Tea	Lipton	0.009	3.8	40.6
Tomato paste	Conaprole	0.017	1.9	36.3
Tomato paste	De Ley	0.012	2.7	34.4
Tomato paste	Qualitas	0.012	2.8	45.8
Yerba mate	Canarias	0.013	2.5	38.1
Yerba mate	Del Cebador	0.013	2.5	36.4
Yerba mate	Sara	0.015	2.2	40.4
Yogurt	Conaprole	0.013	2.6	29.5
Yogurt	Parmalat (Skim)	0.012	2.8	34.1
Sodium hypoclorite	Agua Jane	0.018	1.8	37.7
Sodium hypoclorite	Sello Rojo	0.015	2.2	33.6
Sodium hypoclorite	Solucion Cristal	0.018	1.8	43.3
Diswashing detergent	Deterjane	0.024	1.3	44.1
Diswashing detergent	Hurra Nevex Limon	0.024	1.4	43.3
Laundry soap	Drive	0.015	2.2	43.1
Laundry soap	Nevex	0.023	1.4	44.8
Laundry soap	Skip - Paquete azul	0.018	1.8	45.3
Laundry soap in bar	Bull Dog	0.016	2.0	39.6
Laundry soap in bar	Nevex	0.015	2.2	39.8
Shampoo	Fructis	0.022	1.5	44.5
Shampoo	Sedal	0.016	2.1	47.3
Shampoo	Suave	0.011	3.0	45.0
Soap	Astral	0.018	1.8	46.3
Soap	Palmolive	0.023	1.4	50.0
Soap	Suave	0.013	2.5	46.6
Toilet paper	Higienol Export	0.016	2.1	32.7
Toilet paper	Personal	0.013	2.5	31.8
Toilet paper	Sin Fin	0.021	1.6	41.8
Toothpaste	Closeup Triple	0.009	3.7	38.1
Toothpaste	Colgate Total	0.023	1.4	39.1

Product	Brand	Probability of daily variation	Monthly price duration	Percentage decrease
Toothpaste	Kolynos	0.013	2.5	34.6
Cola	Coca Cola	0.010	3.3	25.5
Cola	Nix	0.008	4.0	34.6
Cola	Pepsi	0.010	3.2	31.7
Sparkling water	Matutina	0.011	3.0	43.0
Sparkling water	Nativa	0.007	4.6	27.0
Sparkling water	Salus	0.013	2.6	35.0

SOURCE: Own elaboration from data of the Uruguayan Ministry of Economy and Finance.

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Price Flexibility in an inflationary Economy: Case Venezuela

León Fernández Bujanda*

1. INTRODUCTION

Over the last 25 years, Venezuela has gone through a chronic inflation process; that is, price variation rate has remained in the neighborhood of two digits. Given this circumstance, agents have devised formal and informal indexation mechanisms. This process, in turn, might be linked to credibility problems, in terms of economic policies, or to the maintenance of imbalances in the economy. These factors could be a reason for the persistence of the behavior of price variation over time, which is common in cases of chronic inflation and has been present in the Venezuelan case (Álvarez et al., 2002; Dorta et al., 2002).

The study on price duration provides us with a mechanical way of looking at this phenomenon. Price rigidity, combined with the overlapping of their adjustments, results in a highly persistent inflation rate, especially if those adjustments are made under time-dependent price setting rules (Taylor, 1999). As a consequence, estimating how long a price could last provides relevant information in terms of formulation of the monetary policy, especially in a context in which price adjustment frequency is also positively associated with inflation rate.

Even though literature on the topic of price duration has been nurtured with new references over recent years, this topic has not been dealt with in Venezuela. An important part of the literature on rigidity assessment comes from the Eurosystem Inflation Persistence Network Project,

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in which the European Central Bank, along with central banks of Continental Europe, was involved. The results of the project have been already summarized in Álvarez et al. (2006), and Dhyne (2006). Furthermore, similar studies with US data (Bils and Klenow, 2004; Klenow and Kryvtsov, 2008; Nakamura and Steinsson, 2008), the United Kingdom (Bunn and Ellis, 2009) and Brazil (Gouvea, 2007) have been carried out. In general, this research project has found that prices in Europe are more rigid than in the USA. For instance, median duration in the first case is 13 months, whereas in the second case is eight months.

With the purpose of knowing the rigidity degree of prices in an inflationary economy, in this paper we analyze the variation frequency of consumer prices in Venezuela with the information contained in the database used to estimate the Consumer Price Index (CPI) of the Caracas Metropolitan Area (CMA). The study covers the period running from January 2000 through December 2007, which is characterized by an average monthly inflation rate of 1.5%, equivalent to 20% per year. The database contains a total number of observations that is close to three million prices observed in more than 34,000 individual products with 80% coverage of CPI. Those items in which imputations play a major role and which are administered by an Executive authority, such as underground transportation rates or gasoline, are excluded from this analysis.

In contrast with the results obtained in other countries, consumer prices in Venezuela show a higher degree of flexibility. In this regard, the estimated duration of a price in Venezuela is 3 months as per the direct method and 2.6 months by the indirect method. This contrasts with the results for Europe (13 months) and the USA (8 months). Likewise, our results show that, in 50% of the items, prices change every 1.9 months, at most, on average.

An aspect that is similar to other international results is the heterogeneity of price duration. In fact, service prices tend to be less flexible than other prices in the CPI basket, which may be indicative of cost rigidity, especially wage costs, presence in these activities. For instance, prices of hospital, preschool, basic, secondary and higher education services remain constant at least for six months. However, prices of those good for which imports are a major component of overall supply tend to be the most flexible ones, as shown by home textile products, vehicles and telephone equipment, which last less than two months, on average.

This paper also presents the hazard rate estimate, showing that it is not constant in time. In fact, probability of a change of price, give that it has not previously changed, increases with the number of months during which the price has remained fixed. This could be explained by the presence of inflation inertia or heterogeneity in price adjustment mechanisms.

The work is divided into the following sections: introduction; section 2 that describes data that will be used in the assessment of price rigidity. The main results, together with a brief methodology description, will be commented in section 3. With the aim of being exhaustive in the estimate, both the direct and indirect methods are applied.

In section 4, the question of whether price duration is the same for all goods in the average consumer basket is answered. The main message of this section is that the highest duration of prices is associated with services and price controls. Section 5 deals with estimating the probability of change in a conditional price as of the date of the last change, that is, hazard rate. Finally, conclusions and remarks are presented in section 6, outlining that the main contribution of this work is the identification of stylized facts relative to price formation in Venezuela, which should be a part of the macroeconomic models adapted to the Venezuelan reality.

2. DATA

Information required to estimate price duration in this work is taken from the database of prices used to calculate CPI in the CMA.[1] The sample period includes price observations since January 2000 through December 2007. However, not all of the items in the CMA-CPI were included in this research.[2] The *rentals for housing* group and the *insurance* subgroup do not belong to this study, since imputations are used for the calculation of their respective indices. Likewise, prices of items that are administered by any government level, either national, regional or local. These correspond to housing services (refuse collection, water supply, electricity, etc.), gasoline and land passenger transportation rates (extra-urban,

[1] The base CMA-CPI basket was changed as from January 2008. A few months later, a new indicator was introduced to measure inflation in Venezuela, i.e. the National Price Consumer Index, which included CMA-CPI as an input data for the calculation. However, the calculation methodology of the indicator for the Caracas Metropolitan Area was not modified with the introduction of the new index.

[2] The 1977's base CMA-CPI basket includes 287 items, which are the most detailed components of goods and services measured by this indicator. These items are classified into 13 groups, which, in turn, are divided into 38 groups.

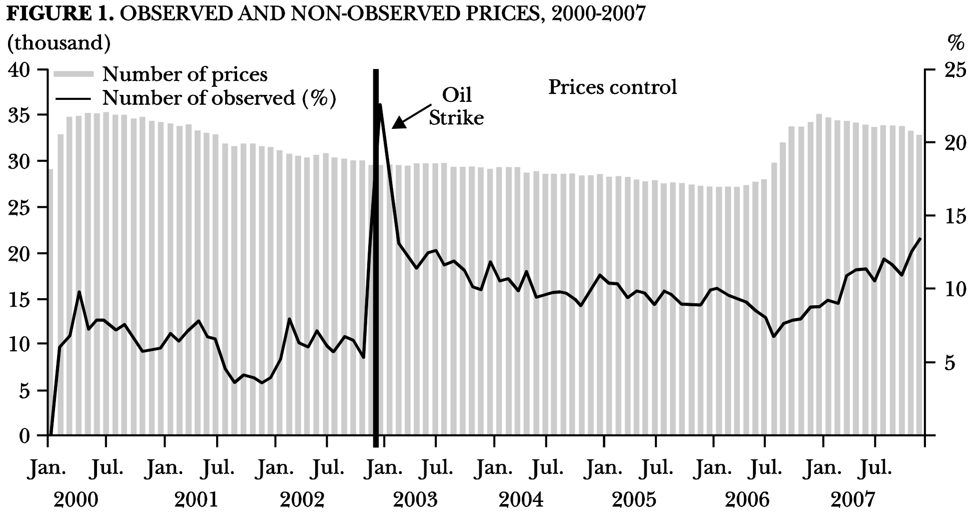
urban, trunk routes, etc.). However, price-controlled items are covered by our study, because prices of these goods and services are not necessarily set at regulated levels in the market.

The database to be used contains the following information: *1)* a field that identifies the specific product, including to which group, subgroup, class, subclass and category this product belongs; *2)* a field that identifies the type of store and another field that identifies the area where the store is located; *3)* the exact current price of the product at time *t; 4)* the month and year when the price was recorded; *5)* an identifier if the price is imputed; and *6)* the date when product follow-up ended.

In general, a potential of almost three million of price observations, of which a few more than 260,000 correspond to non-observed data, have been gathered. Figure 1 shows how potential data and non-observed data are distributed in time. The most outstanding characteristic seen in the figure is the drop in the number of prices within the sample in the period between July 2000 and April 2006, from 35,000 to 27 thousand prices. This decrease can be attributed to methodological changes that were incorporated along with the new base year and to the usual observation loss resulting from erosion of qualified informants. Up until November 2002, the percentage of absences or non-observed prices did not exceed 10% in any of the months.

In December 2002, the political instability climate in Venezuela led to a strike in the oil sector and part of the private sector. As usual in this type

FIGURE 1. OBSERVED AND NON-OBSERVED PRICES, 2000-2007



of situations, a significant level of absence in observed prices occurred, reaching a maximum of 23% of potential observations in January 2003.

In response to the severe economic situation brought about by the political crisis, the National Executive implemented price controls, among other measures. Up until now, price controls have not been lifted, although modifications have been introduced. Prices of almost half of the items of the CPI basket are controlled and this has been associated with an increase in non-observed data. In this regard, the absence of prices reached an average of 10% since February 2003, although it exhibited an increasing trend towards the end of the study period, reaching a maximum of 13% in December 2007. Precisely, due to difficulties in gathering information on prices at the stores' level, the sample size was increased in April 2006.

Non-observed prices were imputed through different methods with the aim of estimating CPI. While these methods are suitable to follow up inflation, they may not be as suitable to estimate price duration. For instance, one method to carry out these corrections is by replacing a non-observed price with an average price taken from data gathered from similar stores. However, this does not necessarily reflect the price that the store would have set if it would have had the missing product available for sale. In this regard, for the purposes of this study, only data truly gathered at the outlet level were used. Furthermore, in this work, non-observed prices, which were in the middle of two prices, were imputed by the carry-forward method. This method consists of allocating the value of the price in the previous month to the non-observed price. The consequence of this decision is that duration could be slightly overestimated. For the effects of this study, this would not be very significant given the size of the sample.

The database used in this paper contains a total over two million and a half observed prices that correspond to more than 82,000 specific products, with 80.3% coverage of CPI, as shown in Table 1. This Table presents the number of prices available for the analysis, divided per CPI group, as well as their share in total prices within the sample and average weighing corresponding to each price in the basket. Almost half of the individual data belong to the *food and nonalcoholic beverages* group, which is the one with the highest weighing in the price indicator and presents the maximum variety of items. Furthermore, the *communications* group has the least amount of observed prices because in Venezuela, residential telephone service is provided by a single company and mobile phone, by three firms.

TABLE 1. PRICE DISTRIBUTION PER GROUP

Group	*Number of prices*	*Percentaje*	*Weighting PCI*
Food & nonalcoholic beverages	1,302,749	47.17	24.38
Alcoholic beverages & tobacco	67,897	2.46	1.43
Clothing & footwear	203,511	7.37	4.41
Home equipment	257,927	9.34	5.54
Health	171,568	6.21	5.56
Transportation	127,675	4.62	13.06
Communications	21,832	0.79	5.24
Recreation & culture	142,603	5.16	4.18
Educational services	50,016	1.81	6.18
Restaurants & hotels	173,066	6.27	6.98
Miscellaneous goods & services	242,894	8.79	3.36
Total	*2,761,738*	*100.00*	*80.31*

NOTE: The number of prices corresponds to actually observed prices and to those obtained by the *carry-forward* method, as explained in the text. CPI weighing is the average of monthly weightings between January, 2000 and December, 2007, used to calculate the index value.

3. DURATION

In this paper, price duration is estimated through two methods: direct and indirect. The direct method estimates how long it takes for a price to change, using duration distribution, which can be calculated using the information contained in the panel data set. The second method estimates duration based on the frequency with which prices change every month, hence its name indirect. This section presents the results of both methods, preceded by a brief description thereof.

3.1 Direct Method

The starting point of the direct method is a sample of price episodes, which are defined as a sequence throughout which prices remain unchanged. Each episode has a duration associated with it; that is, a period that extends from the beginning through the end of the episode. Duration will be expressed by Tj,k,i, where j, k and i refer to the specific good, the store and the episode, respectively. A specific good j purchased at a k[3] store will be referred to as particular product. With this information, we

[3] A specific good corresponds to the observation unit in the price survey, which means a good or service of a specific brand, physical features and determined quality.

are able to estimate direct duration as the simple average of times in each episode; that is:

$$\bar{T} = \frac{\sum_{j=1}^{J}\sum_{k=1}^{K_j}\sum_{i=1}^{N_{j,k}} T_{j,k,i}}{\sum_{j=1}^{J}\sum_{k=1}^{K_j} N_{j,k}}, \tag{1}$$

where $N_{j,k}$ is the number of episodes observed per particular product.

A fact that emerges from the calculation of the simple average is that lower durations tend to be given more weight, since products with prices that change more frequently will provide more observations of $T_{j,k,i}$. To avoid this problem, averaging durations per category and then applying a weighing scheme has been suggested. In the case of this work, a weighted average of duration is estimated using the following formula:

$$\alpha_{j,k,i} = \sum_{j=1}^{J} w_j \bar{T}_j = \sum_{j=1}^{J}\sum_{k=1}^{K_j}\sum_{i=1}^{N_{j,k}} \alpha_{j,k,i} T_{j,k,i}, \tag{2}$$

where w_j is the weight of the corresponding item in the CPI and $\bar{T}_j$ is the simple average of durations in category j (Baudry et al. 2007). The second member of (2) indicates that this average can be obtained directly from the distribution of durations that have been weighted as follows:

$$\alpha_{j,k,i} = \frac{w_j}{\sum_{k=1}^{K_j} N_{j,k}},$$

that is, by dividing the item's weight by the number of episodes corresponding to it.

Table 2 presents some descriptive statistics as to the distribution of durations estimated through the direct method. In the first column, the reference population corresponds to episodes; that is, without applying any type of weighing. In this case, the sample size is close to 1.2 million observations. First, it can be seen that a price in Venezuela remains unchanged for 2.4 months, on average. It is clear that this calculation is influenced by extreme values; for instance, maximum duration is 96 months, or the entire sample period. Second, when we see a central trend measurement, which is affected in a lesser degree by these high values, it is found out that at least 50% of these prices change from one month to the other and that only 25% of these prices last two months or more.

TABLE 2. PRICE DURATIONS DISTRIBUTION

Population	*All episodes*	*Average per item*	*Weighed episodes*
Average	2.35	2.99	2.99
Median	1.00	2.44	1.00
Standard deviation	2.97	1.86	3.94
Minimum	1.00	1.04	1.00
Maximum	96.00	10.30	96.00
First quartile	1.00	1.90	1.00
Third quartile	2.00	3.09	3.00
Number of episodes	1,177,33	270	1,177,338

NOTES: The number of prices corresponds to actually observed prices and to those obtained by the *carry-forward* method, as explained in the text. CPI weighing is the average of monthly weightings between January, 2000 and December, 2007, used to calculate the index value.

The second column in Table 2 contains an estimate of price duration distributions obtained by averaging per items and weighing them based on their respective weight in the CPI basket. As expected due to the reasons described when the methodology was explained, the weighted average of duration (3 months) is slightly higher than the simple average shown on the first column. On the contrary, a significant difference is observed in the median, because in this new distribution, prices of 50% of the items last at least 2.4 months.

The third column of the table presents the results of the price durations estimated by using weighing per episode, instead of item. It is obvious that the price duration average is similar to that in the previous case. However, at least 50% of the prices remain unchanged for only one month, like in the case of the non-weighted episodes. Even with the new weighing scheme, duration distribution is slightly different to that presented by the two previous columns. For instance, the third quartile corresponds to three months, unlike the two-month non-weighted durations and 3.1-month weighed duration estimated by the simplest method.

3.2 Indirect Method

One of the criticisms raised about the direct method has been that longer episodes have a higher probability of being censored toward left or right; therefore, their duration could be underestimated when this method is applied.[4] To avoid this problem, some authors have proposed to use the indirect method instead. This method starts by defining indicator $I_{j,t} = 1$, if $P_{j,t} \neq P_{j,t-1}$ and $I_{j,t} = 0$ in the opposite case.[5] Identifying the size of the indicator sample as $I_{j,t}$ per item Γ_j, we can estimate the average frequency of price change per item using the following formula:

$$F_j = \frac{1}{\Gamma_j} \sum_{t=1}^{\Gamma_j} I_{j,t} .$$

Therefore, the total average frequency of price change can be obtained by the formula below:

$$F_j = \frac{1}{Q} \sum_{j=1}^{J} \sum_{t=1}^{\Gamma_j} I_{j,t} ,$$

where Q is the total number of observations; the weighted average of these frequencies will be computed as follows:

$$F^W = \sum_{j=1}^{J} w_j \bar{I}_j .$$

Finally, a time series of price change frequencies can be estimated by obtaining the weighted average of the series in the month *t* through the following formula:

$$F_t = \sum_{j=1}^{J} w_j I_{j,t} .$$

Then, price duration can be estimated in an indirect fashion using the information provided by price change frequencies; this is also known as implicit duration. Assuming that changes occur continuously throughout a month, duration is estimated using the following formula:

(3) $$\bar{T}^F = 1 \big/ \ln(1-F) .$$

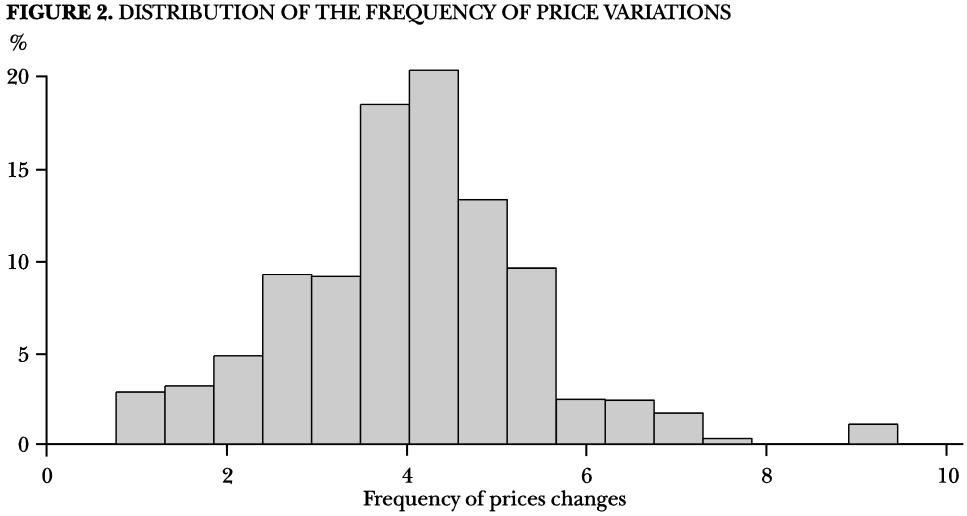
[4] Duration of the initial episode of each price is leftward censored, because the first month of that episode is generally not observed due to how data collection is designed. Durations of final episodes, in turn, are also censored, but in this case rightward, because the particular product is out of the sample or because the end of the data collection period has been reached.

[5] We have avoided the store index so as not to render notation more complicated.

This formula can be applied to any of the frequencies previously defined, by substituting *F* with the corresponding frequency.

Calculations performed according to the formulas described above reveal that distribution of price variation frequencies is slightly skewed toward the left, around the value of 0.4, as shown in Figure 2 that also presents the histogram of these frequencies, averaged by item. According to the same figure, 35%-50% of prices change every month in most items. On the other hand, very few items exhibit a high flexibility degree; that is, their frequency is close to one; whereas, for items with a higher rigidity degree, average price variation frequency is about 10%.

FIGURE 2. DISTRIBUTION OF THE FREQUENCY OF PRICE VARIATIONS



The characteristics of the distribution of the price variation frequencies for each item are summarized in Table 3, which also presents the results of the estimate of implicit price duration. It can be observed that 41% of prices change every month, on average. Therefore, a price remains constant for an average period of 2.6 months. It is worth highlighting that this value is slightly lower than the one computed using the direct method with weighing. Likewise, an asymmetry similar to that seen in direct duration is observed, because prices of 50% of items last less than 1.9 months, on average. Furthermore, prices of goods and services have a quite long duration; this fact that can be verified because the market value of 25% of items remains unchanged for at least 2.7 months.

TABLE 3. DISTRIBUTION OF PRICE VARIATIONS FREQUENCIES AND IMPLICIT DURATIONS

Frequency of price changes (weighed)	
Mean	0.412
Median	0.412
5th percentile	0.106
25th percentile	0.308
75th percentile	0.519
95th percentile	0.677
Number of items	270
Indirect durations (months)	
Mean	2.600
Median	1.884
5th percentile	0.886
25th percentile	1.365
75th percentile	2.712
95th percentile	8.928

NOTES: This table reports the distribution of average frequencies per item, weighed per their corresponding weight within CPI. Indirect durations were calculated using the formula $-1/\ln(1 - F)$, where F_j is the item's average frequency.

3.3 Results Robustness

To conclude this section, a number of estimates carried out to asses robustness of the results described above are presented. In this regard, Table 4 presents the results of several calculation exercises of direct and indirect duration. The first two rows include the same information as that shown in Tables 2 and 3, so that it can be easily assessed. The first of these exercises consists of excluding those paths that only had two observations. In this case, we can see that direct durations are not practically impacted, even though indirect durations are slightly higher.

The next exercise consisted of estimating durations only through the direct method for two-year periods starting in January 2000. To perform these calculations, all episodes that started on a date falling within the corresponding two-year interval were included in the average, regardless of their final date. As expected, estimated durations are longer in inflation deceleration periods, i.e. 2000-2001 and 2004-2005. On the contrary, the period with the shortest estimated duration, 2006-2007, is not precisely the most inflationary one.

In addition, durations were estimated excluding price temporary discounts, which are defined as price decreases that last only one month. Some authors argue that price rigidity should be estimated without including this kind of offer due to their transient nature. Since the database does not have any field that allows us to directly identify offers and sales, it was necessary to use a filter that we described as temporary cutbacks. When a temporary cutback occurs, the price is replaced with that of the previous month; whereas in the case of frequencies, it was considered a non-observed data. As expected, estimated price duration is higher when price temporary cutbacks are not taken into account. In the case of direct duration, it is estimated that prices change every 3.1 months and in the case of indirect duration, 2.8 months.

TABLE 4. ROBUSTNESS ANALYSIS

	Number of episodes/items	*Mean*	*Median*	*Standard deviation*	*25th percentile*	*75th percentile*
Baseline						
Direct duration	1,177,338	2.99	1.00	3.94	1.00	3.00
Indirect duration	270	2.60	1.88	2.21	1.37	2.71
Excluding two-month duration paths						
Direct duration	1,170,640	3.00	1.00	3.94	1.00	3.00
Indirect duration	270	2.70	2.01	2.27	1.37	2.92
2000m01-2001m12						
Direct duration	329,383	3.26	1.00	4.28	1.00	4.00
2002m01-2003m12						
Direct duration	288,182	3.04	1.00	4.49	1.00	3.00
2004m01-2005m12						
Direct duration	245,565	3.12	1.00	3.90	1.00	4.00
2006m1-2007m12						
Direct duration	294,686	2.56	1.00	2.83	1.00	3.00
2000m01-2006m12						
Direct duration	1,019,562	3.13	1.00	4.14	1.00	3.00
Non-censored						
Direct duration	1,025,943	2.72	1.00	3.52	1.00	3.00
Excluding temporary decreases						
Direct duration	1,015,976	3.13	1.00	4.08	1.00	4.00
Indirect duration	270	2.73	2.12	2.20	1.49	2.90

NOTES: This table reports distributions of direct and indirect durations for several cases. The baseline corresponds to the results shown in tables 2 and 3. For direct durations corresponding to specific periods, the date when the episode starts was taken as a reference. For instance, the estimated direct duration for the 2000m01-2000m12 period includes all episodes starting within that period. Non-censored episodes are those for which their start and end are observed. Temporary decreases are those that last only one month. For the calculation of direct episodes, the price of the prior month when a temporary decrease takes place is replaced. For the calculation of indirect duration, the change indicating variable was treated as a non-observe data. All values are weighed per their corresponding price.

4. HETEROGENEOUS NATURE OF DURATIONS

As determined for other countries, price duration in Venezuela is heterogeneous among the different types of products. In general, rates and prices of services tend to remain unchanged longer, particularly, education and health; the same happens with price-controlled products. The more flexible goods and services are those which prices are associated with the exchange rate, as well as others that due to their nature are highly volatile in terms of prices, such as unprocessed food.

4.1 Descriptive Statistics

Table 5 presents estimates of direct durations, price change frequencies and implicit durations per subgroups. We are going to focus on implicit durations only, because both types of durations are the same from a qualitative point of view. The main finding taken from these results is that average price duration is heterogeneous, as stated previously, with durations associated with some services being longer. In this regard, subgroups in which prices appear to be more rigid belong to the *educational services* group. In fact, the three subgroups exhibiting the longer duration are registration fees in secondary education (11 months), in higher education (8.5 months) and in preschool and basic education (8.4 months). This can be attributed to the fact that implicit contracts between educational service providers and their corresponding users prevail, in addition to the institutional characteristic that educational prices have a legally set duration.

Besides those mentioned above, one of the subgroups with the highest price stability is related to health, including hospital services with duration of 5.9 months, on average. Likewise, prices of social services (nursery rates) and telephone and telefax services tend to remain stable, relatively speaking (4.1 months and 3.6 months, respectively). The longest price duration in services mentioned herein can also be related to the high share of labor costs in total costs of these activities. In the Venezuelan case, average wage is very close to the minimum wage that changes twice a year, at most. Therefore, it is not surprising that prices in subgroups associated with hospital and social services are more rigid, with price adjustments practically occurring with the same frequency as that of minimum wage.

The most flexible prices correspond to those of goods and services in which imported supply is significantly high or the prices of which are set

TABLE 5. DIRECT AND IMPLICIT DURATION PER GROUP

	Direct						Indirect		
Groups and	*Number of episodes*	*Mean*	*Median*	*Standard deviation*	*First quartile*	*Third quartile*	*Price frecuenc.*	*Average duration*	*Median duration*
Food & nonalcoholic beverages									
Food	554,860	2.09	1.00	2.57	1.00	2.00	0.50	1.56	1.45
Nonalcoholic	51,467	2.29	1.00	2.64	1.00	2.00	0.44	1.77	1.62
Alcoholic beverages &									
Alcoholic	19,230	2.40	1.00	2.60	1.00	3.00	0.43	1.83	2.03
Tobacco	5,690	3.64	2.00	4.23	1.00	5.00	0.27	3.22	3.22
Clothing & Footwear									
Clothing	61,351	2.42	1.00	3.09	1.00	2.00	0.40	2.00	1.97
Footwear	21,527	2.39	1.00	3.08	1.00	2.00	0.41	1.97	2.22
Home equipment									
Furniture, accessories, decorations & carpets	8,308	2.31	1.00	2.58	1.00	2.00	0.45	1.82	1.56
Home textile	10,929	1.91	1.00	2.47	1.00	2.00	0.53	1.36	1.14
Home equipment	17,391	2.42	1.00	3.43	1.00	3.00	0.45	1.94	1.43
Home equipment	2,081	2.27	1.00	2.38	1.00	2.00	0.44	1.74	1.74
Goods & services for home maintenance	76,914	2.59	2.00	1.99	1.00	4.00	0.39	2.06	2.31
Health									
Medicines and therapeutic equipment	27,281	2.52	1.00	3.02	1.00	3.00	0.40	1.96	1.88
Medical and paramedical services	19,913	3.95	1.00	5.85	1.00	4.00	0.25	3.56	3.50
Hospital	3,610	5.81	3.00	7.71	1.00	8.00	0.16	5.90	6.40
Transportation									
Vehicles	7,429	1.66	1.00	1.37	1.00	2.00	0.61	1.06	1.06
Use and maintenance of personal and transportation equipment	29,011	3.46	2.00	4.26	1.00	4.00	0.31	3.08	3.17
Transportation	12,933	2.29	1.00	2.88	1.00	2.00	0.59	1.69	0.70

Communications									
Telephone and telefax	2,728	1.68	1.00	1.31	1.00	2.00	0.60	1.10	1.10
Telephone and telefax services	4,785	3.61	3.00	2.79	1.00	5.00	0.26	3.58	3.19
Recreation and culture									
Audiovisual, photo and processing equipment & accesories	15,925	2.18	1.00	2.35	1.00	2.00	0.46	1.73	1.61
Recreation items and equipment	18,324	3.69	2.00	4.95	1.00	4.00	0.30	3.38	2.60
Recreation, cultural and sports services	4,700	3.37	2.00	4.30	1.00	4.00	0.26	3.55	3.30
Newspapers, books and stationery	13,252	3.04	1.00	4.07	1.00	3.00	0.33	2.65	3.14
Vacations	2,479	1.40	1.00	0.90	1.00	2.00	0.74	0.75	0.75
Educational									
Preschool and basic education	3,733	7.94	7.00	6.60	2.00	12.00	0.11	8.37	8.93
Secondary	779	9.68	9.00	7.81	4.00	12.00	0.09	11.02	11.97
Higher	1,233	8.18	7.00	5.04	5.00	12.00	0.11	8.54	8.95
Another	1,680	3.88	3.00	3.87	1.00	4.00	0.25	3.46	3.46
Restaurants & hotels									
Restaurants	66,510	2.60	1.00	2.95	1.00	3.00	0.39	2.08	2.30
Hotels	1,696	2.70	1.00	3.44	1.00	3.00	0.36	2.24	2.24
Miscelaneous goods and services									
Personal care	96,408	2.22	1.00	2.90	1.00	2.00	0.47	1.66	1.62
Personal effects	6,733	2.68	1.00	3.82	1.00	3.00	0.37	2.25	2.39
Social services	490	4.47	3.00	3.90	2.00	6.00	0.22	4.10	4.10
Other	5,958	2.42	1.00	3.75	1.00	2.00	0.60	1.87	2.28
Total	*1,177,338*	*2.99*	*1.00*	*3.94*	*1.00*	*3.00*	*0.41*	*2.60*	*1.88*

NOTE: Frequency is the fraction of prices that change in a month. Indirect duration is calculated by the formula $-1/\ln(1-F)$. Weighings used for the calculation of direct durations are indicated in the text; whereas in the case of frequencies, they correspond to weights of items in the PCI basket.

in foreign exchange or are directly impacted by variations in exchange rate. Examples of the latter case are prices of vacation packages, which present the shortest average duration (0.8 month). Likewise, subgroups with the shortest duration include vehicles (1.1 month), telephone and telefax equipment (1.1 month), home textile products (1.4 month) and personal care (1.7 month) including toiletries. The food subgroup, which also has a shorter duration than the average (1.6 month), deserves special attention. This fact is due to the presence of vegetables and fruits in the subgroup, which due to their seasonal character experience frequent price changes.

In addition to services, another group with a higher rigidity degree is that of products with government-mandated price controls, as shown in Table 6. Focusing on duration estimated according to nature, it can be observed that prices of administered goods and services last almost one month longer than the average. This value is lower than expected taking into account that prices of many of the goods covered by this regulation have been subject to official adjustments once a year. Therefore, prices of these goods and services are more rapidly adjusted than the value indicated by the frequency of official authorizations.

Confirming our comments on the duration of prices in the food subgroup, unprocessed groups have an estimated duration of just 1.7 month (the shortest). It is important to note that this group includes vegetables and fruits, which, due to their perishable and seasonal nature, exhibit high price volatility.

4.2 Multinomial Logit Regression

To conclude this section, the results of a multinomial logit regression are presented. In this regression, the dependent variable is a categorical variable that indicates if the price of the particular product was reduced, remained constant or increased from one month to another. As explanatory variables the following were included: a set of indicators based on the nature of the good or service; a year and a month dummy; a set of dummies to identify the month when the value added tax aliquot was changed. A dummy that identifies observations over the six months prior to monetary reconversion; some identifiers of the type of store; and the exchange rate variation, both contemporary and that of the three previous months, were added. Finally, monthly inflation corresponding to the subgroup to which the product belongs was taken into account. The sample includes

TABLE 6. DIRECT AND IMPLICIT DURATION ACCORDING TO THE PRODUCT NATURE

	Direct durations						Indirect duratios		
Nature	*Number of episodes*	*Mean*	*Median*	*Standard deviation*	*First quartile*	*Third quartile*	*Price variation frecuency*	*Implicit duration mean*	*Implicit duration mean*
Processed food	221,307	2.39	1.00	2.77	1.00	3.00	0.43	1.88	1.62
Unprocessed food	132,214	1.65	1.00	1.69	1.00	2.00	0.62	1.08	1.00
Industrial goods except food and textile	136,174	1.94	1.00	2.15	1.00	2.00	0.54	1.39	1.06
Administered goods and services	498,237	3.74	2.00	4.94	1.00	4.00	0.36	3.47	1.98
Non-administered services	104,942	2.98	2.00	3.25	1.00	4.00	0.35	2.58	2.30
Textile and clothing	84,464	2.36	1.00	3.04	1.00	2.00	0.41	1.93	1.97
Total	*1,177,338*	*2.99*	*1.00*	*3.94*	*1.00*	*3.00*	*0.41*	*2.60*	*1.88*

NOTE: Frequency is the fraction of prices that change in a month. Indirect duration is calculated by the formula $-1/\ln(1-F)$. Weighings used for the calculation of direct durations are indicated in the text; whereas in the case of frequencies, they correspond to weights of items in the PCI basket.

all observed values of the dependent variable, regardless of the period; in other words, the panel structure was not considered. The reference price is a non-administered service, marketed at the supermarket in January 2000.

Table 7 presents the estimated coefficients and conditional probability of the model described in the previous paragraph. First, a lower degree of flexibility toward price decrease than price increase is observed. In this regard, estimated probability of a price increase for the reference case is 0.31, whereas probability of a decrease is just 0.08. In other words, in an average month, 80% of price variations correspond to increases, whereas the rest corresponds to decreases. This seems to indicate that higher evidence of downward price rigidity is observed in a moderately inflationary economy, especially compared with Europe and the USA, where over 40% of price variations correspond to decreases.

Second, price duration is heterogeneous and the same happens with the rigidity degree. In effect, unprocessed food exhibits a higher downward flexibility that results from the fact that estimated probability of a price reduction is 11 percentage points higher in this category than in the base case. This result makes sense due to the more volatile and seasonal nature of prices of this type of products, including vegetables and fruits.

Concerning price increases, products with a higher frequency of upward adjustments are those belonging to the reference category; in this case, non-administered services. On the contrary, prices of administered goods and services and textile and clothing are the least flexible, with the remaining factors being constant. In the case of the first ones, as expected and given the type of regulation, probability of a price increase from one month to another is 18%, which is in contrast with the reference case (31%). In the case of the second ones, the difference is slightly higher; probability of a price increase in this category is 17%.

Third, the fact that supermarkets offer products with a shorter price duration, such as vegetables and fruits, may result in a lower probability towards price increase and a higher tendency to price decrease in comparison with others. In fact, the estimated marginal effects seem to confirm the above, because wholesale stores, hypermarkets and department stores show the highest price increase frequency. Precisely, the conditional frequency of price increases in these types of stores can easily double that of supermarkets. Furthermore, it is precisely in supermarkets where price reductions are observed more frequently, which can be confirmed by the negative sign of marginal effects.

Fourth, price increase frequencies do not appear to exhibit a clear seasonal behavior. In general, price decrease or increase frequencies are clearly modified throughout the year.

With regard to variations in the value added tax (VAT) rate, during the study period, the national government modified this eight times. The first took place in August 2008, when it was cut back from 15.5% to 14.5%, so as to encourage consumption and investment. In May 2002, given the impact of the severe political crisis on fiscal revenues, it was decided to modify VAT aliquot from 14.5% to 16%, starting from September 2002. Once the crisis was overcome, the VAT aliquot was reduced by one percentage point as from September 2004, so as to promote aggregated demand. Later, the significant inflow of oil resources made it possible to further reduce VAT aliquot, to 14%, as from October 2005; to 11% in March 2007 and 9% in July of that same year.

Estimates presented in Table 7 seem to verify that changes in VAT aliquots have an immediate effect on price levels. More precisely, when VAT rate applied to products is higher, the frequency of a price increase is also higher, and vice versa. Unfortunately, it is not possible to draw a general conclusion based on the results obtained in this work in terms of increases, because only one episode is observed. However, the fact that 9% of prices were upward adjusted in the month when the rate went from 14.5% to 16%, besides the 31% that is normally introduced, is quite suggesting.
In relation to VAT rate decreases, we can develop more solid conclusions, because five of these decreases took place between 2000 and 2007. Prices decrease in all of them. In fact, the percentage of prices that were reduced rose from the average of 7% to 12% in 2000; to 25% in 2004; to 23% in 2005; to 22% in March 2007; and to 17% in July 2007. On the other hand, this tax policy does not appear to be associated with any variation in frequency of price increase.

Concerning exchange rate, it can be observed that depreciation of this indicator has a positive impact on frequency of price increases, but no effect on the price decrease frequency. However, this effect does not seem to be immediate. More precisely, the impact of exchange rate variations has no significant effect contemporaneously, but it does have it in the following month, when the change of a standard deviation in the exchange rate variation produces an increase of the probability of a price increase by one percentage point.

Finally, monthly inflation rate of the subgroup to which the item belongs has a possible positive incidence on price increase frequency, although

TABLE 7. CONDITIONAL PROBABILITY OF PRICE INCREASES AND DECREASES: MULTINOMIAL LOGIT MODEL

		Price decrease				*Price increase*			
Category	*Variable*	*Coefficient*	*Standard error*	*p Val*	*Marginal effect*	*Coefficient*	*Standard error*	*p Val*	*Marginal effect*
	Intercept	–1.118	0.026	*		–0.495	0.016	*	
Nature	Processed Food	–0.351	0.019	*	–0.014	–0.507	0.011	*	–0.092
	Unprocessed Food	0.990	0.019	*	0.110	–0.123	0.014	*	–0.059
	Industrial goods except food and textile	0.136	0.018	*	0.015	–0.188	0.011	*	–0.042
	Administered goods and services	–0.139	0.013	*	0.004	–0.615	0.007	*	–0.124
	Textile and apparel	–0.453	0.027	*	–0.016	–0.808	0.017	*	–0.138
Type of store	Street vendors	0.057	0.019	0.003	–0.030	1.221	0.012	*	0.290
	Corner stores	–0.587	0.015	*	–0.040	0.322	0.010	*	0.084
	Department store	0.355	0.042	*	–0.025	1.508	0.027	*	0.349
	Hipermarket	0.721	0.033	*	–0.009	1.633	0.024	*	0.363
	Local market	–0.052	0.013	*	–0.012	0.349	0.010	*	0.079
	Mission	–0.026	0.055	0.631	–0.039	1.391	0.030	*	0.334
	Others	–0.966	0.084	*	–0.059	1.026	0.034	*	0.264
	Wholesaler	0.716	0.105	*	–0.034	2.239	0.066	*	0.481
	Services	–1.274	0.015	*	–0.076	–0.577	0.009	*	–0.091
	Specialized store	–0.084	0.012	*	–0.011	0.220	0.009	*	0.050
Year	2001	–0.220	0.017	*	–0.011	–0.184	0.011	*	–0.033
	2002	–0.160	0.020	*	–0.011	–0.017	0.013	0.186	0.000
	2003	–0.237	0.019	*	–0.014	–0.082	0.012	*	–0.012
	2004	–0.478	0.019	*	–0.028	–0.088	0.012	*	–0.009
	2005	–0.269	0.019	*	–0.017	–0.036	0.013	0.004	–0.002
	2006	–0.684	0.019	*	–0.039	–0.094	0.011	*	–0.007
	2007	–0.684	0.036	*	–0.037	–0.192	0.020	*	–0.027
Month	2	0.140	0.020	*	0.010	0.014	0.012	0.221	–0.001
	3	0.190	0.021	*	0.012	0.097	0.012	*	0.016
	4	0.142	0.023	*	0.009	0.072	0.013	*	0.012
	5	0.146	0.020	*	0.009	0.072	0.012	*	0.012

	6	0.148	0.019	*	0.013	−0.059	0.011	*	−0.016
	7	0.084	0.020	*	0.009	−0.104	0.012	*	−0.024
	8	0.003	0.022	0.893	0.001	−0.029	0.013	0.026	−0.006
	9	0.110	0.024		0.006	0.092	0.014	*	0.017
	10	0.139	0.023	*	0.010	0.035	0.014	0.011	0.004
	11	−0.262	0.023	*	−0.014	−0.172	0.013	*	−0.030
	12	−0.246	0.021	*	−0.016	−0.026	0.012	0.028	0.000
VAT changes	VAT cutback August 2000	0.655	0.032	*	0.053	0.201	0.025	*	0.022
	VAT cutback September 2000	−0.114	0.037	0.002	−0.003	−0.236	0.026	*	−0.046
	VAT cutback October 2000	−0.260	0.038	*	−0.012	−0.236	0.025	*	−0.043
	VAT increase September 2002	0.356	0.043	*	0.014	0.452	0.024	*	0.092
	VAT increase October 2002	−0.053	0.042	0.202	−0.003	−0.035	0.025	0.149	−0.006
	VAT increase November 2002	−0.025	0.043	0.559	0.000	−0.058	0.025	0.021	−0.012
	VAT cutback September 2004	1.482	0.036	*	0.177	0.216	0.028	*	−0.022
	VAT cutback October 2004	0.212	0.040	*	0.019	−0.077	0.026	0.003	−0.021
	VAT cutback November 2004	0.403	0.043	*	0.037	−0.080	0.025	0.002	−0.028
	VAT cutback October 2005	1.277	0.033	*	0.157	−0.053	0.028	0.061	−0.061
	VAT cutback November 2005	0.325	0.041	*	0.031	−0.143	0.027	*	−0.038
	VAT cutback December 2005	−0.064	0.043	0.144	−0.001	−0.136	0.025	*	−0.027
	VAT cutback March 2007	1.365	0.043	*	0.152	0.259	0.030	*	−0.005
	VAT cutback April 2007	0.254	0.051	*	0.020	0.028	0.029	0.328	−0.001
	VAT cutback May 2007	−0.137	0.055	0.012	−0.008	−0.058	0.028	0.041	−0.009
	VAT cutback July 2007	1.096	0.037	*	0.106	0.299	0.028	*	0.021
	VAT cutback August 2007	0.326	0.044	*	0.025	0.056	0.027	0.039	0.003
	VAT cutback September 2007	0.069	0.045	0.123	0.004	0.063	0.026	0.017	0.012
	Reconversion	0.345	0.038	*	0.025	0.100	0.020	*	0.012
Exchange rate variation									
	t	0.061	0.070	0.381	0.004	−0.002	0.041	0.968	−0.002
	t−1	−0.042	0.074	0.571	−0.018	0.636	0.043	*	0.136
	t−2	0.888	0.071	*	0.052	0.481	0.043	*	0.081
	t−3	−0.515	0.081	*	−0.032	−0.201	0.048	*	−0.030
	Inflation	−0.049	0.002	*	−0.007	0.150	0.001	*	0.033

NOTE: The number of observations is 2,538,278. Verisimilitude is 911,190; L = 128,919.31; *p*-val ((126 gl) <0.001. The reference price is a non-administered service, marketed at a supermarket in January, 2000. Average monthly inflation is 1.7%. For the reference case, estimated probability of a price decrease is 0.078 and of a price increase is 0.308.

an economically significant impact on price decreases is observed. In this regard, an increase of one percentage point in the price variation rate of the corresponding subgroup is associated with a jump of 3.3 percentage points in the frequency of an increase. On the contrary, the frequency of price decreases drops only by 0.8 percentage points.

5. HAZARD RATE

This section presents the results in terms of the estimates of the survival and hazard functions carried out using direct duration data, by means of non-parametric methods. This is done in order to study their shapes through graphic methods.[6] The main finding is that duration of prices in Venezuela is time-dependent; that is, the probability of a price changing in the following period is not uniform; first, it decreases and reaches a maximum around the tenth month.

From a methodological point of view, in the variation models used in this work, the variable to be explained is the time during which a price remains constant. In other words, we are focusing on price episodes just as they were defined in section 3. The starting point is that the duration of each one of them is governed by an unconditional distribution function, $F(t)=Pr(T\le t)$; although, in fact, for our purposes, its complement is more useful, i.e. $S(t)=1-F(T>t)=Pr(T>t)$. This latter is known as survival function. The other key notion to analyze this type of data is the hazard rate, which is defined as follows:

$$\lambda(t)=\lim_{h\downarrow 0}\frac{P(t\le T<t+h\,|\,T\ge t)}{h}=\frac{f(t)}{S(t)},$$

where $f(t)$ is the density function. This rate may be interpreted as the probability that the price changes immediately after it has lasted a period *t*.

Both reliability function and hazard rate can be estimated by means of non-parametric methods. To explain how this is done, the following notation is introduced: assuming d_j as the number of episodes ending in time t_j, m_j as the number of episodes censored in the interval (t_j,t_{j+1}) and r_j as the number of episodes that have not still changed in time t_j an estimator of hazard rate is given by:

[6] See Cameron and Trivedi (2005), for a description of the method employed and of the terminology used in this section.

$$\hat{\lambda}_j = \frac{d_j}{r_j}.$$

Likewise, the reliability function estimator, known as Kaplan-Meier estimator, is:

$$\hat{S}(t) = \prod_{j|t_j \leq t} \frac{r_j - d_j}{r_j}.$$

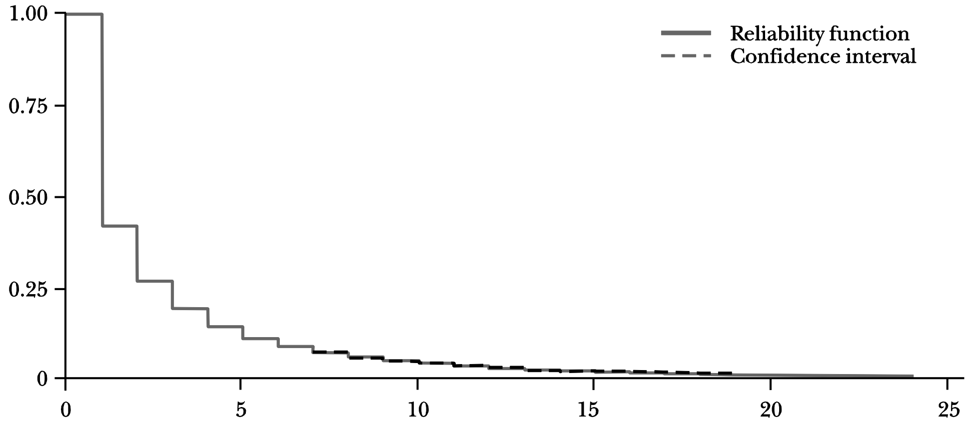
There is direct correspondence between the main assumptions used to incorporate price formation into macro models and the shape how hazard rate. For instance, Calvo (1983) and Taylor (1980) models, that is, time-dependent models, bring about hazard rates that are constant in time. On the other hand, models based on the state of the economy produce duration dependence; that is, hazard rate would increase or decrease with price duration. If marginal costs are not stationary, especially in an environment with intermediate or high inflation, hazard rate would exhibit a positive slope with respect to time. If, on the contrary, marginal costs are stationary but they are subjected to transient shocks, hazard rate could have a negative slope over time.

Figure 3 shows the survival function estimated with the Kaplan-Meier method. This figure is consistent with the results presented in section 3, in the sense that only a little more than 30% of prices remain unchanged after the first month. Likewise, only 10% of prices remain unchanged for more than six months.

Apart from the fact that prices tend to change very rapidly, they also show a positive dependence on duration in the short term, as presented in Figure 4. The estimated hazard rate follows a positive slope until reaching a peak in the tenth month. As mentioned before, this result can be consistent with the inflationary character of the Venezuelan economy and, therefore, with the non-seasonal nature of marginal costs along with frequent imbalances in favor of demand in relation to supply.

An alternative explanation is that when a hazard rate is estimated for all prices, heterogeneous durations are combined. When these heterogeneous durations are aggregated into a single duration, they behave as if they had temporary dependence (Fougère al., 2007). Figure 5, in which hazard rates per group are presented, provides data that support this hypothesis. Therefore, the lack of homogeneity in the shape of this rate among products making up the CPI basket is verified. More specifically, it

FIGURE 3. RELIABILTY FUNCTION OF PRICES DURATION



can be said that there are two groups for which the shape of this rate confirms the dependence on the status, in this case, food and nonalcoholic beverages, and communications. In both cases, hazard rate reaches a peak in around 10 months.

The remaining groups, in turn, exhibit price setting rules that may be described as time-dependent. In particular, alcoholic beverages and tobacco, health, and educational services appear to exhibit a price formation process with a hazard rate that is constant with their duration. On the other hand, both long average duration and the lack of dependence on duration exhibited by the hazard rate in the case of the two last prices could be associated with rigidities in wage formation, as previously noted.

FIGURE 4. HAZARD RATE OF PRICES DURATION

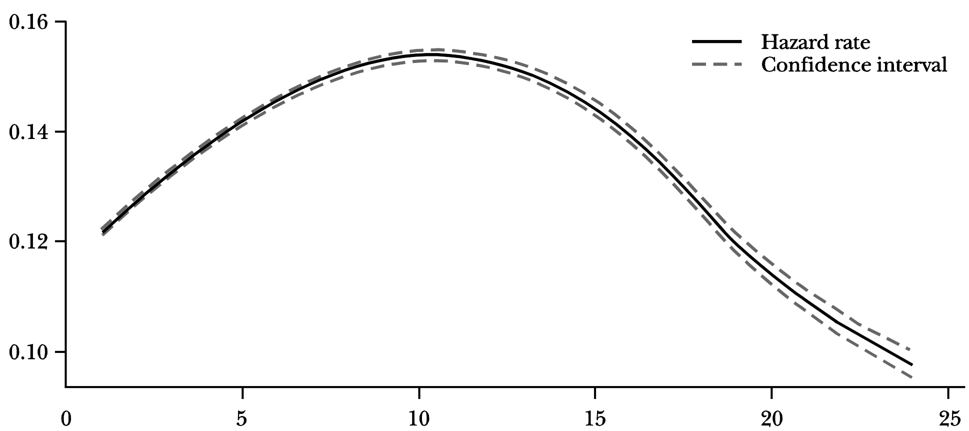
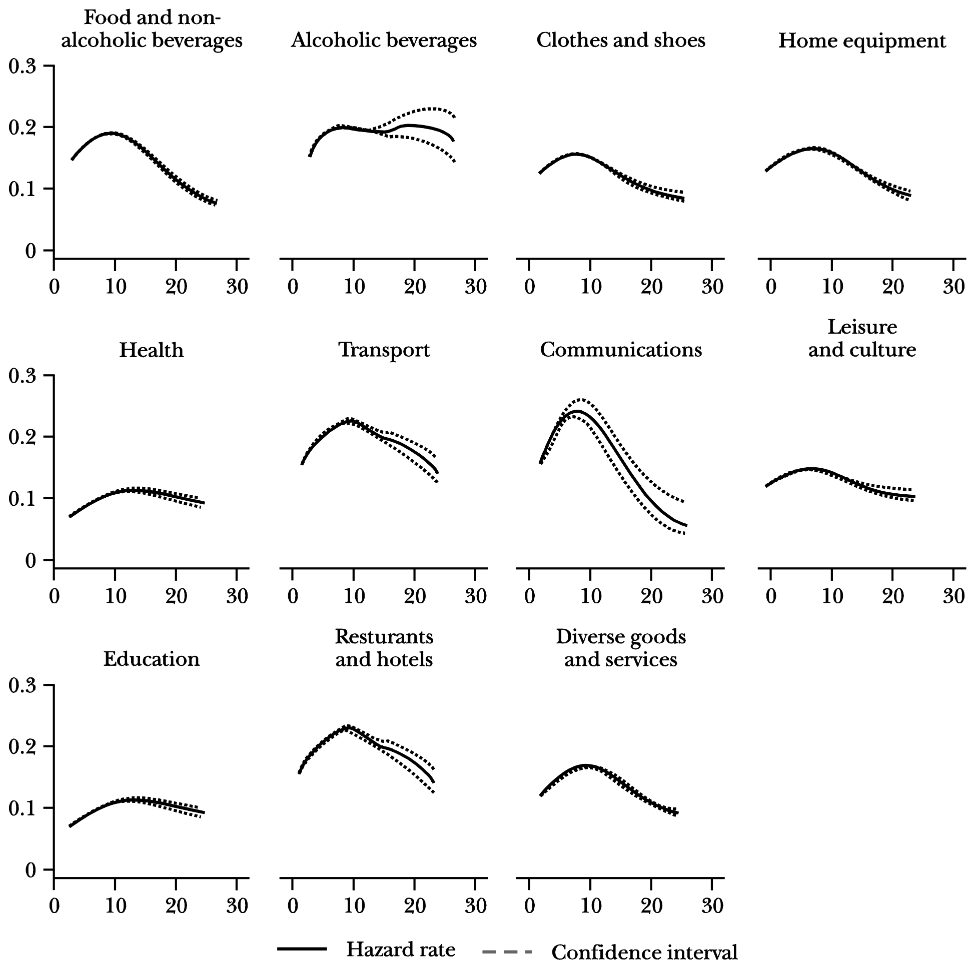


FIGURE 5. SMOOTHED HAZARD ESTIMATES BY GROUP



6. CONCLUSIONS

This paper assesses how rigid prices in Venezuela are, using the information contained in the database used to estimate CPI for the Caracas Metropolitan Area in 2000-2007. The Venezuelan case is interesting, given the relatively high level of inflation experienced throughout the period of study. This work is based on the same methodology applied for USA and Europe, extended for other countries as well. Specifically, average price duration estimated using the direct and indirect method is presented.

Likewise, durations are differentiated based on several categories so as to demonstrate the heterogeneity degree existing in times during which prices remain unchanged. Finally, several hazard functions are estimated by means of non-parametric method.

The main result of this study is that prices in Venezuela change more rapidly than in other countries; i.e. 2.6 months, on average, with a median of 1.9 month. An aspect that is not dealt with in this work is the breakdown of the price variation process into size and frequency, which will be addressed in future research. However, the results obtained at least allow us to infer that a significant component of the inflationary process is expressed in a higher frequency in price variation. If this is so, according to the approach of the new Keynesian school, along with this results, it can be inferred that monetary policy would have a lesser or shorter effect on the product than on prices. It would be interesting to use these durations to calculate the transmission period of an expansive monetary policy over real variables for the Venezuelan case, so that this proposal can be empirically demonstrated.

Furthermore, like in other research works, it has been found that price durations are heterogeneous. Rates in the services sector, especially education and health, tend to be more rigid than prices in the remaining goods. This can be explained by the existence of implicit contracts, in particular those for which it is important to maintain long-time relations with the customers. Another possible reason is the high share of labor costs, which, along with their corresponding little variability throughout the year, results in a less flexible price setting. This heterogeneity would also justify the need to develop models with multiple sectors, which make it possible to better explore the effects of monetary policy on the real economy. It is worth highlighting that the presence of these heterogeneities can bring about non-linearities in the behavior of macro variables, as well as asymmetric impacts by shocks experienced by the economy.

A topic that is related to the point above is that of the relation between price rigidity and heterogeneities found here and the inertia or persistence present in inflation in Venezuela. The existence of overlapped contracts, together with relative price duration, may bring about dependence of today's inflationary rate on values taken by it in the past (Taylor, 1980). This is equivalent to the fact that price adjustment is impacted not only by future expectations, but also by past information, including the observed inflation rate. This is the reason why chronic and moderate inflationary processes are so difficult to eliminate, even in contexts of highly credible policies (Dornbusch and Fischer, 1993).

Quite interestingly, prices in Venezuela exhibit lower downward flexibility, which contrasts with results in other places. The ordinary notion that prices can only move in one direction, in this case, upwards, seems to be right. In the presence of menu costs, an increasing price trend results in prices reaching close to the possible lowest limit. This leads to an asymmetry in how prices respond to shocks in the economy, with prices being more sensitive to the positive than to the negative shocks of demand (Tsiddon, 1993).

Another significant aspect, especially in a context of an anti-inflationary policy, would be to know the impact of a monetary contraction on the frequency of price adjustment and, therefore, on the real effect of a policy of this kind. This would also explain the possible costs that measures in this context may have. These costs appear to be higher when the activity level is close to or over its potential level (Caplin and Leahy, 1991).

Lastly, the estimated hazard function could point to the presence of inflationary inertia at almost all levels, and the little number of rules to set time-dependent prices, except in services. This can be seen especially in the positive temporary dependence exhibited by this rate. However, it would still be necessary to verify how this is related to the heterogeneity found previously.

This work has developed two additional paths to be followed in our research: the study of price duration, but one step back in the commercialization chain, that is, assess price rigidity at the wholesalers' level using the database of the wholesale price index. The second path consists of researching price formation through a direct survey at stores' level. Finally, a future project to be developed would consist of including the results obtained in this work into a dynamic general equilibrium model for Venezuela. This model should start from the duration estimated here and its heterogeneous character.

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Price Formation in Colombian Firms: Evidence Gathered from a Direct Survey

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1. INTRODUCTION

This paper reports the results of a survey asking Colombian businesses about the way in which they set the prices of their main products. The questionnaire's design was based on the works of Blinder (1991, 1994), Blinder et al. (1998) and those they carried out under the framework of the Eurosystem Inflation Persistence Network (IPN) (Fabiani et al., 2005).[1]

This work also supplements other studies on price setting in Colombia which employ different types of approaches. Among the most important of these is research based on the use of quantitative databases originally constructed for creating Colombia's producer price index (Julio and Zárate, 2008).

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[1] This is the first attempt in our country to carry out a survey following strict technical and conceptual guidelines. Nonetheless, it is important to recognize a previous work which, with all the technical and financial limitations of a pregraduate economics thesis, attempted to sound out Colombian businesses on the same topic (Arosemena, 2001).

Interest in clarifying how firms set their prices began to grow during the eighties when a group of authors started to notice an important stylized fact: firms' price setting behavior apparently determines the way in which monetary policy decisions –interest rates, money and inflation– affect the economy as a whole. This goes against one of the main precepts of neoclassical macroeconomic theory, according to which the behavior of monetary variables does not affect real variables. Such theory is based on the fact that changes in prices do not generate costs and therefore take effect immediately.[2] One explanation for this stylized fact emerged from contributions made by New Keynesian economists. According to them, an explanation for such behavior can be found in the fact that price changes are delayed, i.e., they are rigid. The first models in which they specifically collected that idea suggested that strategic interactions among firms, cost conditions, the relationship between firms and their customers, and costs of reviewing price lists, were reasons why prices might not change so frequently.

Nowadays it is accepted that the way monetary policy is implemented can affect economic activity. The essential assumption to obtain real and nominal effects from monetary policy is the stickiness of prices, i.e., that they remain fixed for at least short periods of time. If price adjustment is incomplete after a monetary shock, monetary policy will have real effects in the short-term at least. Thus, the impact of changes in interest rates on inflation and GDP is affected by the degree and type of rigidities prices exhibit. In this context, better understanding of price rigidities is fundamental for analyzing macroeconomic phenomena such as the impact of monetary policy on output and employment, and the size of economic fluctuations.

Microeconomic evidence on price adjustment has grown substantially during the last few years, making it possible to use this in complete macroeconomic models. Such knowledge is essential for constructing inflation models with the macroeconomic fundamentals appropriate to allow improved monetary policy design and performance.[3] These models usually include different types of nominal rigidities through which monetary policy affects real economic activity over the short and medium term. In this regard, the well-known formulas of Calvo (1983) and Taylor (1980) on

[2] This point of view was questioned by Friedman and Schwartz (1963) as well as other authors who found evidence that changes in money and prices (nominal variables) could affect unemployment and output (real variables).

[3] Máckowiak and Smets (2008) warn that results of microeconomic studies cannot be automatically applied to macroeconomic models.

price rigidities have been employed to construct a significant amount of monetary models in which monetary policy has real effects.

Recent studies on the topic have stopped focusing on the price setting of a single company or individual market[4] in order to have a wider reach. Such studies include two types of analysis. The first approach stems from the liberation by statistics bureaus of large databases collected as a base for calculating consumer and/or producer price indexes. Pioneering works in this line of study were those of Bils and Klenow (2004) for the USA and Baharad and Eden (2004) for Israel. Other efforts in this line of research were made later by the European Central Bank's IPN. The second proposal was based on designing direct surveys with straightforward questions on the reasons and procedures businesses followed when fixing the prices of their products. The first of this type of surveys were developed by Blinder (1991, 1994) and Blinder et al. (1998) for the United States (USA), Hall et al. (2000) for the United Kingdom (UK), Apel et al. (2005) for Sweden, Amirault et al. (2006) for Canada and also by the European Union's Inflation Persistence Network (Fabiani et al., 2005).

Studies made with direct surveys have certain advantages over those using consumer or producer price index databases. Although the latter achieve a very complete quantitative characterization of the periodicity and size of changes in prices, they do not provide sufficient understanding of the main determinants guiding the actions of those setting prices. There are certain aspects of firms' pricing policies that can only be researched from qualitative information; such is the case, for instance, of the group of information businesses consider when reviewing their prices. In any case, survey results are useful for verifying and extending evidence obtained with quantitative micro data (Álvarez and Hernando, 2005).

The results reported in this paper come from a direct survey carried out by Banco de la República in two stages.[5] The first was a pilot survey which tested the technical solidity of the questionnaire designed for sounding out businesses. This took place between August and October 2007, questioning 142 business managers. The second stage used the refined questionnaire to survey a final sample of 787 business managers and was carried out between November 2007 and May 2008. Design of the questions on the form was based on the experiences of other countries

[4] Such as, for example, the pioneering works on magazine prices by Cecchetti (1986), sales catalogue prices by Kashyap (1995), gasoline distributer retail prices by Asplund et al. (2000), or supermarket prices by Levy et al. (1997).

[5] Banco de la República encharged field work to Centro Nacional de Consultoría.

which have made similar surveys, including some studies carried out in developing economies.[6]

Under this context, one of the survey's objectives is to deepen knowledge on price setting by Colombian firms. In particular, it explores the degree of autonomy firms have for changing their prices and the existence of periodic pricing review policies (time dependent) or policies dependent on the state of the economy (state dependent). It also investigates the set of information employed in making decisions on price changes, the frequency of pricing reviews and changes, and the use of some type of discrimination for determining prices. Its second objective is to analyze the main factors leading to price changes as well as the speed at which firms react to different shocks. It studies underlying factors (cost structure, degree of competition, among others) explaining sectorial differences observed in the frequency of price changes and the speed of response to different shocks. The final objective is to provide empirical evidence for the different theories set forth by literature for explaining the price adjustment lags.

This introduction is the first of seven sections contained in this paper. The second section presents a review of pertinent literature, while the third explains the methodology employed for carrying out and processing the survey. The characteristics of the firms surveyed are presented in the fourth section and an analysis of the determinants of pricing review is made in the fifth section. Meanwhile, the sixth section shows the way in which changes are made. The factors associated to price changes, such as asymmetries in adjustments and response times after a shock are topics of the next section. Finally, the last section gives the conclusions.

2. A REVIEW OF THE LITERATURE

Since the pioneering studies of Blinder (1991, 1994), the survey approach has become more and more powerful for providing information on the way firms set their prices. Box 1 summarizes the most important studies carried out since then. After Blinder efforts were made at the Bank of England (Hall et al., 1997), the Bank of Japan (Nakagawa et al., 2000) and the Swedish central bank (Apel et al., 2001). Later, in 2003 and 2004 nine euro zone central banks (Italy, Belgium, Germany, France, Spain, the

[6] Section 2 presents a summary of the literature examined in this paper.

Netherlands, Luxembourg, Portugal and Austria) surveyed firms on their price setting behavior. This effort was part of a collaboration project called the Eurosystem Inflation Persistence Network (IPN). Surveys have been carried out more recently in Canada (Amirault et al., 2006), Rumania (Sahinöz and Saraçoglu, 2008) and Mexico (Castañon et al., 2008).

Despite the high costs that collecting information on prices through a direct survey can have, its advantages make it increasingly popular. Among the latter is the possibility to research in depth: *i)* the group of information businesses employ when reviewing prices and *ii)* the relative importance businesses give to different price rigidity theories. In fact, many of the new theories have emerged before previous ones have even been rejected, posing questions that can only be answered through surveys. In addition, the use of direct surveys allows the two stages of the price setting process (review and change) to be studied separately. These also provide a basis for empirically evaluating the response of prices, both their direction and size, to different shocks the economy might experience. Thus, the diverse information that can be extracted from direct surveys surpasses the limits of conventional approaches employing econometric study of aggregate time series data, with which it is not possible to answer many of the relevant questions posed by the topic.

Box 1 shows the date of the surveys,[7] the size of the samples, the response rate of firms surveyed, the sectorial coverage of the survey, the type of sampling used and the price rigidity theories business managers identified as the most important for explaining their behavior.

Although the first surveys were not carried out by central banks, one characteristic of this type of study is that it is mostly made at central banks or with the participation of researchers linked to such institutions. In the majority of cases surveys were carried out directly by the central bank, although some of these institutions used external research centers to collect information using questionnaires they had designed. Such was the case, for instance, of surveys carried out in Germany, Spain, the Netherlands and Austria. In other cases, questionnaires were sent by post after previous telephone contact. Responses could be sent directly to the bank by fax or post, or the questionnaire could be answered by phone or direct interview before the questionnaire was received. Only a few banks used internet as an alternative for collecting survey information (Spain, Portugal, Italy and the Netherlands). The Bank of Canada made direct surveys in

[7] This date does not coincide with the publication of the research's results.

which all the pollsters were officials from the bank. Blinder's (1991) seminal work also included direct surveys. Differences in the procedures used explain the dispersal in the response rate observed in the third column of Box 1.

BOX 1. THE LITERATURE REVIEWED

Country	*Date*	*Firms in the sample/response rate*	*Sectors*	*Sampling technique*	*Theories*
Austria	2004	2,500 / 36%	M, S	Random stratified	Contracts (explicit and implicit)
Belgium	2004	5,600 / 35%	M,Rc, S, Cons	Random stratified	Implicit contracts
Canada	2002 – 2003	170 / 100%	M, Rc, S, Cons	By quota	Idle costs
France	2003 – 2004	4,300 / 38%	M	Random stratified	Coordination failures
Germany	2004	2,740 / 46%	M	Purposive	Explicit contracts
Italy	2003	729 / 46%	M, Rc, S, Cons	Random stratified	Explicit contracts / coordination failures
Japan	2000	1,202 / 56%	M, Rc, S, Cons, Trans	N.A.	Coordination failures
Luxembourg	2004	1,100 / 30%	M, Rc, S, Cons	Random stratified	Explicit contracts
Mexico	2005	745 / 53%	M	Random stratified	Idle costs
Portugal	2004	2,494 / 55%	M, S	Random stratified	Implicit contracts
Rumania	2006	1,901 / 19.8%	The whole economy	Random stratified	Implicit contracts
Spain	2004	3,000 / 69%	M, Rc, S	Random stratified	Implicit contracts
Sweden	2000	1,300 / 48.7%	M, S	Random	Implicit contracts
The Netherlands	2004	1,870 / 67%	M, Rc, S	Random stratified	Implicit contracts
Turkey	2005	999 / 27.7%	M, Ener	Random	Mark-up
United Kingdom	1995	1,100 / 59%	M, Rc, S, Cons	No	Idle costs
United States	1990 – 1991	400 / 50%	M, Rc, S, Cons, Min	Random	Delivery times

SOURCE: Own elaboration

NOTES: A: agriculture; M: manufacturing industry; Rc: retail commerce; S: services; Cons: construction; Ener: energy; Trans: transport; Min: mining; N.A.: not available.

Sectorial coverage of the surveys varies from country to country. In some cases the survey covers the whole economy (Rumania), while in others it focuses on manufacturing industry (Germany, Mexico). Some countries take commerce into account and others do not. Moreover, some countries include services and construction in their samples. The surveys carried out in Turkey and Rumania are different in that they include energy companies in their samples.

The sampling method employed is fundamental for reaching a correct inference on population characteristics. Most European countries employed previously prepared samples used in opinion polls and balance sheets or for other purposes. The most commonly used was random sampling stratified by sector or level of employment. Quota sampling (Canada) and purposive sampling (Germany) were seldom used. The latter type of sampling implies the compulsory inclusion of certain firms which need to be surveyed given their relative importance in the German economy (Stahl, 1995).

The last column of the box shows the theory chosen by those surveyed as the most important for explaining price rigidities. This column is referred to below in the explanation of each theory. At this moment it is used to show the importance of contracts (explicit or implicit) as a theory for explaining price rigidities. This theory explains price rigidities in ten out of the 17 works reviewed.

3. METHODOLOGY

The survey was carried out in two stages. The first of these was a pilot survey which took place in August and October 2007 and questioned 142 business managers. The second stage used an improved questionnaire based on the experience of the pilot survey for questioning a final sample of 787 business managers during November 2007 to May 2008. The survey was carried out by a private company (Centro Nacional de Consultoría) using a questionnaire designed by Banco de la República and constructed taking into account other countries' experiences in the area. The questionnaires were applied in person to those in charge of establishing pricing policies in the companies, such as, for instance, general managers, finance managers, marketing managers or production managers. This took place after a letter signed by the General Manager of Banco de la República had been sent requesting their collaboration and guaranteeing the complete confidentiality of the answers given by those taking part in the survey.

The polling company was given the sample of firms together with a list of replacement firms just in case any of the former was not able to take part in the survey.

3.1 Sample Design

The relevant population for the study comprises all firms who are obliged to report their financial statements to the Superintendencia de Sociedades or the Superintendencia Financiera in 2005. In accordance with 590 Act from the year 2000 they also had to have total assets of above 501 current legal minimum wages (salarios mínimos legales vigentes, SMLV) from the same year in order for them to be classified as non-large (small and medium) and large companies.[8] The population does not, therefore, include microenterprises given that we believe their pricing decisions do not significantly affect the behavior of aggregate prices in the economy. Likewise, the population studied does not include firms producing and/or providing services due to the fact that in such cases it is difficult to identify the main product they supply to the market. Thus, the population only includes firms which according to the International Standard Industrial Classification (ISIC) belong to sectors such as agriculture, hunting and forestry (section A), fishing (section B) and manufacturing (section D). Firms within the aforementioned sections were then separated according to their three digit classification number. From these, only subsectors which, in line with our criteria and research objectives, were relevant to price setting in Colombia were considered. Retail and wholesale firms in the commerce sector were not included in the study due to the difficulty of selecting a representative product which would allow them to correctly answer the questionnaire. A detailed description of the population with its three digit ISIC code can be found in Appendix A.

After employing the two categorizations mentioned above (size and economic sector), a population of 4,626 firms classified into 28 homogeneous strata was reached. Once the strata were identified, stratified random sampling with proportional representation was carried out, resulting in a representative sample of 743 firms at a 95% confidence level. However, in order to obtain greater variability in strata which ended up with a very small sample size, the sample was increased to 787 firms. Table 1 gives a summary of the composition of the final sample, showing both the

[8] According to the Ministerio de la Protección Social, the SMLV for 2005 was \$381.500. Thus, in 2005, a firm was considered large if it reported total assets of over \$5.722.500 thousand million; medium if it reported total assets of between \$1.907.882 and \$5.722.500 thousand million and small if it reported total assets of between \$191.132 and \$1.907.882 thousand million.

sectorial division as well as that between large and non-large firms for each sector and the simple as a whole.

A pilot survey was carried out during the second half of 2007 (August and October) to ensure stratified random sampling was developed correctly. This survey was distributed to 142 randomly selected firms, a number taken from information obtained by Arosemena (2001), who following Blinder (1991, 1994) studied the presence of coordination failures among Colombian firms. The pilot survey had two main objectives. First, it allowed identification of the questionnaire's weaknesses and strengths. In fact, after it was analyzed a number of questions were reworded or eliminated in order to make the questionnaire as short and straightforward as possible. Second, results obtained from the pilot survey were used to construct a group of variance estimators within each stratum which allowed stratified random sampling to be carried out later. A description of the sampling method applied in this exercise can be found in Appendix B.

TABLE 1. SAMPLE DISTRIBUTION

	Size			
ISIC	*Large*	*Non Large*	*Total*	*Total (%)*
Agriculture	28	57	85	10.8
Fishing	2	6	8	1.0
Food products	48	63	111	14.1
Textiles	18	24	42	5.3
Apparel	17	48	65	8.3
Leather	5	16	21	2.7
Wood and paper; Publishing and printing	25	57	82	10.4
Petroleum refining; Chemicals	33	39	72	9.1
Rubber and plastic	26	39	65	8.3
Minerals and metals	18	24	42	5.3
Metal products	16	43	59	7.5
Machinery and equipment	6	18	24	3.0
Electrical appliances[a]	5	14	19	2.4
Vehicles and remaining industry	29	63	92	11.7
Total	*276*	*511*	*787*	
Total (%)	*35.1*	*64.9*		*100*

SOURCE: Own elaboration

[a] Includes communication equipment, medical instruments and other electronic devices

Regarding the response rate of survey participants, it is important to mention that, unlike in other exercises carried out in this field, 100% of the questionnaires were answered. This is due to the fact that a random replacement process was carried out each time a firm in a strata did not respond to the pollster's first contact. Replacement was made by simple random sampling within each stratum following the ideas of Martínez (2002). This therefore allows us to have the representativity necessary to be able to make statistical inferences on the population studied.

3.2 Questionnaire Design and Implementation

The questionnaire employed was based on those developed by Blinder (1991, 1994), Hall et al. (1997), Apel et al. (2001), the members of the European Union's Inflation Persistence Network and others described in the preceding section. The final form has 32 questions grouped into five sections. It was constructed using non-technical language which could be understood by non-economists. The full questionnaire can be found in Appendix 3.

The first part of the questionnaire (questions 1 to 15) collect information on the main product sold by the firm, destination of sales, the existence of discriminatory policies among competitors and the type of relationship it has with its customers.

The second section (questions 16 to 24) investigates the firm's pricing policies. In particular, it asks about the firm's ability to set prices, i.e., if it is a price taker or setter, and about the determining factors it takes into account when setting the price of its main product. It also attempts to analyze the type of pricing review rule followed by Colombian firms: state dependent or time dependent; as well as the frequency of price adjustments and their evolution over the last five years.

The third part of the form (questions 25 to 27) analyzes the reasons explaining changes in prices as well as the period of time between the moment firms experience a shock and adjust their prices. It also studies the phenomenon of asymmetrical responses to economic shocks.

The fourth section (questions 28 to 30) asks about the type and relevance of information used by firms when reviewing prices. Special emphasis is placed on the effect Banco de la República's inflation target and the setting of the minimum wage have on pricing decisions.

Finally, section five (question 31) asks firms to rate the importance of different economic theories on price rigidities. For this reason a group of easily understood statements were prepared which attempt to identify the main idea behind each of such theories.

Once the questionnaire was completed and the sample was designed, each of the firms was contacted by telephone in order to make an appointment between a representative from the polling company and the relevant person from the firm being interviewed, thereby allowing the survey to be carried out in person. Firms contacted by telephone were also asked if their target market was domestic or external. Those which answered that 100% of their production was exported were removed because the research is focused on the process of setting prices inside the country.

The questionnaire contains three types of questions. The first group of questions attempts to determine the importance the person taking part in the survey places on a given statement. The possible answers are "1=not important", "2=not very important", "3=important", "4=very important" and "9=do not know / no answer". Analysis of the results gives the average weighted population of all the alternatives. Likewise, for the questions that merit it, a hypothesis test of equality of means is carried out in order to be able to compare the fact that a pair of options are not statistically equal. This allows option ordering.

The second group of questions consists of the firm choosing an option from a list of posibilities. To analyze these results population shares are estimated in such a way as to be able to present relative frequencies for each question. Finally, the last type of question corresponds to those requiring an exact quantitative answer, for which weighted population means are calculated.

Calculation of stratified and weighted population means is based on developments presented by Hansen et al. (1953a and 1953b) and detailed in Appendix 5.[9] Estimates of each population mean are accompanied by the corresponding estimate of population variance. The latter allows hypothesis testing of equality of means. The weighter used corresponds to the operational revenues reported by each firm to the Superintendencia de Sociedades and the Superintendencia Financiera during the 2005 fiscal year. The chosen weighting scheme gives greater importance to the answers of firms with high operational revenues within each stratum because, presumably, their decisions are more relevant to the general level of prices in the economy.

[9] In order to carry out a correct process of statistical inference, and in light of the existence of omitted values in some survey participant's answers, a multiple imputation procedure is employed in such way as to balance the database with all the answers to each question. More specifically, a Markov Chain Monte Carlo (MCMC) method is used, details of which are shown in Appendix 4.

3.3 Economic Conditions

Economic conditions can affect agents' perceptions and the way they respond to a survey such as the one designed in this work. In the period when Colombian business managers answered the questionnaire (November 2007 to May 2008), Colombia's economy had lost the strength it had been exhibiting around that time. In fact, average growth during the preceding three years had been 7%, figure not observed since the years following the World War II. In particular, an increase in GDP such as the one registered in 2007 (8.2%) can only be compared with those observed in 1978 (8.2%) and 1949 (8.7%). Despite the strength of recent growth, in 2008 the Colombian economy had begun to slow considerably and by the first quarter of the year the figure for annual growth was 4.1%, half the size of that recorded in 2007.

Economic slowdown stemmed from a decline in external demand, rising internal tensions associated to reductions in local government spending, increases in the prices of imported raw materials and higher inflationary pressures affecting household consumption. In response to rising inflation Banco de la República changed its monetary policy stance in April 2006. This fact also contributed to reducing the strength of domestic demand and, as a consequence, to slowing economic growth (Banco de la República, 2008).

4. CHARACTERIZATION OF THE MARKET WHERE FIRMS OPERATE

The characteristics of the markets where firms operate are important determinants of price setting policies. The first section of the questionnaire therefore asks about some of these including, for instance, the destination of sales, the level of competition they face, the type of relationship they have with their customers and the type of product they produce.

Firms from the population studied are mainly oriented towards the domestic market. The results in Table 2 indicate that 81.9% of Colombian firms channel their sales to the domestic market, while the remaining 18.1% do so to the external market. In the external market firms sell mostly to countries other than Venezuela and the USA. At sectorial level, local markets are very important for agriculture and food products, while vehicles are largely dependent on the Venezuelan market. In addition, most firms (71.6%) consider they have a long term relationship with customers for their main product. Evidence on the type of customer firms have is relevant –it has traditionally been argued that long term customer relationships can cause firms to delay price adjustments in response to shocks. At the sectorial level, answers to the questionnaire show that this type of relationship is fundamental for sectors such as that of vehicles and petroleum refining (plus chemicals) and much less important for firms producing food and agricultural products.

TABLE 2. POPULATION CHARACTERISTICS: SALES DISTRIBUTION AND BUSINESS RELATIONSHIPS[a]

CIIU	*Domestic sales (%)*	*USA sales (%)*	*Venezuela sales (%)*	*Other sales (%)*	*Sales percentage sales with long term customers*
Agriculture	97.2	0.6	0.0	2.2	77.1
Fishing	74.1	21.1	0.0	4.9	80.9
Food products	94.9	0.5	0.3	4.3	43.9
Textiles	62.6	19.4	6.2	11.9	86.4
Apparel	73.3	2.8	14.0	10.0	86.3
Leather	77.1	13.3	1.5	8.1	81.0
Wood and paper; Publishing and printing	81.6	1.0	7.4	10.1	86.1
Petroleum refining; Chemicals	68.7	0.8	9.5	21.0	93.6
Rubber and plastic	85.1	2.3	4.6	8.0	84.3
Minerals and metals	87.1	2.1	3.6	7.3	86.1
Metal products	87.8	1.4	3.1	7.7	87.9
Machinery and equipment	81.8	0.9	7.2	10.1	90.7
Electrical appliances	63.5	0.0	12.8	23.7	86.1
Vehicles and remaining industry	48.8	1.9	40.8	8.5	93.2
Total	*81.9*	*2.44*	*7.64*	*8.03*	*71.6*

SOURCE: Own elaboration.
[a] Characteristics inferred from a representative sample

Most Colombia firms produce consumption goods as their end product (68.4%), followed by intermediate goods (32.4%), while production of capital goods is very small (1.3%). This structure, shown in Table 3, is in line with the system of national accounts information. On the other hand, one very important characteristic obtained from the results of the questionnaire is that Colombian firms face a relatively small number of competitors. In general, Colombian firms have an average of five competitors. Ten out of the fourteen economic sectors into which Colombian firms were divided were characterized by having less than five competitors. According to survey participants' declarations, the four remaining sectors have between five and twenty competitors.

This result concerning the degree of competition faced by firms is more important for understanding the way these adjust their prices. In highly competitive markets firms are more likely to change their prices in response to a shock given that the opportunity cost of not doing so to an optimum level is very high. In contrast, the opportunity cost of not setting an optimum price is reduced for firms with market power. Álvarez and Hernando (2005) cite some relevant literature to illustrate the relationship between price rigidity and the degree of competition. Geroski (1992) finds that the response of prices to supply and demand shocks is faster in industries with greater competition. Hall et al. (2000) and Carlton (1986) also find something similar when they affirm that companies working in highly competitive markets tend to adjust their prices faster than firms facing less elasticity of demand.

TABLE 3. POPULATION CHARACTERISTICS: GOOD PRODUCED, PERCEIVED COMPETITION AND EXISTENCE OF LEADERS[a]

ISIC	*Finished Good Producer (%)*[b]	*Intermediate Good Producer (%)*	*Capital Good Producer (%)*	*Average number of competitors (%)*	*Existence of industry leaders (%)*[c]	*Leaders*[d]
Agriculture	95.2	4.6	0.2	5 - 20	16.5	48.2
Fishing	97.6	2.4	0.0	5 -20	55.3	100.0
Food products	80.4	22.5	0.0	5 -20	75.5	82.2
Textiles	14.7	85.3	0.0	Less than 5	47.8	76.7
Apparel	99.1	0.9	0.0	5 -20	22.6	63.0
Leather	4.7	95.3	0.0	Less than 5	1.2	41.8
Wood and paper; Publishing and printing	39.4	60.6	0.2	Less than 5	16.3	46.2
Petroleum refining; Chemicals	61.4	39.5	0.0	Less than 5	52.0	82.4
Rubber and plastic	63.9	47.9	0.2	Less than 5	45.5	84.9
Minerals and metals	62.1	40.9	1.3	Less than 5	49.6	12.5
Metal products	33.0	58.9	8.2	Less than 5	78.6	48.8
Machinery and equipment	86.7	1.0	12.3	Less than 5	65.6	17.3
Electrical appliances	91.8	5.1	3.1	Less than 5	60.3	71.2
Vehicles and remaining industry	89.1	5.4	5.7	Less than 5	15.9	84.8
Total	*68.4*	*32.4*	*1.3*	*Less than 5*	*48.7*	*72.4*

SOURCE: Own elaboration.
[a] Characteristics inferred from the representative sample. [b] Percentage of firms in each industry producing each type of good. [c] Percentage of firms in each industry which recognize existence of a leader in their industry. [d] Percentage of firms which recognize the existence of a leader in their industry and consider themselves the price leader.

The questionnaire asks about the existence of leaders in the industry and also if the firm being surveyed considers itself as such. These are obviously very subjective measurements but the results are extremely interesting. In this regard, it is important to research the perception firms have regarding the competitive structure that surrounds them. Firms which recognize the existence of leaders in their industry are indicating the presence of monopolistic structures or monopolistic competition, evidence which is essential for the study of price formation. Out of the total, only 48.7% of firms consider that there is a leader in their industry and 72.4% of these believe that they themselves are the leader. Cases differ among the sectors. There are sectors where a large share of company managers recognizes leaders exist and think that their company is the industry leader (food products and electrical equipment). There are also cases where a small share of firms considers there are industry leaders, answering that they are one of them (apparel, vehicles and remaining industry).

5. PRICING REVIEW

Literature related to the topic of this paper establishes two stages in the process of setting prices (Fabiani et al., 2005). First is the pricing review process. In this stage firms evaluate the price they eventually want to set, verifying its optimality and comparing it with the cost implied by changing it. Thus, in order to evaluate a new price, the firm takes available information into account and compares it with the price it charges at that moment. This procedure implies the fixed cost of collecting, analyzing and evaluating information. For this reason firms do not carry it out continually but at determined times or in response to relevant events. The second stage is making actual changes in prices. There are costs associated with this also (new pricing tables, labels, etc.). It is worth mentioning that not all pricing reviews necessarily result in price changes. Below are the results of the survey regarding the pricing review process.

5.1 Pricing Review Policies: Time Dependent vs. State Dependent

Individual firms employ two types of pricing review policies. Theoretical literature has modeled this fact considering two types of rule: *i)* time dependent price setting rules, and *ii)* state dependent price setting rules.

In the first case, firms review their pricing at specific intervals of time (Fischer, 1977; Taylor, 1979 and 1980; Calvo, 1983). Thus firms review pricing periodically either using a deterministic price adjustment process according to Taylor or a stochastic process according to Calvo. This implies that the pricing review interval is exogenous and does not depend on the state of the economy. In contrast to this, firms following a state dependent rule review their prices according to the economic variables affecting them. As a consequence, a large shock leads them to review their pricing. One standard justification for this type of discontinuous price adjustment is the existence of the fixed costs associated to making such price changes (Sheshinski and Weiss, 1977).

In response to an economic shock, both types of pricing review policies have different implications for the evolution of the real sector. Firms following a state dependent policy review their prices immediately after a shock. This is not the case for firms using a time dependent policy because they must strictly follow their rule and wait until their next pricing review date. Price rigidity is higher in the latter case. It is clear that the impact of monetary policy will be different in each situation and for this reason it is important to discern which type of behavior predominates in the economy.

The questionnaire (question 18 in Appendix 3) allows companies reviewing their prices to be cataloged as time or state dependent. Nonetheless, other possibilities are also considered, such as firms which follow a time dependent rule but review their prices at times of economic turbulence, i.e., firms which follow mixed strategies. The results indicate that 19.1% of firms review the pricing of their main product on daily basis and 27.7% review it at fixed time intervals. Only 9.4% review prices in the event of an economic shock and employ both rules (Table 4). The latter companies usually review their prices at predetermined time intervals, but change to a state dependent policy in response to an important shock.

TABLE 4. PRICING REVIEW PROCEDURE

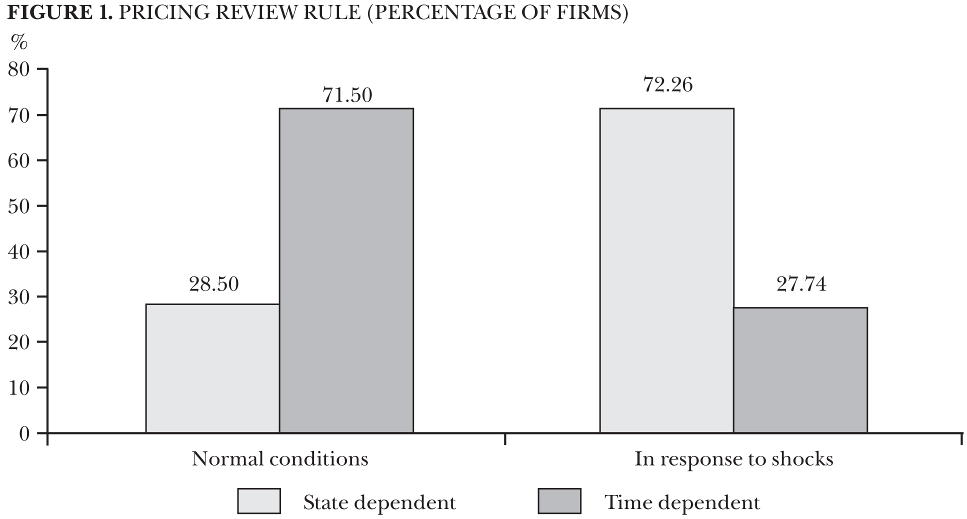
Review procedure	*Frequency*	*Relative frequency(%)*
Daily review	883	19.1
Fixed time intervals	1,283	27.7
Fixed intervals and in response to an event	2,025	43.8
In response to an event	436	9.4

SOURCE: Own elaboration.

Refining the information allows for a more comprehensive view of the problem. As can be seen in Figure 1, in periods when the economy is calm (normal conditions), most Colombian firms (71.5%) review their pricing according to a time dependent rule, while 28.5% only review pricing when they consider the economy is subject to some kind of shock. This indicates that under normal economic conditions state dependent firms exist even though the states are not changing per se, but their decision to review pricing is contingent upon the existence of shocks. On the other hand, when disturbances do occur they affect the pricing review process and some time dependent firms change to a state dependent rule. In this case 72.2% of companies follow a state dependent rule and only 27.7% continue to employ a time dependent rule. This behavioral profile remains the same if firms are divided into large and non-large (Figure 2). However, dividing by sectors reveals some different results. Thus, in non-industrial, agricultural and fishing sectors the share of firms which continue to follow a time dependent rule does not change considerably even in the event of shocks. Meanwhile, state dependent pricing review rules are widely used under normal conditions, to such an extent that change to state dependent rules during disturbances is less pronounced than in industrial sectors.

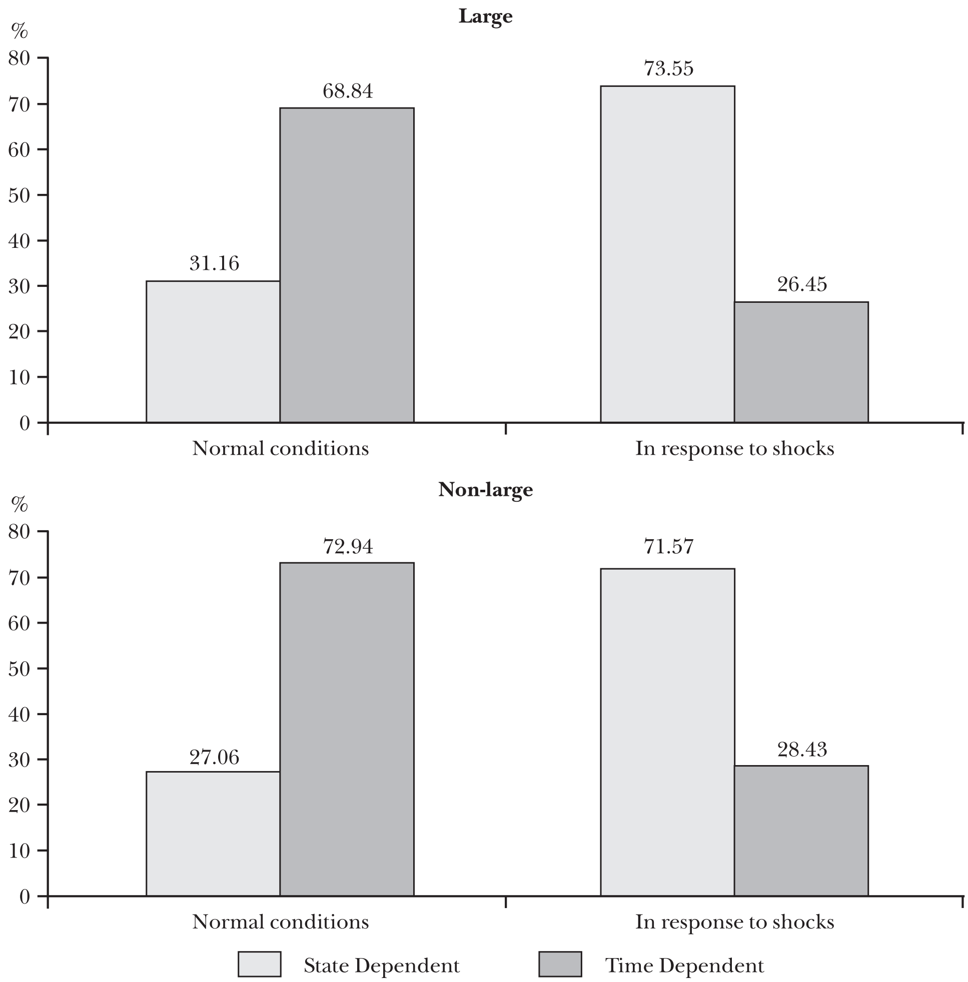
Interesting results are obtained if the number of competitors reported by firms participating in the survey is taken into account. Firms which

FIGURE 1. PRICING REVIEW RULE (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

FIGURE 2. PRICING REVIEW RULE ACCORDING TO SIZE OF FIRM (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

perceive a high level of competition in their industry employ state dependent rules (Figure 4). This result is in line with the idea that firms facing a larger number of competitors react faster to changes in economic conditions.

5.2 Body of Information Employed in Pricing Review

One important factor in firms' price setting strategies is the body of information they employ when making such decisions. In particular, the existence of forward looking price setting firms is a central element of New Keynesian models used for monetary policy analysis and which emphasize the rationality of economic agents' expectations. Despite their theoretical success, models with New Keynesian Phillips curves do not manage to replicate the smoothing exhibited in price behavior. This has led to the specification of hybrid Phillips curves containing rules-of-thumb and rules based on the past behavior of prices. In other words, firms can set their prices by not only observing forecasts and current information on relevant variables, but also by taking into account past information regarding the same variables. In such cases, deviations in optimizer behavior generate an additional source of smoothing in the way inflation responds to different shocks.

In order to study this aspect, the questionnaire asks about the information firms employ when reviewing their prices as well as about the importance they give to past, present or future information. Inflation is dealt with individually within the total body of information (question 28).

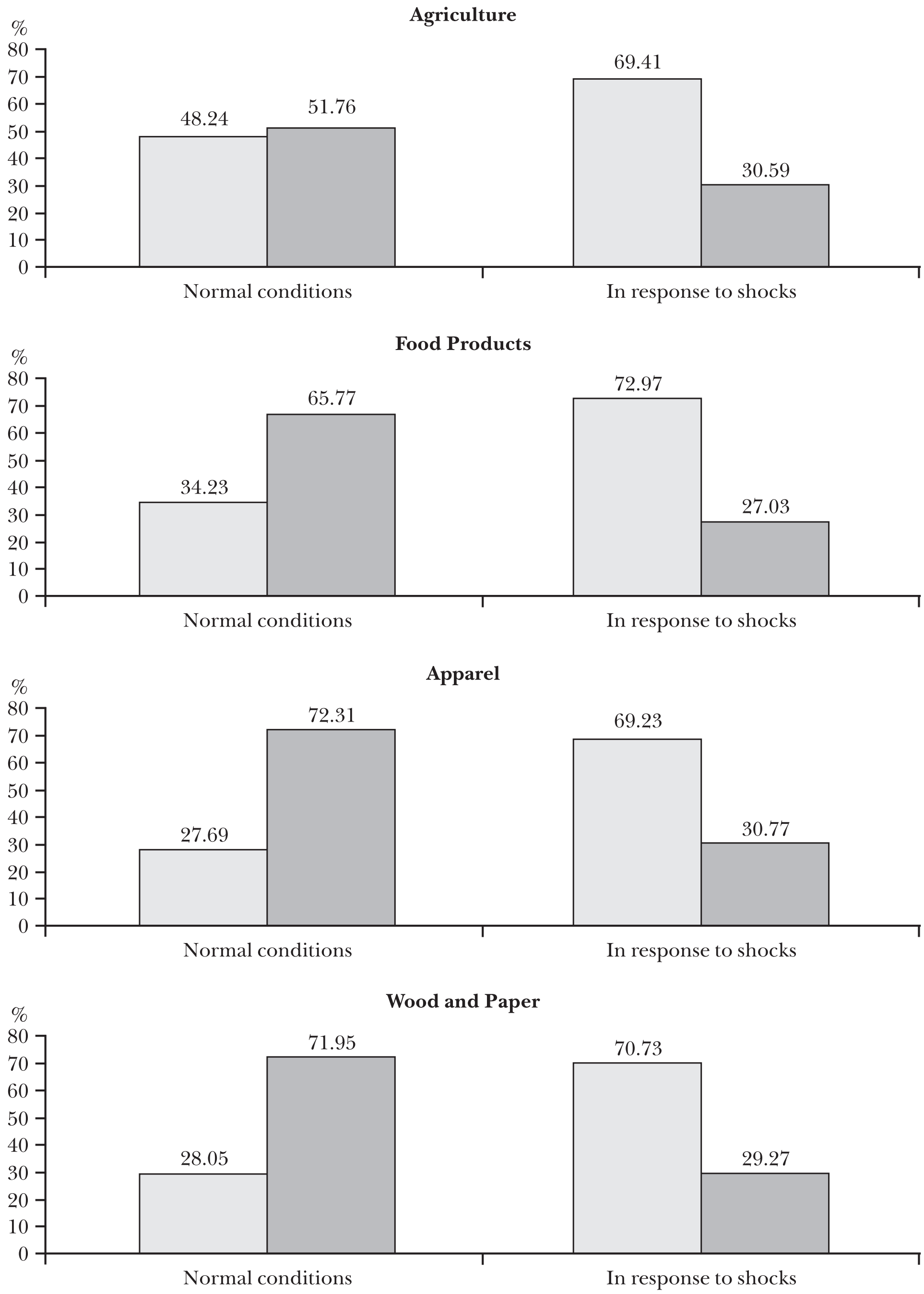
Figure 5 shows the results regarding the information employed by Colombian firms when reviewing their prices. As can be seen, present and future information is the most important for Colombian firms. Large firms give much more importance to forecasted information on the relevant variables. This is not the case for non-large companies which place greater importance on current information. At the sectorial level, it can be seen that current information is more important for both agriculture and industry. Meanwhile, in the case of fishing, future information competes for hierarchy with current information.

Both current and expected inflation are important for Colombian firms pricing review processes. This is true whether companies are viewed by size or by sector. However, the latter is relatively more important than the former in the case of industry and fishing.

The results place least importance on past information, meaning that arbitrary or indexed linked rules are not the price setting strategies used by Colombian businesses. This evidence suggests that firms' pricing does not deviate substantially from optimum prices set in the event of a shock affecting Colombia's economy.

The questionnaire also investigates the importance given in pricing reviews to the inflation target and the minimum wage. Those taking part in the survey are asked to grade the level of importance of each variable (questions 29 and 30). The results shown in Figure 6 refer to two variables measured simultaneously in the same bar, where zero divides the importance

FIGURE 3. PRICING REVIEW RULE BY ECONOMIC SECTOR (PERCENTAGE OF FIRMS)



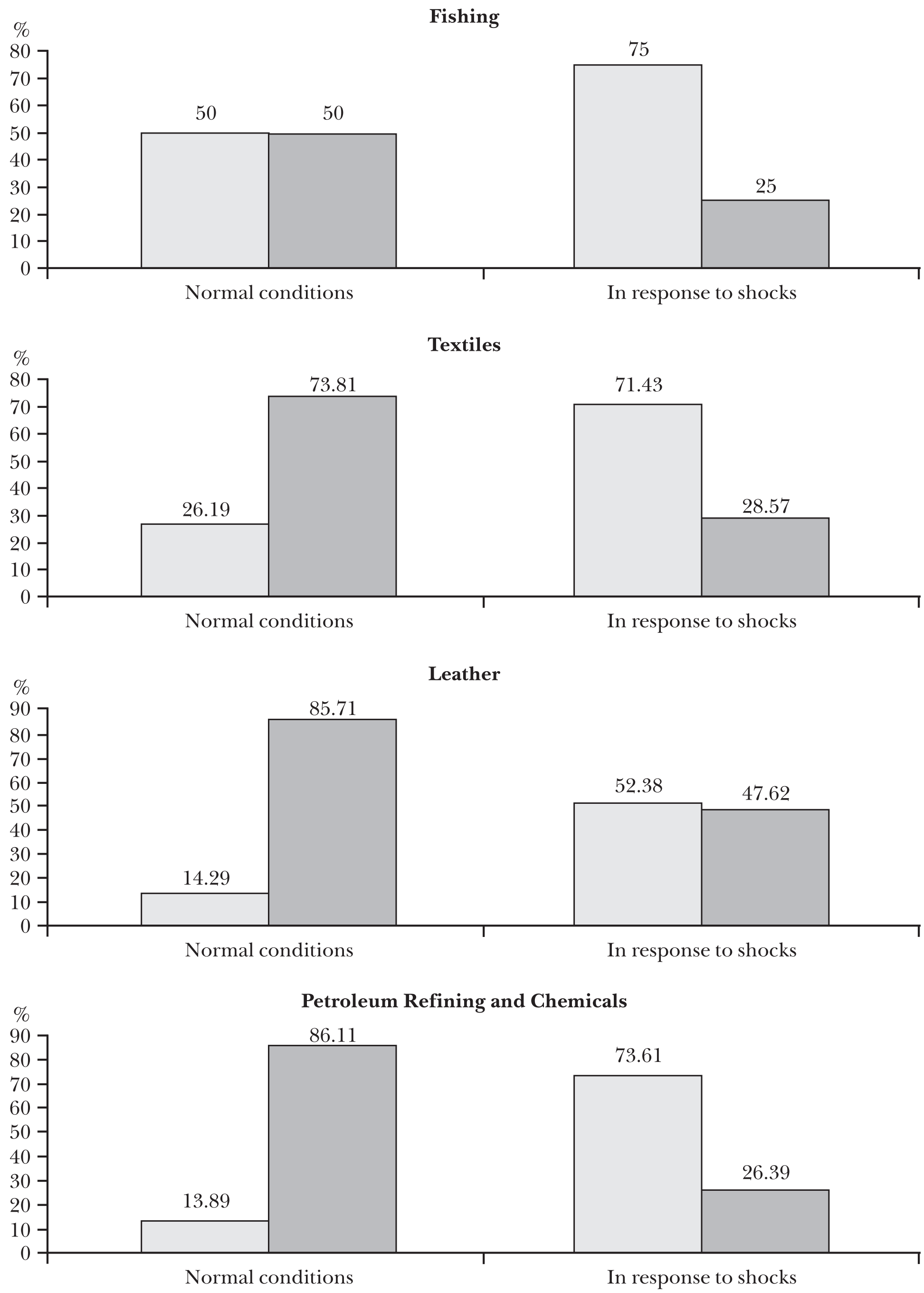
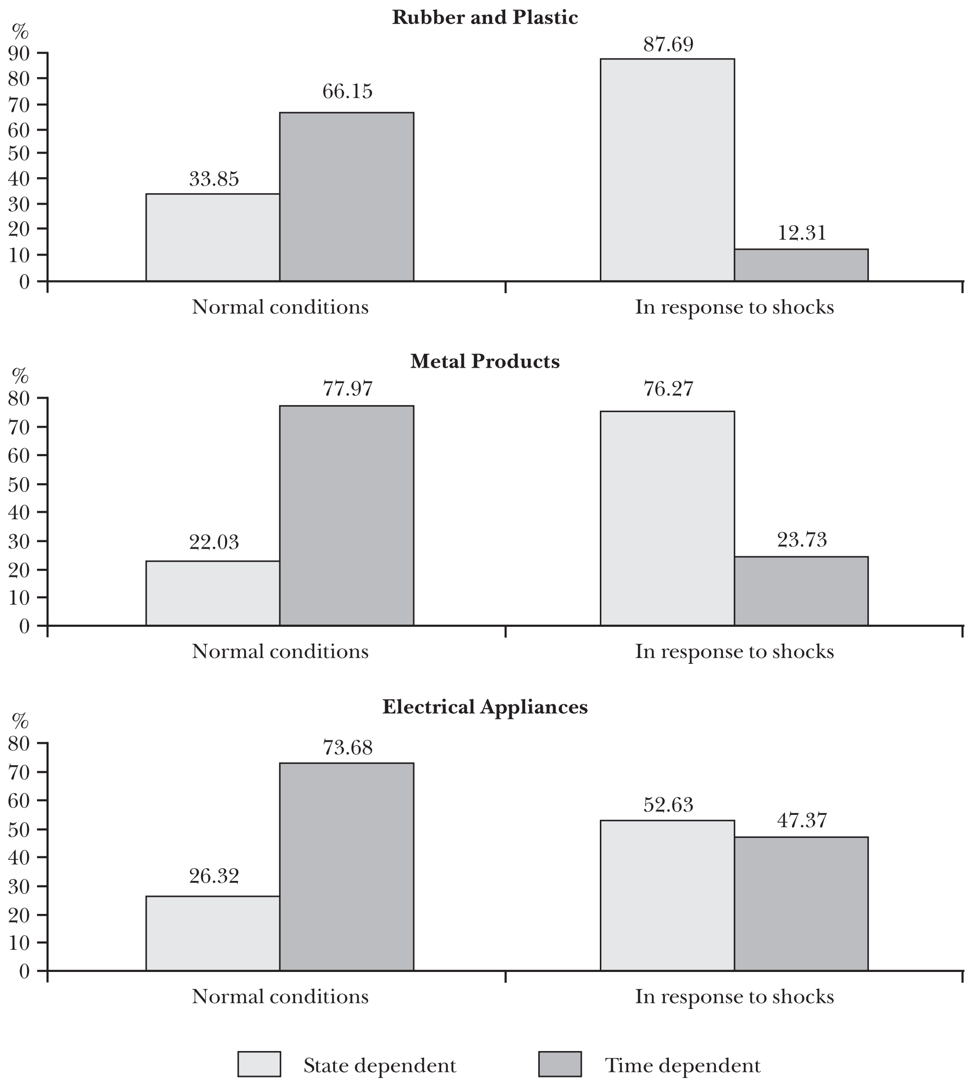
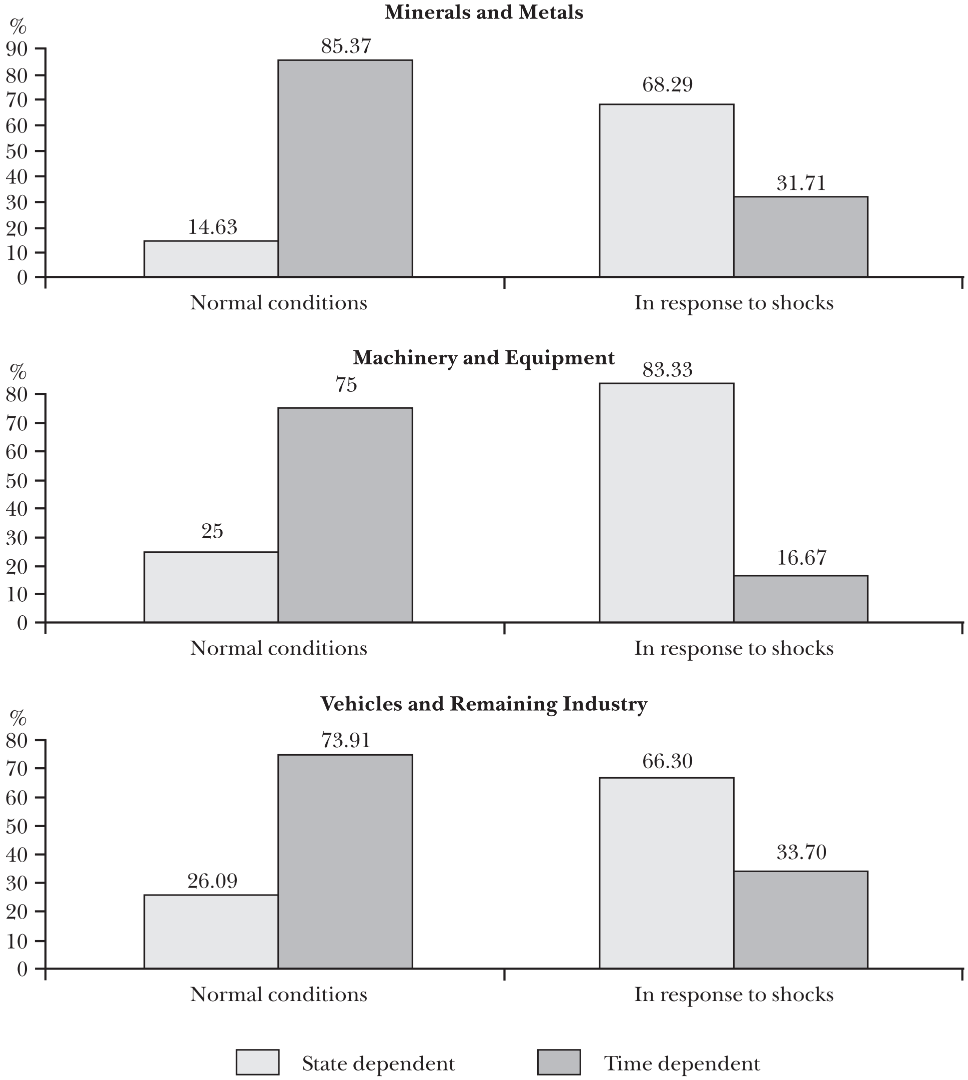

Fishing
%
75
50
50
25
Normal conditions
In response to shocks
Textiles
%
73.81
71.43
26.19
28.57
Normal conditions
In response to shocks
Leather
%
85.71
52.38
47.62
14.29
Normal conditions
In response to shocks
Petroleum Refining and Chemicals
%
86.11
73.61
26.39
13.89
Normal conditions
In response to shocks

FIGURE 3 *(concluded)*



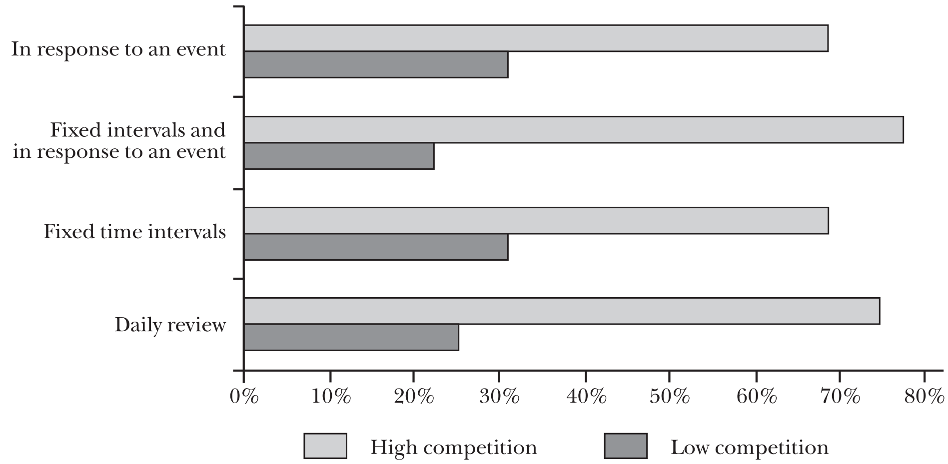
SOURCE: Own elaboration.

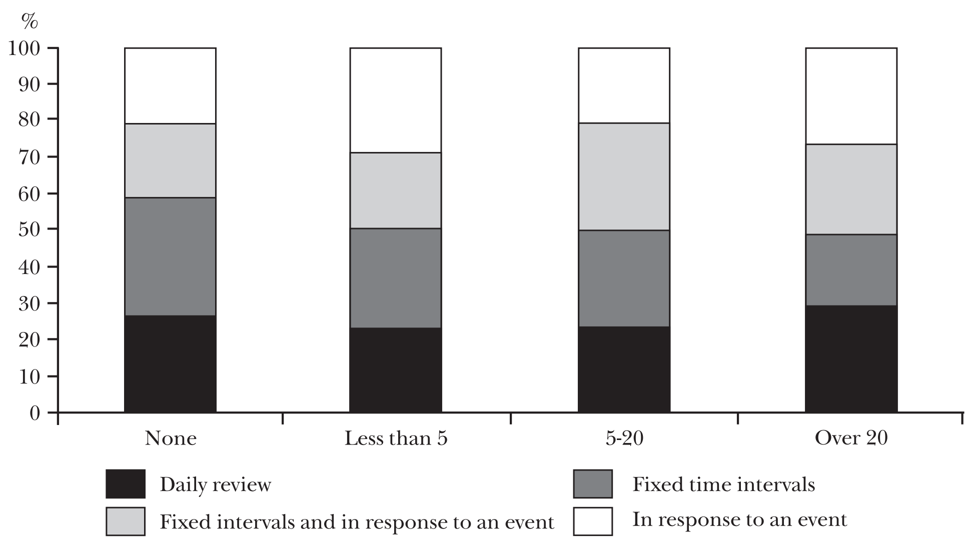
placed on each of them. The total shows that both variables are important for firms, although the inflation target has slightly more interest. For large firms the inflation target is more important than the minimum wage, while the minimum wage is more relevant for non-large companies.



The difference between the sectors regarding the value they place on each of these variables is significant. Businesses in the agricultural sector consider both variables to be of similar importance, while the inflation target is more important for those in industry. Firms in the fishing sector place less importance than the other sectors on both the referred variables.

FIGURE 4. PRICING REVIEW PLAN VS. PERCEIVED COMPETITION (PERCENTAGE OF FIRMS)



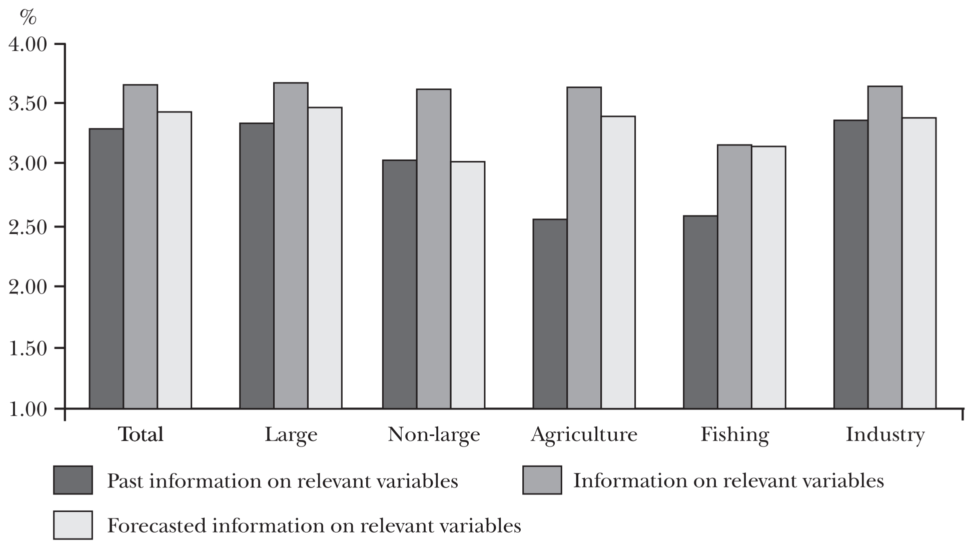


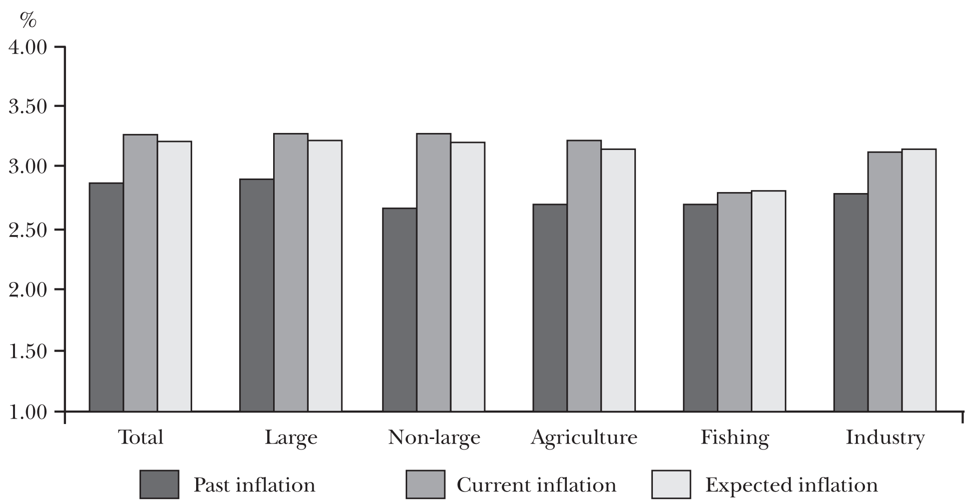
SOURCE: Own elaboration.

5.3 How Often Do Firms Review Pricing?

Firms following a time dependent pricing review rule are also asked about the frequency with which they check their prices (question 19). The results reported in Figure 7 show that a large proportion of companies review their prices monthly (around 32%), while many firms do so on a

FIGURE 5. INFORMATION USED FOR REVIEWING PRICES (AVERAGE SCORE)

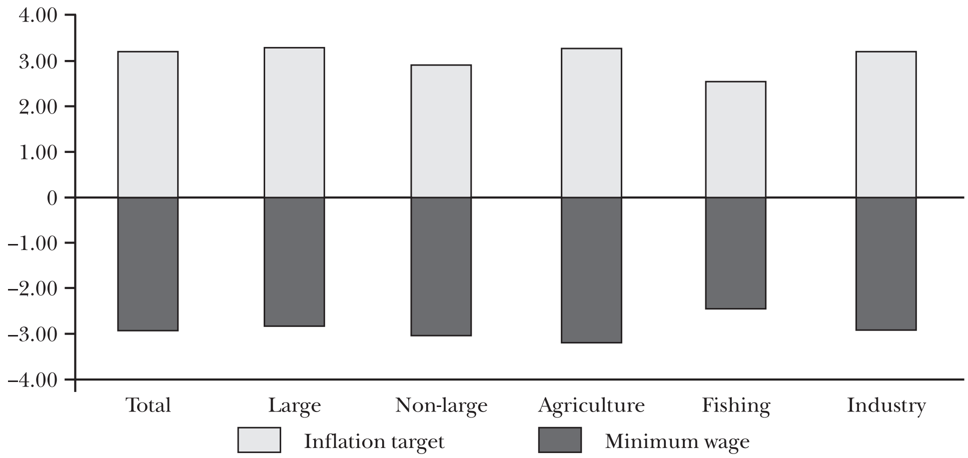




SOURCE: Own elaboration.

quarterly basis (approximately 22%). These are followed by six monthly and annual pricing reviews. The amount of firms which check their prices at intervals of more than one year is very small. Although large firms exhibit the same pricing review pattern, within the group of non-large firms the proportion of companies which review their prices weekly is higher than those which do so on a six monthly or annual basis. These results

FIGURE 6. IMPORTANCE OF THE INFLATION TARGET AND MINIMUM WAGE IN MAKING PRICING DECISIONS (AVERAGE SCORE)



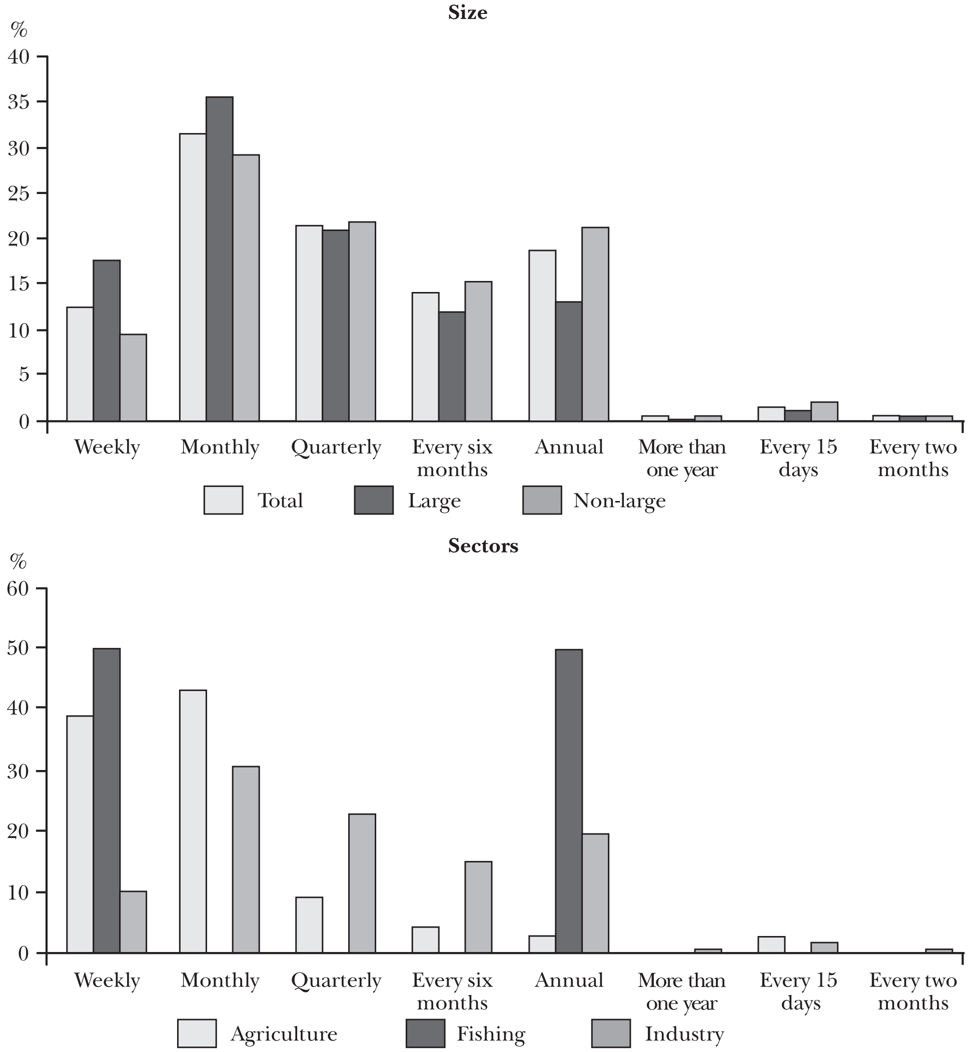
SOURCE: Own elaboration.

contrast with those observed, for instance, in the Eurozone, where in the majority of firms review their prices three times per year at the most (57% for the region as a whole). Moreover, small firms in those countries review prices less frequently, arguing that the cost of reviewing prices in a company with few staff members can be extremely high (Fabiani et al., 2005).

Some significant differences appear when economic sectors are studied separately. Firms in the agriculture sector review their prices more frequently than industrial firms. Weekly and monthly pricing reviews are the most common among the former, while industrial firms tend to review prices more on a monthly and quarterly basis. Fishing firms exhibit the two extremes of annual or weekly review.

The results in Figure 8 show that firms facing greater competition review their prices more frequently. Firms which do not face competition review pricing quarterly and annually. Some important differences also emerge if pricing review frequency is studied from the point of view of economic destination (Figure 8). A very high proportion of pricing reviews in the capital goods sector are carried out on a monthly basis (47%). Although relatively less important, such frequency is also predominant in sectors producing consumption and intermediate goods. It is worth pointing out that the high frequency of pricing review for capital goods is surprising given that this type of good is characterized by high unit costs.

FIGURE 7. PRICING REVIEW FREQUENCY (PERCENTAGE OF FIRMS)

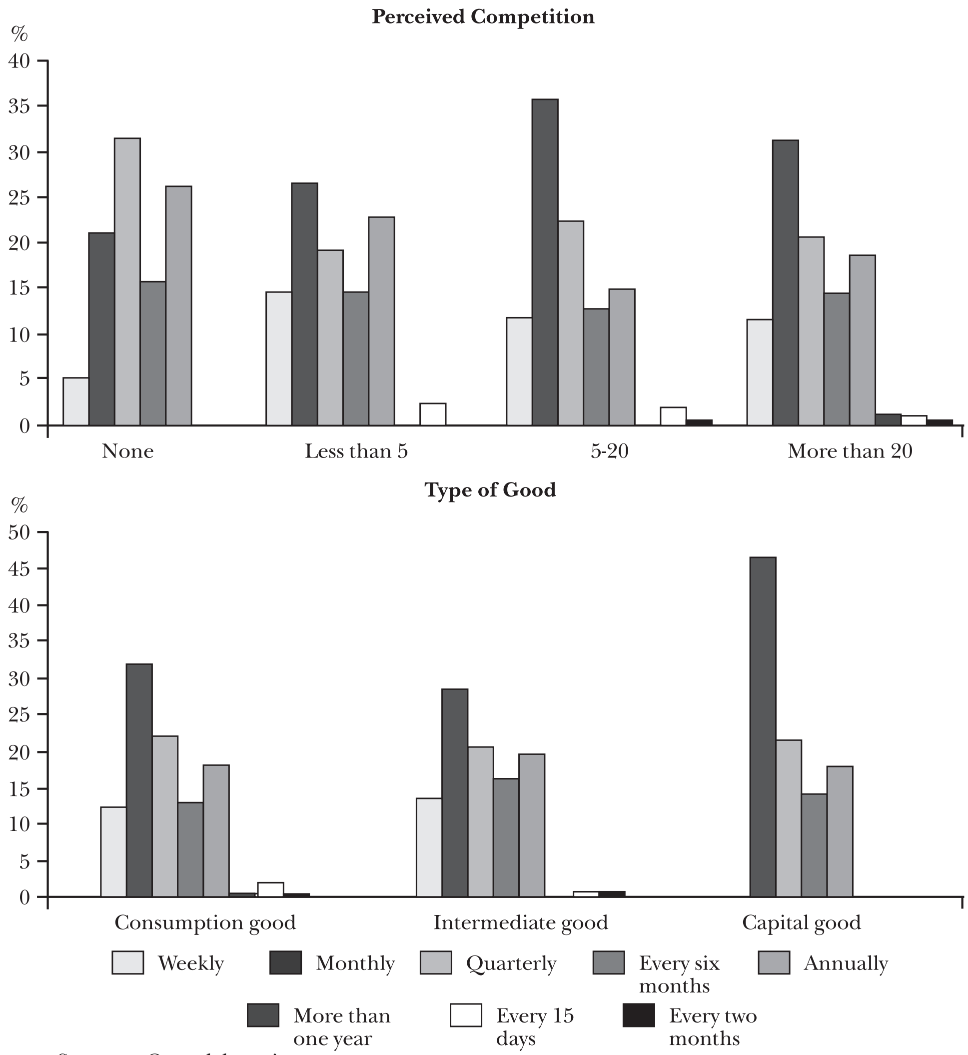


SOURCE: Own elaboration.

6. PRICE CHANGE

Pricing reviews do not necessarily lead to changes in prices. It is possible that the spread between the current and optimum price is less than the cost of making the change. This section explores the determinants of price

FIGURE 8. RELATIONSHIP BETWEEN PRICING REVIEW, COMPETITION AND TYPE OF GOOD (PERCETAGE OF FIRMS)



SOURCE: Own elaboration.

setting by firms. In particular, it investigates if firms discriminate their prices, especially if they do it in accordance with the market where they are selling their product. Finally, the frequency of pricing changes and the relation between pricing change and review is also studied.

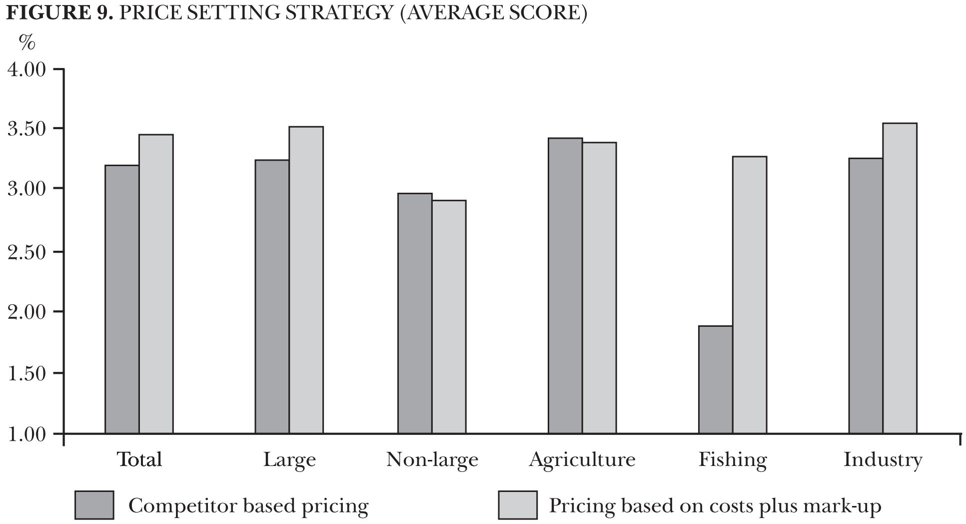
6.1 How Do Firms Set Prices?

6.1.1 Price Setting Model

A standard result of models of imperfect competition is that, under certain conditions, firms set a price based on marginal costs plus a margin. Under this scheme, firms keep a space allowing them to maintain their price if costs vary. In the case of perfect competition, on the other hand, all firms belonging to a determined market set their prices at one level which the market takes. In this case there is no margin above costs and the price is equal to the marginal cost.

In order to investigate this aspect further in the case of Colombian firms, the questionnaire asks businesses about the relative importance of competitor based or costs plus mark-up price setting strategies (question 24). The results shown in Figure 9 indicate that for Colombian firms as a whole, the most important price setting strategy is that based on costs plus mark-up. Nevertheless, the difference is not visually very important because the bars representing the importance given to a competitor based pricing strategy and one based on costs plus mark-up are similar in size. In order to clear up this point, a statistical test was carried out to ascertain whether the respective means were different or not. The results of this test for means are shown in Table 5. According to the test, although numerically different, the means reported are not statistically different to

FIGURE 9. PRICE SETTING STRATEGY (AVERAGE SCORE)



SOURCE: Own elaboration.

TABLE 5. PRICE SETTING STRATEGY

	Average score[a]	*% Importance*
Competitor based pricing	3.22	73.03
Pricing based on costs plus mark-up	3.46	93.26

SOURCE: Authors' calculations.
[a] Means are not statistically different to 5%. *p*-value = 0.86.

5%, i.e., in reality both strategies are equally important for Colombian firms.

For large firms the difference is much more pronounced and a price setting strategy based on costs plus mark-up is clearly dominant. This is not the case for non-large companies, for whom both strategies are equally important. In the agricultural sector both strategies are equally important, while in fishing and manufacturing a pricing strategy based on costs plus mark-up dominates.

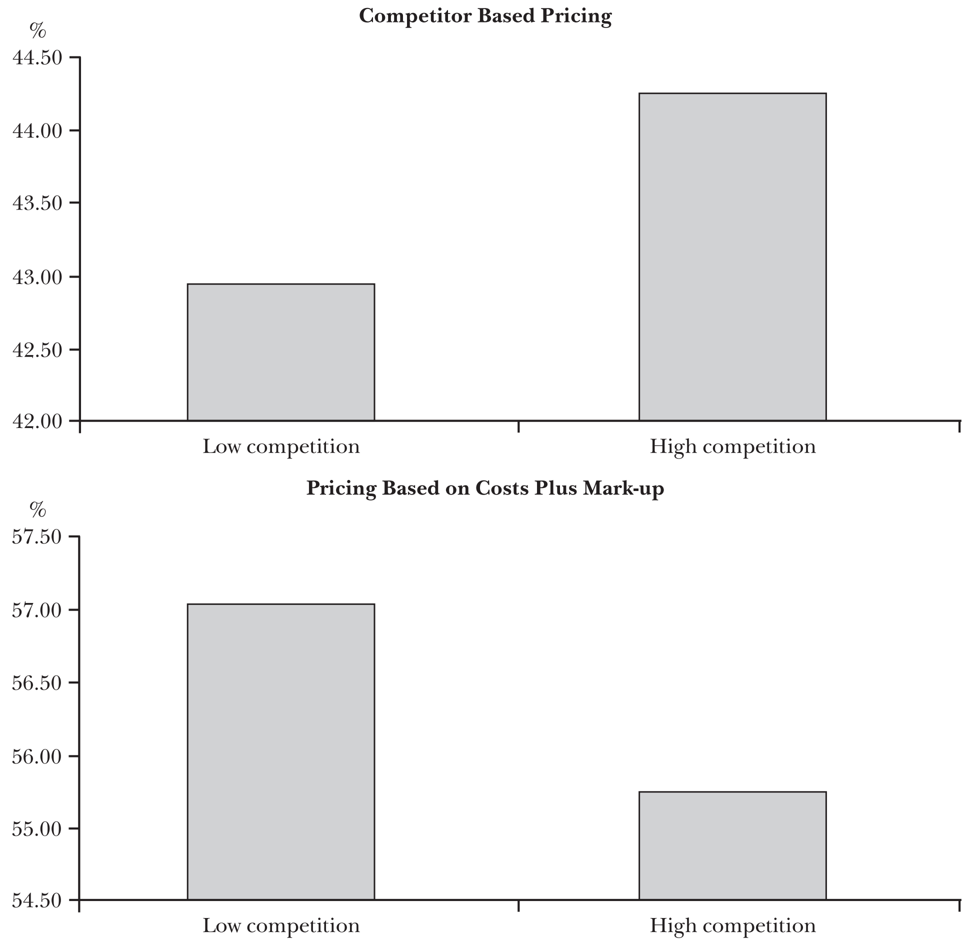
Finally, the pricing strategy is associated with the level of competition firms perceive (Figure 10). The result shows that in a highly competitive environment, firms are sustantialy price-takers, but in a low level of competition firms use the costs plus mark-up strategy. The negative relationship between the percentage of firms following a costs plus mark-up strategy and the degree of competition has also been found in other countries (see for instance Fabiani et al., 2005).

6.1.2 Price Discrimination

Firms are interested in implementing some kind of price discrimination for different reasons and this phenomenon has been studied in literature on industrial organization. Such literature defines discrimination as the event when two units of the same physical good are sold at different prices either to the same or different consumers. Firms obtain greater benefits from this nonlinear behavior than if they fixed the same price in the different markets (Tirole, 1985).

To investigate price discrimination by Colombian firms, the questionnaire asks businesses about the possibility of having different prices for buyers of the firm's main product (question 11). The results in Figure 11 show that use of a uniform price scheme as a general rule describing Colombian firms' pricing strategies can be rejected outright. As can be seen in the figure, most companies (close to 70%) follow a price discrimination plan.

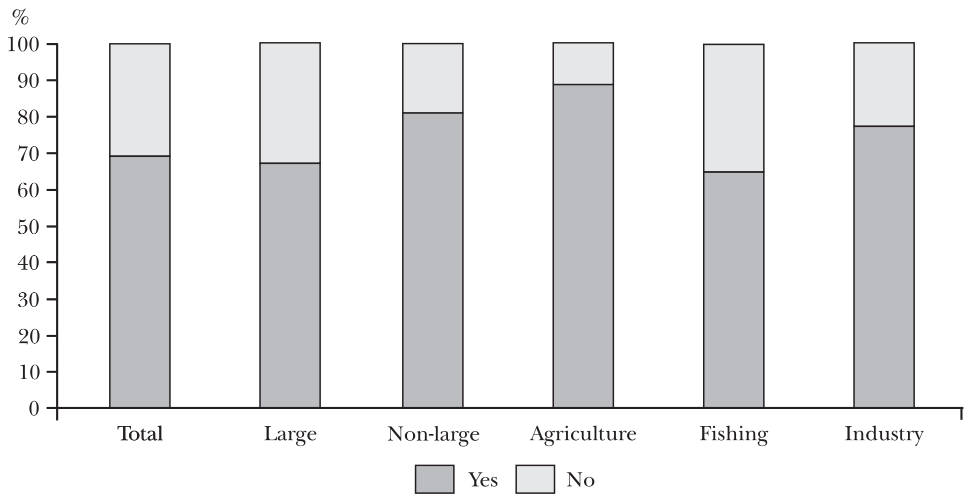
FIGURE 10. PRICE SETTING PLAN AND PERCEIVED COMPETITION (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

Some clear relations appear regarding price discrimination if firm size and economic sector are taken into account (Figure 11). This behavior is more pronounced in non-large companies (81% of firms), firms in the agricultural sector (around 89%) and, to a lesser extent, in the industrial sector (78%). On the other hand, there is a relation between price discrimination and the degree of competition (Figure 12). It can be seen that, as competition increases so does price discrimination, although it declines slightly for companies with more than 20 competitors.

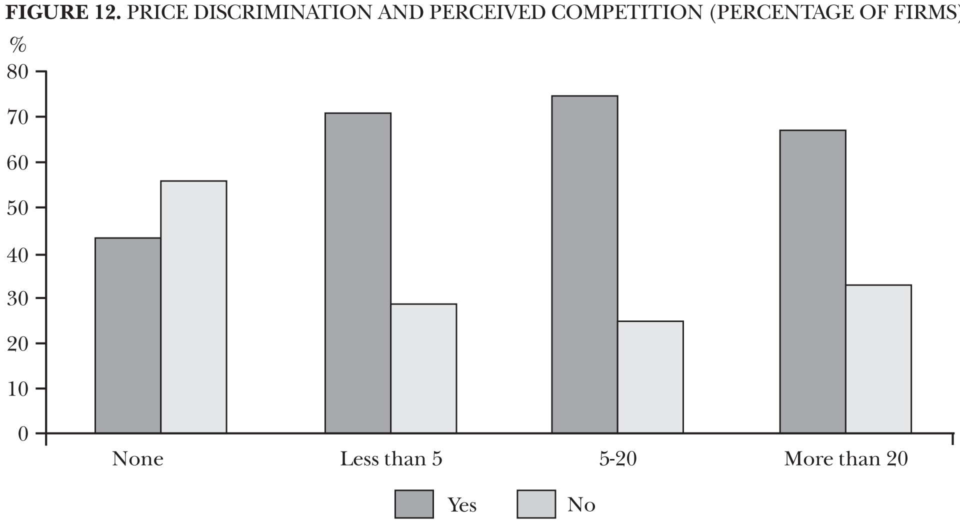
FIGURE 11. PRICE DISCRIMINATION (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

Price discrimination can take several forms: the price can be different according to the type of customer, the geographical area where the product is sold and the number of units sold, among others. Thus, business managers were also asked to indicate the importance of the reasons why they discriminate their prices. The results show sales volume is the most important

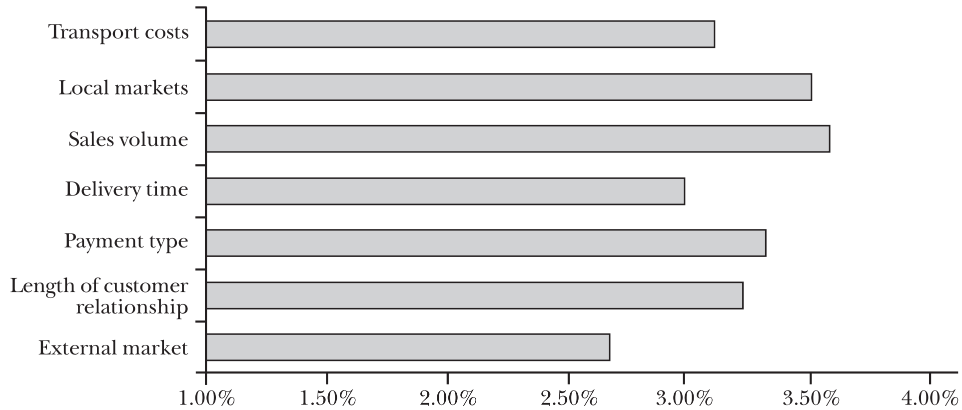
FIGURE 12. PRICE DISCRIMINATION AND PERCEIVED COMPETITION (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

reason for price discrimination, followed closely by the fact that it is about local markets (Figure 13).

FIGURE 13. DETERMINANTS OF DISCRIMINATION BETWEEN PURCHASERS (AVERAGE SCORE)



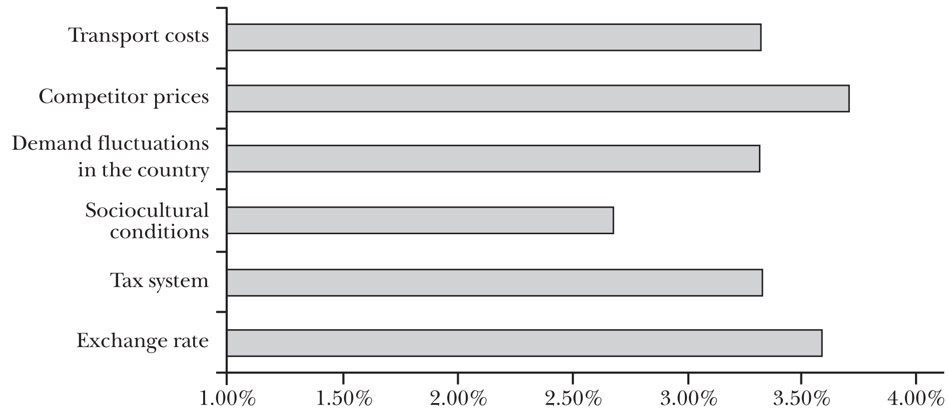
6.1.3 Pricing to Market

Fabiani et al. (2005) remind us that the law of one price states that, taking into account exchange rate adjustments, prices of a product should be the same in all markets. Nevertheless, empirical studies reject the value of this hypothesis in the short-term. One explanation of this result is that transaction costs between geographically different markets are so high that they allow price discrimination between countries. This phenomenon is known in literature as pricing to market.

The Colombian economy is not particularly open to international trade. This explains why the latter is not one of the main reasons explaining the price discrimination described in the previous section.[10] Nonetheless, when external market discrimination does occur, businesses do it for two major reasons: competitor prices and exchange rate. Such result was reached by asking businesses about their reasons for discriminating between prices in domestic and external markets (question 13).

[10] It is important to remember that the population studied does not include net exporters, i.e., businesses which sell their products abroad. Caution should therefore be taken when interpreting the results shown in this section.

FIGURE 14. DETERMINANTS OF DISCRIMINATION BETWEEN EXTERNAL AND DOMESTIC MARKETS (AVERAGE SCORE)



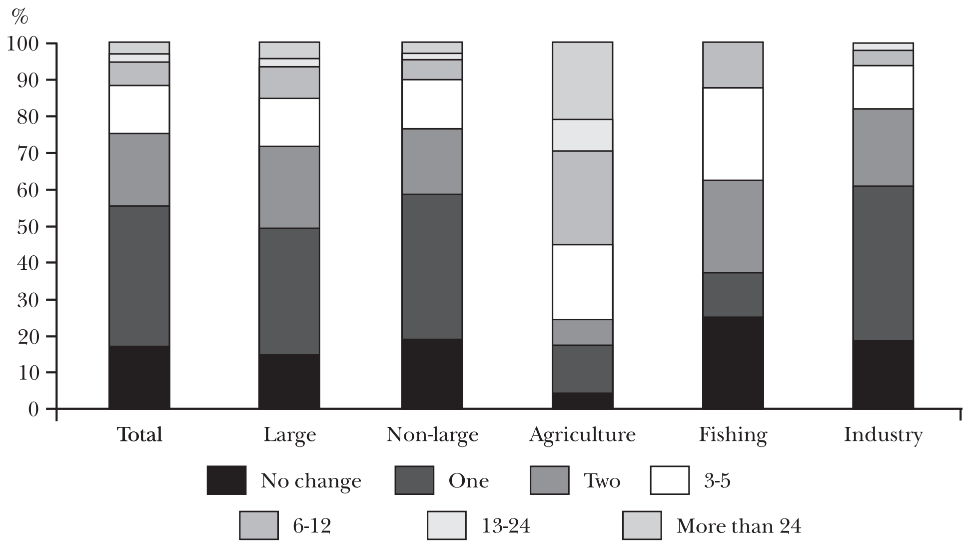
6.2 Frequency of Price Changes

One measure of the degree of price rigidity in an economy is provided by the number of times the price of a good changes during one year or, in other words, the period of time between two consecutive changes in prices of that product. An approximation of this measurement is essential for improving the macroeconomic models used to support monetary policy.

The questionnaire asks businesses about the number of times they have changed the price of their main product during the last year (question 20). The questionnaire's answers reveal that, on average, the relative frequency of price changes is low (Figure 15). Most firms change the price once a year (38%) and 75% do so a maximum of two times. This structure remains if the size of company is taken into account, with price changes occurring predominantly once per year. According to the results, non-large companies change the price of their main product even less frequently than large firms. Behavior differs between economic sectors. For instance, industrial firms change prices much less frequently than those in the agricultural or fishing sectors. More frequent changes predominate in the latter. This behavior confirms that, in terms of price changes, primary activities are more flexible than those which add more value.

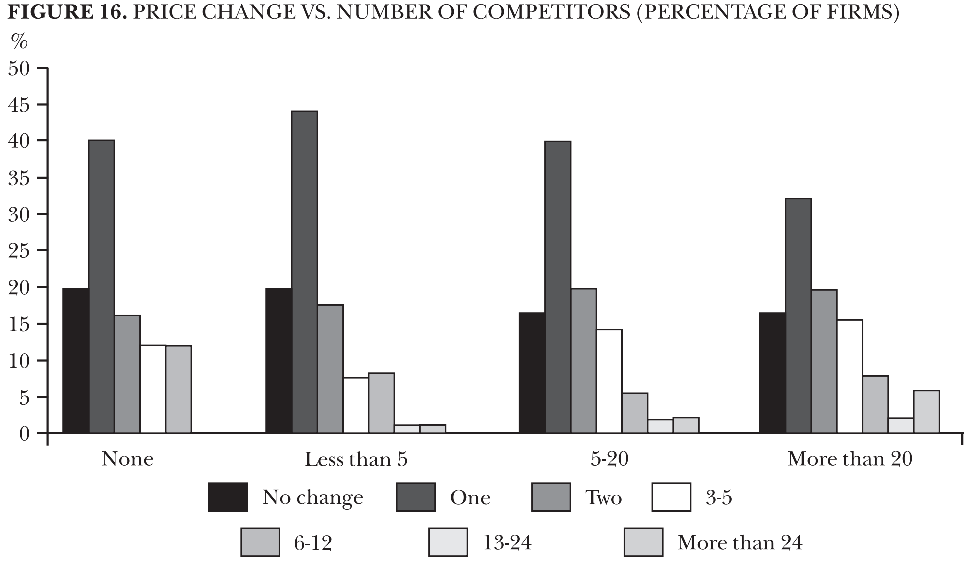
Figure 16 relates the frequency of price changes to the structure of competition in the firm's market. The results lead to the conclusion that, as the number of competitors increases, the proportion of firms making one change per year decreases. Meanwhile, as firms face more competitors, a larger share of those taking part in the survey answer that they must

FIGURE 15. NUMBER OF PRICE CHANGES IN THE LAST YEAR (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

FIGURE 16. PRICE CHANGE VS. NUMBER OF COMPETITORS (PERCENTAGE OF FIRMS)

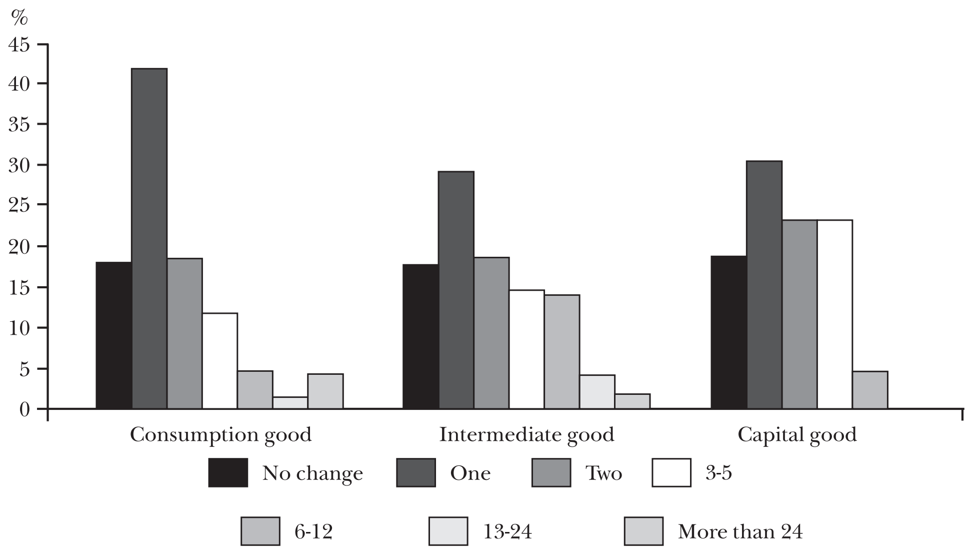


SOURCE: Own elaboration.

change the price at least twice a year. A similar situation is seen for firms which change the price of their main product more than 24 times per year.

If firms are classified according to the economic destination of their main product and this result is related to the number of times the firm changes the price of this good (Figure 17), it is found that firms producing consumption goods change their prices less frequently. In this case, one price change per year predominates (42%), while in the other cases two, and between two and five changes per year become more important.

FIGURE 17. PRICE CHANGE BY TYPE OF GOOD (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

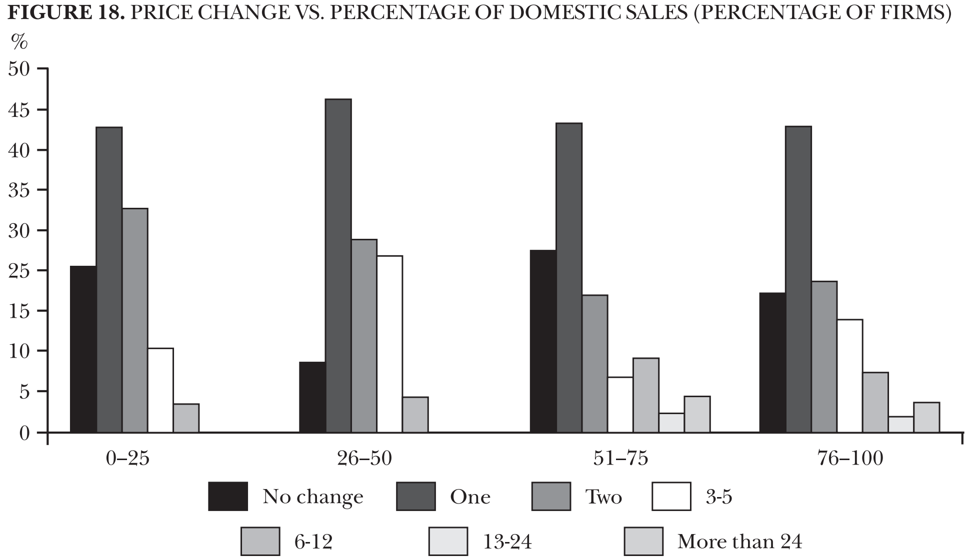
6.2.1 Changes in Price Adjustments During the Last Five Years

The frequency of price adjustment can change according to the phase of the business cycle the economy is in. The existence or not of demand side pressures and the way in which economic authorities address such situations directly affect price adjustment. The implementation of inflation targeting during the current decade has led to lower, more stable and predictable inflation. Nonetheless, as stated previously, at the time the survey was carried out, inflationary pressures had risen, mainly as a consequence of the strength of domestic demand, higher energy prices and increases in the prices of different raw materials, partly offset by the revaluation of the peso.

The decline in inflation during the first half of the decade reduced the need for more frequent price changes. The opposite should therefore happen when inflation increases as it did in the most recent period when the survey was carried out. Recent years have generally been characterized by a very strong global economy with technological innovations and movements of goods, services and capital. This has affected the way businesses set their prices.

Taking into account the importance of measuring if businesses have modified their behavior regarding the number of price changes, survey participants were asked if the frequency of price adjustments had changed during the five years preceding the survey (question 21). Such time period was chosen because various works have calculated it as the average length of the Colombian economy's business cycle (Arango et al., 2007). Survey participants were given the option to indicate the direction of the change.

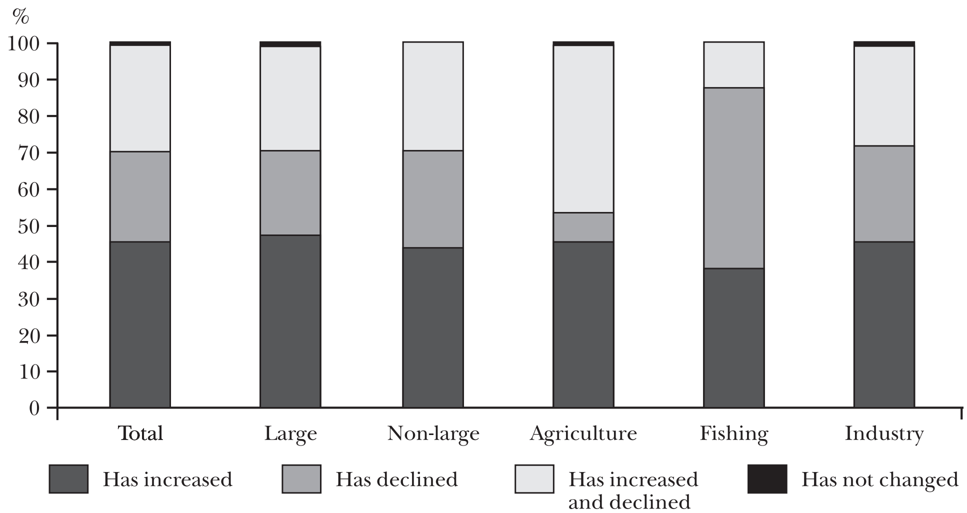
FIGURE 18. PRICE CHANGE VS. PERCENTAGE OF DOMESTIC SALES (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

The answers suggest that price setting frequency has changed (Figure 19). Most businesses believe the frequency has increased, some that it has declined and others that both of these have happened. If the division of

FIGURE 19. CHANGE IN THE FREQUENCY OF PRICE ADJUSTMENT (PERCENTAGE OF FIRMS)



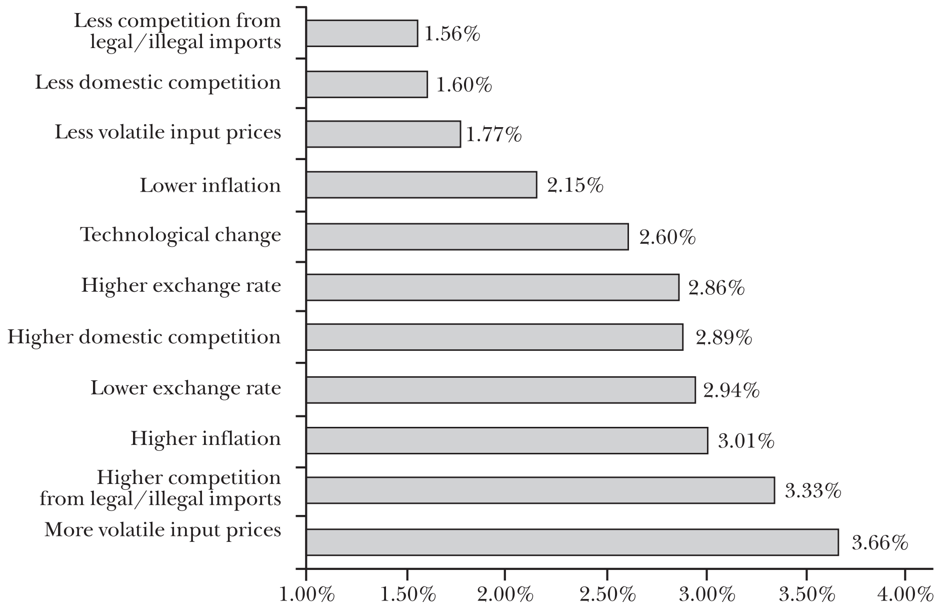
SOURCE: Own elaboration.

large and non-large companies is analyzed, a larger proportion of small and medium sized companies consider that the frequency of price adjustment has decreased. The opposite is observed in the case of large firms. Meanwhile, the frequency of price adjustments has risen in the industrial and agricultural sectors.

The main reasons for changing the frequency of price adjustments are, in the order of importance given by survey participants, greater competition from imports, higher inflation and the lower exchange rate (Figure 20). Cost volatility is linked to increases in the prices of energy, transport and raw materials observed throughout the period. The second answer can be understood as the definition that the price can be outside the market regarding the imported product and the costs of being outside increase substantially as competition increases. As an explanation, inflation can be another way of saying the same as the option marked as most important, or it can also be explained by an increase in inflation expectations. Appreciation of the exchange rate is also important during the period and can doubtlessly have affected price setting in some firms.

By sector it is interesting to see that for industry the most important reason for changing the frequency of price adjustments during the last five years was a higher exchange rate. This result suggests that the appreciation of the exchange rate led to an increase in the frequency of price

FIGURE 20. REASONS FOR CHANGING FREQUENCY OF PRICE ADJUSTMENT (AVERAGE SCORE)



SOURCE: Own elaboration.

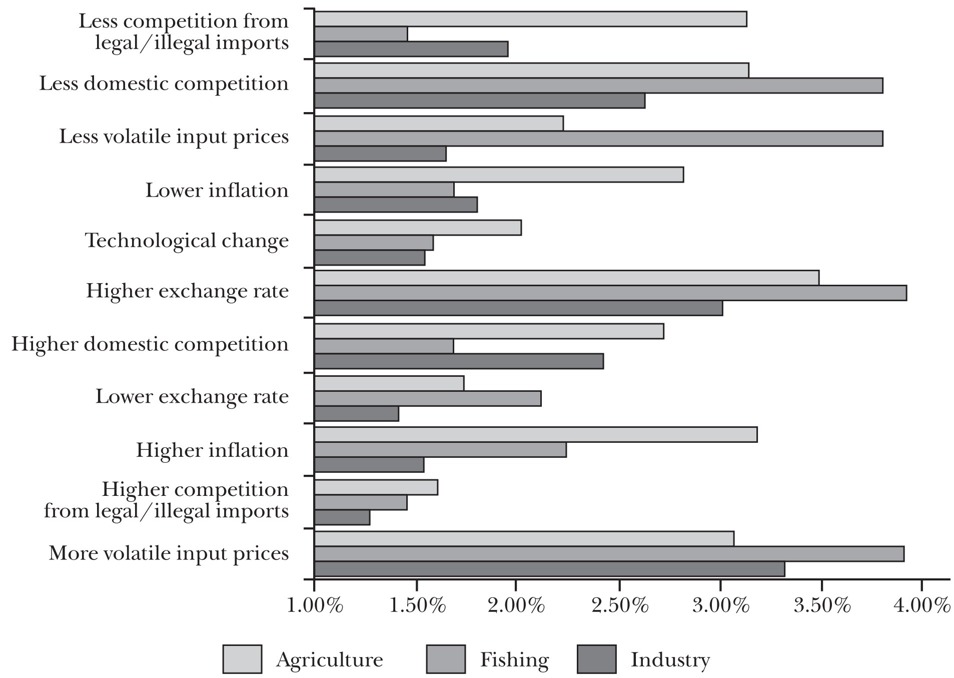
changes possibly because of greater imports competition for companies which sell their products domestically, or due to a loss of competitiveness abroad for firms which sell a percentage of their products externally. Meanwhile, for agriculture and fishing, the greater volatility of input prices and the higher exchange rate were the reasons behind firms changing the frequency of price adjustments (Figure 21).

When the answers of firms which stated they had increased the frequency of price adjustments are cross referenced with the reasons why they did so, it can be seen that a large proportion of survey participants consider greater volatility of input prices caused the change in frequency. This result remains true for firms which indicate that the frequency has decreased (Figure 22).

6.3 Relation between Pricing Review and Change

As mentioned, in the price setting process, reviews do not necessarily imply change. It is possible to compare the frequency of pricing changes and reviews using survey information, which shows that pricing reviews are more frequent than changes (Table 6). The table can be interpreted in

FIGURE 21. REASONS FOR CHANGING FREQUENCY OF PRICE ADJUSTMENT BY ECONOMIC SECTOR (AVERAGE SCORE)



SOURCE: Own elaboration.

the following manner: 67.09% of total companies review their prices more than three times per year, while those that change their prices more than three times per year represent 18.07% of total companies.

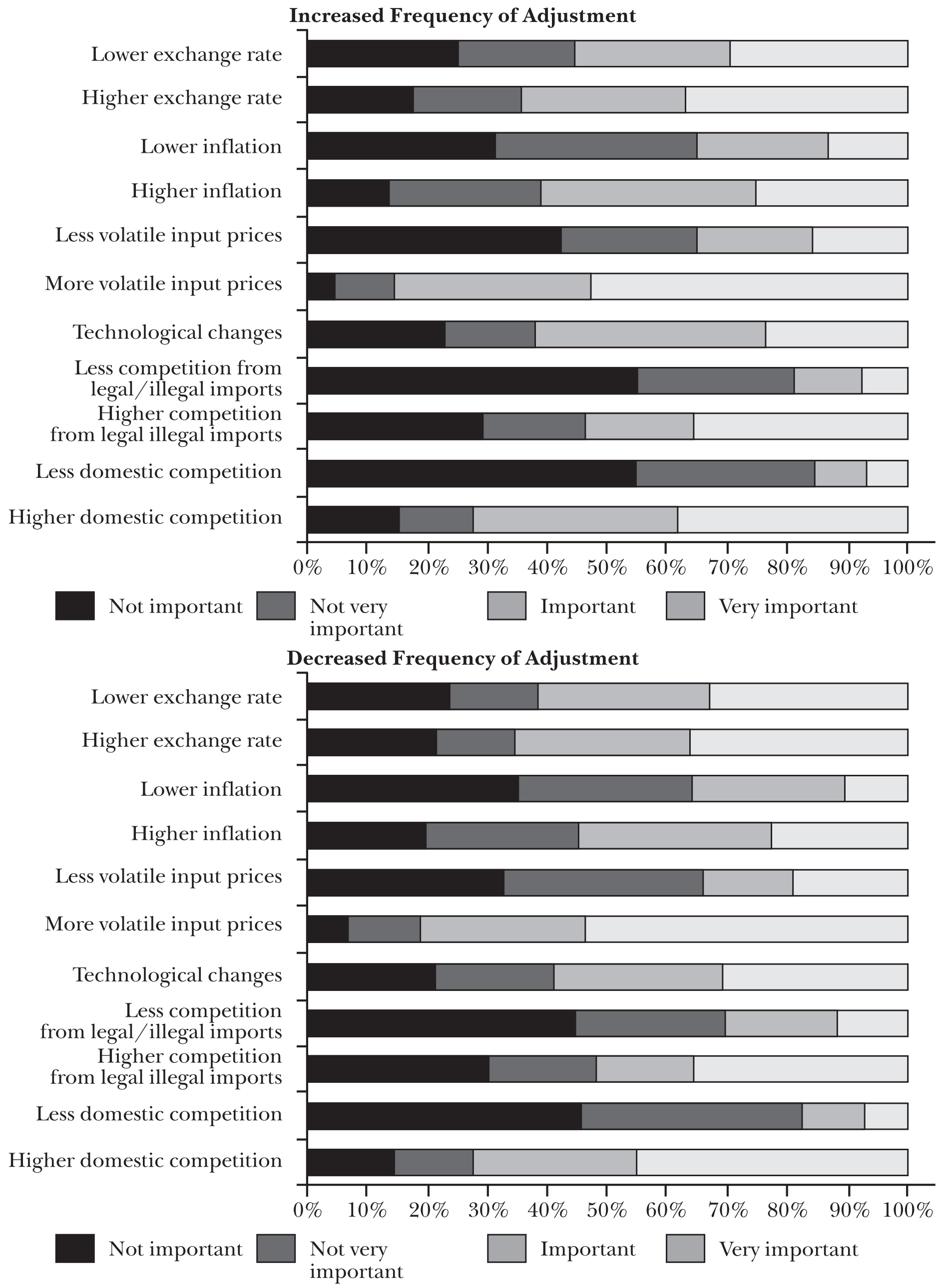
TABLE 6. PRICING REVIEW VS. PRICING CHANGE

	Relative frequency (%)
Pricing review > 3	67.09
Pricing change > 3	18.07

SOURCE: Authors' calculations.
NOTE: Omitted values are not included.

An explanation for this behavior might be that the companies which review their prices do not change them because there is no reason to do so. On the other hand, if companies incur costs for reviewing prices, there must be compelling reasons not to change them. The problem, therefore, resides in finding out what these reasons are.

FIGURE 22. REASONS FOR CHANGING FREQUENCY OF ADJUSTMENT: FREQUENCY INCREASE VS. DECREASE (PERCENTAGE OF FIRMS)

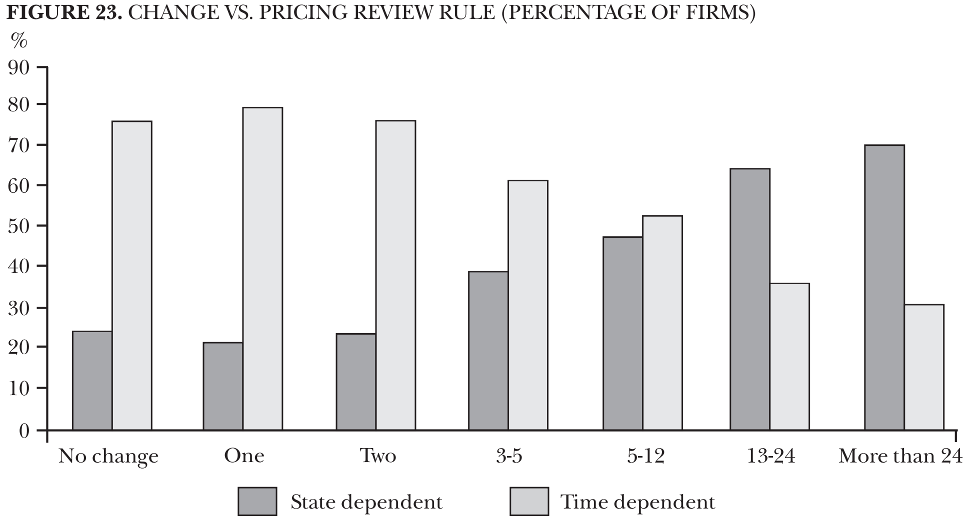


SOURCE: Own elaboration.

The next section deals with studying the possible motivations behind why companies do not change their prices. Nevertheless, the first idea can be found in relating the flexibility of price changes with the strategy for their review (Figure 23). The more flexible companies are those that use a state-dependent review strategy. The opposite occurs when the companies follow a time-dependent strategy, a strategy which is characterized as highly rigid.

The higher reaction capacity of firms which follow a specific strategy is by itself an interesting result. Flexibility is an important result of an inflation targeting strategy and knowing how to achieve this is a relevant question. However, it is only possible to obtain such information by asking agents about the factors which make them behave the way they do. An explanation of the pricing review strategy is inadequate because it does not indicate the business's reasons and motives for not pursuing it.

FIGURE 23. CHANGE VS. PRICING REVIEW RULE (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

6.4 Theories on Price Rigidity

One of the survey's objectives was to investigate the causes of price inflexibility inside companies. With respect to this, theories offering various explanations are tested in this section of the document. To this end, we accept Blinder's suggestion to question businesses as a way of examining the empirical relevance of the different theories (Blinder et al., 1998).

The survey explained each of these to those taking part in the survey and asked them to rate each option in order of importance.

The results in Table 7 show the theories in order of importance as ranked by survey participants in response to the different statements presented by the survey. The theories were presented in straightforward language and businesses were asked to rank the theory in one of four ways: *1)* not important, *2)* not very important, *3)* important and *4)* very important. The theory we have named "idle costs"[11] is the most important according to the business managers surveyed.

TABLE 7. IMPORTANCE OF DIFFERENT PRICE RIGIDITY THEORIES

	Average Score	*Standard Dev.*
Idle costs	3.14	0.22
Explicit contracts	2.90	0.18
Implicit contracts	2.90	0.11
Product quality	2.63	0.14
Coordination failures	2.51	0.15
Irregular information	2.45	0.10
Transitory situation	2.41	0.24
Price point	2.24	0.16
Menu costs	1.95	0.15

SOURCE: Authors' calculations.

NOTE: Dotted lines indicate that a two-tailed test rejects that the theory above and below the line has the same measurement with a 95% level of confidence.

The idea that prices are mainly determined as a function of the final product's production inputs is not formally recognized by the international literature as a price rigidity theory. The argument is based on the idea that the lag between a cost shock and a price change is too short. Nonetheless, authors such as Gordon (1981) and Blanchard (1983) show that due to the fact that a product's production is tied to a production chain composed of many processes, a cost shock for one of these takes time to propagate to the other stages of production and, in this way, to the final consumer. For this reason, even short lags in the adjustment process of one single company can lead to long lags when the entire production chain is considered. Additionally, according to this *theory*, prices do not change due to the fact that input costs do not change, i.e., prices are rigid because other prices are also rigid.

[11] Also known in the literature as *cost-based pricing* or constant marginal costs.

The second group of explanations corresponds to explicit or implicit contracts. These two theories are extremely interrelated. Both coincide in that agents are looking to avoid price variations. The first of these theories was proposed by Fischer (1977) and Phelps and Taylor (1977) and is based on the existence of contractual relations between companies and consumers in which the former guarantees to sell a product to its customers at a predetermined price. Companies offer this type of contract in order to build long term relationships with their clients. This should prevent customers from buying elsewhere and establish the foundation for the company's future sales. Additionally, the clients are attracted by constant prices as it helps them minimize search time costs.

The theory of implicit contracts (Okun, 1981, and Rotemberg, 2005) is based on the fact that companies look to build long term relationships with their clients in order to make their future sales more predictable. In contrast to explicit contracts, implicit contracts try to create customer loyalty by changing prices as little as possible. According to Okun (1991), price increases should be differentiated between those due to cost shocks or demand shocks. Higher costs are rationally accepted as leading to price increases, while price increases due to an increase in demand are seen as unfair. Therefore, companies do not change their prices due to increases in demand as they do not want to impair their relationship with their customers. These companies only adjust their prices due to cost shocks. Rotemberg's (2005) idea is based on the theory that clients want to buy from companies whose prices are seen as fair.

The theory of product quality, the fourth most important, refers to the fact that companies prefer not to reduce their product prices as the client could perceive this as a drop in product quality. According to this rationale, companies prefer to maintain constant nominal prices.

Coordination failures between companies could lead to price rigidity. The theory with this name started its academic journey with Clower (1965) and Leijonhufvud's (1968) work on labor market analysis. Later, Ball and Romer (1991) applied these ideas in the context of the price setting process. According to this theory, companies do not like to change their prices because this might have severe implications for both consumers and the competition. In fact, a company could decide not to increase their price for fear of losing clients. On the other hand, a company might decide not to reduce its price as this strategy does not guarantee a higher market share if its competition does the same. Therefore, after a shock, the company only changes its price if there is an agreement with the other companies about the way in which to react. Nominal prices of companies remain rigid without this coordination mechanism.

The irregular information theory is postulated as a deficient flow of information. The business's gathering of required information is slow and wasteful as a consequence of temporary lags in the production of certain variables. Price change decisions could be prolonged as a consequence of the delay in the collection of the required statistical elements.

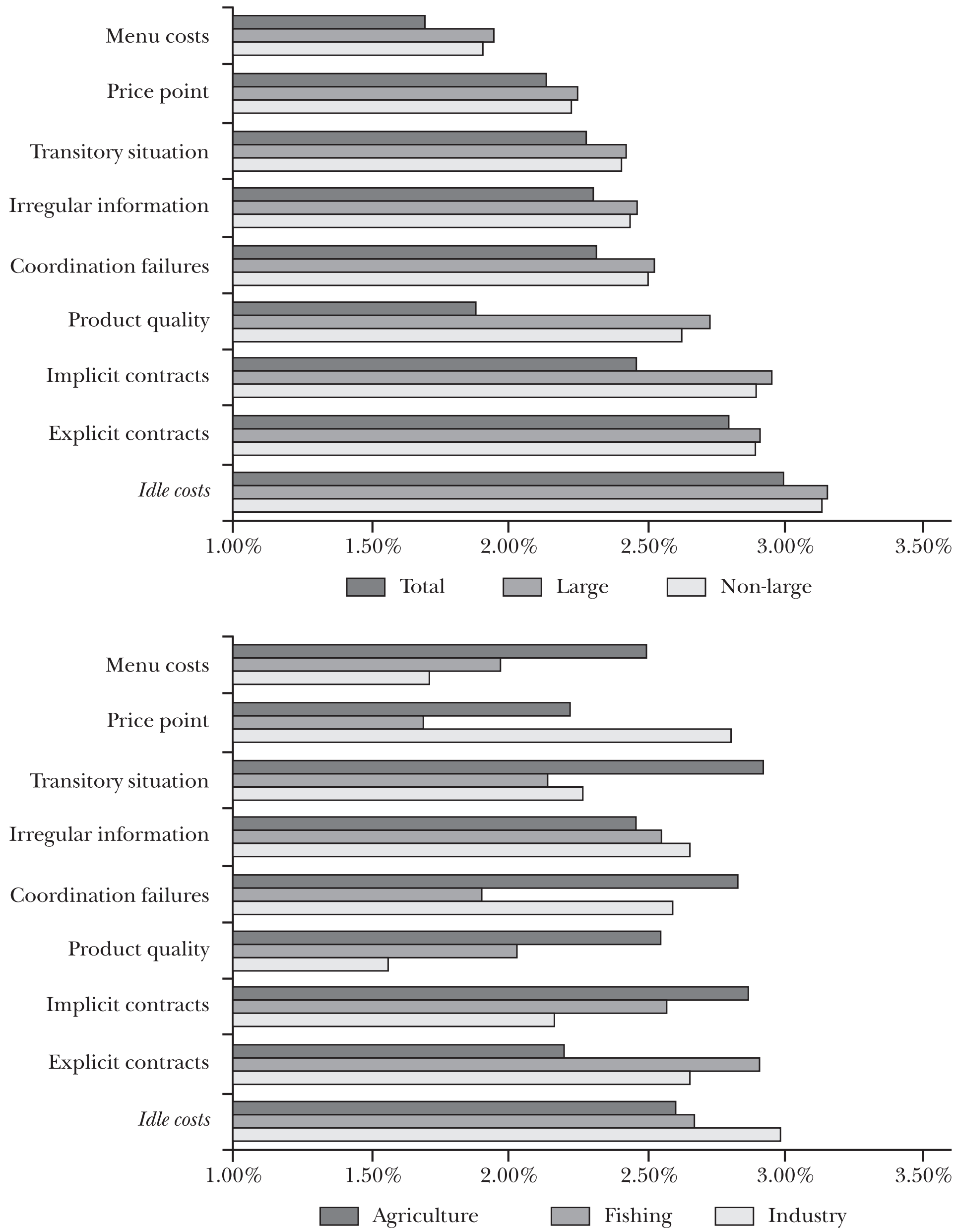
The company must make the decision of whether or not to change its prices when confronted with a shock. According to the theory of transitory situations or temporary shocks, it is possible that the company will not change prices if it thinks that the shock is transitory. The new optimal price could be temporary and the company would incur new costs if the decision had to be reversed. Companies prefer not to change prices until they are sure that the shock is permanent. Thus, frequent price changes are considered to be detrimental to customer relationships.

The price point theory suggests that companies set their prices at psychologically attractive points, a situation associated with discontinuities in the demand curve. Companies choose price *points* as an increase in price beyond that point would imply a disproportionate decrease in demand. Companies do not immediately react to the presence of small shocks which would suggest correspondingly small price changes. On the contrary, price changes are postponed until new events justify a larger price change and bring them to the next price point.

Menu cost theory, the last on the list, is derived from the work of Barro (1972), Sheshinski and Weiss (1977), Akerlof and Yellen (1985) and Mankiw (1985). It is based on the idea that the act of changing prices has costs in itself, such as printing and distributing new price lists or changing price labels. A company confronted with these costs might change its prices less that a company which does not.

Some differences can be detected if companies are divided by size and economic activity (Figure 24). In the first case, the importance given by large firms to implicit contracts and product quality as theories to explain price rigidity can easily be seen. For non-large companies, product quality theory is much less important than for large firms and for companies as a whole. By sector, the differences are much more apparent. In fact, the ordering of theories changes substantially. The most important theories for agriculture, in descending order, are idle costs, price point and irregular information. For industry, transitory situations, implicit contracts and coordination failures are the main reasons for keeping their prices stable.

FIGURE 24. IMPORTANCE OF DIFFERENT PRICE RIGIDITY THEORIES (AVERAGE SCORE)



SOURCE: Own elaboration.

And finally, for fishing, idle costs and explicit and implicit contracts are the most important.

7. FACTORS ASSOCIATED WITH PRICE CHANGES

7.1 Asymmetries

Empirical literature provides evidence of the differences which exist, in terms of conditional probability, of increasing or reducing prices. Dhyne et al. (2005) show that there is evidence of a smaller frequency of price reductions than price increases in the euro zone. The results for the USA are similar (Klenow and Kryvtsov, 2005). Two papers for Columbia also show similar results (Zárate and Julio, 2008 and López, 2008).

The survey asks businesses questions on the importance of several price determination factors in order to perform an analysis of the factors which determine price changes and stipulate if there are asymmetries which depend on the direction of price adjustments. They are asked to rate a list of factors which could influence their decision to increase (question 26) or lower their prices (question 27). Table 8 shows the results of those surveyed in relation to price increase and Table 9 in relation to price decreases.

TABLE 8. ASYMMETRIES IN DECISIONS TO INCREASE PRICES

	Average score	*Standard deviation*
Change in raw material costs	3.81	0.05
Change in competitor prices	3.25	0.08
Change in energy and fuel prices	2.99	0.08
Change in taxes and contributions	2.97	0.17
Change in demand for their main product	2.89	0.10
Change in the exchange rate	2.83	0.16
Change in financial costs	2.63	0.13
Change in labor costs	2.52	0.15

SOURCE: Own elaboration.
NOTE: Dotted lines correspond to a two-tailed equality of averages test.

Table 8 shows that changes in the cost of raw materials (with an average importance of 3.8) and a change in competitor prices (3.2) are the most important factors for explaining a price increase. The most important elements explaining price decreases are a change in competitor prices (3.4 score) and changes in the cost of raw materials (3.2). It is slightly

TABLE 9. ASYMMETRIES IN DECISIONS TO DECREASE PRICES

	Average rating	*Standard deviation*
Change in competitor prices	3.39	0.11
Change in costs of raw materials	3.20	0.08
Change in demand for their main product	2.91	0.10
Change in taxes and contributions	2.77	0.21
Change in the exchange rate	2.72	0.15
Change in energy and fuel prices	2.56	0.13
Change in financial costs	2.27	0.14
Change in labor costs	2.22	0.15

SOURCE: Own elaboration.
NOTE: Dotted lines correspond to a two-tailed equality of averages test.

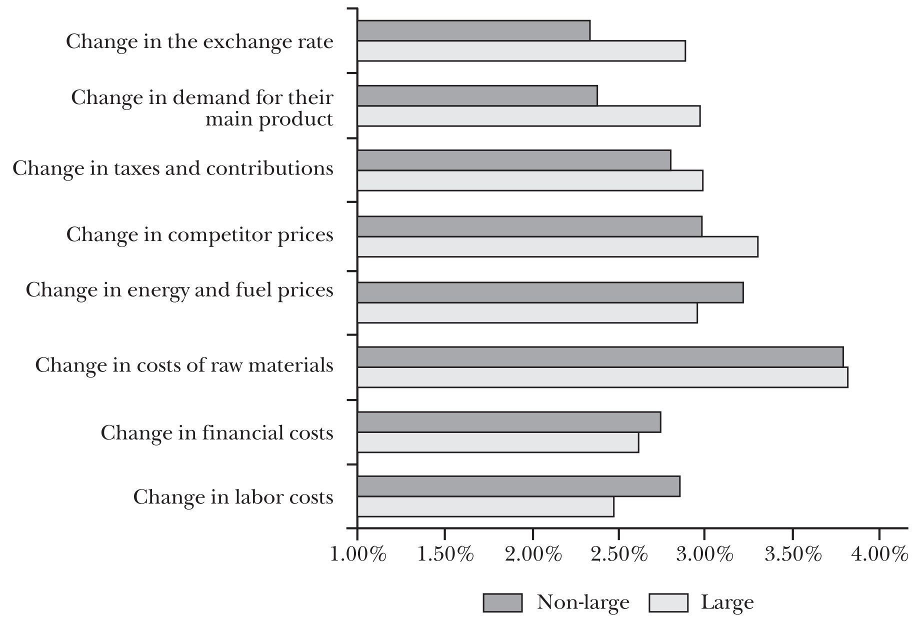
strange that the same explanatory factors, in a different order, are found. Based on these results, one could come to the conclusion that the company is willing to respond to shocks that affect their bottom line (competitor costs and pricing).[12] On the other hand, changes in financial and labor costs are not important in either of the events contemplated.

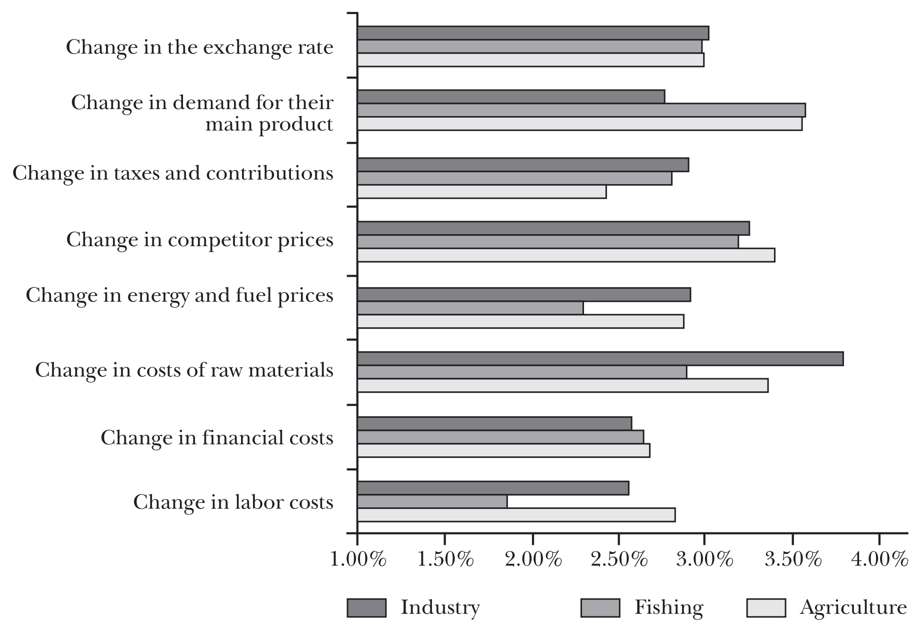
If groupings are made by company size and by economic sector the following is found. With regard to decisions to increase prices, large companies and non-large companies agree that the main motivation is changes in the costs of raw materials (Figure 25). Likewise, a change in the costs of fuel and energy is very important for non-large companies. For this last group of companies, importance given to labor costs increase in significance, an aspect that could be interpreted as a reflection of the importance that this factor could have on the technology they use. In contrast, the change in demand for their main product is very important in the decision to increase prices for agriculture and fishing, while changes in raw material costs is extremely important to industrial companies (Figure 26).

With respect to price decreases, the most relevant factors for large companies are prices of the competition and raw material costs (Figure 27). The importance given to the first factor contrasts with that seen in decisions to increase prices. Changes in the demand for its principle product is the determining factor in the decision to reduce prices for agriculture and fishing, while changes in raw material costs are the most important for industrial companies (Figure 28).

[12] The dotted lines in Tables 8 and 9 correspond to the results of an equality of averages test. Their reading is similar to that presented in Section 6.4.

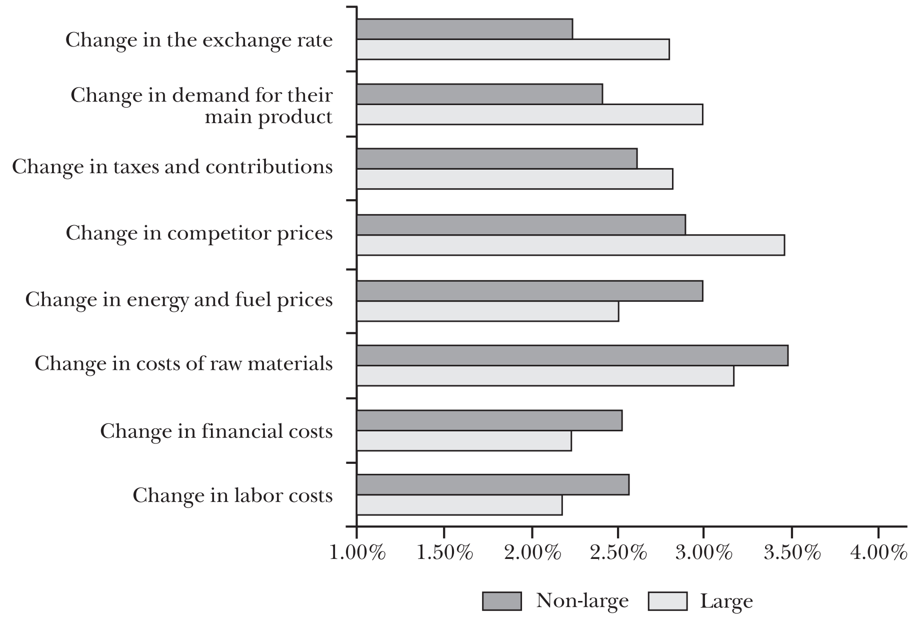
FIGURE 25. ASYMMETRIES IN DECISIONS TO INCREASE PRICES (AVERAGE RATING)

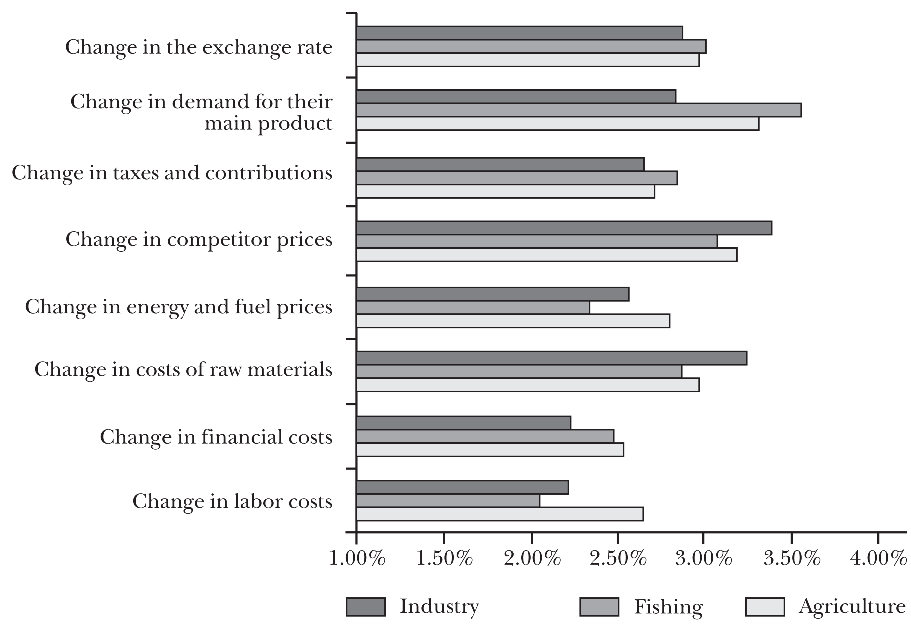




SOURCE: Own elaboration.

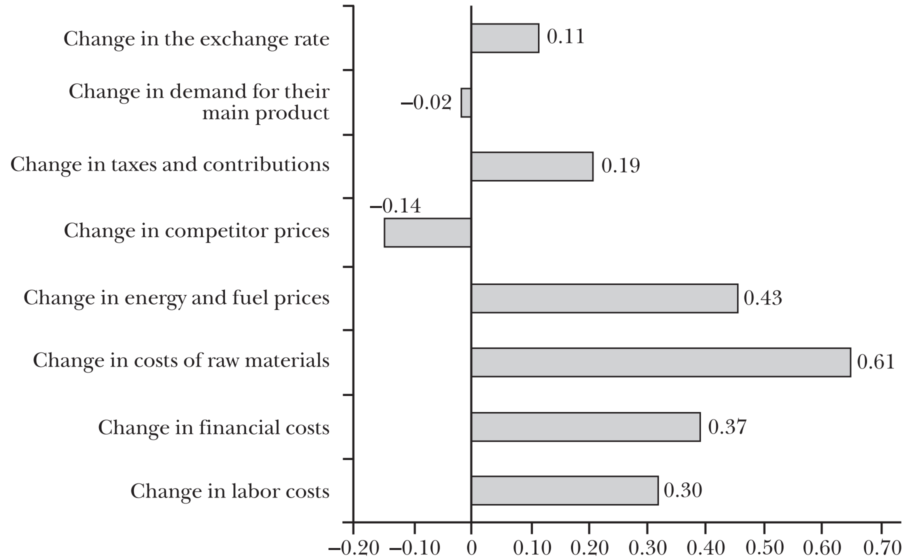
FIGURE 26. ASYMMETRIES IN DECISIONS TO DECREASE PRICES (AVERAGE SCORE)





SOURCE: Own elaboration.

FIGURE 27. ASYMMETRIES IN FACTORS DETERMINING PRICES[a]



SOURCE: Own elaboration.

NOTE: [a] Corresponds to the difference between the average when they decide to increase and the average when they decide to decrease. A positive score indicates that a factor is more important when increasing than when decreasing.

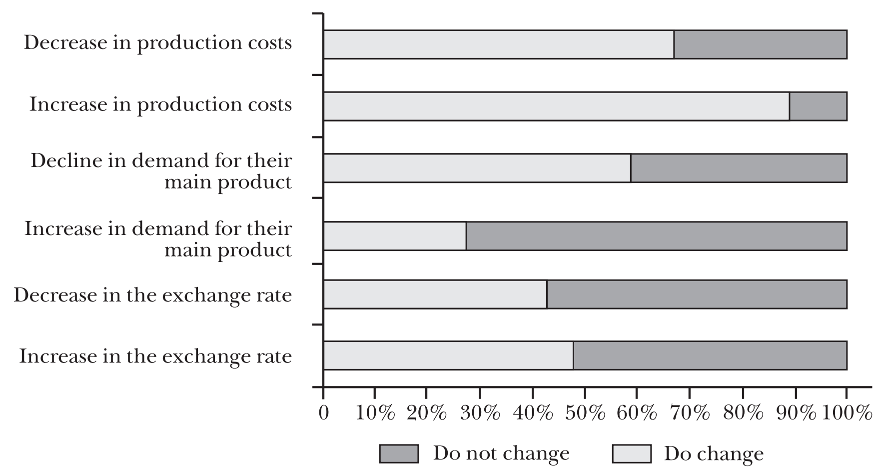
One way of understanding the asymmetries is to combine the degree of importance that each factor confers on the increase and decrease in prices into one statistic. Using the information gathered by the survey, a balance is constructed that corresponds to the difference between the average score given by businesses to each factor used when they decide to increase or decrease prices. A positive number indicates that a specific factor is more important in the decision to increase than to decrease. A negative number signifies the exact opposite. The magnitude is also important because a larger number means that the difference between the importance given to a factor for price increases or decreases is greater than in the case of a smaller number. The results of this exercise are shown in Figure 27. In general, a regular pattern of positive asymmetries exists for costs and a negative one for market conditions. The importance of changes in raw material costs is evident as an explanation for price increases in comparison to price decreases. Fuel and energy costs display similar behavior. The opposite is seen for changes in competitor prices. This factor is extremely relevant in the decision to reduce prices.

7.2 Adjustment of Prices after Shocks

The response of prices after different types of shocks that could affect the economy will be analyzed next. In this regard, survey participants are first asked if they change the price of their main product when an unanticipated event occurs. If so, they are then asked to rate the importance of a series of events (question 25).

Around 90% of firms modify the price of their main product when a production cost increase occurs, while 67% do so when a decrease occurs. Around 60% react to a decrease in demand. Only 28% change the price when demand increases (Figure 28). Meanwhile, when a cost change occurs, the percentage of large companies and non-large companies which change prices is similar. On the contrary, if decreases as well as increases in demand occur, the vast majority of firms which change their prices are large ones.

FIGURE 28. RESPONSE OF PRICES TO SHOCKS (PERCENTAGE OF FIRMS)

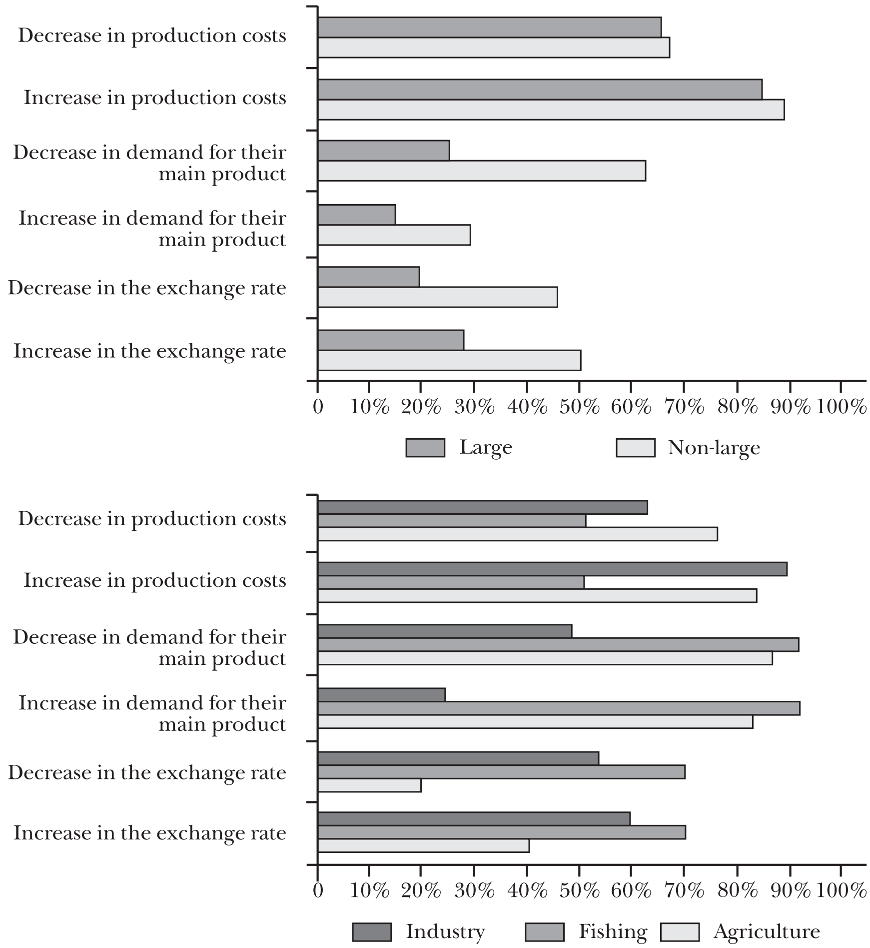


SOURCE: Own elaboration.

On the other hand, if input costs increase, agricultural and industrial companies change their prices in similar percentages. A decrease in costs affects a higher percentage of agricultural than industrial firms. Fishing companies react more than any other type of firm when demand moves either up or down (Figure 29).

Finally, the time taken for a firm to change the price of its main products once a shock occurs is investigated (Figure 30). Companies change

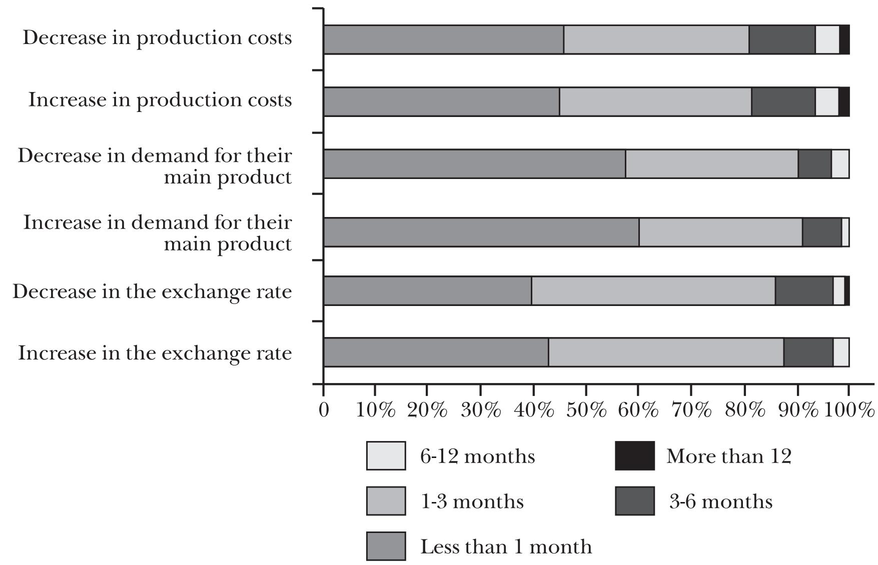
FIGURE 29. PERCENTAGE OF FIRMS WHICH CHANGE THEIR PRICES



SOURCE: Own elaboration.

prices relatively quickly whatever the type of shock. In almost all cases, the most important changes take place in less than one month; their relative importance is always over 40%. It should be pointed out that in the case of a decrease in the exchange rate, the reaction time could expand to between one and three months. If the shock that occurs is related to demand, whether positive or negative, firms react with even greater alacrity than in other cases. It rarely takes between six months and a year to see a price change after the shock.

FIGURE 30. PASS THROUGH TIME OF DIFFERENT SHOCKS TO PRICES (PERCENTAGE OF FIRMS)



SOURCE: Own elaboration.

8. CONCLUSIONS

This document presents the results of a survey given by the Banco de la República to 787 Colombian companies from November 2007 to May 2008. This survey sought to analyses how companies set their prices. The sample was constructed using a stratified probabilistic test. The study examines the topics of determination, adjustment, rigidity and asymmetry of company prices. The approach used allowed equal distinction between the different existing price rigidity hypotheses in the literature.

The most important conclusions that can be drawn are:

- With respect to the markets in which firms participating in the survey operate, it can be concluded that the majority of sales by Colombian companies are to the domestic market and to long term clients. Furthermore, the markets where Colombian companies operate are not very competitive. Companies face, on average, less than five competitors.

- In relation to the pricing review stage, the evidence suggests that the majority of Colombian companies use time-dependent rules when the economy is stable. This is true for companies with few competitors. Meanwhile, in times of economic turbulence, companies follow state-dependent rules. This type of rule is seen more frequently in companies which face a high level of competition.

- When reviewing prices, Colombian companies consider actual and expected inflation equally important, as well as other relevant variables within the productive process. In this way, companies are forward-looking in their pricing decisions.

- The inflation target set each year by Banco de la República and minimum wage are considered to be important factors when reviewing prices. Large companies attribute higher importance to the inflation target, while small and medium size companies consider the minimum wage more important.

- Firms which review their prices at set time intervals do so mostly on a monthly or quarterly basis. Large firms review their prices more frequently than the rest. Meanwhile, in the industrial sector, agricultural firms are the ones that review their prices with more frequence.

- Companies which have little competition review their prices every three months, while firms with a high level of competition review their prices monthly.

- In general, Colombian firms follow costs plus mark-up and competitor based pricing strategies. Large companies, on the whole, operate in non-competitive markets, while small and medium sized companies are price takers.

- As for the second stage of the price setting process, findings show that 38% of Colombian firms change their prices once a year, while 75% of companies change their prices a maximum of two times a year. In sectorial terms, primary sector industries are more flexible than those in the secondary sector. Along the same lines, evidence is found that companies whose production is destined for the domestic market are more flexible than those whose production is mostly exported. Likewise, consumption goods producers are less flexible than firms producing intermediate and capital goods.

- Previous studies suggest that prices respond asymmetrically to different types of shocks. The survey results allow for the conclusion that cost shocks (exchange rate, raw material prices, fuel and energy prices, financial and labor costs) are more important for explaining price increases than for explaining decreases, while demand shocks are more important for explaining price reductions.

- Price adjustment practices changed over the five years previous to when the survey was carried out. The main reason for these changes was higher input price variability.

- Price changes were found to be less frequent than pricing reviews when comparing the results obtained for the two stages of price setting. On the other hand, under normal economic conditions, more flexible companies followed state-dependent rules while less flexible companies followed time-dependent rules.

- The hypothesis of cost based prices is the principle explanation for why companies did not change their prices more frequently. Even so, theories associated with customer preferences for stable nominal prices, such as explicit and implicit contracts, are also very important for explaining price rigidity.

Appendix 1

Detailed Population by Three Digit ISIC Code

Three digit ISIC Code		
Section	*Category*	*Description*
A	011	Growing of crops
A	012	Farming of animals
B	050	Fishing, aquaculture and service activities incidental to fishing
D	151	Production, processing and preservation of meat and fish
D	152	Manufacture of fruit, legumes, vegetables, oils and fats
D	153	Manufacture of dairy products
D	154	Manufacture of grain mill products, starches and starch products, and prepared animal feeds
D	155	Manufacture of macaroni, noodles, couscous and similar farinaceous products
D	156	Manufacture of coffee products
D	157	Sugar refineries and mills

D	158	Manufacture of other food products
D	159	Manufacture of beverages
D	171	Preparation and spinning of textile fibers
D	172	Weaving of textiles
D	173	Textile product finishing of textiles not produced at the same production unit
D	174	Manufacture of other textile products
D	175	Manufacture of knitted and crocheted fabrics and articles
D	181	Manufacture of wearing apparel, except fur apparel
D	191	Tanning and dressing of leather
D	192	Manufacture of footwear
D	193	Manufacture of luggage, handbags and the like, saddlery and harness
D	201	Sawmilling and planing of wood
D	202	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board and other panels and boards
D	203	Manufacture of builders' carpentry and joinery
D	204	Manufacture of wooden containers
D	209	Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials
D	210	Manufacture of pulp, paper and paperboard
D	221	Publishing
D	222	Printing
D	223	Service activities related to printing
D	224	Reproduction of recorded media
D	232	Manufacture of refined petroleum products
D	241	Manufacture of basic chemicals
D	242	Manufacture of other chemical products
D	243	Manufacture of man-made fibers
D	251	Manufacture of rubber products
D	252	Manufacture of plastic products
D	261	Manufacture of glass and glass products
D	269	Manufacture of non-metallic mineral products
D	271	Manufacture of basic iron and steel
D	281	Manufacture of structural metal products, tanks, reservoirs and steam generators
D	289	Manufacture of other fabricated metal products; metalworking service activities
D	291	Manufacture general-purpose machinery
D	292	Manufacture of special-use machinery
D	293	Manufacture of domestic appliances
D	311	Manufacture of electric motors, generators and transformers
D	312	Manufacture of electricity distribution and control apparatus
D	313	Manufacture of insulated wire and cable
D	314	Manufacture of accumulators, primary cells and primary batteries
D	315	Manufacture of electric lamps and lighting equipment
D	319	Manufacture of other electrical equipment
D	321	Manufacture of electronic valves and tubes and other electronic components
D	322	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy

Three digit ISIC Code		
Section	*Category*	*Description*
D	323	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
D	331	Manufacture of medical appliances and instruments and appliances for measuring, checking, testing, navigating and other purposes, except optical instruments
D	332	Manufacture of optical instruments and photographic equipment
D	341	Manufacture of motor vehicles and their engines
D	342	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
D	343	Manufacture of parts and accessories for motor vehicles and their engines
D	359	Manufacture of other transport equipment
D	361	Manufacture of furniture
D	369	Manufacturing

SOURCE: DANE.

Appendix 2

Stratified Random Sampling

The group of firms taking part in the research is selected through random stratified sampling. This type of procedure requires that the population of size N be subdivided into subpopulations of sizes $N_1, N_2, ..., N_L$ in such a way that $\sum_{h=1}^{L} N_h = N$. These subpopulations are defined as strata and their sizes refer to the number of individuals that each of them comprise. In order to achieve an optimal population subdivision or stratification, the stratification factors are defined as those which are closely related to the characteristics under investigation, and in such a way that the individual only belongs to one subpopulation or stratum.

Once stratification has taken place, a process of random sampling without replacement of each of the strata is performed. Samples of $n_1, n_2, \cdots, n_L$ sizes are thus obtained. In this way, the size of the sample is equal to $n = \sum_{h=1}^{L} n_h$. In particular, the simple random sampling can be carried out in such a way that the proportions N_h / N and n_h / n $\forall h = 1, \ldots, L$ are equal, which is known as proportional assignment. That is to say, the individuals are distributed in the sample strata in similar proportions to those found in the population strata. This concept allows for the construction of central population tendency measurements within each stratum.

Substitution of those individuals selected through the simple random sampling process who do not want to participate in the investigation takes place in order to maintain proportional assignment. In other words, they do not respond to the survey and therefore do not become part of the sample. In theory there should be no substitution of individuals so as to not contaminate the selection process as per Martínez (2002). However, in practice, the applications of some substitution methods are accepted without debating the results. For instance, some individuals from those not selected are randomly chosen to substitute the non-participating selected individuals.

According to Cochran (1977) there are different reasons why stratified sampling is a widely used technique. It may be that the most important of them centers on the higher precision of the estimation of the population's characteristics based on the relatively homogenous grouping of individuals in each stratum.

It is important to define the following concepts, which will be used to calculate the sampling measurement and variance and its spread to the population, in order to apply the stratified random sampling method. N_h is the total number of individuals in h_{th} population stratum, n_h the number of total individuals in the h_{th} sampling stratum, y_{hi} the value of variable y observed for the i_{th} individual in the h_{th} stratum. The ensuing variables are defined as follows:

– Population measurement of stratum *h:*

$$\overline{Y}_h = \frac{\sum_{i=1}^{N_h} y_{hi}}{N_h}$$

– Sampling average of stratum *h:*

$$\overline{y}_h = \frac{\sum_{i=1}^{n_h} y_{hi}}{n_h}$$

– Population variance of stratum *h:*

$$S_h^2 = \frac{\sum_{i=1}^{N_h} \left(y_{hi} - \overline{Y}_h \right)^2}{\left(N_h - 1 \right)} .$$

It is possible to construct an estimator of the total population average through the stratified average $\overline{y}_{est}$ on the basis of the preceding definitions:

$$\overline{y}_{est} = \frac{\sum_{h=1}^{L} N_h \overline{y}_h}{N} .$$

The variance of this estimator is given by:

$$VAR\left[\overline{y}_{est}\right] = \frac{1}{N^2} \sum_{h=1}^{L} N_h \left(N_h - n_h \right) \frac{S_h^2}{n_h} .$$

It can be demonstrated that this estimator complies with the unbiasedness property, that is to say,

$$E\left[\overline{y}_{est}\right] = \overline{Y} ,$$

being

$$\overline{Y} = \frac{\sum_{h=1}^{L} \sum_{i=1}^{N_h} y_{hi}}{N} .$$

Under stratified sampling, the estimation of the population proportion is based on the stratified sampling proportion:

$$\hat{p}_{est} = \sum_{h=1}^{L} \frac{N_h p_h}{N} ,$$

being $p_h = \frac{\sum_{i=1}^{n_h} a_{hi}}{n_h}$, with $a_{hi} = 1$ if company *i* in stratum *h* takes the specific alternative; $a_{hi} = 0$, in another case.

Appendix 3

Questionnaire

Fecha de Impresión | **C O N F I D E N C I A L*** | Fecha de Impresión

BANCO DE LA REPÚBLICA
C.C 1780- 03

Centro Nacional de Consultoría Ltda.
Diag. 34 N° 5-27 - Santa Fé de Bogotá
Conmutador: (1) 339 4888

Encuesta sobre Formación de Precios Banco de la República

Elaborado por : El Banco de la República | Revisado por :Maria José Roldán | Revisado por : Juan Carlos Parra A.

Buenos días/tardes/noches, mi nombre es ______ (dar nombre COMPLETO) y soy entrevistador del Centro Nacional de Consultoría, una empresa que hace estudios para mejorar los productos y servicios que reciben las empresas y las personas. En estos momentos estamos realizando por solicitud del Banco de la República, un estudio sobre el proceso de fijación de los precios en Colombia y necesito hablar con la persona responsable del manejo de este tema en su empresa. Me gustaría hablar con el Gerente General, Gerente de Producción, Gerente de Mercadeo o el Gerente Financiero

ENCUESTADOR: UNA VEZ LO COMUNIQUEN CON LA PERSONA A ENCUESTAR REPITA LA PRESENTACIÓN ANTERIOR Y PREGUNTE:

a. Me podría decir de acuerdo con el valor o volumen de ventas ¿cuál es el principal producto de su empresa?

b. ¿El **100%** de las ventas del principal producto de su empresa se realiza en el exterior, es decir, fuera del país?.

ENCUESTADOR: SI LA RESPUESTA ES AFIRMATIVA, TERMINE Y REEMPLACE

c. ¿Es usted la persona encargada de fijar los precios de comercialización o venta de ese producto o participa directamente de ese proceso?

Sí → Su opinión es muy importante. ¿Me podría dar una cita para responder una encuesta? ¿me puede decir qué día y a qué hora lo puedo visitar? | Día y Hora ____________ y ________

No → ¿Me podría decir por favor el nombre de la persona o personas que fija (n) los precios de comercialización o venta de ese producto principal o participa (n) directamente de ese proceso? | Nombre (s):

ENCUESTADOR: REALIZAR CITA Y CONTACTAR LA NUEVA PERSONA

Fecha: | Código Entrevistador:

1. Ciudad | 2. N.I.T

2. Nombre de la Empresa | Teléfono | Dirección

3. Nombre del Entrevistado | Cargo | E-Mail

5. Número Total de Empleados en su Empresa (Tiempo Completo, Parcial, Temporales, a Término Indefinido, outsourcing y otros contratos)

6. De acuerdo con el valor o volumen de ventas, ¿cúal es su principal producto?

7. ¿Cuál es el criterio para elegir el principal producto?

Volumen de ventas	1
Valor de ventas	2

8. En el último año contable, ¿qué porcentaje de las ventas totales de su empresa corresponden a ventas de su principal producto <u>en Colombia</u>?

____ %

Nota: Las preguntas 9 a 13 deben ser contestada teniendo en cuenta su PRINCIPAL PRODUCTO independientemente de donde se venda o distribuya

9. ¿Cómo clasifica usted su principal producto de acuerdo con los siguientes criterios? (*Multiple respuesta,* MOSTRAR TARJETA)

Bien Final	1
Bien Intermedio	2
Bien de Capital	3

10. ¿Cuál es la distribución de ventas de su principal producto en los siguientes mercados? (*en porcentaje*)

1. Interno	%
2. EE.UU	%
3. Venezuela	%
4. Otros destinos internacionales	%
	100%

11. ¿Existen distintos precios para diferentes compradores de su principal producto? (***si su respuesta es negativa pase a nota 1 y léasela al informante***)

Si	1
No	2

12. Para su principal producto, ¿cuál es la importancia de los siguientes factores a la hora de diferenciar sus precios entre diferentes compradores? (**Si la respuesta para mercado externo es 3 o 4 continúe, de lo contrario pase a la nota 1**) (1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante 9 = No sabe / No responde) MOSTRAR TARJETA

Mercado externo	1	2	3	4	9
Tiempo de relación con el Cliente	1	2	3	4	9
Formas de Pago	1	2	3	4	9
Plazo de Entrega	1	2	3	4	9
Volumen demandado	1	2	3	4	9
Mercados locales	1	2	3	4	9
Costos de Transporte	1	2	3	4	9

13. ¿Cuál es la importancia de los siguientes factores para diferenciar sus precios entre el mercado interno y el externo ? (*1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante, 9 = No sabe / No responde*) MOSTRAR TARJETA

Tipo de cambio	1	2	3	4	9
Sistema impositivo del país	1	2	3	4	9
Condiciones socioculturales particulares a cada país	1	2	3	4	9
Fluctuaciones en la demanda del país	1	2	3	4	9
Precios de competidores	1	2	3	4	9
Costos de transporte	1	2	3	4	9

NOTA 1 para leerle al informante: Responda las preguntas restantes para su principal producto teniendo en mente la proporción de éste que es vendida únicamente en el mercado doméstico

14. De las ventas totales de su principal producto, que porcentaje se realiza con clientes con los cuales la relación comercial es:

De largo plazo (más de 1 año)	%
De corto plazo (menos de 1 año)	%
	100%

15. ¿Cuántos competidores existen para su principal producto en el mercado doméstico?

Ninguno	1
Menos de 5	2
Entre 5 y 20	3
Más de 20	4

16. ¿Existe una empresa líder en establecer los precios en el mercado de su principal producto? (***Si la respuesta es No o No sabe / No Responde pase a la pregunta 18***)

Si	1
No	2
No Sabe / No Responde	9

17. Para su principal producto, ¿es su empresa la líder en precios?

Si	1
No	2
No Sabe / No Responde	9

18. ¿Con que frecuencia chequea usted el precio de su principal producto?

- Se revisa diariamente (o más frecuentemente)	***(Pase a la pregunta 20)***	1
- Se revisa únicamente en intervalos fijos de tiempo		2
- Se revisa principalmente en intervalos fijos de tiempo, pero también en respuesta a eventos especificos (ej. Cambios radicales en los precios de los insumos)		3
- Se revisa únicamente en respuesta a eventos especificos	***(Pase a la pregunta 20)***	4

19. Si usted chequea el precio de su principal producto en intervalos fijos de tiempo, ¿con qué frecuencia lo hace?

Semanal	1
Mensual	2
Trimestral	3
Semestral	4
Anual	5
Más de un año	6

20. En los últimos doce meses, ¿cuántas veces ha cambiado el precio de su principal producto?

21. De acuerdo con su experiencia, ¿cree usted que hoy frente a cinco años atrás, ha cambiado la frecuencia de ajuste de precios de su principal producto? (***Si su respuesta es No o No sabe / No responde pase a la pregunta 23.***) (Marque sólo una opción)

Si, ha aumentado	1
Si, ha disminuido	2
No ha cambiado	3
No Sabe / No Responde	9

22. Pensando en los últimos cinco años, señale la importancia de cada una de las siguientes razones para explicar porqué ha cambiado la frecuencia de ajuste de los precios *(1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante, 9=No Sabe / No Responde)*

Mayor competencia interna	1	2	3	4	9
Menor competencia interna	1	2	3	4	9
Mayor competencia por Importaciones legales/ilegales	1	2	3	4	9
Menor competencia por importaciones leagles/ilegales	1	2	3	4	9
Cambios tecnológicos	1	2	3	4	9
Mayor volatilidad en los precios de los insumos	1	2	3	4	9
Menos volatilidad en los precios de los insumos	1	2	3	4	9
Mayor inflación	1	2	3	4	9
Menor inflación	1	2	3	4	9
Mayor tasa de cambio	1	2	3	4	9
Menor tasa de cambio	1	2	3	4	9

23. En el mercado interno a la hora de fijar el precio de su principal producto enfrenta usted algún tipo de limitación diferente a la competencia u otras fuerzas del mercado:*(Múltiples opciones* , MOSTRAR TARJETA)

Legales / Regulatorias	1
Precios Internacionales Comunes	2
Directrices Casa Matriz	3
Reducido poder de negociación frente a sus compradores	4
Ninguna de las anteriores	5

24. ¿Señale la importancia de las siguientes estrategias en la fijación de precios de su principal producto en el último año? (*1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante ,9=No Sabe / No Responde*) MOSTRAR TARJETA

Fijar precios basados en los precios de los competidores	1	2	3	4	9
Fijar precios basados en costos más un margén de ganancia	1	2	3	4	9

25. Ante cada uno de los siguientes eventos no previstos ¿modifica usted los precios de su principal producto?
25a. Si los modifica, ¿cúanto tiempo se demora en hacerlo?

Evento	**Si se modifican**	**No se modifican**	**Menos de 1 mes**	**Entre 1 y 3 meses**	**Entre 3 y 6 meses**	**Entre 6 y 12 meses**	**Más de 12 meses**
Un incremento significativo e inesperado de la tasa de cambio.	1	2	1	2	3	4	5
Un descenso significativo e inesperado de la tasa de cambio.	1	2	1	2	3	4	5
Un incremento significativo e inesperado en la demanda por su principal producto.	1	2	1	2	3	4	5
Un descenso significativo e inesperado en la demanda por su principal producto.	1	2	1	2	3	4	5
Un incremento significativo e inesperado en los costos de producción distintos a la tasa de cambio.	1	2	1	2	3	4	5
Un descenso significativo e inesperado en los costos de producción distintos a la tasa de cambio.	1	2	1	2	3	4	5

26. En la decisión de **aumentar** el precio de su principal producto, califique la importancia de cada uno de los siguientes factores: *(1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante*) MOSTRAR TARJETA

Factores					
1. Un cambio en los costos laborales	1	2	3	4	9
2. Un cambio en los costos financieros	1	2	3	4	9
3. Un cambio en los costos de las materias primas	1	2	3	4	9
4. Un cambio en los precios de la energía y el combustible	1	2	3	4	9
5. Un cambio en los precios de los competidores	1	2	3	4	9
6. Un cambio en los impuestos y otras cargas tributarias	1	2	3	4	9
7. Un cambio en la demanda por su producto	1	2	3	4	9
8. Un cambio en la tasa de cambio	1	2	3	4	9

27. En la decisión de **disminuir** el precio de su principal producto, califique la importancia de cada uno de los siguientes factores: (1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante) MOSTRAR TARJETA

Factores					
1. Un cambio en los costos laborales	1	2	3	4	9
2. Un cambio en los costos financieros	1	2	3	4	9
3. Un cambio en los costos de las materias primas	1	2	3	4	9
4. Un cambio en los precios de la energía y el combustible	1	2	3	4	9
5. Un cambio en los precios de los competidores	1	2	3	4	9
6. Un cambio en los impuestos y otras cargas tributarias	1	2	3	4	9
7. Un cambio en la demanda por su producto	1	2	3	4	9
8. Un cambio en el tipo de cambio	1	2	3	4	9

28. Califique la importancia de la siguiente información al momento de calcular el precio de su principal producto: *(1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante, 9= No Sabe / No Responde) MOSTRAR TARJETA*

- Información sobre el comportamiento **pasado** de variables tales como: demanda, costos, precio de los competidores…	1	2	3	4	9
- Información sobre el comportamiento **actual** de variables tales como: demanda, costos, precio de los competidores…	1	2	3	4	9
- Información sobre **pronósticos** de todas las variables relevantes en la maximización de sus ganancias.	1	2	3	4	9
- Inflación pasada	1	2	3	4	9
- Inflación actual	1	2	3	4	9
- Inflación esperada	1	2	3	4	9

29. Evalue la importancia de la meta de inflación fijada por el Banco de la República para las decisiones de precios que toma su empresa (*1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante*) MOSTRAR TARJETA	1 2 3 4 9
30. Evalue la importancia de la fijación del salario mínimo legal por parte del gobierno para las decisiones de precios que toma su empresa (*1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante*) MOSTRAR TARJETA	1 2 3 4 9

31. Si existen razones para cambiar los precios de su principal producto, ¿qué importancia tiene cada uno de los siguientes factores para **NO** hacerlo? (1 = No importante, 2 = Poco importante, 3 = Importante, 4 = Muy Importante) MOSTRAR TARJETA

	No importante	Poco importante	Importante	Muy importante	No sabe
* La existencia de contratos escritos especificando que los precios sólo pueden ser cambiados cuando el contrato sea renegociado.	1	2	3	4	9
* A pesar de la ausencia de un contrato escrito, existe un acuerdo implícito con sus clientes, según el cual ellos esperan que no aumenten los precios cuando las condiciones económicas así lo ameriten.	1	2	3	4	9
* La existencia de unos costos asociados con los cambios en los precios. Por ejemplo, la impresión de nuevas listas de precios, los costos de anunciar los cambios, etc.	1	2	3	4	9
* El riesgo de que los competidores no cambien los precios, es decir, la empresa no quiere ser la primera en cambiar los precios.	1	2	3	4	9
* La frecuencia de la información usada para revisar (y finalmente cambiar) los precios de su principal producto es irregular. Por lo tanto, los precios responden lentamente a nuevas condiciones	1	2	3	4	9
* La situación que generaría el cambio de precio es considerada como transitoria	1	2	3	4	9
* Las caracteristicas del producto podrían ser modificadas o alteradas	1	2	3	4	9
* Los costos laborales y de materias primas empleados en la producción de su principal producto no cambiaron	1	2	3	4	9
* Existen umbrales de precios que pueden ser más atractivos para los clientes. Por ejemplo se puede pensar que su producto se vende más fácil a $4.999 que a $5.000.	1	2	3	4	9

32. ¿Las respuestas entregadas por usted respecto a su producto principal representan de igual manera sus otros productos?

Si	1	No	2	No Aplica. La compañía tiene un solo producto	8

Appendix 4

Treatment of Variables Missing Due to No Response

The existence of missing values, or non-responses to survey questions, could potentially lead to a bias in the estimation of the population's characteristics as pointed out by Lohr (1999), Durrant (2005), SAS/STAT 9.1 User's Guide (Proc MI) and Särndal et al. (2005). Different methods exist to impute plausible values to the missing data to produce a complete collection of information. Thus, the main reason for using the imputation method is to reduce nonresponse bias occurring because the distribution of missing, but supposedly known, values generally differs from the distribution of the actual answers.

The method used in this paper pertains to the category of multiple imputation methods. The basic idea of these methods is centered on the random assignment of different values to the missing response which allows inclusion of uncertainty about the true non-observed value. In practice, one of the most employed methods in the context of multiple imputations is the Bayesian focus parameter of Markov Chain Monte Carlo (MCMC),[13] which assumes a multivariate normal distribution of the collection of variables with missing information (Schafer, 1997).

In those cases where it was not possible to obtain imputation by applying the MCMC, a non-conditional mean method was used belonging to the simple deterministic imputation deduction methods (see Durrant, 2005). This method assigns the simple average of the values observed in its strata to the missing value.

Appendix 5

Calculation of the Mean and the Stratified Weighted Variance

The stratified sampling average, Appendix 1, is adjusted by weighting the importance of each of the companies by its importance in the strata with the objective of reaching a better representativeness of the measurement of the central tendency by strata. Declared company operating income for 2005 (to the Superintendencia de Sociedades and the Superintendencia Financiera) is used as the measurement of importance in this paper.

In general, calculation of the stratified weighted average is based on the theoretical development of the estimate of a ratio of random values by stratum and by its weighted average (see Hansen et al., 1953a, and Hansen et al. 1953b). As such, the stratified weighted average, by a measure of the importance of the company, is defined as:

$$\hat{\bar{y}}_{est} = \frac{\sum_{h=1}^{L} N_h \sum_{i=1}^{n_h} \frac{y_i x_i}{n_h}}{\sum_{h=1}^{L} N_h \sum_{i=1}^{n_h} \frac{x_i}{n_h}} = \frac{\sum_{h=1}^{L} N_h \sum_{i=1}^{n_h} \frac{y_i^{'}}{n_h}}{\sum_{h=1}^{L} N_h \sum_{i=1}^{n_h} \frac{x_i}{n_h}}.$$

In our case, y_i is the answer to a particular question by the i_{th} company in the h_{th} stratum and x_i is the value of the net operating income of the corresponding company. Additionally, the variance of this estimator can be defined as follows:

[13] The imputation exercise (MCMC) was carried out using the SAS of MI V.9.1 Procedure.

$$VAR\left(\hat{\bar{y}}\right)=\frac{1}{\left(\sum_{h=1}^{L}N_h\sum_{i=1}^{n_h}\frac{x_i}{n_h}\right)^2}\left[\sum_{h=1}^{L}\left\{N_h\left(\frac{N_h}{n_h}-1\right)\right\}\left(S_{y'_{(h)}}^2+\hat{C}^2S_{x(h)}^2-2\hat{C}S_{y'x(h)}\right)\right]$$

$$=\frac{1}{\left(\sum_{h=1}^{L}N_h\sum_{i=1}^{n_h}\frac{x_i}{n_h}\right)^2}\left[\sum_{h=1}^{L}\left\{N_h\left(\frac{N_h}{n_h}-1\right)\right\}\left(S_{y'_{(h)}}^2+\left(\frac{\sum_{i=1}^{n_h}\frac{N_h}{n_h}y_ix_i}{\sum_{h=1}^{L}N_h\sum_{i=1}^{n_h}\frac{x_i}{n_h}}\right)^2S_{x(h)}^2-2\left(\frac{\sum_{i=1}^{n_h}\frac{N_h}{n_h}y_ix_i}{\sum_{h=1}^{L}N_h\sum_{i=1}^{n_h}\frac{x_i}{n_h}}\right)S_{y'x(h)}\right)\right]$$

$$=\frac{1}{\left(\sum_{h=1}^{L}N_h\sum_{i=1}^{n_h}\frac{x_i}{n_h}\right)^2}\left[\sum_{h=1}^{L}\left\{N_h\left(\frac{N_h}{n_h}-1\right)\right\}\left(\left\{\frac{\sum_{i=1}^{n_h}\left(y'_i-\frac{\sum_{i=1}^{n_h}y'_i}{n_h}\right)^2}{n_h-1}\right\}+\left(\frac{\sum_{i=1}^{n_h}\frac{N_h}{n_h}y_ix_i}{\sum_{h=1}^{L}N_h\sum_{i=1}^{n_h}\frac{x_i}{n_h}}\right)^2\left\{\frac{\sum_{i=1}^{n_h}\left(x_i-\frac{\sum_{i=1}^{n_h}x_i}{n_h}\right)^2}{n_h-1}\right\}-\right.\right.$$

$$\left.\left.-2\left(\frac{\sum_{i=1}^{n_h}\frac{N_h}{n_h}y_ix_i}{\sum_{h=1}^{L}N_h\sum_{i=1}^{n_h}\frac{x_i}{n_h}}\right)\left\{\frac{\sum_{i=1}^{n_h}\left(y'_i-\frac{\sum_{i=1}^{n_h}y'_i}{n_h}\right)\left(x_i-\frac{\sum_{i=1}^{n_h}x_i}{n_h}\right)}{n_h-1}\right\}\right)\right].$$

On the other hand, taking the weighted importance of the company in the stratum, the stratified weighted proportion is defined as:

$$\hat{p}=\frac{\sum_{h=1}^{L}\sum_{i=1}^{n_h}\frac{N_h}{n_h}a_{hi}x_i}{\sum_{h=1}^{L}\sum_{i=1}^{n_h}\frac{N_h}{n_h}x_i},$$

where a_{hi} takes a value of one if the company chooses a specific alternative and zero for the opposite situation.

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Consumer Price Behavior in Mexico Under Inflation Targeting: A Microdata Approach

Carla Ysusi[*]

1. INTRODUCTION

In this paper we do a statistical analysis of the Mexican consumer price index (índice nacional de precios al consumidor, INPC) microdata set to study the price setting process in the different sectors of the Mexican economy and characterize its rigidities. The microdata set goes from July 2002 to December 2009, comprising part of the period during which the Mexican central bank has been working under an inflation targeting regime and inflation has been historically low in Mexico. A better knowledge of the way prices are set is important for understanding the short-term effects of the monetary policy. An adequate response to shocks will depend on the understanding of the price dynamics, the rigidity levels, and the differences between sectors. Studying nominal rigidities, where prices do not change instantly after a shock but remain rather constant for a period, is essential for understanding the implications of monetary policy on the short run. In this respect, it is important to understand to what extent price rigidities are present in the INPC.

The identification of the rigidities that dominate the price setting process could also be the starting point for a microeconomic analysis that

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studies the incentives that are causing these rigidities in different sectors. The results presented here may point out rigid sectors and the need for further research to understand the source of such price rigidities.

Furthermore, the result may be helpful to validate existent macroeconomic models based on assumptions about the price rigidities. There are studies documenting that price setters follow time dependent strategies where the frequencies of price changes are exogenous (Taylor, 1980; Calvo, 1983), state dependent strategies where such frequencies are endogenous (Dotsey, King and Wolman, 1999; Caplin and Spulber, 1987), or a combination of both suggesting the co-existence of firms which use different pricing strategies (Dotsey et al., 1999). In time dependent models monetary shocks typically have longer lasting effects on real output than in the state dependent ones, so it is important to empirically distinguish between them.

In some countries important studies have been done addressing the previous issues, see for example, Bils and Klenow (2004), Klenow and Kryvtsov (2008), and Nakamura and Steinsson (2008) for United States (USA). In the Inflation Persistence Network, Aucremanne and Dhyne (2004) did a study for Belgium; Hoffmann and Kurz-Kim (2005) for Germany; Álvarez and Hernando (2004) for Spain; Baudry et al. (2004) for France; Veronese et al. (2005) for Italy; Jonker et al. (2004) for the Netherlands; Baumgartner et al. (2005) for Austria; Dias et al. (2004) for Portugal; Lünnemann and Mathä (2005b) and Vilmunen and Laakkonen (2005) for Finland; and Dhyne et al. (2005) sum up results for the European Central Bank joint research. A review of different literature studying price microdata was done in Mackowiak and Smets (2008), and Klenow and Malin (2010).

For Latin America the empirical evidence has until recently been particularly scarce. To fill this gap, a joint project with other Latin American Central Banks has been organized, from which this paper forms part. Nevertheless, notice that for Mexico there were already two studies about the price setting process: Castañón et al. (2008) and Gagnon (2009). The first paper is based on firms survey data and the second one on prices microdata (although as explained later, the microdata set stops in 2002). The results of these two papers will be compared to our results at the end of this paper.

In this document, we will try to quantify the degree of nominal rigidity of consumer prices in the Mexican economy at the sector level. This was previously done by Gagnon (2009) with data from 1994 to 2002 (extending it to 2004 but without linking the series). Nevertheless, most of his sample covers the high inflation era and the disinflation period. The 3% annual inflation target was set by the Mexican central bank in 2003,[1] so Gagnon (2009) sample incorporates only few months of this regime. Here we will focus on studying a low inflation period under inflation targeting, our sample starts in 2002 and finishes in 2009.

Broadly, results show that in Mexico there exists a considerable heterogeneity in the price setting behavior across different sectors (fruits and vegetables change prices on average more than once a month but housing prices take more than 12 months on average to change) and over time. Evidence was found that when big shocks affect inflation, there is a strong co-movement of the fraction of the firms that change prices with inflation, i.e. the frequency of price changes moves strongly with inflation under these circumstances.

In this paper, we shall first describe the Mexican Consumer Price Index and the microdata set to be used (Section 2). Some definitions will be given in Section 3, followed by the main results about frequencies, implied durations, and magnitudes in Section 4. Also in Section 4 a comparison between our results and previous studies for Mexico will be given. Finally conclusions and possible further work are presented in Section 5. In the Appendix, the same statistics for a few products are shown using an alternative dataset (the collected prices and not the monthly averaged prices).

2. MEXICAN CONSUMER PRICE INDEX

The Mexican consumer price index, INPC, is an economic indicator that measures the variations of a representative basket of goods and services in Mexico throughout time. For its construction, there is a continuous collection of the prices of specific items that form 315 homogeneous product categories of goods and services. Each month around 235,000 prices of these specific items are recorded to calculate the price variations of the categories (see Banco de México, 2010). Each category has a different weight in the INPC. The categories and their weights are determined based on the Encuesta Nacional de Ingreso y Gasto de los Hogares

[1] In 2003 the 3% annual inflation target was fully established by the Mexican central bank, although announced since 2002 (see Banco de México (2002)). Nevertheless, some features of this regime were introduced since 1999 leading to a disinflation period. See Ramos-Francia and Torres (2005) for an extensive discussion on implemented measures.

(ENIGH), survey done by the Mexican statistical institute, INEGI. This national survey takes into account households' income and how they spend it. The last update of the INPC basket was done on the second fortnight of June 2002. The geographic representation of the index is ensured by including 46 cities of the country from all the different states. For more information about the construction of the INPC see Banco de México (2002).

Headline inflation is computed using the price variations of the 315 product categories. Given that not all product prices have the same pattern of behavior, it is convenient to classify categories into groups for the analysis. In this document we will do our analysis at group level. Merchandise can be divided in two groups, food and rest of merchandise; services in three groups, housing, education, and rest of services; agricultural products in two groups, fruits and vegetables and farm-related goods (that include cattle products and eggs); and lastly administered goods (that include gasoline, electricity, and gas) and regulated goods and services (that include, for example, public transport, parking fees, driving licence fee, etc.). The products included in each group that were used in this paper are shown in Tables 6 to 14.

2.1 The Microdata

In this paper we will study the nine groups of the INPC described above. The studied period goes from July 2002 to December 2009. The first observation of our database corresponds to the first observation of the latest basket.

Our dataset consists of quotes that correspond to the monthly average of the collected prices of a given item, which are published each month in the Diario Oficial de la Federación. Each quote corresponds to a specific city, outlet, and good and can be identified by a code. In total we have more than 100,000 price trajectories[2] consisting of more than six million quotes and forming the 315 product categories (see Table 1).

Our database has some features that need to be specified before presenting the results. Our results will depend greatly on them, therefore they need to be analyzed carefully.

The main one is that the individual prices are not published; the Diario Oficial de la Federación only publishes the monthly average of these prices. For some items (the most volatile ones, like agricultural goods), up

[2] Banco de México collects the prices of around 85,000 different goods and services at a time; we have around 100,000 trajectories due to substitutions.

TABLE 1. CATEGORIES, TRAJECTORIES, AND QUOTES OF THE WHOLE DATABASE

	All Products	*Excluding 38 Categories*
Total		
Categories	315	277
Weight	100%	79.94%
Trajectories	102,615	75,496
Quotes	6,510,431	5,192,170
Mean Monthly Quotes	73,151	58,339
Minimum Monthly Quotes	57,568 (Aug. 2002)	-
Maximum Monthly Quotes	85,837 (Oct. 2007)	-
Unregulated Products		
Categories	295	257
Weight	82.83%	69.78%
Trajectories	97,592	70,473
Quotes	6,118,069	4,855,792
Regulated Products		
Categories	20	20
Weight	17.16%	17.16%
Trajectories	5,024	5,024
Quotes	391,854	336,378

to four prices are collected per month, but only their average is available.[3] Our quantitative results may be biased due to this averaging, nevertheless the qualitative conclusions will stand.[4]

Sales cannot be identified in our dataset. Discounts are taken into account when recording prices (except for conditional discounts), but they are not flagged in the Diario Oficial de la Federación. As documented in Bils and Klenow (2004), Nakamura and Steinsson (2008), and Mackowiak and Smets (2008), an important number of price changes are temporary discounts. Nevertheless it has been argued that sales and substitutions may have a macroeconomic content and that both may be much related to inflation. Therefore our dataset will include sales and product substitutions.

Another fact to take into account is that not all quotes correspond to individual items, some quotes are an average of a small sample of similar goods (for example: three different brands of trousers form a sample of

[3] Gagnon (2009) uses a filter to smooth these averages. Nevertheless, different filters can be used and each will give different results; therefore we decided to work with raw data.

[4] In the Appendix results for a few products are given using all the collected prices and not the published averages.

one of the trouser quotes). All products composed of a small sample of items are excluded from our database (this feature is mainly observed in clothing products).[5] Own housing, hotels, car insurance, gold and silver (in the jewelry category), phone services, education, electricity, and highway tolls quotes are calculated through subsystems which are calculated with observed prices. This kind of products will also be dropped from the dataset, except those that have regulated prices (as regulated products will be studied separately). Additionally, some item prices are sampled at each source around every six months, e.g. housing rent. These trajectories are also eliminated. Finally, as in all databases, there can exist outliers, i.e. prices that seem highly improbable. Given that we are taking the prices from the Diario Oficial de la Federación, this can be of importance given that typos cannot be ruled out. We exclude the biggest price increases and decreases keeping 99.9% of our database.

The second column of Table 1 shows the characteristics of the database once the previous facts have been taken into account. Here 38 product categories will be excluded, leaving us with 277 product categories, 75,496 trajectories and more than five million quotes. These represent 79.94% of the INPC.

2.2 Unregulated and Regulated Products

The prices of some of the sampled products are regulated. These products form the administered and regulated goods and services groups. Given that the frequencies and magnitudes of the changes of these prices are not determined by the market, they can present very different dynamics from the other products and can bias our results. Therefore we will study separately the groups of regulated products and the ones of unregulated products.

Table 2 shows this division and gives the number of categories and weights of each of the groups. Once the weights of the excluded categories are accounted, the regulated products account for around 21% of the INPC.

[5] Clothing products are not composed of small sample of items nowadays but of prices of individual items. However, given that at the beginning of our sample they were, we are excluding them.

TABLE 2. CATEGORIES AND WEIGHTS OF REGULATED AND UNREGULATED GROUPS

	All Products	*Excluding 38 Products*
Unregulated products		
Categories	295	257
Weight	82.83%	78.53%
Food		
Categories	67	67
Weight	14.67%	18.35%
Rest of merchandise		
Categories	124	90
Weight	22.35%	21.68%
Housing		
Categories	6	4
Weight	17.86%	4.22%
Education		
Categories	8	8
Weight	5.2%	6.50%
Rest of services		
Categories	35	35
Weight	14.68%	17.69%
Fruit and vegetables		
Categories	34	34
Weight	3.27%	4.09%
Farm-Related		
Categories	21	21
Weight	4.8%	6.00%
Regulated products		
Categories	20	20
Weight	17.16%	21.47%
Administered		
Categories	4	4
Weight	7.77%	9.72%
Regulated		
Categories	16	16
Weight	9.39%	11.75%

3. SOME DEFINITIONS

In line with other countries' research on the topic, we will follow Klenow and Kryvstov (2008) notation and decomposition. The monthly price changes will be decomposed into two components, the fraction of items that present a price change on that month (extensive margin adjustments) and the weighted average of the size of the change (intensive margin adjustments). So if pit is the log-price of the i-th item at time t, the indicator function of a price change is

$$I_{it} = \begin{cases} 0 \text{ if } & p_{it} = p_{it-1} \\ 1 \text{ if } & p_{it} \neq p_{it-1} \end{cases}.$$

So if the weight corresponding to a product divided by the number of items of that product category that registered a price change is w_i then the frequency or the weighted fraction of products that present a price change at time t is

$$fr_t = \sum_i w_{it} I_{it},$$

and the average magnitude of the price changes at time t is

$$dp_t = \frac{\sum_i w_i I_{it}(p_{it} - p_{it-1})}{\sum_i w_{it} I_{it}}.$$

Therefore inflation (measured as the difference of log-prices) at time t can be expressed as

$$\pi_t = fr_t * dp_t.$$

An equivalent decomposition can be done by separating positive price changes from negative price changes. So the indicator functions for price increases and price decreases at time t are respectively

$$I_{it}(+) = \begin{cases} 1 & if \quad p_{it} > p_{it-1} \\ 0 & if \quad p_{it} = p_{it-1} \end{cases} \qquad I_{it}(-) = \begin{cases} 1 & if \quad p_{it} < p_{it-1} \\ 0 & if \quad p_{it} = p_{it-1} \end{cases},$$

the frequencies of price increases and price decreases at time t are

$$fr_t(+) = \sum_i w_{it} I_{it}(+) \qquad fr_t(-) = \sum_i w_{it} I_{it}(-)$$

and finally the average magnitude of price increases and price decreases at time t are

$$dp_t(+) = \frac{\sum_i w_i I_{it}(+)(p_{it} - p_{it-1})}{\sum_i w_{it} I_{it}(+)} \qquad dp_t(-) = \frac{\sum_i w_i I_{it}(-)(p_{it} - p_{it-1})}{\sum_i w_{it} I_{it}(-)}.$$

Now inflation can be expressed in function of the frequencies and magnitudes of price increases and the frequencies and magnitudes of price decreases

$$\pi_t = fr_t(+) * dp_t(+) + fr_t(-) dp_t(-).$$

The average duration of a price spell can also be computed. A simple way of estimating it is by calculating the implied average duration from the frequencies of each item, that is

$$\bar{d}_j = \frac{-1}{\ln(1 - fr_j)}.$$

4. MAIN RESULTS FROM MICRODATA

In this section we will present the decomposition of our data in frequencies, implied duration, and magnitudes for each group (in Table 6 to 14 these statistics are shown for all products).[6] Weighted statistics and raw ones will be presented as they give us different information. If we want to study headline inflation or one of its subindexes, it is convenient to look at the weighted ones. Instead, if we need to detect categories or sectors with atypical rigidities, as a starting point for a microeconomic analysis, it is convenient to look at the raw ones.

4.1 Frequencies and Implied Duration

4.1.1 Group level

On average, in Mexico, during the sample period, 35% of prices are changing each month. The average frequency of price increases per month is 24% while the one of price decrease is only 11%. Nevertheless there is a big difference between regulated products and unregulated ones. On average, 32% of unregulated product prices are changing each month, from which 20% are increases and the remaining 12% are decreases. In contrast, the average frequency of price changes of regulated products is 47%, from which the majority are increases (40%) and decreases are rare (7%). Although, in general, there is an asymmetry between the upward and downward changes, price decreases are not that infrequent (more than a third of the changes are decreases). This goes in line with previous literature, for example, for the Euro area see Altissimo et al. (2006) and for the United States see Peltzman (2000). Peltzman

[6] The results in this section may be statistically biased as we use the published averaged monthly prices. In the Appendix the results for a few products are given using the collected prices, and it can be inferred that our main conclusions stand.

(2000) concludes that "output prices tend to respond faster to input increases than to decreases" and that this "asymmetric response to cost shocks is substantial and durable". Ball and Mankiw (1994) give a menu-cost model as a possible explanation for these asymmetries.

There is also a considerable heterogeneity in the frequency of price changes across sectors. In Table 3, the average frequency of price changes, increases, and decreases are given for the nine groups of the INPC. Notice how the prices for the groups of fruits and vegetables, farm-related goods,

TABLE 3. WEIGHTED AND UNWEIGHTED AVERAGE FREQUENCIES OF PRICE CHANGES

	Unweighted	*Weighted*		*Unweighted*	*Weighted*
All products					
Price changes	0.39	0.35			
Price increases	0.23	0.24			
Price decreases	0.16	0.11			
Unregulated products			Regulated products		
Price changes	0.40	0.32	Price changes	0.27	0.47
Price increases	0.23	0.20	Price increases	0.22	0.40
Price decreases	0.17	0.12	Price decreases	0.05	0.07
Food			Administered		
Price changes	0.43	0.37	Price changes	0.90	0.90
Price increases	0.26	0.23	Price increases	0.81	0.81
Price decreases	0.17	0.14	Price decreases	0.09	0.09
Rest of merchandise			Regulated		
Price changes	0.29	0.32	Price changes	0.11	0.12
Price increases	0.17	0.19	Price increases	0.07	0.06
Price decreases	0.12	0.13	Price decreases	0.04	0.06
Housing					
Price changes	0.10	0.10			
Price increases	0.08	0.08			
Price decreases	0.02	0.02			
Education					
Price changes	0.14	0.15			
Price increases	0.13	0.14			
Price decreases	0.01	0.01			
Rest of services					
Price changes	0.12	0.15			
Price increases	0.09	0.11			
Price decreases	0.03	0.04			
Fruit and vegetables					
Price changes	0.86	0.85			
Price increases	0.45	0.44			
Price decreases	0.41	0.41			
Farm-related					
Price changes	0.61	0.64			
Price increases	0.34	0.37			
Price decreases	0.27	0.27			

TABLE 4. WEIGHTED AND UNWEIGHTED AVERAGE MAGNITUDES OF PRICE CHANGES

	Unweighted	*Weighted*		*Unweighted*	*Weighted*
All products					
Price changes	0.016	0.022			
Price increases	0.094	0.075			
Price decreases	0.133	0.132			
Unregulated products			Regulated products		
Price changes	0.015	0.022	Price changes	0.024	0.022
Price increases	0.096	0.085	Price increases	0.063	0.041
Price decreases	0.133	0.143	Price decreases	0.129	0.089
Food			Administered		
Price changes	0.015	0.013	Price changes	0.006	0.006
Price increases	0.065	0.062	Price increases	0.014	0.015
Price decreases	0.069	0.067	Price decreases	0.059	0.064
Rest of merchandise			Regulated		
Price changes	0.011	0.010	Price changes	0.029	0.035
Price increases	0.101	0.085	Price increases	0.075	0.063
Price decreases	0.135	0.110	Price decreases	0.147	0.110
Housing					
Price changes	0.028	0.028			
Price increases	0.099	0.105			
Price decreases	0.337	0.395			
Education					
Price changes	0.028	0.031			
Price increases	0.099	0.061			
Price decreases	0.337	0.228			
Rest of services					
Price changes	0.042	0.047			
Price increases	0.115	0.103			
Price decreases	0.233	0.196			
Fruit and vegetables					
Price changes	0.006	0.005			
Price increases	0.147	0.153			
Price decreases	0.149	0.155			
Farm-related					
Price changes	0.007	0.008			
Price increases	0.067	0.061			
Price decreases	0.071	0.063			

and administered goods change the most (85%, 64% and 90% respectively). Fruits and vegetables and farm-related goods prices increase and decrease almost with the same frequency, probably due to seasonal characteristics. Quite the opposite, administered goods prices are continuously increasing and rarely decreasing. On the other hand, unregulated services (the groups of housing, education, and rest of services) and regulated goods and services show few price adjustments and, in all of these groups, upward adjustment of their prices are much more common than downward ones.[7] Education almost does not present downward changes. The groups of food and other merchandise show less extreme behaviors having average frequencies of 37% and 32% respectively. This important heterogeneity across sector has previously been documented for other countries, for the euro area see Altissimo et al. (2006), and for USA see Carvalho (2006). The last one studies how this sectoral heterogeneity affects the dynamics of monetary economies.

There is also no dominant spell length. Different implied durations predominate for different groups (Table 5). On average there is a price change every five months. However there is a price increase on average every eight months but a price decrease every 30 months. Notice how the groups of administered goods, fruit and vegetables, and farm-related products change prices on average at least once a month. On the other hand, the prices of the services are stickier. The housing group changes prices on average once a year or less, education less than every six months and rest of services less than every three quarters. In all the groups, as expected, it takes much longer to have a price decrease than a price increase. Regulated goods and services seem to change prices once a year on average; however this is just an average, notice that these prices can be constant for very long periods and then change more frequently in others.

4.1.2 Product Level

At product level (see Tables 6 to 14), the average frequency of price changes of unregulated goods ranges from 3.98% (newspapers) to 97% (tomato). This heterogeneity is clearly illustrated in Figure 1 where average frequencies for each product are shown in progressive order. The x-axis shows the accumulated percent of products plotted to that point. The median for unregulated products is 37% while the mean was 32%. In contrast, for regulated products the median is 7% while the mean was 27% indicating a highly skewed distribution (many products with few price changes and not many products with a big number of them).

All previous results are reinforced with Figure 2. The box plots show the distribution properties of the frequencies of price changes, increases, and decreases of the items for each of the groups. The differences in location, symmetry, and dispersion between the groups are perfectly captured.

[7] The results from the group of housing need to be analyzed carefully given that the trajectories of their main components, housing rent and own housing, were taken out of the database.

TABLE 5. WEIGHTED AND UNWEIGHTED AVERAGE DURATIONS OF PRICE CHANGES

	Unweighted	*Weighted*		*Unweighted*	*Weighted*
All products					
Price changes	4.6	5.5			
Price increases	7.3	8.7			
Price decreases	20.3	30.7			
Unregulated products			Regulated products		
Price changes	4.0	5.1	Price changes	12.4	7.2
Price increases	6.2	7.0	Price increases	21.8	15.1
Price decreases	18.0	28.6	Price decreases	50.1	38.2
Food			Administered		
Price changes	2.0	2.6	Price changes	0.4	0.4
Price increases	3.6	4.3	Price increases	0.6	0.6
Price decreases	7.1	10.2	Price decreases	23.4	20.8
Rest of merchandise			Regulated		
Price changes	3.9	3.5	Price changes	15.4	12.7
Price increases	6.5	5.8	Price increases	27.1	27.0
Price decreases	12.7	11.6	Price decreases	56.7	52.5
Housing					
Price changes	12.3	12.5			
Price increases	14.8	15.0			
Price decreases	65.5	67.8			
Education					
Price changes	7.0	6.3			
Price increases	8.0	7.0			
Price decreases	69.2	70.1			
Rest of services					
Price changes	12.2	9.7			
Price increases	15.8	12.1			
Price decreases	62.6	58.8			
Fruit and vegetables					
Price changes	0.5	0.5			
Price increases	1.7	1.8			
Price decreases	2.0	2.0			
Farm-related					
Price changes	1.1	1.0			
Price increases	2.4	2.2			
Price decreases	3.4	3.3			

Notice that the distribution of the administered goods is skewed to the left, concentrating most of the frequencies around 90% and having mainly upward movements. Meanwhile fruits and vegetables and farm-related goods have more symmetric distributions. Also the distributions of the frequencies of price increases and decreases are very similar for these agricultural groups, meaning that it is almost as likely to have a downward than an upward movement. Education is an extreme case, it has the lowest median, the smallest dispersion, and almost all the distribution is explained

TABLE 6. STATISTICS OF FOOD CATEGORIES

	fr	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur. (+)*
Corn tortilla	0.19	0.14	0.040	0.086	0.084	4.61	6.53
Corn dough and flour	0.35	0.22	0.018	0.065	0.060	2.36	4.06
Corn (maize)	0.39	0.24	0.028	0.090	0.074	2.00	3.57
Sweet rolls, coffeecakes	0.39	0.23	0.016	0.054	0.041	2.03	3.76
White bread	0.37	0.21	0.011	0.058	0.053	2.15	4.14
Tin loaf (sliced bread)	0.45	0.30	0.017	0.046	0.040	1.69	2.82
Pastries and cakes	0.33	0.21	0.019	0.062	0.062	2.52	4.14
Soup pasta	0.55	0.31	0.009	0.069	0.067	1.26	2.74
Popular cookies (crackers)	0.54	0.32	0.012	0.070	0.070	1.29	2.61
Whole-wheat tortillas	0.35	0.24	0.021	0.062	0.064	2.31	3.70
Other cookies	0.48	0.28	0.013	0.072	0.072	1.54	3.00
Wheat flour	0.49	0.29	0.012	0.068	0.068	1.48	2.90
Cereal flakes	0.53	0.29	0.007	0.068	0.068	1.33	2.89
Rice	0.59	0.34	0.016	0.076	0.065	1.12	2.41
Ham	0.58	0.34	0.007	0.056	0.063	1.14	2.40
Sausages	0.58	0.34	0.010	0.061	0.063	1.16	2.39
Chorizo sausage	0.44	0.27	0.011	0.055	0.059	1.71	3.14
Other cold cuts	0.46	0.29	0.010	0.058	0.070	1.63	2.96
Dried beef	0.32	0.20	0.012	0.067	0.079	2.59	4.46
Bacon	0.47	0.28	0.011	0.059	0.059	1.56	0.57
Canned tuna and sardine	0.57	0.34	0.014	0.060	0.053	1.17	2.39
Other fish and seafood in brine	0.34	0.21	0.014	0.113	0.139	2.38	4.26
Pasteurized and whole milk	0.29	0.21	0.019	0.045	0.049	2.93	4.24
Powdered milk	0.47	0.29	0.009	0.045	0.051	1.57	2.89
Evaporated and sweetened milk	0.47	0.30	0.010	0.041	0.046	1.57	2.75
Fresh Cheese	0.51	0.30	0.009	0.057	0.065	1.42	2.76
Yoghurt	0.57	0.30	0.000	0.062	0.067	1.18	2.85
Oaxaca or Asadero cheese	0.54	0.32	0.009	0.052	0.055	1.28	2.56
Cream	0.47	0.26	0.004	0.059	0.063	1.56	3.29
Manchego Chihuahua cheese	0.54	0.33	0.010	0.055	0.059	1.29	2.51
Other types of cheeses	0.49	0.30	0.014	0.072	0.072	1.47	283
Ice cream	0.38	0.21	0.000	0.070	0.091	2.11	4.18

American yellow cheese	0.50	0.29	0.007	0.062	0.070	1.46	2.91
Butter	0.41	0.26	0.210	0.072	0.068	1.89	3.31
Vegetable oils and fats	0.58	0.34	0.014	0.064	0.057	1.16	2.39
Other dried vegetables	0.40	0.24	0.019	0.081	0.077	1.96	3.56
Canned juices	0.57	0.31	0.004	0.069	0.076	1.19	2.67
Processed peppers	0.48	0.29	0.016	0.075	0.071	1.51	2.95
Canned vegetables	0.45	0.27	0.013	0.067	0.068	1.65	3.15
Tomato puree and canned soups	0.46	0.27	0.008	0.069	0.078	1.62	3.19
Other canned fruits	0.48	0.28	0.009	0.060	0.059	1.54	3.09
Babies food (fruits and vegetables)	0.44	0.27	0.009	0.052	0.057	1.53	3.25
Sugar	0.52	0.31	0.024	0.076	0.051	1.35	2.69
Instant coffee	0.48	0.29	0.008	0.047	0.052	1.54	2.93
Toasted coffee beans	0.34	0.22	0.017	0.067	0.071	2.40	4.10
Bottled sodas	0.32	0.18	0.001	0.063	0.079	2.55	4.99
Bottled water	0.35	0.19	0.002	0.082	0.092	2.30	4.70
Mayonnaise and mustard	0.48	0.28	0.010	0.063	0.065	1.52	3.01
Salt and chicken seasoning	0.40	0.24	0.011	0.069	0.076	1.95	3.63
Other condiments	0.37	0.22	0.003	0.066	0.086	2.14	4.04
Chips and similar items	0.46	0.28	0.014	0.069	0.069	1.61	3.06
Soda powder	0.43	0.23	0.007	0.082	0.079	1.79	3.84
Chocolate	0.53	0.31	0.009	0.057	0.059	1.33	2.71
Sweets, caramel and honey	0.40	0.24	0.012	0.074	0.084	1.94	3.58
Powder gelatin	0.56	0.33	0.013	0.072	0.069	1.22	2.52
Other cooked food	0.25	0.17	0.024	0.084	0.108	3.53	5.41
Fried (pork) beef	0.14	0.11	0.029	0.066	0.082	6.39	8.66
Roasted chicken	0.33	0.23	0.017	0.048	0.057	2.54	3.85
Barbecued goat meat or birria	0.15	0.12	0.030	0.062	0.078	6.14	8.13
Pizzas	0.23	0.16	0.014	0.072	0.108	3.84	5.91
Beer	0.36	0.21	0.007	0.054	0.060	2.23	4.22
Tequila	0.44	0.21	−0.005	0.060	0.066	1.74	4.22
Other spirits	0.39	0.22	0.004	0.062	0.069	2.05	4.13
Rom	0.40	0.24	0.006	0.052	0.058	1.93	3.73
Brandy	0.43	0.23	0.006	0.061	0.056	1.78	3.86
Wine	0.31	0.18	0.023	0.099	0.085	2.70	4.98
Cigarettes	0.20	0.18	0.047	0.060	0.069	4.59	5.15

TABLE 7. STATISTICS OF OTHER MERCHANDISE CATEGORIES

Other merchandise	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
Hats	0.10	0.07	0.017	0.124	0.230	9.19	13.45
Other expenses for footwear	0.12	0.08	0.002	0.093	0.199	7.91	11.78
Bags, baggage and belts	0.15	0.09	0.008	0.174	0.242	6.35	10.93
Kitchen furniture	0.30	0.17	0.003	0.099	0.132	2.81	5.21
Dining tables	0.32	0.18	0.009	0.099	0.117	2.62	4.92
Stoves	0.35	0.20	0.006	0.080	0.095	2.30	4.43
Boilers	0.26	0.17	0.018	0.071	0.080	3.25	5.30
Living room furniture	0.34	0.20	0.007	0.090	0.105	2.39	4.57
Dining room furniture	0.31	0.17	–0.002	0.102	0.134	2.70	5.25
Mattresses	0.34	0.21	0.006	0.096	0.132	2.39	4.30
Other home furniture	0.28	0.16	0.005	0.123	0.158	3.04	5.65
Bedroom furniture	0.34	0.19	0.003	0.089	0.115	2.44	4.63
Fridges	0.34	0.20	0.004	0.069	0.085	2.37	4.53
Washer machine	0.35	0.19	0.005	0.082	0.089	2.32	4.65
Other electric appliances	0.29	0.16	–0.003	0.102	0.142	2.96	5.62
Air conditioning	0.23	0.12	0.005	0.117	0.126	3.92	7.74
Fans	0.25	0.15	0.021	0.130	0.144	3.52	6.21
Irons	0.30	0.18	0.010	0.112	0.138	2.78	5.06
Blender	0.32	0.19	0.010	0.094	0.117	2.57	4.64
TV sets	0.29	0.14	0.011	0.135	0.110	2.96	6.53
Computers	0.21	0.09	–0.010	0.141	0.129	4.20	10.17
Sound system	0.28	0.14	–0.008	0.124	0.136	3.03	6.73
Video players	0.26	0.11	–0.034	0.134	0.154	3.30	8.69
Radios and recorders	0.24	0.13	–0.002	0.134	0.163	3.64	7.15
Bulbs	0.25	0.15	0.018	0.114	0.123	3.45	6.17
Matches	0.11	0.08	0.056	0.143	0.133	8.46	12.58
Batteries	0.30	0.17	0.012	0.107	0.120	2.85	5.27
Candles	0.26	0.18	0.020	0.099	0.148	3.34	5.15
Brooms	0.28	0.17	0.003	0.098	0.135	3.04	5.51
China and glassware	0.28	0.16	–0.002	0.113	0.170	3.10	5.61
Cooking battery	0.26	0.15	0.006	0.136	0.179	3.29	5.99
Plastic cookware	0.25	0.15	0.012	0.132	0.175	3.42	5.99

Other cookware appliances	0.24	0.14	–0.008	0.124	0.187	3.67	6.76
Bedspreads	0.20	0.12	0.007	0.139	0.183	4.56	8.11
Linen	0.21	0.14	0.023	0.116	0.153	4.27	6.82
Bed sheets	0.20	0.12	0.005	0.121	0.173	4.43	7.68
Blankets	0.15	0.09	–0.005	0.154	0.249	6.23	10.66
Towels	0.21	0.13	0.001	0.112	0.166	4.17	7.32
Curtains	0.16	0.10	0.008	0.122	0.190	5.90	9.60
Detergents	0.52	0.30	0.010	0.059	0.057	1.35	2.77
Fabric softener and cleaners	0.53	0.28	–0.001	0.066	0.076	1.33	3.05
Bleach	0.50	0.27	0.000	0.068	0.079	1.46	3.19
Soap for clothes	0.44	0.27	0.015	0.071	0.072	1.72	3.19
Air freshener	0.37	0.22	0.014	0.093	0.098	2.20	4.12
Pesticides	0.42	0.23	0.002	0.102	0.117	1.84	3.88
Antibiotics	0.41	0.27	0.024	0.078	0.084	1.91	3.15
Painkillers	0.40	0.27	0.020	0.075	0.089	1.94	3.23
Cardiovascular medicine	0.36	0.26	0.027	0.067	0.081	2.25	3.33
Nutritional supplements	0.37	0.25	0.018	0.082	0.103	2.13	3.55
Contraceptives and hormones	0.39	0.28	0.030	0.073	0.073	1.99	3.05
Gastrointestinal medicine	0.39	0.26	0.019	0.074	0.094	2.03	3.31
Expectorants and decongestants	0.39	0.25	0.020	0.078	0.087	2.02	3.42
Other medicine	0.35	0.24	0.022	0.072	0.084	2.29	3.62
Dermatological medicine	0.33	0.21	0.011	0.085	0.116	2.53	4.34
Antiviral medicine	0.37	0.24	0.011	0.082	0.115	2.15	3.72
Healing supplies	0.27	0.16	0.005	0.105	0.146	3.17	5.62
Lenses and other appliances	0.11	0.07	0.015	0.105	0.203	9.01	12.93
Dental prothesis	0.06	0.06	0.054	0.111	0.317	15.12	17.59
Hair products	0.48	0.26	0.001	0.083	0.094	1.51	3.29
Lotion and perfumes	0.26	0.16	–0.006	0.116	0.183	3.29	5.92
Face soap	0.41	0.24	0.010	0.070	0.075	1.88	3.62
Toothpaste	0.37	0.21	0.004	0.072	0.086	2.13	4.18
Deodorant	0.44	0.24	0.004	0.072	0.079	1.72	3.59
Skin creams	0.43	0.24	0.011	0.103	0.106	1.80	3.66
Razors and shaving machines	0.31	0.18	0.008	0.100	0.119	2.73	5.10
Make-up	0.28	0.16	–0.004	0.107	0.160	3.02	5.56
Other toiletry	0.26	0.15	0.006	0.116	0.147	3.26	5.98

TABLE 7 *(concluded)*

Other merchandise	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
Other make-up supplies	0.29	0.17	0.004	0.108	0.145	2.97	5.41
Toilet paper	0.47	0.27	0.008	0.088	0.100	1.57	3.16
Diapers	0.47	0.28	0.017	0.085	0.080	1.56	3.06
Sanitary towels	0.45	0.24	0.005	0.087	0.092	1.69	3.62
Napkins	0.46	0.27	0.009	0.073	0.077	1.60	3.24
Tissues	0.38	0.22	0.007	0.081	0.095	2.11	4.04
Automobile	0.31	0.21	0.008	0.035	0.043	2.67	4.34
Bicycle	0.23	0.14	0.010	0.111	0.143	3.85	6.73
Tires	0.31	0.21	0.011	0.066	0.102	2.71	4.32
Other spare parts	0.19	0.13	0.012	0.083	0.142	4.68	7.06
Accumulators	0.23	0.18	0.028	0.060	0.077	3.83	5.13
Text books	0.12	0.10	0.037	0.081	0.129	7.66	9.84
Other books	0.12	0.08	0.032	0.125	0.179	7.72	11.38
Notebooks and files	0.22	0.14	0.014	0.111	0.152	4.03	6.65
Pens, pencils and others	0.19	0.12	0.023	0.118	0.145	4.88	7.95
Newspapers	0.04	0.03	0.054	0.156	0.446	24.59	29.72
Magazines	0.06	0.05	0.059	0.096	0.181	15.86	18.41
Toys	0.22	0.13	0.004	0.150	0.194	4.05	7.42
CDs and cassettes	0.17	0.09	–0.005	0.114	0.144	5.40	10.50
Pets food	0.39	0.23	0.014	0.077	0.082	2.05	3.73
Photographic material and equipment	0.20	0.11	0.000	0.103	0.134	4.40	8.21
Musical instruments and others	0.15	0.10	0.006	0.102	0.171	6.30	10.00
Sporting appliances	0.17	0.11	0.003	0.126	0.212	5.27	8.60

TABLE 8. STATISTICS OF HOUSING CATEGORIES

Housing	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
Housing maintenance materials	0.21	0.15	0.014	0.066	0.102	4.14	6.21
Housing maintenance services	0.08	0.06	0.020	0.082	0.253	12.39	15.31
Domestic services	0.06	0.05	0.028	0.129	0.606	15.37	17.85
Other housing services	0.06	0.05	0.050	0.118	0.383	17.26	20.01

TABLE 9. STATISTICS OF EDUCATION CATEGORIES

Education	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
College	0.15	0.13	0.020	0.052	0.269	6.27	7.02
Elementary school	0.17	0.16	0.037	0.052	0.151	5.24	5.71
High school	0.15	0.13	0.025	0.060	0.263	6.17	6.99
Junior high school	0.16	0.15	0.040	0.058	0.214	5.57	6.02
Kindergarten	0.16	0.14	0.044	0.063	0.162	5.83	6.43
Technical career	0.10	0.08	0.053	0.109	0.247	9.67	11.61
Further education	0.08	0.07	0.042	0.135	0.340	11.27	14.17
Play school and nursery	0.16	0.15	0.036	0.057	0.170	5.71	6.35

TABLE 10. STATISTICS OF OTHER SERVICES CATEGORIES

Other services	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
Dry-clean service	0.10	0.08	0.022	0.075	0.196	9.56	12.01
Laundry service	0.07	0.06	0.052	0.132	0.283	13.90	17.30
Medical consultation	0.05	0.05	0.067	0.125	0.298	18.33	21.39
General hospitalization	0.08	0.07	0.046	0.082	0.148	11.90	14.21
Surgical procedure	0.07	0.06	0.067	0.116	0.189	13.84	16.56
Dental care	0.06	0.05	0.058	0.125	0.297	15.34	18.31
Cabinet medical studies	0.08	0.07	0.041	0.097	0.188	11.48	14.45
Labor hospitalization	0.08	0.07	0.061	0.100	0.152	11.97	14.25
Clinical analysis	0.08	0.06	0.046	0.106	0.174	12.14	15.61
Medical consultation during pregnancy	0.05	0.05	0.086	0.125	0.200	18.39	20.97
Medical services during labor	0.05	0.05	0.072	0.120	0.272	18.04	20.60
Clinical analysis during pregnancy	0.09	0.07	0.029	0.096	0.198	11.07	14.48
Haircut	0.07	0.06	0.049	0.127	0.287	13.58	16.90
Beauty parlor	0.08	0.07	0.057	0.150	0.314	11.65	14.68
Air transportation	0.75	0.44	0.001	0.080	0.115	0.73	1.71
Car repair	0.09	0.07	0.033	0.104	0.300	10.54	12.87
Car washing and waxing	0.08	0.06	0.013	0.102	0.291	12.29	16.03
Car maintenance	0.14	0.10	0.024	0.103	0.165	6.82	9.90
Travel service packages	0.62	0.34	−0.004	0.093	0.120	1.04	2.45
Movie theaters	0.10	0.08	0.036	0.071	0.147	9.51	11.41
Night clubs	0.06	0.05	0.024	0.116	0.259	14.97	20.02
Cable or satellite TV services	0.08	0.06	0.017	0.097	0.253	12.09	15.83
Other entertainment	0.06	0.04	0.072	0.184	0.262	17.42	23.41
Sporting club	0.08	0.06	0.062	0.113	0.222	12.63	14.99
Sports shows	0.06	0.04	0.058	0.185	0.312	17.25	23.20
Internet services	0.04	0.02	−0.028	0.187	0.229	23.65	49.52
Movie rentals	0.08	0.06	0.029	0.125	0.268	12.35	16.50
Diners/Snack bars	0.13	0.12	0.072	0.105	0.153	7.04	8.13
Restaurants	0.14	0.12	0.040	0.071	0.156	6.78	7.95
Canteen, bars	0.08	0.06	0.030	0.101	0.263	12.58	15.76
Coffee shops	0.11	0.09	0.072	0.129	0.237	8.39	10.03
Professional services	0.06	0.05	0.043	0.179	0.491	14.91	18.89
Funeral services	0.09	0.08	0.034	0.085	0.238	10.60	12.67

TABLE 11. STATISTICS OF FRUIT AND VEGETABLES CATEGORIES

Fruits and vegetables	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
Apple	0.88	0.46	0.004	0.092	0.092	0.47	1.62
Bananas	0.83	0.42	0.003	0.111	0.108	0.57	1.83
Orange	0.90	0.46	–0.002	0.148	0.160	0.43	1.61
Avocado	0.93	0.48	–0.001	0.127	0.135	0.37	1.54
Mango	0.55	0.29	0.015	0.201	0.206	1.26	2.87
Papaya	0.89	0.45	0.004	0.109	0.107	0.46	1.65
Lime	0.94	0.52	0.011	0.200	0.227	0.36	1.36
Other fruits	0.79	0.42	0.008	0.131	0.132	0.65	1.84
Grape	0.92	0.51	0.017	0.155	0.155	0.40	1.41
Melon	0.94	0.48	0.008	0.161	0.152	0.35	1.53
Watermelon	0.88	0.45	0.004	0.158	0.157	0.46	1.66
Pear	0.87	0.47	0.007	0.092	0.094	0.49	1.56
Peach	0.87	0.47	0.012	0.146	0.144	0.49	1.57
Grapefruit	0.89	0.46	0.001	0.117	0.125	0.46	1.61
Pineapple	0.92	0.47	0.007	0.133	0.124	0.40	1.58
Guava	0.87	0.44	0.002	0.109	0.109	0.49	1.71
Tomato	0.97	0.50	0.001	0.248	0.256	0.28	1.45
Potato	0.88	0.47	0.010	0.122	0.114	0.46	1.60
Onion	0.93	0.48	0.007	0.192	0.195	0.38	1.51
Other vegetables	0.78	0.41	0.005	0.127	0.130	0.66	1.91
Green tomato	0.94	0.46	–0.001	0.199	0.193	0.35	1.62
Zucchini	0.95	0.48	0.005	0.201	0.198	0.34	1.51
Serrano pepper	0.93	0.45	0.000	0.181	0.171	0.38	1.67
Carrots	0.88	0.45	0.005	0.130	0.124	0.47	1.68
Other fresh peppers	0.90	0.46	0.002	0.160	0.161	0.44	1.64
Poblano pepper	0.95	0.49	0.008	0.175	0.168	0.32	1.47
Lettuce and cabbage	0.87	0.45	0.006	0.149	0.147	0.50	1.69
Peas	0.72	0.38	0.008	0.132	0.134	0.78	2.06
Nopales (cactus)	0.72	0.40	0.008	0.127	0.136	0.78	1.98
Chayote or pear squash	0.92	0.46	–0.001	0.189	0.188	0.40	1.63
Cucumber	0.93	0.48	0.002	0.179	0.187	0.37	1.52
Green beans	0.88	0.47	0.005	0.149	0.159	0.47	1.58
Beans	0.57	0.32	0.010	0.078	0.077	1.20	2.59
Dried peppers	0.48	0.28	0.011	0.084	0.087	1.53	3.08

TABLE 12. STATISTICS OF FARM-RELATED CATEGORIES

Farm-related	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
Chicken parts	0.71	0.40	0.007	0.064	0.066	0.81	1.95
Fresh whole chicken	0.71	0.40	0.006	0.061	0.064	0.80	1.95
Pork flesh	0.64	0.35	0.005	0.059	0.061	0.97	2.29
Chops and lard	0.54	0.31	0.012	0.069	0.066	1.28	2.68
Beef tenderloin	0.49	0.28	0.007	0.049	0.049	1.50	3.04
Leg of pork	0.68	0.37	0.005	0.062	0.065	0.88	2.14
Beef steak	0.59	0.35	0.009	0.051	0.054	1.12	2.30
Ground beef or mince	0.59	0.35	0.008	0.056	0.060	1.11	2.35
Beef culet and ribs	0.60	0.35	0.008	0.059	0.067	1.11	2.28
Short loin	0.54	0.32	0.009	0.056	0.061	1.30	2.57
Special selection of beef	0.50	0.30	0.008	0.054	0.062	1.46	2.81
Beef liver	0.48	0.26	0.009	0.100	0.103	1.54	3.29
Entrails	0.58	0.32	0.011	0.095	0.094	1.15	2.56
Other cuts of meat	0.46	0.28	0.006	0.068	0.092	1.63	3.05
Other fish	0.66	0.36	0.005	0.077	0.082	0.93	2.25
Prawn	0.73	0.37	–0.001	0.059	0.063	0.77	2.17
Crappie or kelp bass	0.70	0.37	0.003	0.075	0.078	0.84	2.18
Other seafood	0.59	0.33	0.006	0.078	0.081	1.11	2.53
Sea bass and mere	0.58	0.32	0.006	0.075	0.077	1.17	2.63
Snapper	0.66	0.35	0.004	0.076	0.080	0.94	2.31
Egg	0.72	0.42	0.014	0.072	0.067	0.78	1.85

TABLE 13. STATISTICS OF ADMINISTERED GOODS CATEGORIES

Administered	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
Electricity bill	0.97	0.77	0.007	0.032	0.091	0.27	0.68
Domestic gas	0.82	0.73	0.007	0.013	0.037	0.59	0.77
Low-octane gasoline	0.89	0.86	0.004	0.006	0.063	0.45	0.50
High-octane gasoline	0.90	0.88	0.005	0.006	0.043	0.43	0.48

TABLE 14. STATISTICS OF REGULATED GOODS AND SERVICES CATEGORIES

Regulated	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*
Water rights	0.15	0.15	0.031	0.039	0.146	5.97	6.28
Housing taxes	0.06	0.06	0.054	0.069	0.218	16.20	17.14
Local telephone service	0.26	0.07	–0.005	0.020	0.015	3.35	13.61
Long distance national phone service	0.07	0.00	–0.009	0.000	0.009	14.33	89.00
Long distance international phone service	0.04	0.00	–0.009	0.104	0.009	22.00	89.00
Telephone line	0.08	0.04	–0.040	0.205	0.320	12.51	23.87
Collective/public transportation	0.06	0.05	0.095	0.103	0.110	17.02	17.69
Urban bus	0.06	0.06	0.077	0.091	0.220	16.21	16.98
Taxi	0.05	0.04	0.050	0.100	0.310	21.14	24.19
Subway or electric train	0.02	0.01	0.061	0.066	0.051	64.71	67.54
Interstate bus	0.20	0.15	0.018	0.052	0.108	4.59	6.00
Lubricating oils	0.21	0.15	0.025	0.076	0.101	4.17	6.05
Car taxes	0.31	0.12	–0.004	0.004	0.009	2.73	7.53
Highway tolls	0.11	0.10	0.024	0.032	0.078	8.88	9.63
Parking	0.05	0.04	0.053	0.135	0.391	20.16	23.99
License and other documents fees	0.08	0.06	0.043	0.097	0.251	12.55	14.96

FIGURE 1. FREQUENCY OF PRICE CHANGES BY PRODUCT (accumulated number of products in percentages)

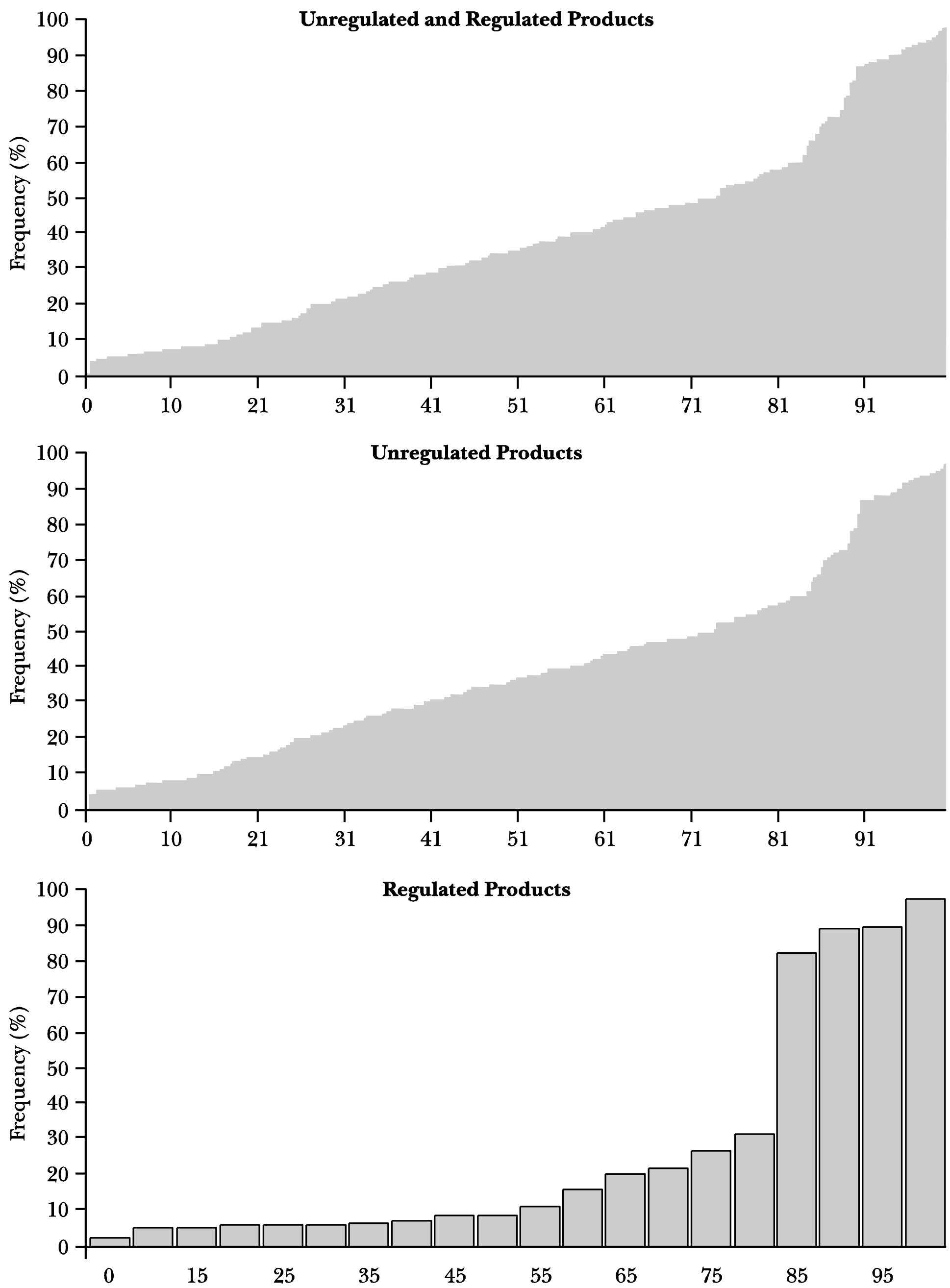
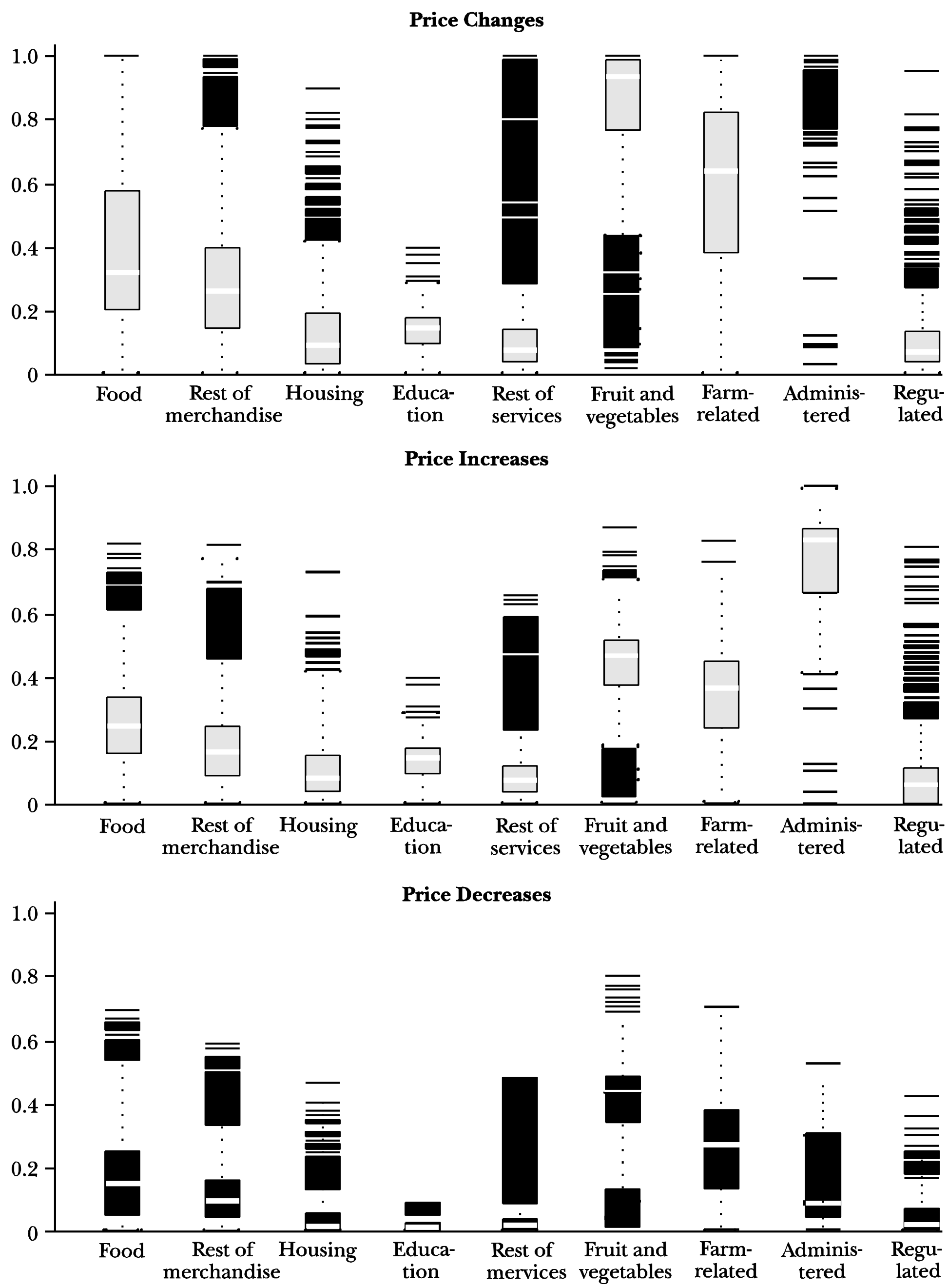


FIGURE 2. BOX-PLOT OF THE FRECUENCIES OF PRICE CHANGES FOR EACH GROUP

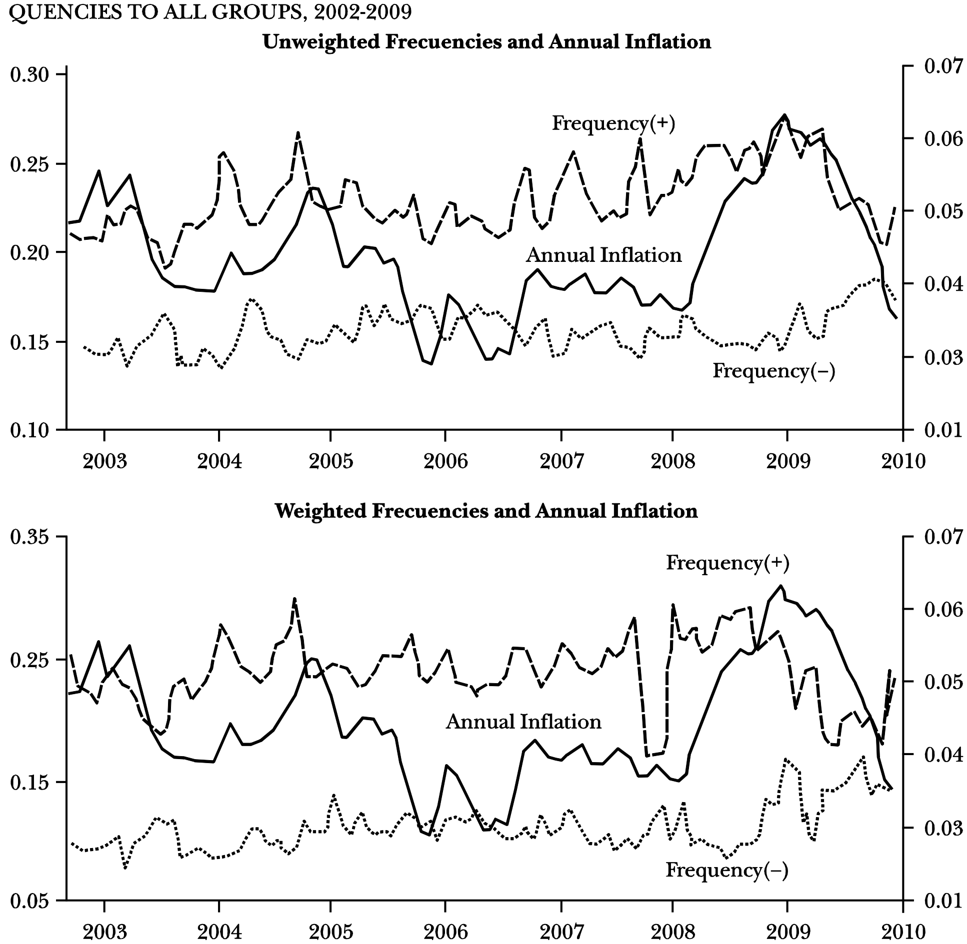


by the price increases. Housing and rest of services distributions are strongly skewed to the right given that most of their items do not change prices frequently.

4.1.3 Time series

When studying the time series of frequencies, it seems that the frequency of price changes moves importantly with the annual headline inflation (Figure 3). As inflation trends upward the proportion of products with price increases also broadens, and when inflation shows a downward trend the proportion of price increases diminishes. An inverse relation is

FIGURE 3. TIME SERIES OF ANNUAL HEADLINE INFLATION AND THE PRICE CHANGES FREQUENCIES TO ALL GROUPS, 2002-2009

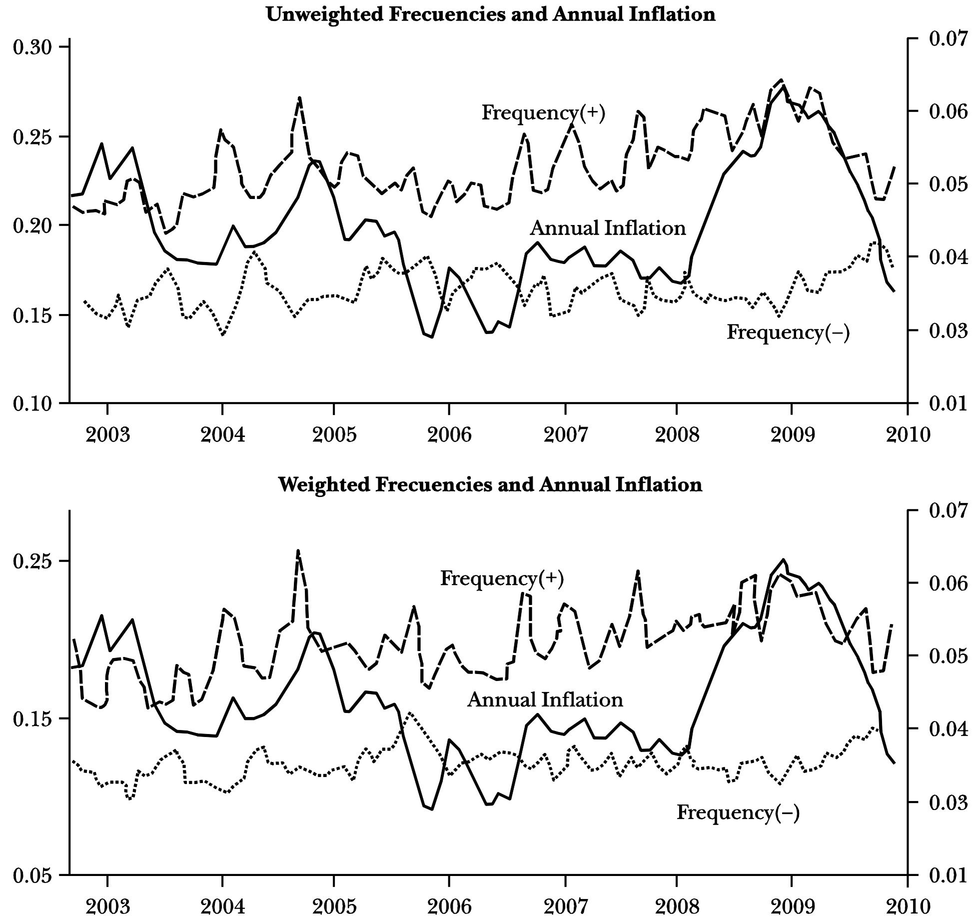


exhibited with the price decreases, although less strong compared to the price increases. Now, looking carefully at two important episodes, the increase of international commodity prices from mid-2006 to 2008 and the economic recession of 2009, the previous result is evident. From mid-2006 until end of 2008, the share of products increasing their prices boomed and the share of decreasing prices seemed to have stayed stable causing an important increase in headline inflation. When looking at 2009, it is clear how the number of price increases lowered considerably and the number of price decreases raised since the beginning of the year causing the important fall of headline inflation.

Nevertheless, as pointed out previously, not all sectors have the same price behaviors. Looking at Figures 4 to 7 the differences between the groups are clear. The different groups present very different behaviors. Firstly there is an important difference between the unregulated and the regulated groups. For unregulated goods and services (Figure 4), the frequencies of price increases exhibit an upward trend since 2006. This trend changes direction only at the beginning of 2009. The frequency of price decreases is more stable, however it exhibits a slight upward slope since the end of 2008. This change of trend for the frequencies of both price increases and decreases since the beginning of 2009 match the fall of annual headline inflation. Importantly, notice that the frequencies of unregulated goods move strongly with annual headline inflation; the correlation between this inflation series and unregulated goods price increases frequency is 0.51 and between it and the price decreases frequency is –0.28. So as pointed out before, when inflation is rising the number of firms increasing prices augments and the number of firms reducing prices drops.

From all the groups (Figures 6 and 7), fruits and vegetables and farm-related products seem to have the fewer rigidities; upward and downward movements of prices are common. It is easily seen in the farm-related group, that when headline inflation is increasing the difference between the share of its product with price increases and those with price decreases is positive and large. In episodes when this inflation has a downward trend, this difference is very small or even negative. In contrast, services groups (housing, education, and rest of services) show strong seasonality and strong rigidities. The frequencies of the group of rest of services show a continuous upward trend and, even during the recent episode of recession, its prices seem to be the ones reacting the less from all the groups of unregulated products. The groups of food and rest of merchandise also

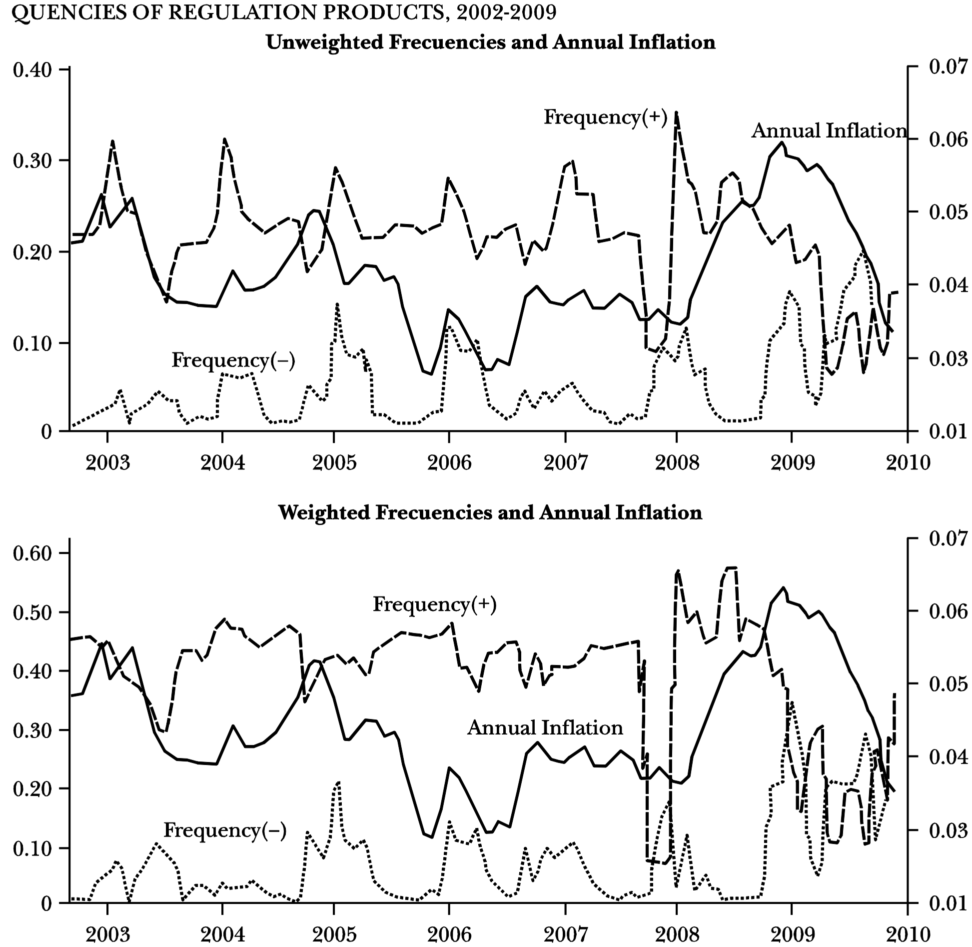
FIGURE 4. TIME SERIES OF ANNUAL HEADLINE INFLATION AND THE PRICE CHANGES FREQUENCIES OF UNREGULATED PRODUCTS, 2002-2009



show an upward trend mainly after 2006 on their price changes frequencies, nevertheless after the first quarter of 2009 there is a change of trend. This is due mainly to an important fall on the frequencies of rising prices. The frequency of negative price changes raised but in a smaller proportion.

For regulated products (Figure 5), frequencies of price changes do not follow a clear pattern given that they are dependent of public policies. The average frequencies of price changes of administered goods (Figures 6 and 7) are mainly constant at very high levels except for periods where the government freezes or reduces prices, like the recent period starting at the beginning of 2009. Regulated goods and services have a relatively

FIGURE 5. TIME SERIES OF ANNUAL HEADLINE INFLATION AND THE PRICE CHANGES FREQUENCIES OF REGULATION PRODUCTS, 2002-2009



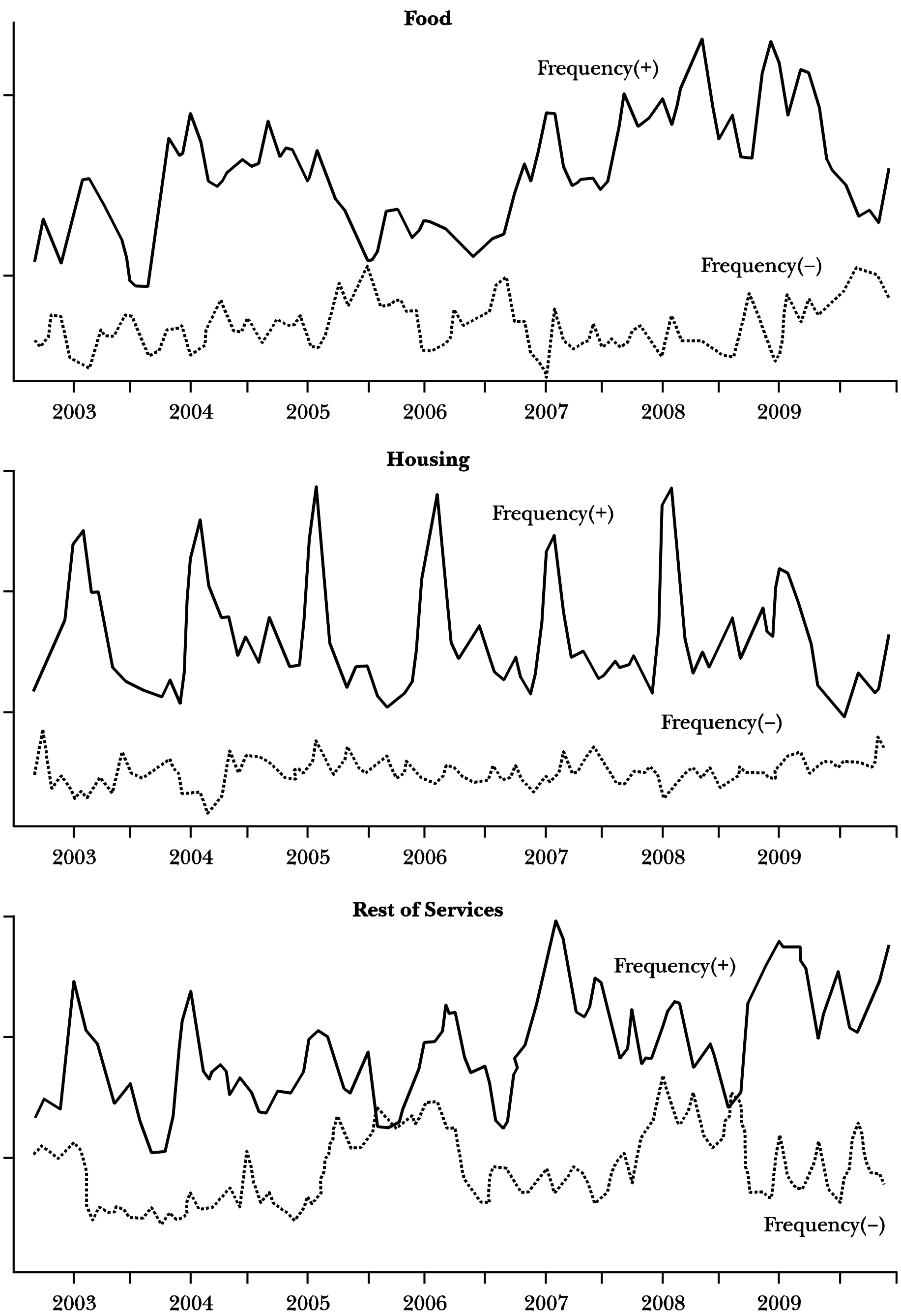
constant level of price frequencies (after accounting for seasonality) except for the past last years where the average frequencies of price increases seem to have risen significantly.

4.2 Magnitudes

4.2.1 Group level

In Mexico, as with frequencies of price changes, there is a big heterogeneity between sectors in the average size of their price increases and decreases (see Table 4). From all unregulated product categories, the services

FIGURE 6. TIME SERIES OF THE UNWEIGHTED FREQUENCIES OF PRICE INCREASES AND



DECREASES, 2002-2009 (Unweighted Frecuencies)

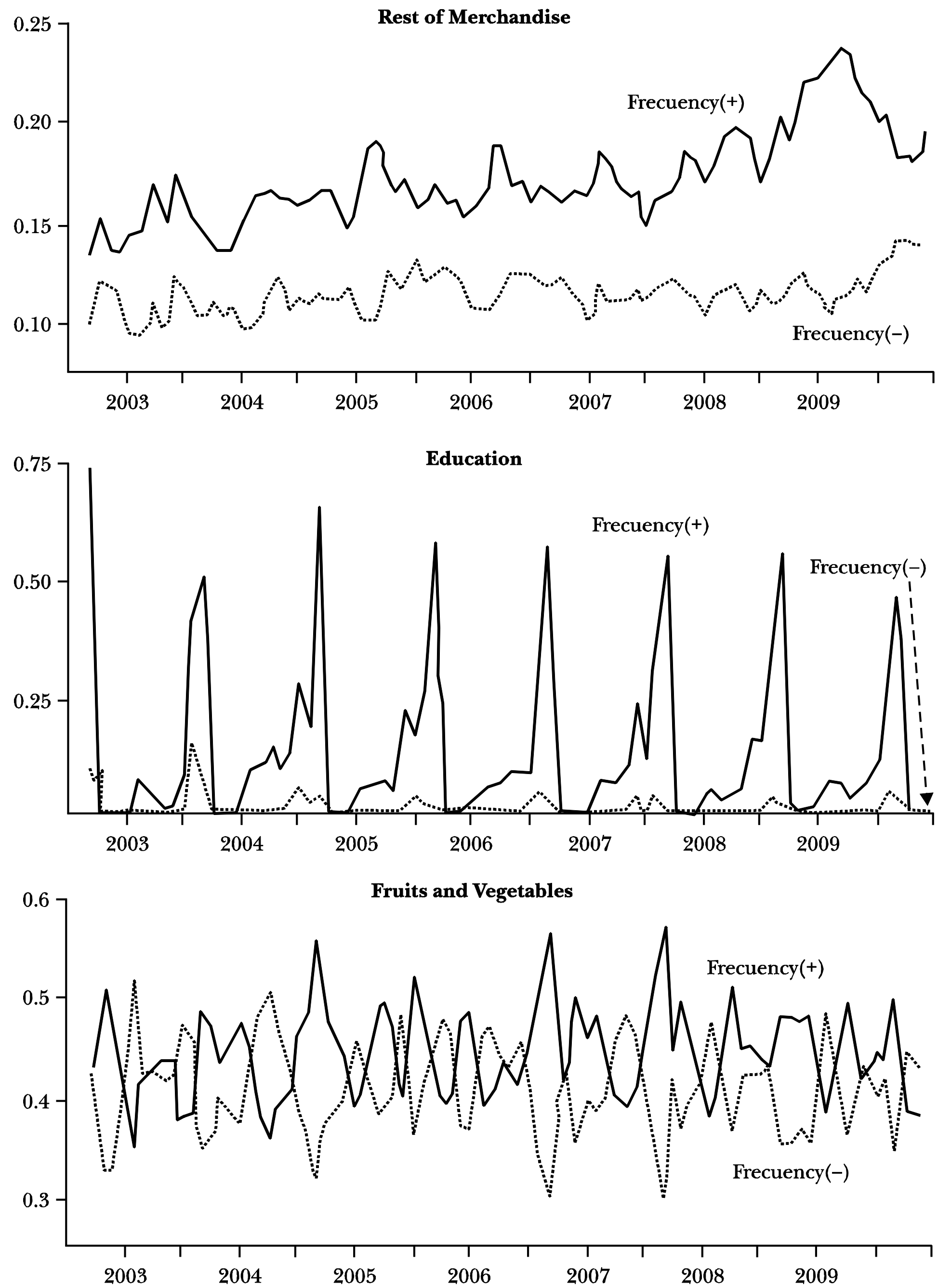
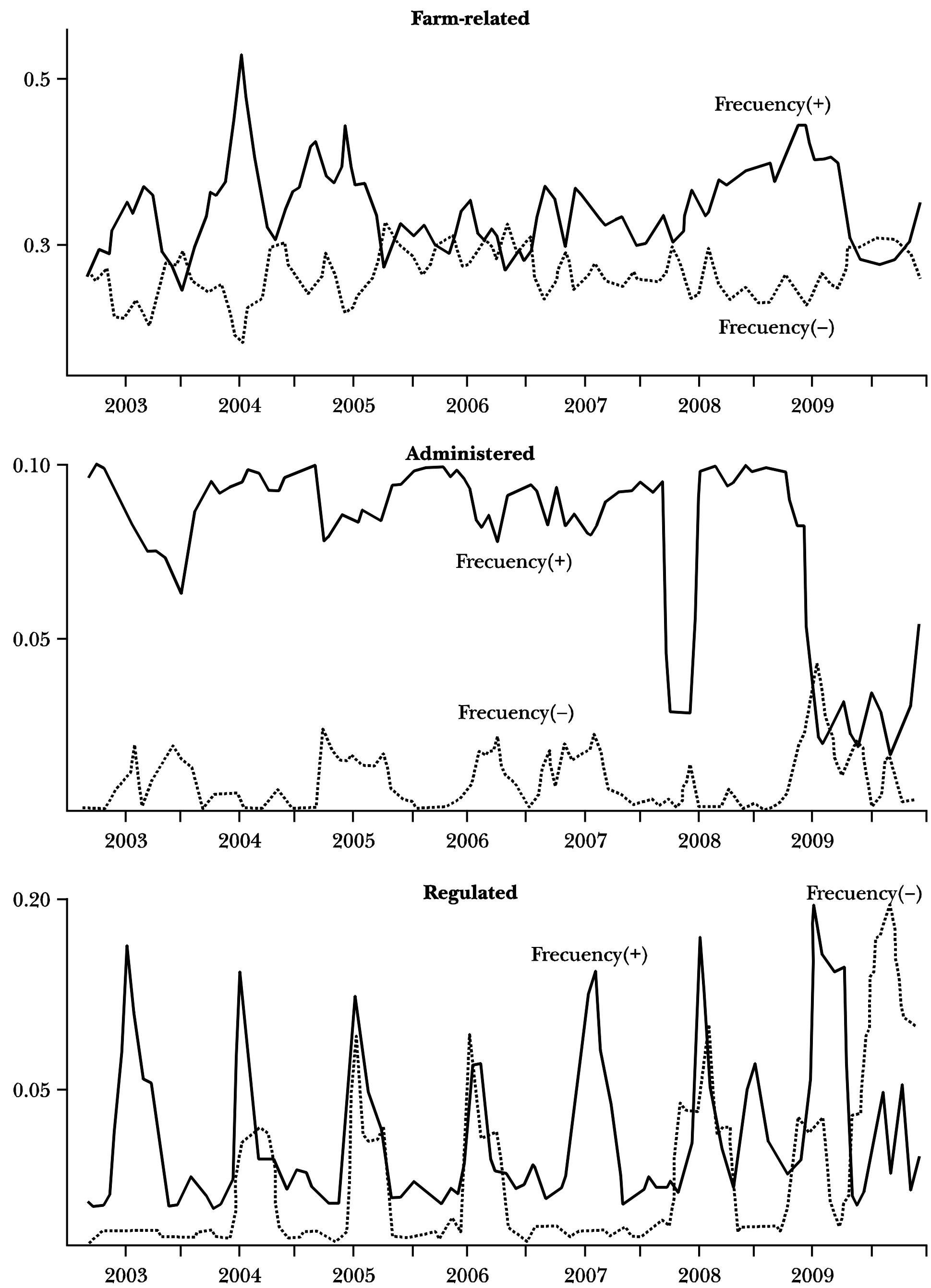


FIGURE 6 (*concluded*)



have the larger price movements (although infrequent) while agricultural goods have the smaller ones (although very frequent). Regulated products show big disparities as well, administered goods have many tiny changes while regulated goods and services have more unfrequent bigger ones.

The previous result can be easily seen in a histogram. Figure 8 shows the distribution of the sizes of price changes (for all products, unregulated products, and regulated ones). The distribution of unregulated products show fat tails; there are many small price changes, but there are some large price changes. Although there are more price increases, the number of price decreases is also important. Regulated products show a completely different story; most price changes are very small and mainly positive (this mainly due to administered goods). Compare how around 47% of unregulated price changes are smaller than 5% in absolute value, while more than 86% of regulated price changes are in that range. Also notice that more than 13% of unregulated price changes, but only 4% of the regulated ones, are above 20% in absolute value.

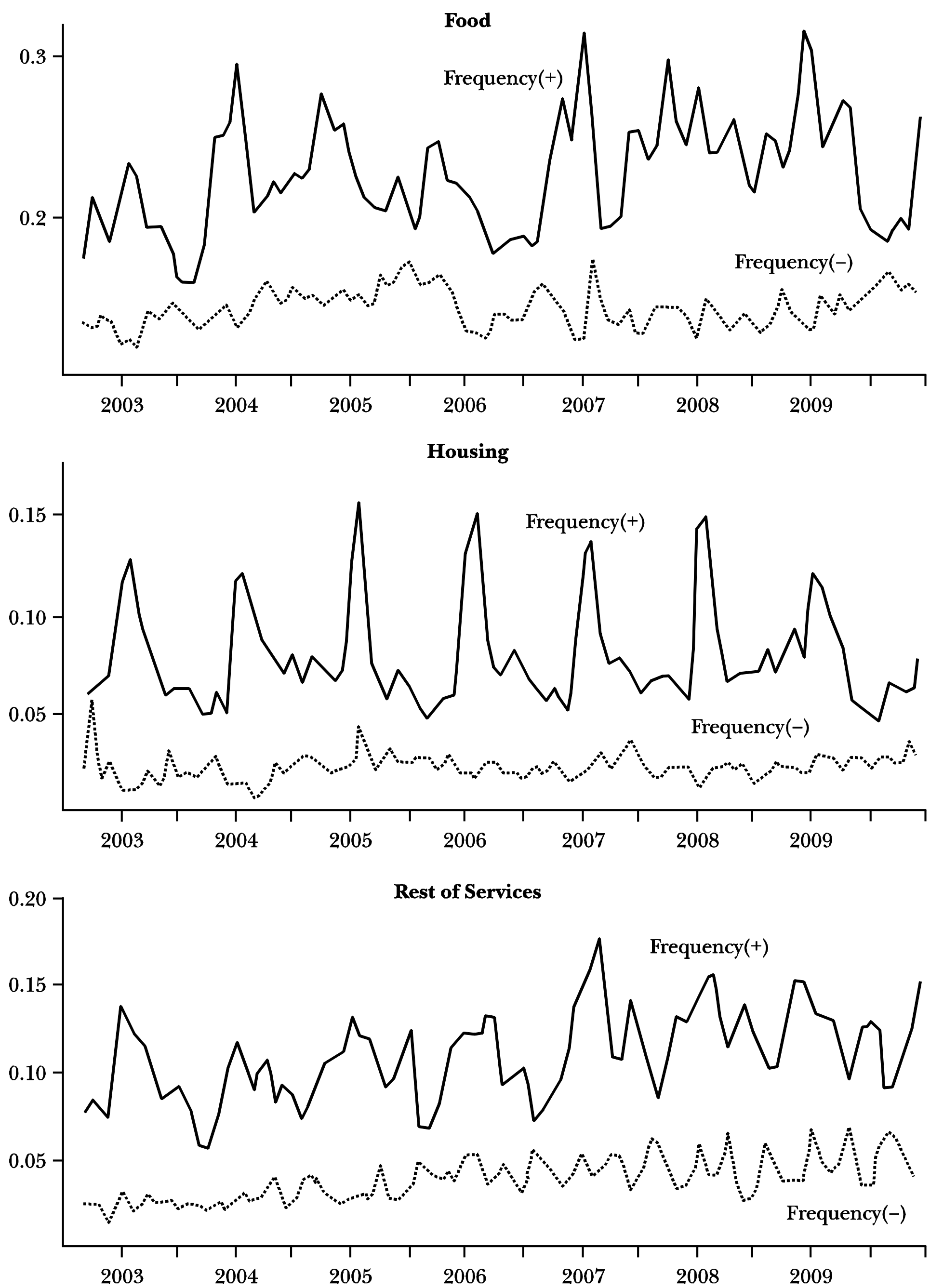
4.2.2 Time series

The size of price increases and decreases, differently from frequencies, do not seem to move importantly with annual headline inflation (Figure 9). Even during episodes when inflation increases or falls significantly, the size of price increases and decreases seem to be stable. There is a subtle increase in the size of price decreases during 2009, but the adjustment is not as important as the adjustments in frequencies shown in Figure 3. The story is not very different for unregulated and regulated products, which do not seem to co-move strongly with inflation (Figures 10 and 11). Although when looking at each group separately (Figures 12 and 13), the magnitudes of the price changes from the groups of food, rest of merchandise, and farm-related products vary slightly according to inflation.

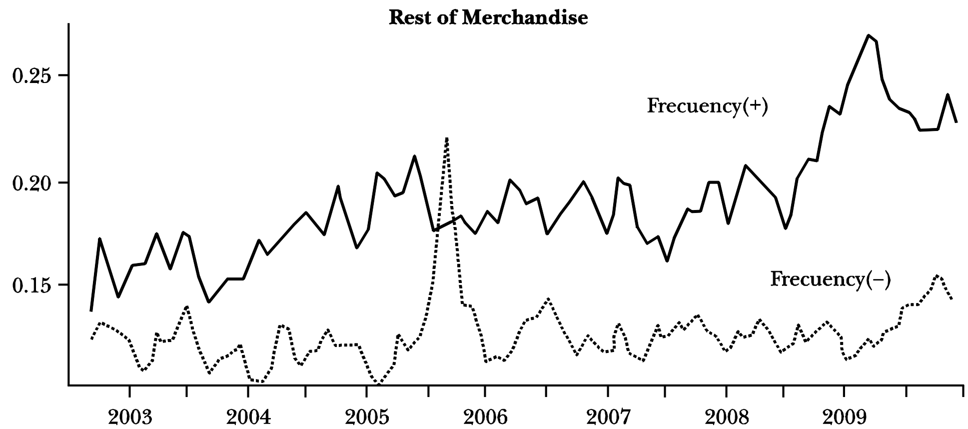
4.3 Time or State Dependent

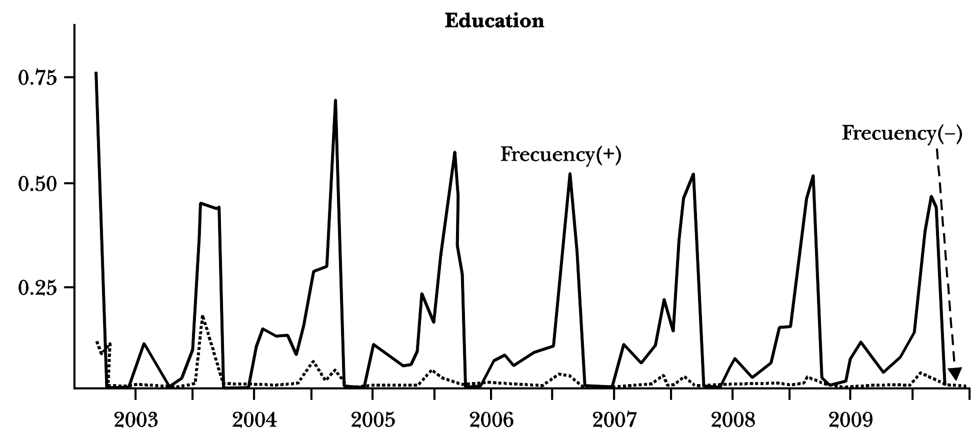
The results given in this paper have been showing that there is evidence of both state and time dependence. In some sectors, adjustments in the frequencies of price changes move strongly with annual headline inflation pointing out the need to study the extensive margin and a possible state dependent scenario. Nevertheless, in other sectors, seasonality is

FIGURE 7. TIME SERIES OF THE WEIGHTED FREQUENCIES OF PRICE INCREASES AND



DECREASES, 2003-2009 (Weighted Frequencies)





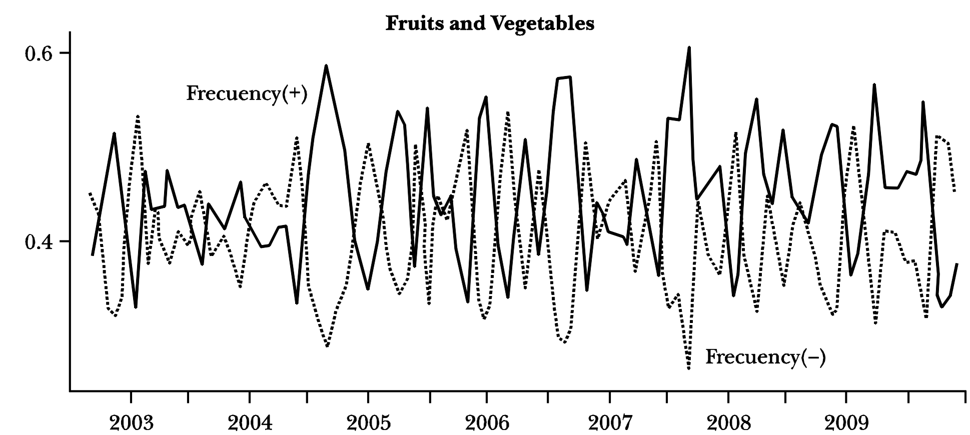
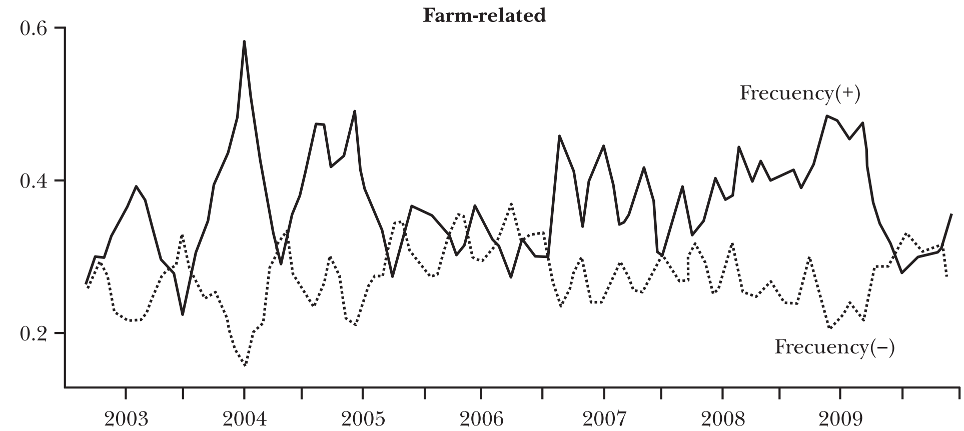
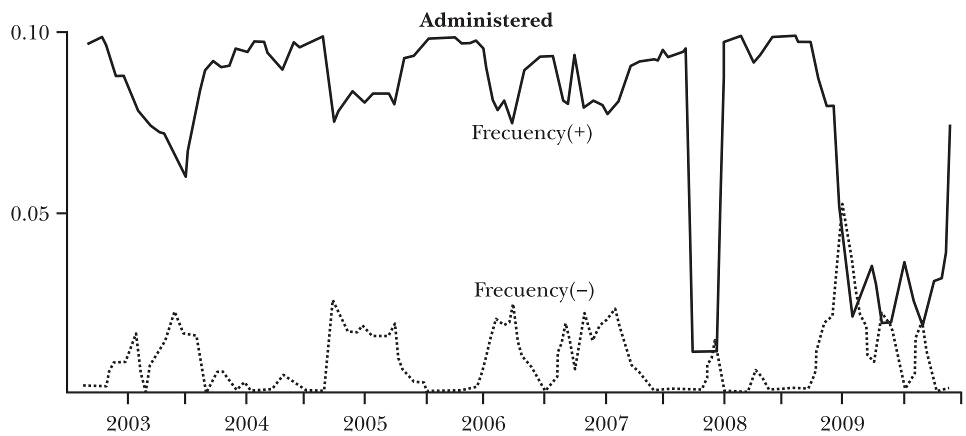


FIGURE 7 (*concluded*)





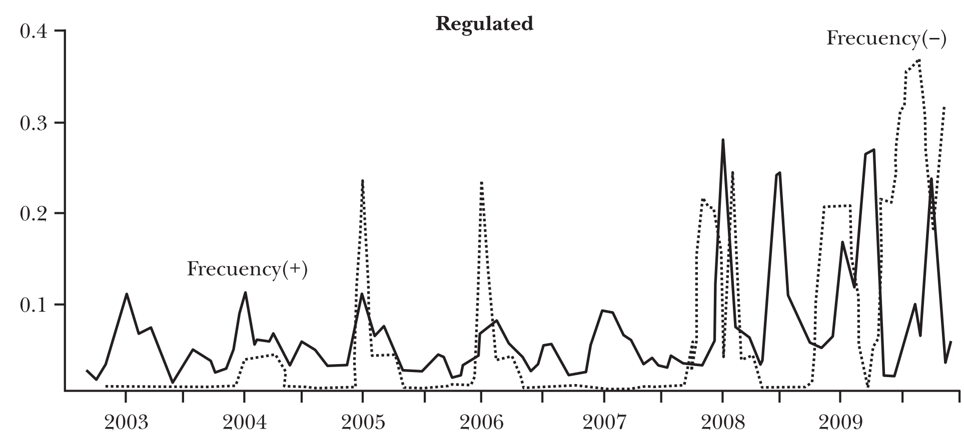


FIGURE 8. DISTRIBUTION OF THE SIZE OF PRICE CHANGES

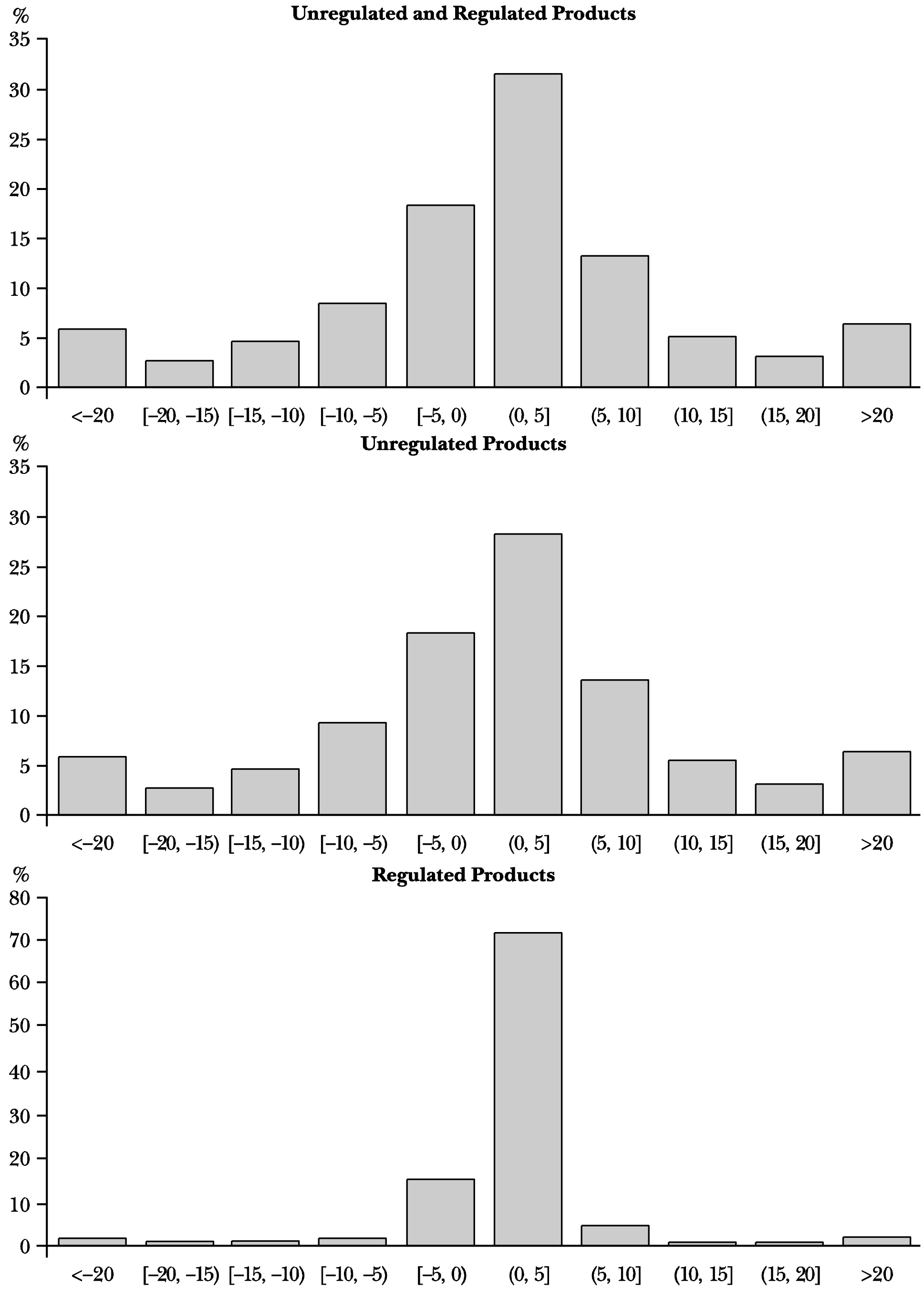
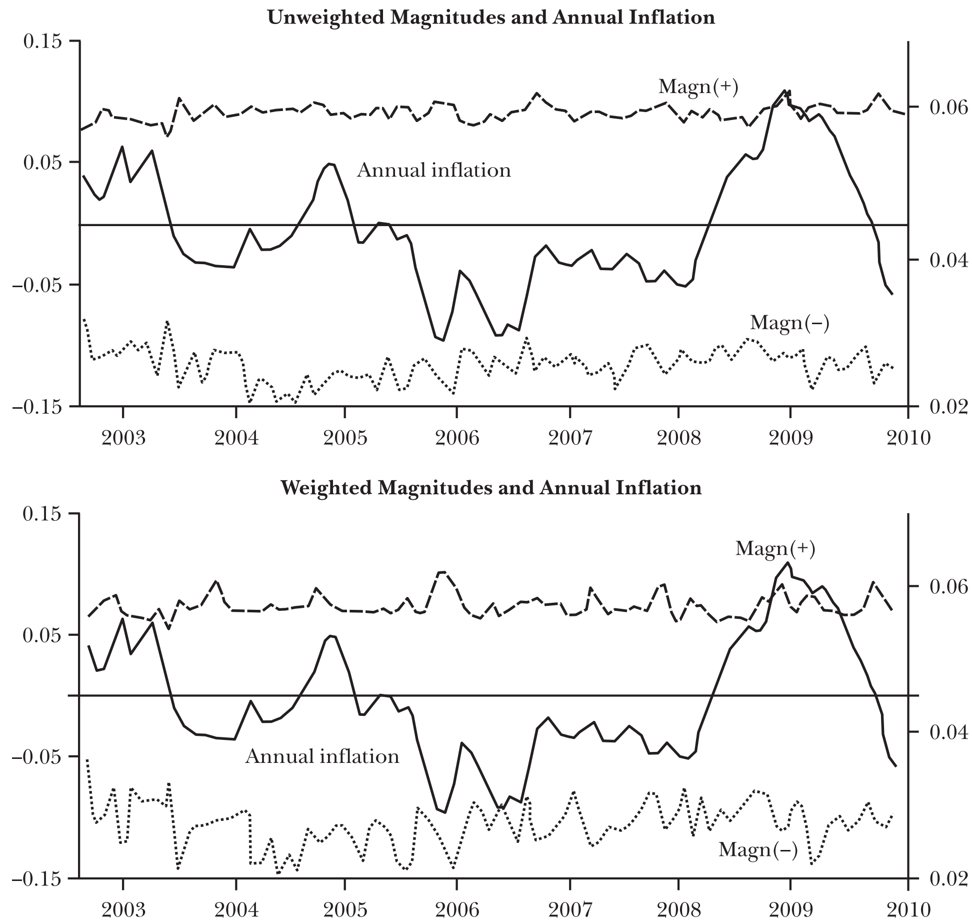


FIGURE 9. TIME SERIES OF ANNUAL HEADLINE INFLATION AND THE SIZE OF PRICE CHANGES OF ALL PRODUCTS, 2002-2009

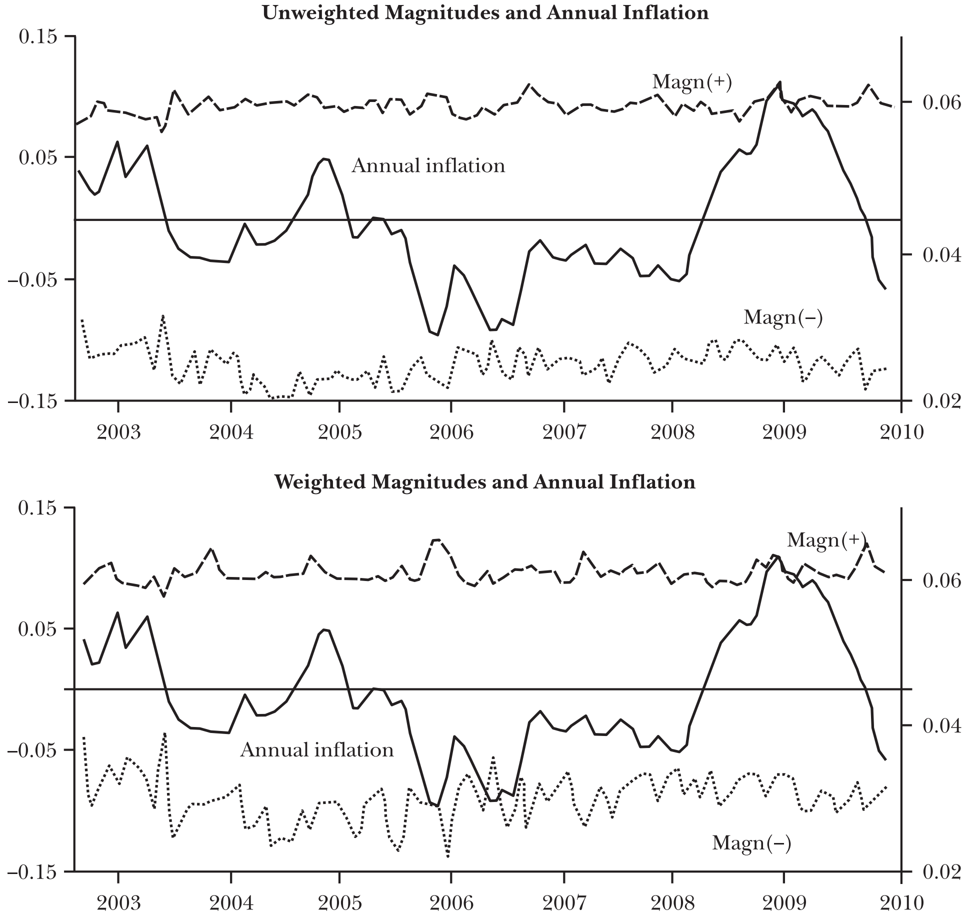


strong, giving evidence of time dependence. To complement the research a study based on scatter plots is done. The corresponding graphs are not included in this book.[8]

Analysis of the scatter plots shows that some seasonality can be identified in many of the groups. Housing and education are the most obvious cases when looking at frequencies. Nevertheless, other groups like food, farm-related goods, and regulated goods and services also show some seasonal effects. When looking at average magnitudes, education is again the one with the strongest dependence. Fruits and vegetables, and farm-related

[8] The full paper can be found in ⟨www.banxico.org.mx⟩.

FIGURE 10. TIME SERIES OF ANNUAL HEADLINE INFLATION AND THE SIZE OF PRICE CHANGES OF UNREGULATED PRODUCTS, 2002-2009

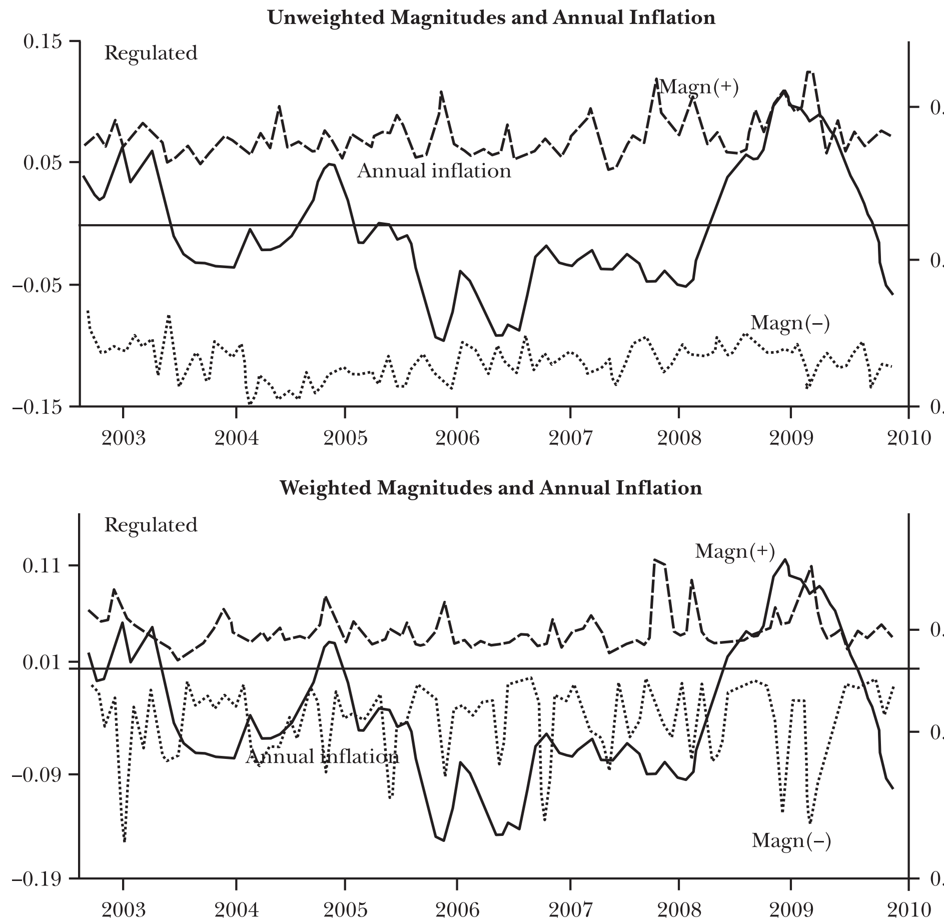


goods show some cycles in their patterns of average magnitudes although less strong than for average frequencies.

The scatter plot analysis also shows that the average frequencies seem to move strongly with inflation. This is particularly evident for food, rest of merchandise, and rest of services. As word of caution, a simple scatterplot is not a robust way of detecting relations and dynamics. In some cases the relations shown may not be significant, there may be a lag on the responses of certain groups, or extreme values may be causing unwanted effects. As further research, a good model may need to be developed to confirm or reject the results given here.

Summing up, in Mexico heterogeneity of the pricing dynamics between sectors is crucial. Some groups, like housing (excluding rents and own housing) and education, seem to be time dependent. All the other unregulated groups seem more to be state dependent.

FIGURE 11. TIME SERIES OF ANNUAL HEADLINE INFLATION AND THE SIZE OF PRICE CHANGES OF REGULATED PRODUCTS, 2002-2010



4.4 Comparison with Previous Research

Finally we should compare our results to previous papers done for Mexico, specifically Castañón et al. (2008) and Gagnon (2009). Castañón et al. (2008) study the price setting process through a survey of firms of the manufacturing industry. Gagnon (2009) uses a similar database as ours, microdata collected from the Diario Oficial, although the sample stops in 2004.

Comparing average monthly frequencies, Gagnon (2009) reports that 22.1% of unregulated prices changed each month on average in 1994, 39.2% in 1995 and 27.3% in 2001. We have that on average for our complete sample (2002-2009) the average monthly frequency for unregulated goods is 32%. This figure seems a bit high compared to Gagnon's one; this is due to the fact that Gagnon filters the data to get a lower bound while we do not use any filter as explained previously (so ours may be seen as a higher bound for the frequencies (see appendix)). Despite this difference, both papers register that on average 42% of the price changes are decreases and the remaining 48% are increases.

Castañón et al. (2008) report that firms maintain prices unchanged for around six months. Gagnon, after restricting his basket for it to be comparable to the one of Bils and Klenow (2004), gives a mean duration of 6.6 months for the period June 2000 to June 2002 and seven months for the period January 2003 to December 2004. For our complete sample, the mean duration for unregulated goods is 5.1 months.[9]

Nonetheless the three papers give the same conclusion, there is a big heterogeneity in the price setting process between sector. There is evidence of both time and state dependent strategies.

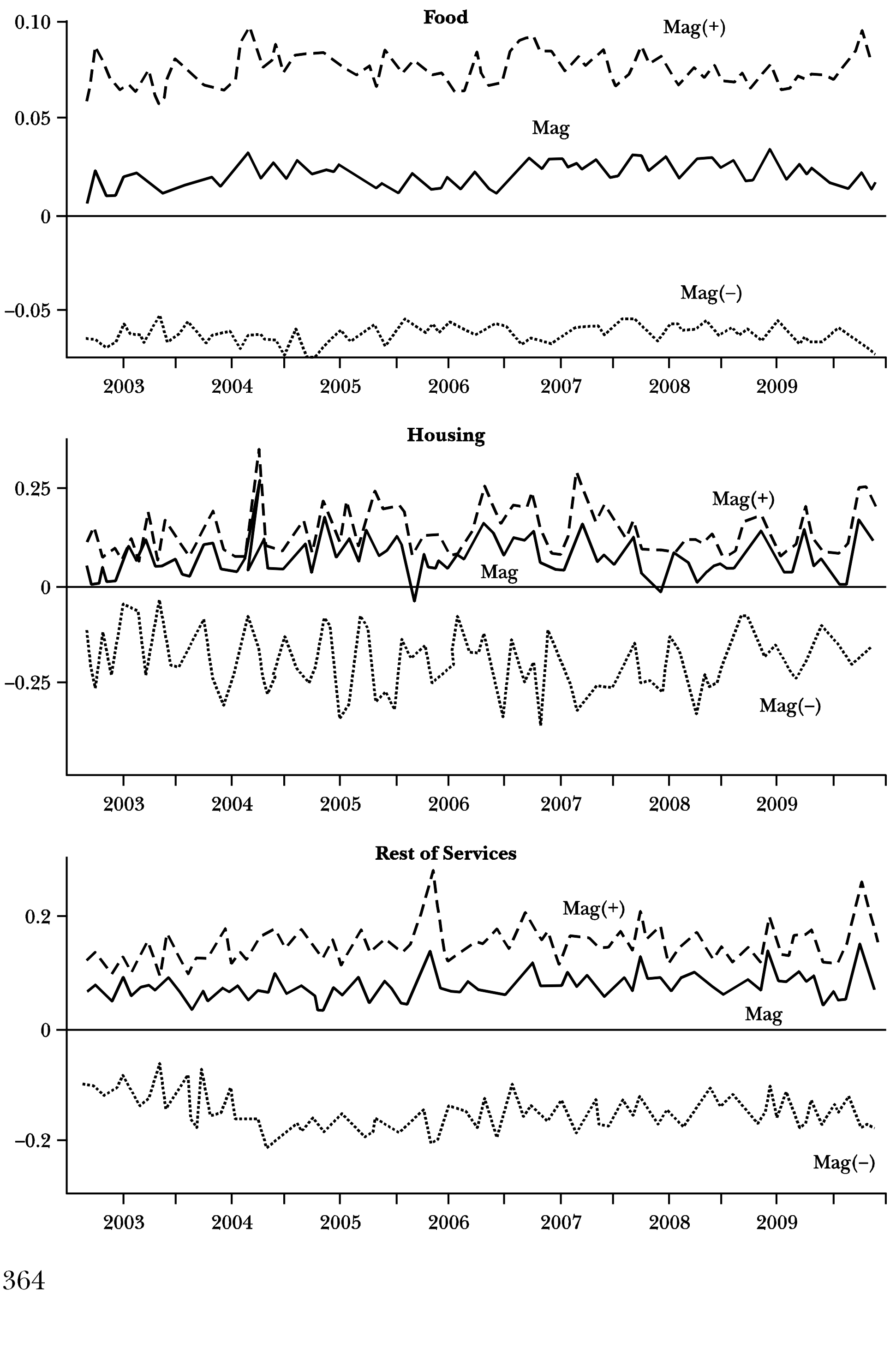
5. CONCLUSIONS

In this paper we studied the dynamics of price changes of the product categories included in the INPC using microdata published in the Diario Oficial de la Federación from July 2002 to December 2009. This period is characterized by a regime of inflation targeting and by historically low and stable levels of inflation, although some temporary shocks were present. Main findings can be synthesized as follows:

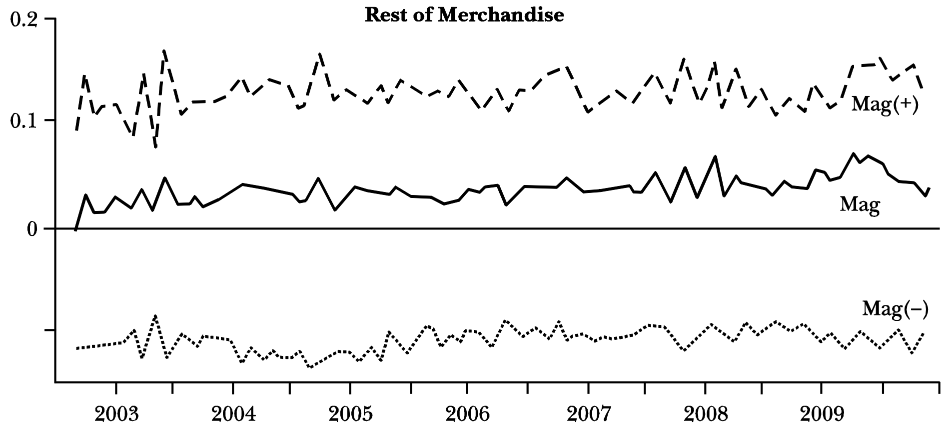
A main feature of the price setting behavior in Mexico is the heterogeneity between sectors. As expected, there are big differences between unregulated and regulated sectors, but important differences also exist between the unregulated ones.

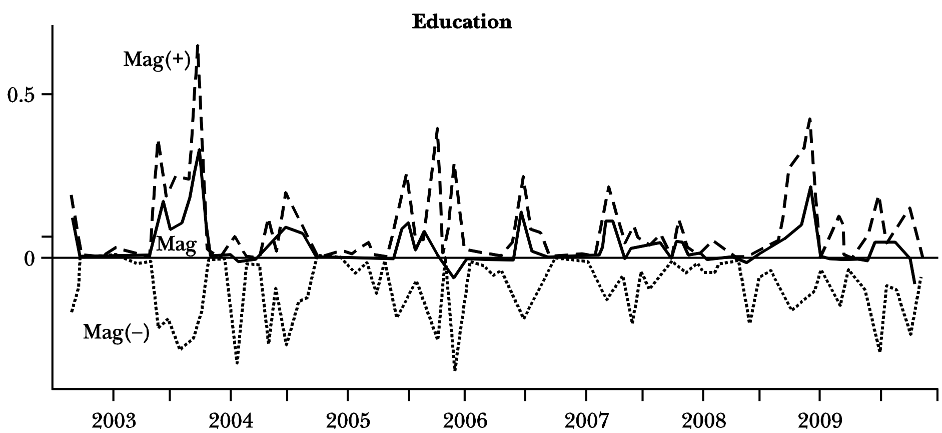
[9] Both Gagnon's figures and our figures may be biased given the datasets, the exact frequency and durations can only be obtained using the collected prices and not the averaged ones.

FIGURE 12. TIME SERIES OF THE UNWEIGHTED MAGNITUDES OF PRICE CHANGES, 2002-2009



(Unweighted Magnitudes)





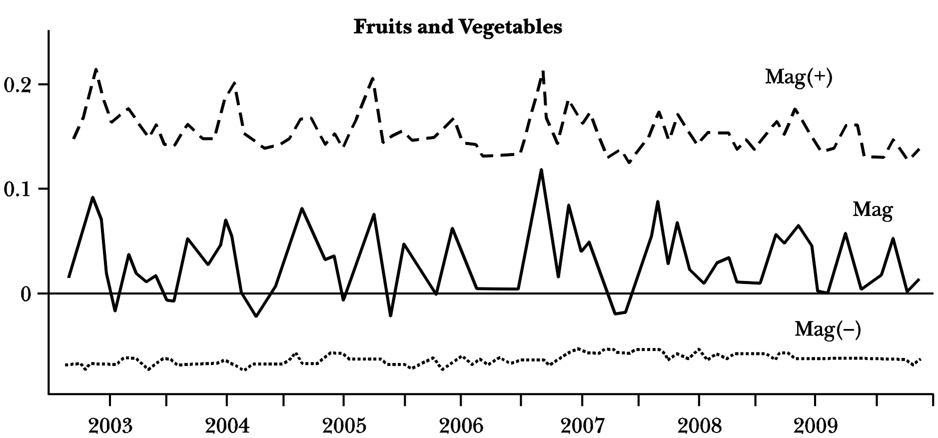
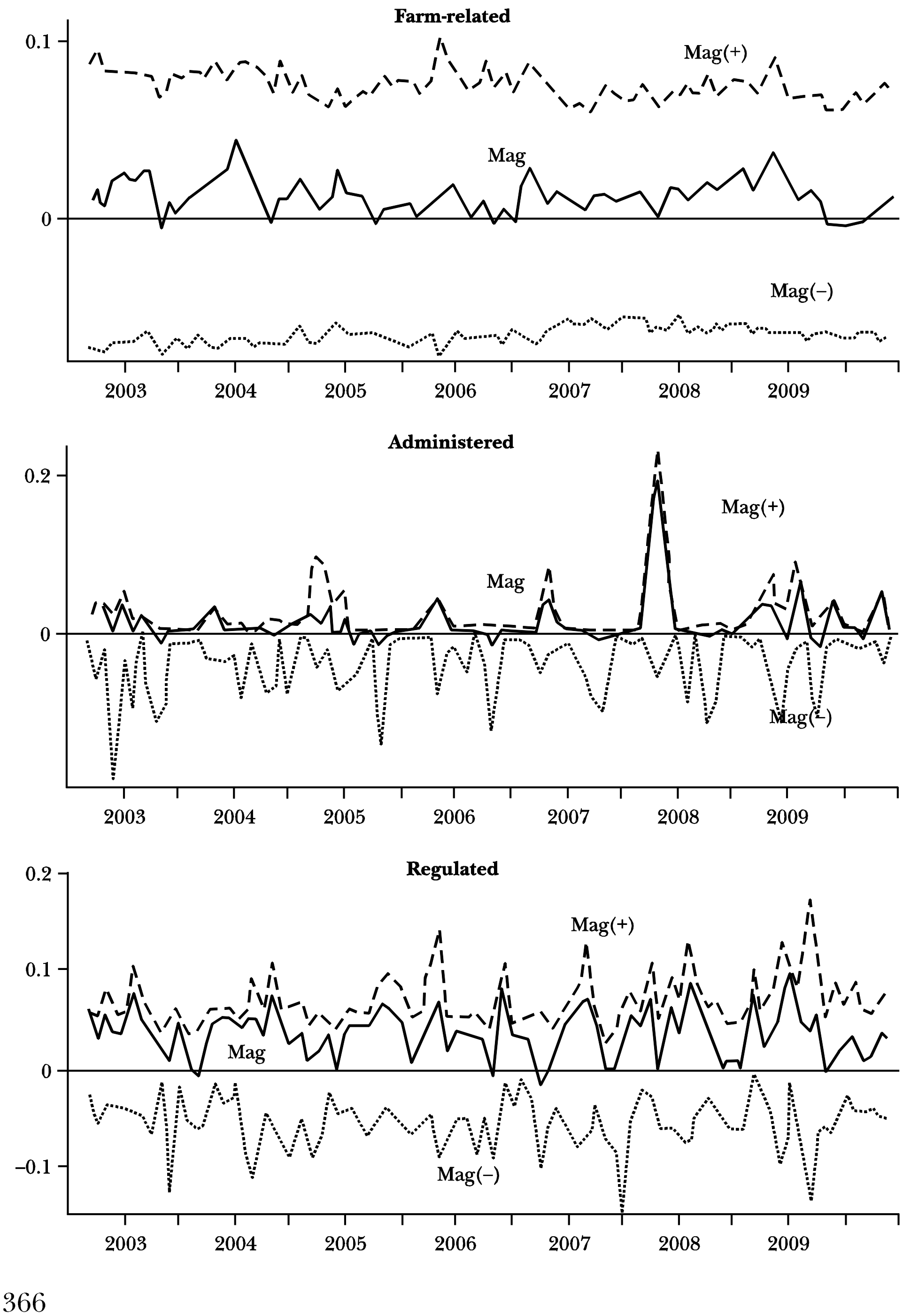


FIGURE 12 (*concluded*)



When studying price changes frequencies, services seem to be stickier than the average, and agricultural goods change prices constantly.

Price increases are more common than price decreases. The agricultural sector seems to have the more symmetrical distribution on this respect and services the more skewed one.

The average size of the price changes also differ between sectors. There are many small price changes, but big changes are not uncommon.

Average frequencies are correlated with annual headline inflation while average magnitudes do not seem to move that strongly with it. When big shocks affect inflation, the fraction of firms adjusting their prices seem to vary considerably.

When focusing on the time series, at the beginning of our sample, average frequencies and magnitudes were rather stable. Nevertheless, when inflation is importantly affected by shocks, mainly frequencies of price changes respond. Although on average the price setting in Mexico seem to be state dependent (mainly under big shocks), each sector seem to have a different strategy when setting prices and there is also evidence of time dependent behaviors.

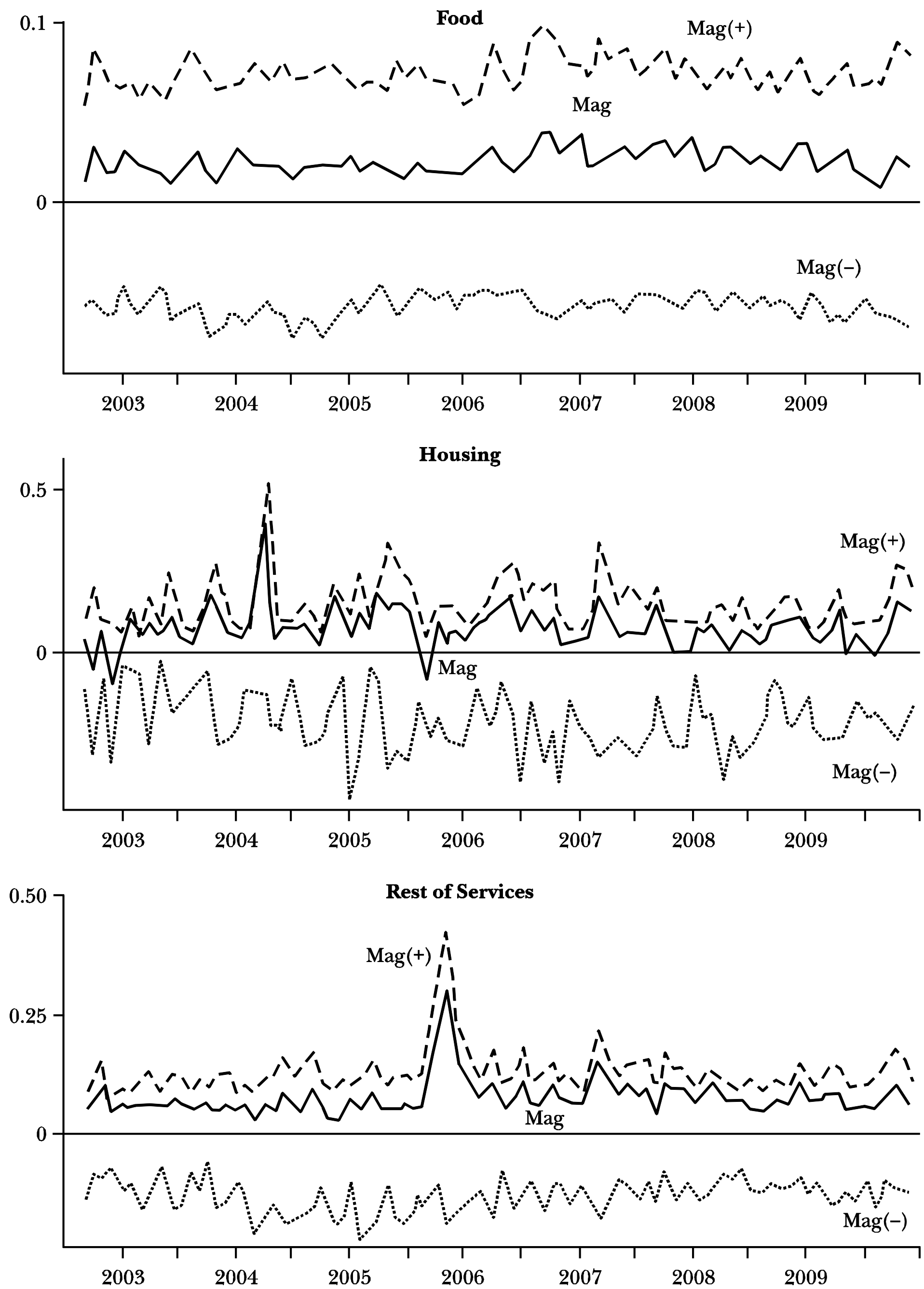
This paper gives an initial insight of the price setting process in Mexico. Nevertheless it only gives descriptive statistics, and it should be taken as a starting point for a better model or a microeconomic analysis of specific sectors that can provide deeper conclusions.

Appendix

The results given in this paper are based on the monthly averages of the collected prices of items that form the Índice Nacional de Precios al Consumidor which are published each month in the Diario Oficial de la Federación. As explained carefully in Gagnon (2009), the fact of working with monthly averages instead of the collected prices may bias the results. For example, if the price change for a weekly sampled item does not happen at the beginning of the month, but instead, let us say, in the last week, the averaged price of that month will differ from the last observed price. This fact can cause that one given price change may be reflected in the averages as two smaller consecutive ones, therefore frequencies may be overestimated and magnitudes underestimated when using averages.

In this appendix, the average frequencies and average magnitudes of price changes will be estimated for a few products using the collected

FIGURE 13. TIME SERIES OF THE WEIGHTED MAGNITUDES OF PRICE CHANGE, 2002-2009



(Weighted Magnitudes)

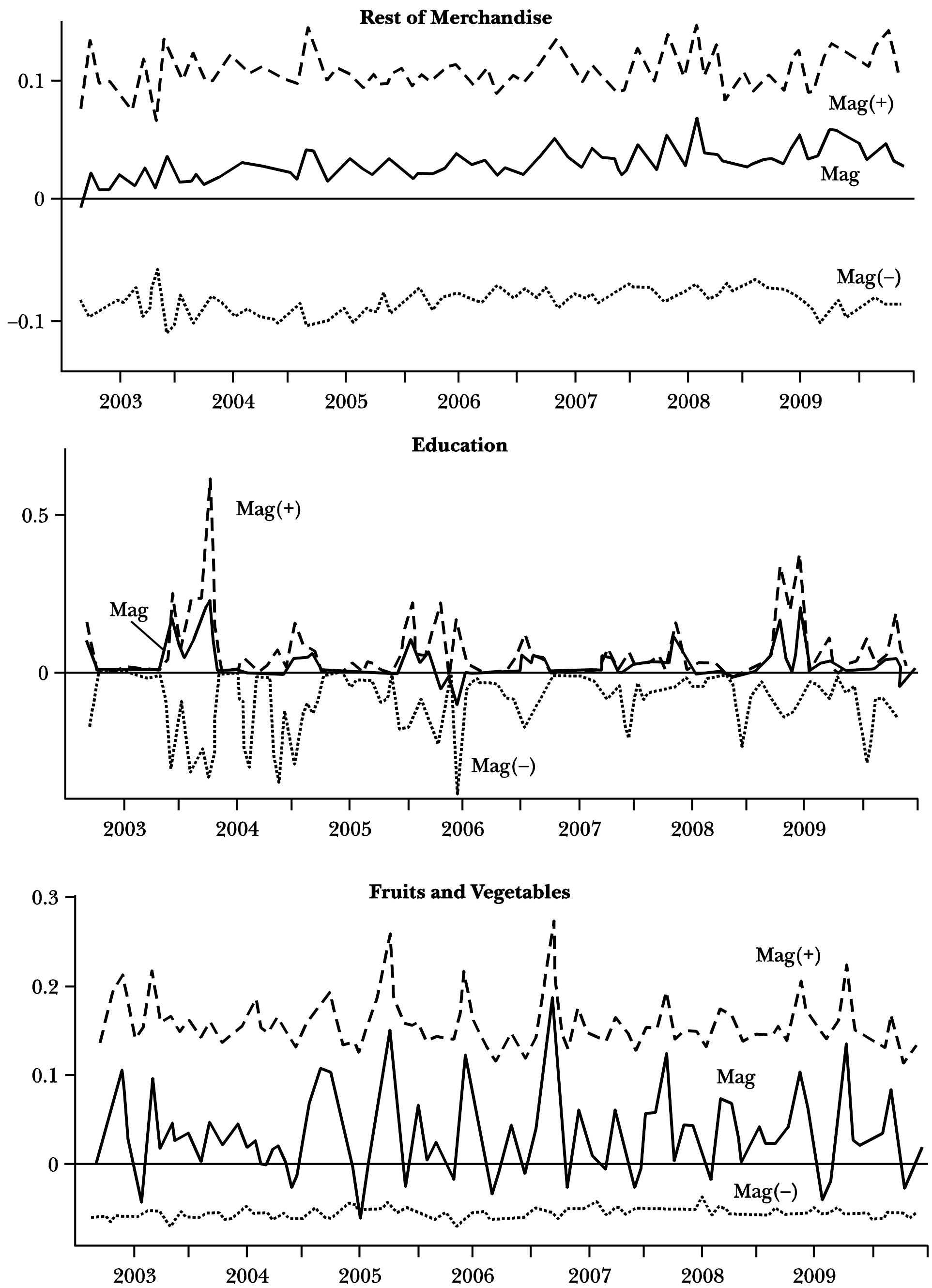
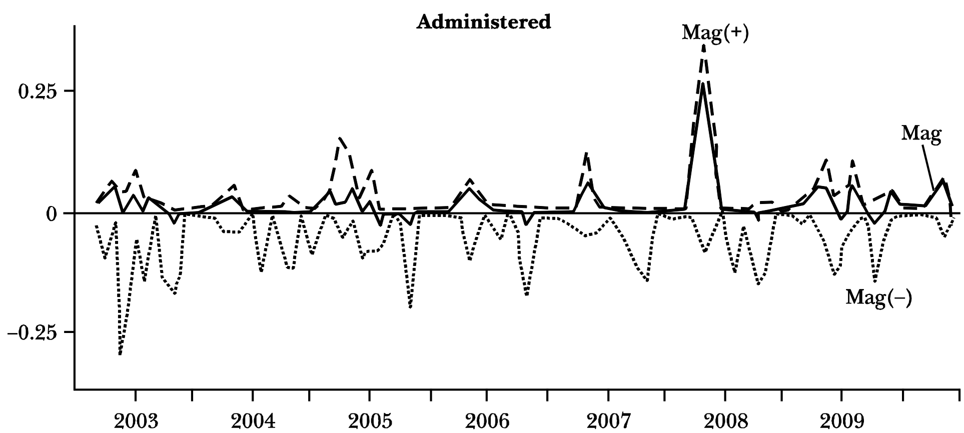
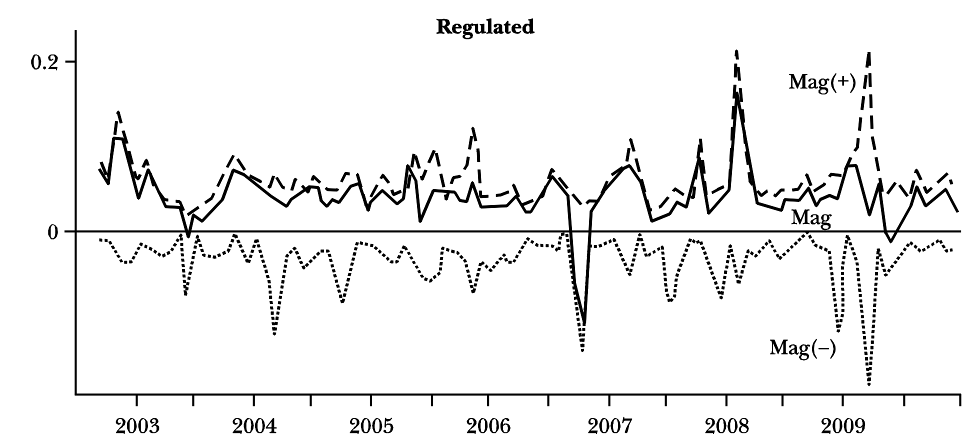


FIGURE 13 (*concluded*)





prices and not the monthly averages. This will allow us to have an idea of how biased are the results if averages are used.

Monthly average frequencies and average magnitudes for price changes, price increases, and price decreases are shown in Table A.I for few of the product categories of the Índice Nacional de Precios al Consumidor using the collected prices and not the monthly averages. Comparing these figures with the corresponding ones in Tables 6 to 14, it can be seen that by using monthly averaged prices the average frequencies tend to be overestimated and the average magnitudes underestimated. Nevertheless, all the statistics are biased and in the same direction for all items. So even if the quantitative results are not exact, the qualitative results of the paper stand.

The conclusions given in this document can be drawn independently of the inherent problems of using averaged prices. However, it will be of interest as future work to use all collected prices, and not the monthly averages, to do the estimations given that additional characteristics of the price setting process can be studied (for example synchronization, survival analysis and hazard functions, the use of psychological and round prices).

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TABLE A.I. STATISTICS FOR CERTAIN PRODUCTS USING ALL COLLECTED PRICES INSTEAD OF THE MONTHLY AVERAGED PRICES

Products	*fr*	*fr(+)*	*dp*	*dp(+)*	*dp(-)*	*impl. dur.*	*impl. dur.(+)*	*fr*
Food								
Bottled sodas	0.26	0.14	0.12	0.001	0.100	0.113	3.41	6.78
Cigarettes	0.13	0.11	0.02	0.068	0.099	0.145	7.09	8.22
Other merchandise								
Matches	0.10	0.07	0.03	0.166	0.346	0.209	9.99	15.06
Pesticides	0.31	0.17	0.14	0.003	0.147	0.167	2.66	5.39
Housing								
Housing maintenance services	0.07	0.05	0.02	−0.014	0.171	0.56	15.20	20.49
Domestic service	0.05	0.04	0.01	−0.042	0.214	0.912	18.21	23.73
Education								
Elementary school	0.17	0.14	0.03	0.040	0.064	0.085	5.26	6.35
High school	0.15	0.12	0.03	0.033	0.079	0.167	6.27	7.88
Other services	0.10	0.07	0.03	0.061	0.191	0.312	14.99	20.39
Laundry services	0.05	0.04	0.01	0.062	0.190	0.358	17.41	22.92
Movie theaters	0.07	0.06	0.01	0.049	0.110	0.204	12.92	16.14
Fruits and vegetables								
Mango	0.44	0.24	0.20	0.021	0.281	0.283	1.73	4.42
Tomato	0.87	0.44	0.43	0.001	0.338	0.345	0.48	1.71
Farm-related								
Beef liver	0.31	0.17	0.14	0.014	0.171	0.180	2.65	5.25
Other cuts of meat	0.31	0.18	0.13	0.007	0.112	0.143	2.69	4.95
Administered								
Electricity bill	0.86	0.70	0.16	0.007	0.039	0.127	0.51	0.84
Low-octane gasoline	0.75	0.72	0.03	0.005	0.008	0.081	0.72	0.79
Regulated								
Car lubricating oils	0.18	0.12	0.06	0.030	0.099	0.109	4.94	7.68
Parking	0.05	0.04	0.01	0.030	0.297	0.750	19.97	26.96

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Wage Rigidities

Introduction

María Teresa Ramírez

This section of the book analyzes the presence of wage rigidities in two Latin American countries: Chile and Colombia. The study of wage rigidities has been driven by the effect they can have on the labor market and monetary policy.

The fact that wage rigidities partly determine inflation persistence and volatility, means understanding their causes is essential for improving the work of economic authorities. This type of analysis is also relevant for central banks given its contribution to improving the microfoundation of their price and wage models by incorporating nominal and real rigidities.

The studies presented below employ microeconomic data, allowing wage rigidities to be examined individually and at the company level. It is important to point out that the study of wage rigidities using microdata and survey information does not seem to have received sufficient attention. As far as we know there are four exceptions to this: the papers on Chile and Colombia included in this section, Iregui et al. (2011), who made an empirical examination of wage rigidities in Colombia based on wage samples at the company level,[1] and Castellanos et al. (2004), which analyzes wage rigidities in Mexico.[2]

As mentioned, this part of the book presents studies for Latin America. In particular, in their paper on Chile, Cobb and Opazo use information from 588,000 wage histories for the period December 2001 to

[1] See Iregui, Melo and Ramírez (2011), "Are wages rigid in Colombia?: Empirical evidence based on a simple of wages at the firm level", *Monetaria*, vol. XXXIV, number 1, January -March, pp. 63-91.

[2] See Castellanos, García-Verdú and Kaplan (2004), "Nominal wage rigidities in Mexico: evidence from social security records", *Journal of Development Economics*, vol. 75, pp. 507-533.

December 2007 obtained from the Chilean Security Association (*Asociación Chilena de Seguridad*) to examine the frequency of nominal wage adjustments in Chile and, particularly, the frequency of wage decreases as a measure of labor market rigidity. The authors find that, on average, wages took close to nine quarters to adjust. According to their calculations, the degree of downward flexibility of wages depends positively on the participation of young workers and the size of company, while it depends negatively on the percentage of high income employees.

In the case of Colombia, Iregui, Melo and Ramírez, prepare and apply a survey of 1,305 Colombian firms in order to study the nature and sources of wage rigidities in the country. The survey also enables the authors to evaluate different wage rigidity theories that explain firms' behavior regarding wage adjustments in Colombia. The results show the presence of downward rigidities in real and nominal wages in the country. Furthermore, according to the survey the most important reasons why firms do not cut wages during times of economic difficulty are: to avoid losing their most productive workers and to prevent decreases in employee motivation. Such reasons are related to the efficiency wage theory.

Microeconomic Evidence of Nominal Wage Rigidities in Chile

Marcus Cobb C. and Luis Opazo R.*

1. INTRODUCTION

The labor market, and its wage dynamics in particular, is a central element of macroeconomic analysis. In this context, the main objective of this paper is to provide evidence on the frequency of nominal wage adjustments in Chile and, in particular, the frequency of wage reductions as a measure of labor market rigidity. For such purpose, we constructed a panel with 588,000 wage histories between December 2001 and December 2007 from the Asociación Chilena de Seguridad (Chilean Social Security Association, AChS).[1] This database contains worker information including gender, age, income, company, and sector.

It is worth mentioning that despite a growing international interest in this type of study, and the importance of its subject to monetary policy, to our knowledge, this is the first study of its type in Chile.[2] Additionally, the

* M. Cobb C. and L. Opazo R., Studies Division, Banco Central de Chile, and Financial Policy Division, Banco Central de Chile, respectively. We are grateful for the comments and suggestions of Roberto Álvarez, David Bravo, Luis Felipe Céspedes, Kevin Cowan, Jaime Ruiz-Tagle, two anonymous referees and participants in the Prices and Wages Workshop 2009 (Banco Central de Chile), the 2008 Conference of the Economics Society of Chile and the XIV Meeting of the Central Bank Researchers Network of the Americas, November 11-13, 2009; Salvador, Bahia, Brazil. Originally published in *Journal Economía Chilena*, Central Bank of Chile, Vol. 13, No. 1, April 2010, pp. 23-37. Errors and omissions are the sole responsibility of the authors. Emails: ⟨mcobb@ bcentral.cl⟩ and ⟨lopazo@ bcentral.cl⟩.

[1] The Asociación Chilena de Seguridad is a private, non-profit organization which develops risk prevention programs and provides health coverage to its members in case of accident. About 35% of salaried employees are affiliated to this association.

[2] Jadresic (1992) uses information added to identify rigidity in Chile.

sample period under study is of special interest as it is characterized by near 10% unemployment rates until the end of 2005, which then declined to an average of 7% in 2007. It is an especially attractive scenario for studying the frequency of wage adjustments in this context, as it provides information which allows for a more integrated look at the level of the Chilean labor market flexibility during that period, an aspect that has been under discussion in numerous Chilean case studies (Cowan et al., 2005; Sapelli, 2007).

This paper focuses on downward nominal wage rigidity as a first step toward an integrated understanding of wage dynamics. It is worth noting that the study of the frequency of nominal wage reduction is considered by literature as one of the measures used for analyzing labor market rigidity. Nevertheless, it is important to point out that other countries' studies are not limited to nominal rigidities but also include real rigidities (Messina et al., 2008; Hall, 2005; among others). From the monetary authority's perspective, each of these phenomena represents different problems. While higher inflation can neutralize the impact of nominal rigidity, this does not occur in the case of real rigidity. On the other hand, the effects of nominal rigidity are particularly evident at the macroeconomic level when inflation is very low (Fehr and Goette, 2005).

In reference to the methodology used in this study, the econometric technique of structural breaks developed by Bai and Perron (2003) is used to reduce possible data measurement errors. This has been employed previously for the United States (USA) by Gottschalk (2005) and is based on the assumption that wages remain fixed for a certain number of periods and only experience discrete adjustments. The methodology not only reduces measurement errors, but also decreases temporary fluctuations that are not necessarily related to a change in the individual's wage profile such as, for example, a prearranged bonus. The disadvantage of this methodology is that this type of modification can mask wage movements of more flexible wage arrangements (or the movements of a variable component, such as would be the case for salesmen) because it reflects real changes as measurement errors. Nonetheless, the fact that the results of Gottschalk (2005) allow for the reconciliation of the estimates from a national survey with administrative macroeconomic information suggests that the benefits of the methodology outweigh its potential disadvantages.

The most important finding resulting from an examination of the compiled wage histories is that the average number of periods it would take for wages to adjust is higher than nine quarters, with some sector specific differences. In reference to the determinants of these adjustments, the degree of downward wage flexibility correlates positively to young employees (less than 30 years of age) share, positively to the size of the firm and negatively to the proportion of high income employees. Sector specific effects are statistically and economically significant.

The rest of the study is divided into four sections. Section 2 provides a review of the international evidence. Section 3 describes the database. Section 4 shows estimates for adjustment frequency as well as an analysis of the factors determining them. Section 5 sums up the main findings.

2. INTERNATIONAL EVIDENCE

The most recent studies in the area of downward nominal wage adjustments have been carried out using estimates based on microdata.[3] The results, however, vary from country to country (Table 1). For example, the frequency of wage reduction in Mexico is 21% for the period 1983-1986, while it was between 0.3% and 0.4% in Canada. Estimates also differ significantly in studies carried out for the same country. For example, Blinder and Choi (1990) found that wages in the USA were relatively flexible while Altonji and Devereux (1999) concluded that they were quite rigid. Different authors came to contradictory conclusions even in cases where the same source of information was used. For instance, McLaughlin (1994, 1999) argues for the absence of wage rigidities based on the Panel Study of Income Dynamics (PSID) while Card and Hyslop (1997) find evidence to the contrary using the same database.

It is necessary to point out that, for various reasons, the numbers found in Table 1 are not directly comparable with each other and are only shown to give an idea of the diversity of studies and estimates, as well as the inherent complexity of calculating the frequency of downward wage adjustments. As such, for example, the degree of comparability can be affected by the fact that various countries and time periods used in the studies imply, with a high degree of probability, different macroeconomic scenarios –a simple example being that a certain figure will have different readings depending on whether it was calculated in a period of high or low inflation. Moreover, if a country and a time period analyzed in two

[3] Another area of study corresponds to Fortin and Dumont (2000) and to Farès and Lemieux (2001), who use the Phillips curve and distinct wage increase measurements to make inferences on wage rigidity.

TABLE 1. SELECTED WAGE RIGIDITY STUDIES, 1970-2001

Study	*Period*	*Annual frequency of wage reductions (percentage)*
Mexico		
Castellanos et al. (2004)	1986-2001	24.2
United States[a]		
McLaughlin (1994)	1976-1986	17.3
Card and Hyslop (1996)	1976-1993	15.0-20.0
Kahn (1997)	1970-1988	10.6-24.3
Akerlof et al. (1996)	1994-1995	1.6-5.8
Altonj and Devereux (1999)	1971-1992	0.5-2.5
Gottschalk (2005)	1986-1993	1.5-2.0
Australia		
Dwyer and Leong (2000)	1987-1999	3.5-8.0
Canada		
Faruqui (2000)	1983-1986	0.3-0.4
	1996-1999	0.2-1.3
Switzerland		
Fehr and Goette (2005)	1991-1997	6.8-15.5

[a] Information from Gottschalk (2005).

studies are the same, the differences in methodologies and sources of information directly prevent the comparability of the studies. For example, the use of a national survey requires a different approach than a study based on administrative information from private companies and could also respond to a different set of questions.

The abovementioned makes it very clear that direct comparison of studies should be avoided without first clearly and precisely establishing the differences between them. Regarding this point, it is important to mention two current initiatives. First, the International Wage Flexibility Project (IWFP), from a network which studies wage rigidities in 17 OECD countries; preliminary results suggest that real rigidities predominate over nominal ones in European countries but not in the USA or the United Kingdom (UK) (Dickens et al., 2007). Second, the European Central Bank's Wage Dynamics Network (WDN) has recently concluded various surveys referring to such topics as marginal adjustments and price and wage synchronization, among others.[4] Some of these studies conclude that wage reductions are very infrequent.[5]

[4] The WDN organized a conference in Frankfurt in June 2008 to present progress.

[5] Babecky et al. (2009) shows that only 398 of 14,122 (2.82%) of those surveyed declared a reduction in wages during the last five years.

3. THE DATA

3.1 General Information

The database was constructed from the information reported monthly to the AChS by its affiliated companies during 2001m12-2007m12. The data was taken from the payrolls provided by each company which contains employee taxable income information, i.e., it includes both the variable and fixed wage components and worker gender and age. It also contains the reporting company's economic sector information, classified by a digit, namely: agriculture; mining; industry; construction; electricity; gas and water; commerce; transport; and services.

It is important to emphasize that the other source of national wage information, the income survey from the Instituto Nacional de Estadísticas (National Statistics Institute, INE), does not allow for studies like the one presented in this paper. In fact, the INE's survey only reports information at the company level, basically just costs by wages and number of employees, which does not permit a direct examination of the phenomenon of labor flexibility at the microeconomic level. In addition, it should be emphasized that AChS information comprises almost 35% of all salaried employees from around 25% of companies in the country, which translates into good sample coverage for the study.[6] Finally, according to previous studies, the information reported to the AChS does not present any major reporting problems.[7]

As for the limitations of the database, the most significant of these is a lack of information for the number of hours of work, which means that wage modifications derived from a change in the number of hours of work cannot be isolated. Unfortunately, the wages reported are truncated to the maximum taxable wage. This limit was USD 2,300/month in December 2007 and, according to income distribution surveys, affected around 5% of Chile's salaried workers.

The information is also limited to the affiliated companies, and a study of employment flows is therefore not so viable. Finally, the use of the AChS as a source of information restricts the study of wage dynamics to formal employees; consequently, the present database cannot be used for a study of informal workers' wages.

[6] Based on information from the Servicio de Impuestos Internos.

[7] Aravena (2006) finds problems such as a repetition of the worker identifier and missing information are not significant for general use for the 2002- 2005 period.

3.2 Panel Construction

The original base sample consisted of the average monthly wage information for 1.5 million workers during the period examined. This data was used to construct an unbalanced panel of worker wage histories. For example, if a worker stops working at AChS affiliated companies, the worker's wage history is suspended. This point, which is in line with previous studies on the topic (see below), is dealt with by establishing a minimum presence criteria in each individual's observations database.[8] In light of the aforementioned, it was necessary to filter the base sample due to the presence of certain inconsistencies probably produced by the manual entry of information, incomplete information, truncated histories or the sporadic appearance of workers.[9] To be specific, reported workers who fulfilled one of the following criteria were removed from the database:

i) The same identification number as another worker during the same period.

ii) Wage higher than the taxable maximum or lower than the current legal minimum.

iii) Wage equal to the taxable maximum for more than two consecutive periods.

It should be mentioned that criteria *(i)* and *(ii)* control data inconsistencies, while criteria *(iii)* attempts to eliminate truncated wage histories starting from a certain period and which, therefore, could lead to an underestimation of the actual degree of wage flexibility. In relation to criteria *(i),* we found that, on average, 4% of the identifiers are not unique within the same month. With respect to criteria *(ii)* and *(iii),* the sample contains, on average, 2% of workers who report wages below the legal

[8] It should be mentioned that as it cannot be determined if workers who stop reporting in AChS firms become unemployed or go to work at another non-AChS company, this represents a strong limitation for the study of employment flows and transitions.

[9] In cases where there is no wage information for up to three consecutive periods, and as long as the worker returns to work for the same employer, it is assumed that the worker remained employed by the company and that the company stopped reporting the worker's wage. When the wage does not change within the aforementioned period, it is assumed that it remained constant during the periods without data; if the wage did change, the wage adjustment is attributed assuming a uniform probability of wage adjustment in those periods for which data was missing.

minimum, while 3% of the observations imply a truncated wage, which means, equal to or over the maximum for more than two consecutive periods.

Once the base was filtered, in line with Fehr and Goette's (2005) approach, a sample is built using those workers with a wage history of at least 24 consecutive months. This procedure attempts to construct a panel of wage histories with sufficient length to allow for the best inference of wage adjustment dynamics.

The final sample, which contains an average of 429 thousand workers per month, represents 11% of Chilean workers at the national level on the panel (table 2). Regarding economic sectors, Services and Industry has the largest representation with 14%; the rest of the sectors fluctuate between 3% and 11%, which allows for a reasonable margin of reliability for our calculations.

TABLE 2. NUMBER OF WORKERS IN THE SAMPLE BY ECONOMIC SECTOR

	Number of workers[a]	*Percentage of salaried workers*[b]
Agriculture	36,455	8.4
Mining	2,302	3.1
Industry	89,417	14.0
Construction	14,574	4.1
Electricity, gas and water	3,131	11.3
Commerce	68,414	10.8
Transport	18,785	5.7
Services	195,067	13.7
Total	*428,528*	*10.9*

SOURCE: Own elaboration based on information from the AChS.
[a] Monthly average. [b] Estimate based on information published by the Instituto Nacional de Estadísticas.

As for the number of companies, the database includes information on workers from over 50,000 companies (Table 3), which according to information from the Servicio de Impuestos Internos de Chile (Chilean Internal Tax Service) represents around 23% of the total number of firms registered in Chile.[10] With respect to the distribution of firms, small, medium and large companies account for 51%, 46% and 3% of the sample, with coverage by size of 17%, 40% and 35% respectively. In this way, the sample used tends to over-represent medium and large companies, a

[10] This estimate takes into account all companies with at least one employee.

TABLE 3. NUMBER OF COMPANIES IN THE SAMPLE BY SECTOR AND NUMBER OF WORKERS

	Number of companies	*Less than 10 workers*	*11 to 199 workers*	*200 or more workers*
Agriculture	7,928	4,351	3,419	158
Mining	367	138	199	30
Industy	11,598	6,090	5,166	342
Construction	4,603	2,345	2,188	70
Electricity, gas and water	490	316	157	17
Commerce	7,330	3,749	3,324	257
Transport	4.329	2,853	1,427	49
Services	13,843	5,998	7,101	744
Companies in the base sample	*50,488*	*25,840*	*22,981*	*1,667*
Base sample/total of companies in Chile (%)	*23.3*	*16.6*	*40.1*	*35.1*

SOURCE: Own elaboration based on information from Servicio de Impuestos Internos and Asociación Chilena de Seguridad.

situation suggesting that subsequent analysis should consider an analysis of wage adjustments by size of firm so as to not influence added statistics.

As for the sample's representativeness of worker characteristics, the distribution of the sample does not differ significantly from INE figures for the population as a whole with respect to gender, although younger workers are under-represented as compared with national total (Table 4).

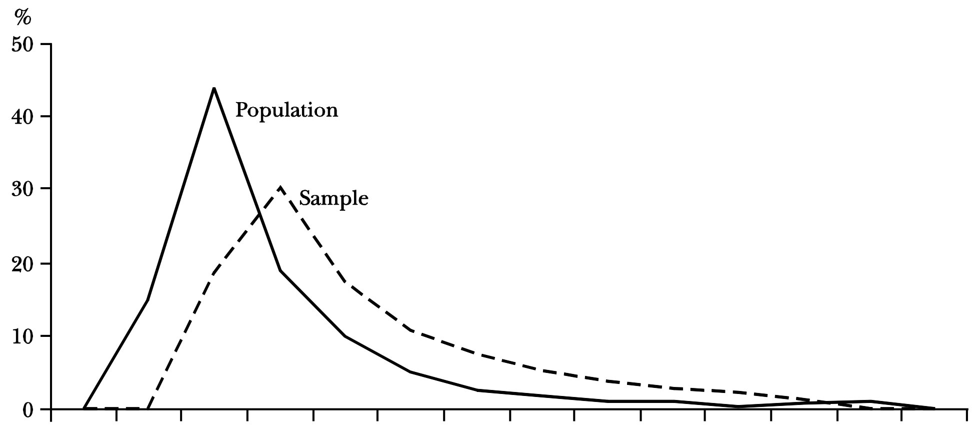
Regarding the representativeness of the sample with respect to wage distribution, an upward bias is observed with respect to the distribution derived from the Social Protection Survey (Figure 1). This is not surprising given the characteristics of the database used. Companies affiliated to the AChS belong to the formal sector, meaning they cannot pay wages that are below the legal minimum, which explains the absence of workers earning less than the minimum wage in the sample. Thus, the estimates obtained refer to companies and salaried workers in the formal sector.

TABLE 4. SAMPLE REPRESENTATIVENESS: AGE AND GENDER

	Sample (percentaje)	*Population (percentaje)*
Gender		
Female	37.7	35.2
Male	62.3	64.8
Age		
Under 30	17.4	27.5
30-49	60.0	55.2
50 or over	20.6	17.3

SOURCE: Own elaboration using data from AChS and Instituto Nacional de Estadísticas.

FIGURE 1. SAMPLE REPRESENTATIVENESS OF WAGE DISTRIBUTION, 2004



SOURCE: Population distribution from the Social Protection Survey, Universidad de Chile.

One final point, concerning the sample used, is that the estimation of wage flexibility determinants carried out in section 4.2 employs two other criteria to purge the database and, thereby, control for worker characteristics. Thus, the database used to calculate adjustment frequencies excludes wage histories for workers who fulfill one of the following conditions:

i) Non-specified age or gender;

ii) Over 90 or under 15 years of age.

Around 25% of cases in the original base sample fall under one of these categories. In fact, 9% of the sample does not contain information about gender and 23% of the sample does not comply with age criteria. Thus, as a result of these adjustments, the base sample used to estimate the determinants of wage adjustment frequency contains close to an average of 336 thousand wage histories per month. Note that the number of wage histories in the panel which do not take the filter of not reporting gender or age over 90 or under 15 into account differs less significantly than the panel obtained by not applying these criteria –i.e., 23% vs. 21.5%–, which reflects a small overlap with the population which does not simultaneously fulfill the two aforementioned criteria.

3.3 Wage Adjustments

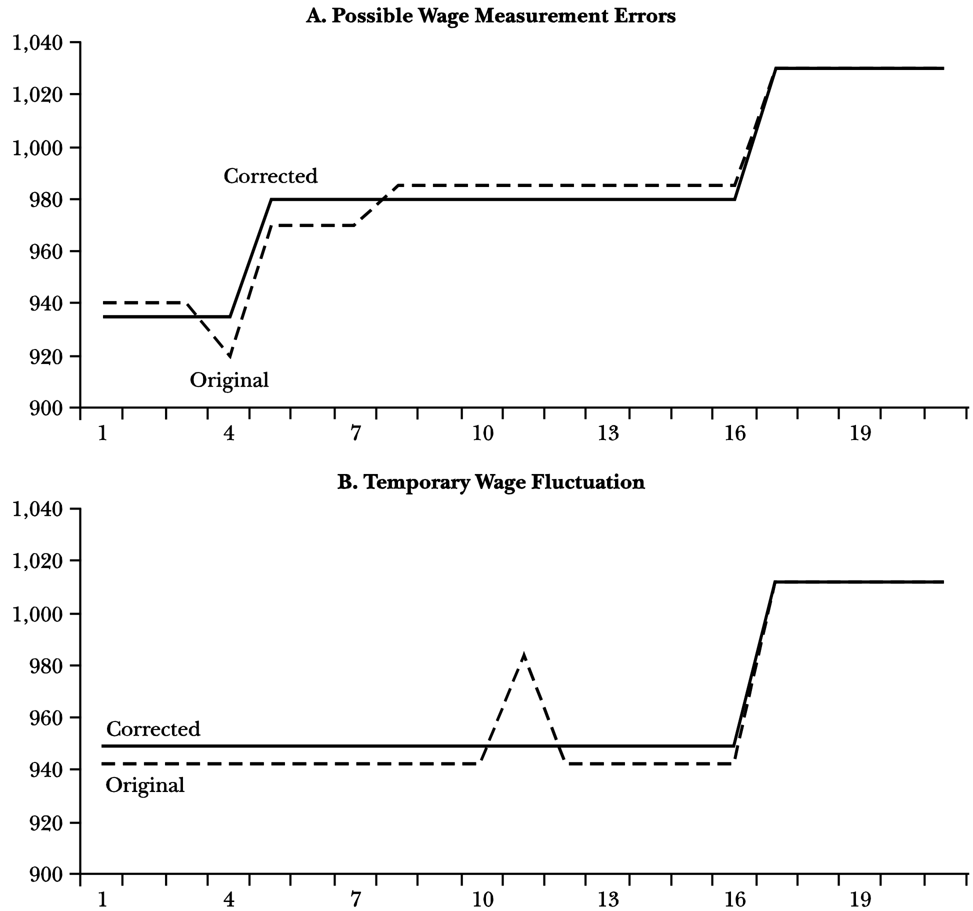
As mentioned above, the wages reported in the base sample could be subject to measurement errors, and eventually include temporary fluctuations that do not necessarily represent actual changes in workers' wages. One example is the case of a fixed year-end bonus on contract basis or benefits such as an education bonus which some companies give to employees with children at the start of the school year.

In light of this phenomenon, the wages are corrected using the approach employed by Gottschalk (2005). The methodology rests on the assumption that nominal wages remained fixed for a number of periods and move in a discrete manner when they are adjusted. This assumption is implemented by employing the structural break detection method developed by Bai and Perron (2003).

Taking the above into account, it is immediately apparent that the assumed fundamentals of this methodology have the potential disadvantage of ignoring short term wage changes due to the fact that the identification of the change requires that the adjustment have a significant impact on the average wage. This could lead to an underestimation of the actual level of wage flexibility. However, the results produced by using this methodology for the US suggest that this disadvantage does not play an important role. In fact, a direct reading of the PSID survey indicates that around 17% of the workers surveyed experienced a wage reduction once a year, but after this base sample is corrected with the method proposed by Gottschalk (2005), it can be concluded that this percentage overestimates the real number by approximately a factor of three, finding that the corrected estimate is in line with other estimates calculated with administrative information provided by private companies.

Figure 2 illustrates the application of the adjustment methodology. The left panel shows a wage history from the base sample and its respective corrected history. Fluctuations are observed in the actual series of wages around the date on which a discrete wage change can be observed –the dotted line–, while the solid line corresponds to the wage sequence once Gottschalk's (2005) method has been applied. As can be seen on the Figure, the simulated history follows the original wage sequence very closely; nonetheless, this ignores small deviations in months three and six. On the right panel, in contrast, the effect of a bonus on the wage history can be observed. As might be expected, the structural change methodology considers the bonus as a transitory event and not as a significant wage

FIGURE 2. ORIGINAL AND CORRECTED WAGE[a]

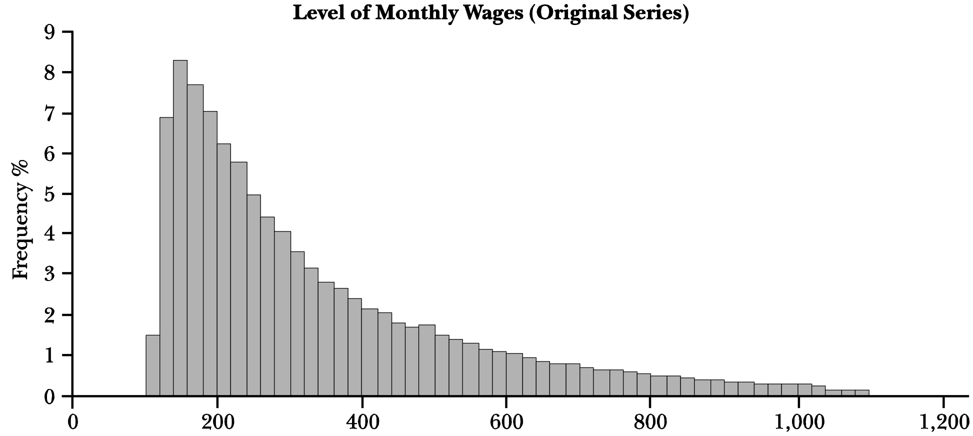


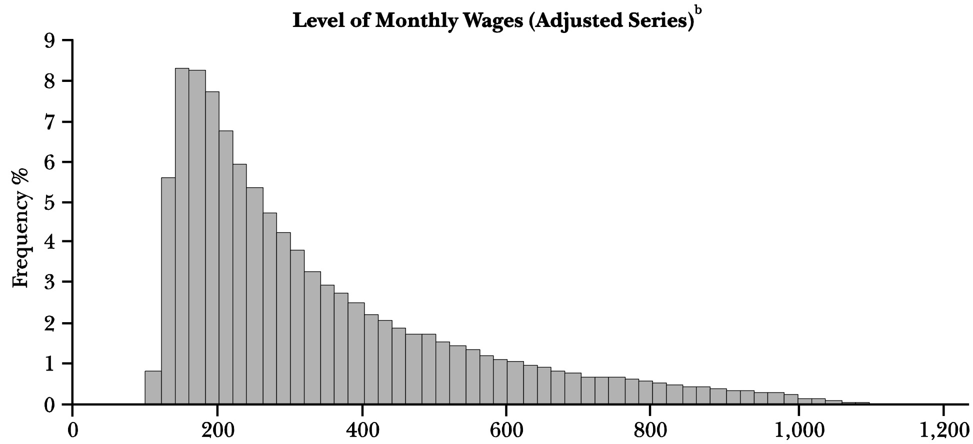
SOURCE: Own elaboration based on information from AChS.
[a] Using Gottschalk's (2005) methodology.

change.[11] However, it is important to point out that the methodology identifies wage changes in those cases where the magnitudes of the eventual bonuses change significantly. For example, if a wage history considers a bonus equivalent to one month's wage in December of each year, then the method assumes a constant wage equal to 1+1/12 wages per month; on the other hand, if the December bonus is increased to 2 months wages, then the methodology will indicate a wage of 1+1/12 wages per month for

[11] Appendix 1 contains a description of the methodology.

FIGURE 3. HISTOGRAMS OF ANNUAL WAGE LEVEL AND GROWTH



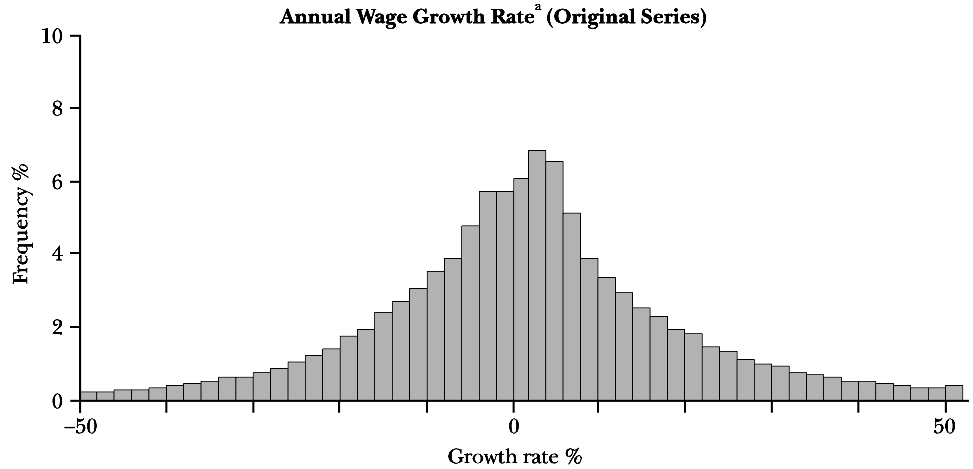


SOURCE: Own elaboration based on AChS information.
[a] Only effective wage changes taken into consideratión. [b] Using Gottschalk's (2005) methodology.

the period previous to the increase and, for the period after the increase, the average monthly wage will be 1+2/12 wages per month.

It should be pointed out that in aggregate terms the application of structural change methodology does not modify significantly the level of wage distribution; however, the impact on the frequency of changes is considerable (Figure 3). In fact, the unadjusted frequency change is more or less symmetric centered on a number slightly higher than zero, while

Annual Wage Growth Rate[a] (Original Series)



Annual Wage Growth Rate[a] (Adjusted Series)[b]

that of the adjusted base sample demonstrates a clearly asymmetric distribution with a bias toward wage increases. These results imply that, if the methodology is not applied, the sample frequency of adjustments reflects flexibility that is significantly higher than could be obtained by adjusting the base sample. Considering Gottschalk's (2005) results, the unadjusted series has a high probability of overestimating the real frequency of adjustment.

4. WAGE ADJUSTMENTS IN CHILE

4.1 Description of Frequency of Adjustments in Chile

Wage adjustment estimates are divided into wage changes not associated with a change of workplace by the worker and those which coincide with workers who change their workplace. Regarding the former, the average adjustment frequency is 3.7% per month, with increases and decreases being 3.4% and 0.3% respectively. These figures suggest that the time it would take for all the wages in the economy to adjust would be, on average, something over nine quarters (Table 5). This last result is consistent with the estimates obtained by the DSGE model for Chile, where the average adjustment is 12.5 quarters with a lower boundary of 5.6 and a 66% confidence level.[12] Furthermore, the frequency of nominal wage reductions is very low, which, to a certain extent, suggests that the labor market could exhibit a low degree of wage flexibility as suggested by studies such as Cowan et al. (2005). It is necessary to point out that if Gottschalk's (2005) adjustment methodology is not applied, the frequency of wage reductions increases to 30.97%, a very high number in comparison to estimates for other countries and beyond that expected for this type of statistic.

TABLE 5. FREQUENCY OF WAGE ADJUSTMENTS IN CHILE

Item	*Wage changes (monthly, percentage)*	*Average time for a complete adjustment (quarters)*	*Wage increases (monthly, percentage)*	*Wage reductions (monthly, percentage)*
Without changing workplace	3.68	9.05	3.36	0.32
With changing workplace[a]	58.90	–	35.40	23.50

SOURCE: Own elaboration based on information from the AChS.
[a] Frequency calculated using last wage reported at previous company.

Among those workers who change their workplace, 34% receive higher wages, 24% receive lower wages and around 42% do not experience any significant change in wages. The fact that a change in workplace is not linked exclusively to an increase in wages may be associated with one of the two following factors. First, the partial flexibility of wages has temporary unemployment as its counterpart, a situation which definitely translates

[12] This estimate is obtained using Bayesian methodology applied to a DSGE model for Chile. See Caputo et al. (2006).

into the involuntary character of some of the labor changes reported and, as a consequence, not necessarily associated with wage increases. Second, these results are also consistent with the existence of complementary wage factors used to determine the benefits associated with working in a particular place and, as a consequence, a worker might be willing to change their workplace and accept a lower wage in exchange for other compensatory elements to the lower wage; for example, better employment prospects and more flexible hours, among others. However, it is not possible to establish the specific role of each of these factors with the information available and it is beyond the objective of this present paper.

Analysis by company size indicates that small companies have slightly higher frequency than the other two groups (Table 6), although the size of such differences does not appear to be significant. Considering the frequency of wage reductions as a more direct indicator of labor flexibility, the bigger companies are the most rigid. Nevertheless, these numbers should be considered with caution, as these frequencies can be affected not only by company size but also by worker characteristics. A formal analysis of the incidence of these characteristics in the adjustment frequency is carried out in the next section.

TABLE 6. FREQUENCY OF WAGE ADJUSTMENT BY SIZE OF COMPANY (monthly, percentage)

Size	*Wage changes*	*Wage increases*	*Wage reductions*
Less than 10 workers	3.79	3.42	0.38
From 10 to 199 workers	3.67	3.30	0.36
200 or more workers	3.67	3.40	0.27

SOURCE: Own elaboration based on information from the AChS.

Wage adjustment frequency by economic sector indicates a high degree of heterogeneity (Table 7). For example, the adjustment frequency of the Services and Construction sectors are the highest (4.28% and 3.95% per month, respectively), while the Industry sector shows the lowest (3.11%). By focusing on reductions, it is interesting to note that the frequencies observed are very similar in all sectors, with the sole exception of Construction which is almost double that of the other sectors, a situation consistent with the fact that hiring in this sector is determined to a large extent by the execution of projects for limited time periods.

TABLE 7. FREQUENCY OF WAGE ADJUSTMENTS BY ECONOMIC SECTOR

Sector	*Wage changes (monthly, percentage)*	*Average time for a complete adjustment (quarters)*	*Wage increases (monthly, percentage)*	*Wage reductions (monthly, percentage)*
Agriculture	3.29	10.14	2.97	0.31
Mining	3.33	10.00	3.04	0.29
Industry	3.20	10.40	2.90	0.30
Construction	4.01	8.30	3.50	0.52
Electricity, gas and water	3.29	10.13	3.02	0.27
Commerce	3.44	9.69	3.12	0.32
Transport	3.40	9.81	3.06	0.34
Services	4.24	7.85	3.94	0.30
Total	*3.68*	*9.05*	*3.36*	*0.32*

SOURCE: Own elaboration based on information from the AChS.

4.2 Determinants of Wage Flexibility: Econometric Focus

Literature uses worker and company characteristics to explain the degree of wage rigidity present in the economy. In reference to worker characteristics, Campbell and Kamlani (1997) emphasize that variables related to worker skills are crucial for understanding labor rigidities. In contrast, Messina et al. (2008), and Franz and Pfeiffer (2006) consider information on company size and the economic sector to which it belongs to be relevant.

Similar variables will be used in the following to explain econometrically the percentage of workers in each company whose wages are adjusted downwards on a quarterly basis. It is worth noting that a quarterly frequency, not a monthly one as used in the previous analysis, is used here due to the fact that a monthly frequency would introduce too much noise to the estimates without generating any significant effect on the results. The variable to be explained was measured as the percentage of workers at each company whose nominal wage decreased during the quarter, without this decrease being associated with a change in work place by the worker. In relation to the statistics associated with this variable, the average unconditional value is 1.3% per quarter, a number which compares with the close to 0.3% average monthly frequency of wage reduction.

Regarding worker characteristics, we have information on worker gender and age. The former characteristic is introduced to the model as the ratio of female workers in each company over time, while for the latter, a dummy variable was employed in order to differentiate between three groups of companies: companies with an average worker age fewer than 30, those between 30 and 50 and those over 50 years of age. In addition, as an approximation of the skill level of the company's workers, a percentage of the company's workers who receive wages higher than the sectorial average was calculated, white vs. blue collar workers. In terms of the characteristics of the company, the size of the firm was used (small, medium, or large) and the economic sector to which they belong.[13] The level of sectorial unionization was also controlled for.

Employing these variables –and those mentioned previously– regressions were estimated whose dependent variable was the percentage of workers in each company who experienced a wage decrease each quarter, with the explanatory variables being those mentioned in the last paragraph.[14] It should be noted that the dependent variable is restricted to interval $[0,1]$, and therefore the ordinary least squares procedure is not appropriate in this case. For this reason, following Papke and Wooldrige (1996) and Messina et al. (2008), the fractional logit of the following logistic function was estimated:

$$E(y_{it} \mid w_{it}, f_{it}) = \frac{\exp(w_{it}\alpha_0, f_{it}\alpha_1)}{1+\exp(w_{it}\alpha_0, f_{it}\alpha_1)}, \tag{1}$$

where y_{it} is the percentage of workers who experience a wage reduction at company i in quarter t, w_{it} the collection of worker characteristics of company i, and f_{it} represents characteristics of company i in quarter t. The estimate covers 2001-2007 and the frequency of data is quarterly.

Table 8 shows the marginal effects on the dependent variable, whose unconditional average value is 1.3% per quarter. As observed, with respect to the worker characteristics, the percentage of women at each firm was not statistically significant, a result which is consistent with those reported in European countries by Messina et al. (2008). Age variables show that a larger percentage of workers under 30 years of age (the regression reference group) is associated with a higher frequency of downward wage adjustments, i.e., that older workers experience a lower frequency of nominal wage decreases. Thus, for example, companies with a majority of workers in the age range of 30 to 50 will have a wage reduction frequency

[13] There is no further information to allow for a higher heterogeneity between companies.

[14] The reported numbers only include those for workers who remain with their companies, but the results are consistent with the complete sample.

0.3 percentage points lower than those firms with a higher percentage of workers less than 30 years of age. This result conceptually validates the role of the outsider assigned to young workers.[15] This, however, contrasts with what is reported by Messina et al. (2008) for Europe, which shows the opposite.

As for company characteristics, those with less than 10 workers exhibit a lower downward wage adjustment than larger companies (over 200 workers), this being a statistically significant effect when the percentage of

TABLE 8. DETERMINANTS OF DOWNWARD NOMINAL RIGIDITY. DEPENDENT VARIABLE: PERCENTAGE OF WAGE REDUCTIONS AT THE COMPANY LEVEL (marginal effects, percentage points)

Variable	*(1)*	*(2)*	*(3)*	*(4)*
Ratio of women	−0.05	−0.07	−0.05	−0.07
Dichotomous variable for age of worker in the company:				
Average age of worker between 30 and 49 years of age	−0.34[a]	−0.26[b]	−0.34[b]	−0.26[c]
Average age of worker equal to or over 50 Years of Age	−0.25[b]	−0.20[c]	−0.25[b]	−0.20[c]
Dichotomous variable for number of workers in the company:				
9 workers or less	−0.07	−0.15[a]	−0.07	−0.15[a]
Between 10 and 199 workers	−0.01	−0.05	−0.01	−0.05
Ratio of workers with income over the sectorial average		−0.54[a]		−0.54[a]
Sectorial level of unionization			−0.03	−0.02
Sectorial fixed effects				
Mining	0.32	0.47[c]	0.53	0.70
Industry	0.36[a]	0.42[a]	0.38[a]	0.44[a]
Construction	0.81[a]	0.87[a]	1.05[a]	1.11[b]
Electricity, gas and water	−0.02	0.04	−0.01	0.05
Commerce	0.31[a]	0.39[a]	0.30[a]	0.39[a]
Transport	0.42[a]	0.49[a]	0.50[a]	0.57[a]
Services	0.38[a]	0.50[a]	0.38[a]	0.49[a]
Temporary effect	Yes	Yes	Yes	Yes

SOURCE: Own elaboration based on information from the AChS.
[a] 1% significance. [b] 5% significance. [c] 10% significance.

[15] The *insider-outsider* theory states that companies do not fire formal employees (insiders) to hire unemployed workers (outsiders) at a lower wage due to the cost of firing workers and hiring and training new ones.

workers with high wages is controlled for (columns 2 and 4); the marginal effect associated with these companies as compared to larger ones is 0.15 percentage points less downward wage adjustments. An explanation for this could be related to larger companies' more favorable position to apply more complex remuneration schemes that allow them a greater degree of flexibility. Furthermore, particularly in the case of small firms, companies avoid wage reductions because the impact of the loss of a small number of employees arising from such reductions is relatively more important to the company the smaller it is. Regarding workers' skill levels (measured as the percentage of workers in each company with higher wages than the sectorial average), a negative relation between the proportion of workers with higher wages and wage flexibility was found, possibly indicating that these workers' higher skill levels give them a higher degree of labor mobility, which, following the nomenclature set out for age variables, would let them play the role of the outsiders in the labor markets and/or, additionally, this is consistent with the conceptual framework of efficiency wages, as workers with more highly skilled positions are more difficult to monitor. The degree of unionization does not appear to be statistically significant.

As for fixed sectorial effects, the marginal effects are measured with respect to the Agriculture sector, and the most important results indicate that sectors exist for which the marginal effect is both very statistically and economically significant. For instance, the marginal effect for the Construction sector indicates that companies in this sector have a frequency of quarterly wage reductions on average 1 percentage point higher than the frequency for companies in the Agriculture sector. This number is very significant if the sample average of quarterly downward adjustments of 1.3% is taken into consideration. Significant statistical effects, although to a less extent, are also observed in the Commerce, Transport and Services sectors.[16]

5. MAIN FINDINGS

This paper shows the dynamics of wage adjustments in Chile based on a microeconomic information panel composed of an average of 429 thousand wage histories for the period 2001m12-2007m12. The main finding is

[16] The non-linearness of the model implies that the marginal effects of the dummy sector variable cannot be isolated completely.

that the frequency of wage adjustments for this period is approximately 3.7% per month, where 0.3% corresponds to nominal wage reductions.

The frequency of wage adjustments shows some differences among economic sectors. In particular, the Construction, Commerce, Transport and Services sectors exhibit a higher relative adjustment frequency. These differences are economically significant, especially for the Construction sector. This may be a reflection of the fact that there are a significant percentage of short term wage contracts in Construction.

Econometric analysis of the determinants of the downward nominal rigidity indicates that both the characteristics of the worker and the company are relevant. With reference to worker characteristics, the ratio of female workers is not statistically significant, but that of young workers is, given that a positive relationship is observed between young workers and the frequency of nominal wage reductions. Likewise, the frequency of downward adjustments is less in companies with a higher percentage of workers with high wages (compared to the sectorial average). Regarding the company, small and medium sized companies show a lower frequency of reductions than larger companies (over 200 employees).

Although this paper shows evidence for the labor market, some interesting questions remain unanswered. In particular, the main shortcoming of the base sample, which limits its use for exploring other topics, is the lack of information on worker characteristics such as education level and contractual conditions. The spectrum of studies should be increased significantly as more complete base samples become available.

Appendix A

Bai-Perron (2003) Methodology

This appendix gives a description of the contrast of structural breaks used to determine wage changes. Bai and Perron (2003) formally present the contrast.

T is defined as the number of periods for which a particular worker's wage was observed, with m being the number of breaks observed in periods T_1, T_2, ..., T_m. The wage in any period is equal to constant plus a measurement error in the following manner:

(A. 1)
$$\begin{aligned} w_t &= \beta_1 + \mu_t; & t &= [1, T_1] \\ w_t &= \beta_2 + \mu_t; & t &= [T_1 + 1, T_2] \\ &\vdots \\ w_t &= \beta_{m+1} + \mu_t; & t &= [T_m + 1, T] \end{aligned}$$

Bai and Perron (2003) proposed an estimator MCO for β and T. For this purpose, it is assumed that the number of breaks is known and is equal to m. In this case, the idea is to estimate βs and Ts that minimizes the residual quadratic sum (SSR) of system A.1. However, this calculation can be very demanding in computer terms due to the fact that the duration between breaks is unknown and as such there is a very large number of T combinations. Bai and Perron (2003) show that the problem can be reduced through dynamic programming in the following way:

(A. 2)
$$S\tilde{S}R(\hat{T}_1,...,\hat{T}_m) = S\tilde{S}R(\hat{T}_1,...,\hat{T}_{m-1}) + \min_{T_m} SSR(\hat{T}_m)$$

The algorithm is resolved recursively according to the following procedure. Calculations are made for the SSR for T–2h potential breaks that divide the T observations in two segments of a minimum length of h. The break point of the minimum SSR is selected from among T–2h potential break points. The two segments derived from the last step are taken and the procedure is repeated until m segments are obtained. From there the SSR minimum of all the possible combinations of m breaks is obtained with a minimum segment length of h.

To determine the optimal m, a sequential procedure is used. First, by dividing the sample in two, the null structural break existence hypothesis is contrasted using SSR with and without structural break with an F contrast. In the event that the null hypothesis is rejected, the contrast from the segments obtained of the last stage is carried out. The process is repeated until the null hypothesis cannot be rejected.

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Downward Wage Rigidities and Other Firms' Responses to an Economic Slowdown: Evidence from a Survey of Colombian Firms

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1. INTRODUCTION

It is important to understand the nature and causes of wage rigidities, since such rigidities partly determine the persistence and volatility of inflation, as one of the main components of the firms' marginal cost. Also, wage rigidities offer a microeconomic explanation to a macroeconomic phenomenon: voluntary unemployment. As Tobin (1972) and Akerlof et al. (1996) state, when nominal wages are downwardly rigid, a certain level of inflation allows for a greater flexibility in real wages, thereby helping adjustments in the labor market.

The reduction of inflation and the adoption of an inflation targeting regime, which took place in several countries during the past two decades, have renewed interest in the study of wage rigidities, due to the impact they can have on the labor market.[1] The Colombian case is no exception.

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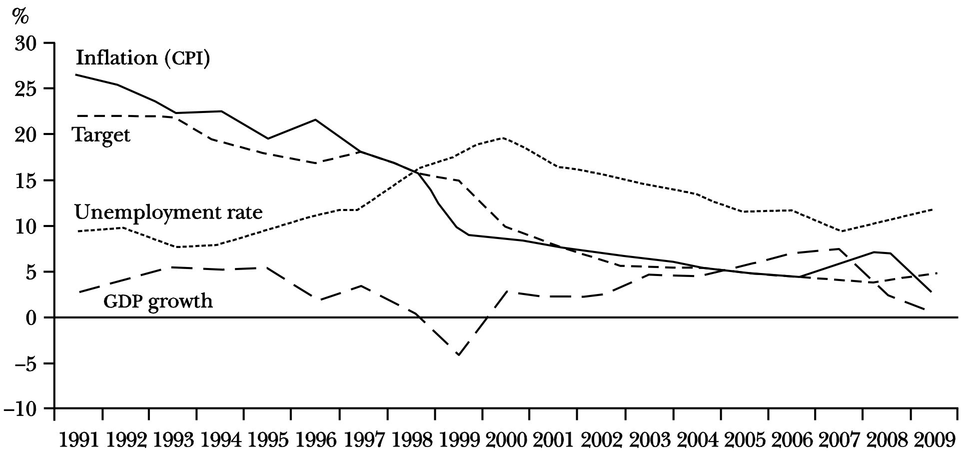
[1] See, for example, European Central Bank, *Wage Dynamics in Europe: Final Report of the*

FIGURE 1. INFLATION, UNEMPLOYMENT AND GDP GROWTH IN COLOMBIA: 1991-2009



SOURCES: DANE and Banco de la República.

Colombia has experienced a gradual fall in inflation since the beginning of the nineties; however, it was only after 1997 that inflation came close to the announced target.[2] The main decline in inflation took place between 1998 and 1999, when it went from 16.7% to 9.3%. Since then, inflation has remained in the single digit level. On the other hand, unemployment increased, reaching a peak in 1999-2000, when the economy faced a deep recession. By 2009, the scenario in Colombia was one of low inflation, high unemployment and signs of an economic slowdown (figure 1). Since the aim of this paper is to study wage rigidities, the economic conditions prevailing in the country offer a suitable context for applying a survey to Colombian firms.

To explore wage setting mechanisms, analyze the nature and sources of wage rigidities and test different theories of wage rigidities in the country, we designed and applied a survey to Colombian firms. The survey allows us to obtain answers directly from those who set wages in a firm and helps us to understand the behavior of firms and the labor market. In addition, it provides evidence for the microfoundation of the Central Bank's wage and price models, by incorporating real and nominal rigidities, and offers elements for monetary policy decisions.

A study of wage rigidities in an emerging country, such as Colombia, is also important because the country's institutions and labor market could

Wage Dynamics Network (WDN), December 2009.

[2] In Colombia, explicit inflation targets have existed since 1991. For details on the implementation of an inflation targeting regime in Colombia, see Gómez et al. (2002).

have characteristics that differentiate it from developed countries where this type of study has been concentrated. For instance, Colombia has high levels of informality. In fact, informal workers accounted, on average, for 58% of the total number of workers during the period 2001-2007. Unlike the situation in Europe, union density in Colombia is very low: less than 5% in recent years (Guataquí et al., 2009). As a result, we would expect the role of unions in explaining wage rigidities in Colombia to be less important than in Europe. Furthermore, the legal minimum wage in Colombia plays a very important role in setting wage increases (Iregui et al. 2009b). Another aspect to highlight is the presence of high non-wage labor costs, which come to 58% of base wages in 2008 (Sánchez et al. 2009).[3]

The empirical studies of wage rigidities have used information based on datasets and surveys at both the firm and worker levels. Among the studies that use datasets on both firms and workers, it is worth pointing out the International Wage Flexibility Project, which analyzes changes in individual labor incomes by using 31 databases from 16 European countries over the past three decades (Dickens et al., 2007). Other studies that have used microeconomic information in Europe and the United States are those by McLaughlin (1994), Kahn (1997), Stiglbauer (2002), Lebow et al. (2003), Schweitzer (2007), Brzoza-Brzezina and Socha (2007), Messina et al. (2008) and Knoppik and Beissinger (2009), among others. These studies offer mixed evidence regarding wage rigidity, as they vary in accordance with their respective methodology and source of information. In the Latin American context, the study of wage rigidities does not appear to have received a great deal of attention. Three exceptions are Castellanos et al. (2004) for Mexico, Iregui et al. (2009a) for Colombia and Cobb and Opazo (2010) for Chile.

On the other hand, the literature on downward wage rigidities using firm surveys dates back to the studies of Kaufman (1984) and Blanchflower and Oswald (1988) for the United Kingdom, Holzer (1990), Blinder and Choi (1990), Bewley (1995, 1998, 1999) and Campbell and Kamlani (1997) for the United States, and Agell and Lundborg (1995, 2003) for Sweden. In general, these studies found that firms do not cut wages because they do not want to affect the motivation, effort and morale of workers. Consequently, this leads to downward nominal wage rigidity.

[3] Non-wage labor costs include social security contribution (health and pensions), work injury, mandatory bonuses, paid vacations, severance pay, training and family allowances.

Similar results associated with efficiency wage theories in explaining wage rigidities were found recently by Agell and Bennmarker (2002, 2007) for Sweden, Franz and Pfeifer (2003, 2006) for Germany, Zoega and Karlsson (2006) for Iceland, Copaciu et al. (2010) for Rumania, Kawaguchi and Ohtake (2008) for Japan, and Amirault et al. (2009) for Canada. In addition, Franz and Pfeifer (2003) and Agell and Bennmarker (2002, 2007) found that the existence of collective agreements is another important factor in preventing wage cuts.

The Eurosystem Wage Dynamics Network (WDN), a research network composed of economists from the European Central Bank and the central banks of the European Union, conducted an ad hoc survey on price and wage setting behavior among nearly 17,000 firms in 17 countries of the European Union between the end of 2007 and the first half of 2008. The results of the WDN survey indicate the existence of significant downward rigidity in base wages in the European Union, with important cross-country differences. For example, downward nominal rigidity prevails in the Netherlands, Greece, Germany, Austria and Portugal, whereas downward real rigidity is more prevalent in Belgium, Finland, Luxembourg, Spain and Sweden. According to the survey, the most important reasons for preventing wage cuts are the impact on work morale and effort, preventing the most productive workers from leaving the firm, and labor regulations or collective agreements.[4]

In particular, in this paper we applied a wage setting survey to 1,305 Colombian firms in thirteen Colombian cities, taking into account nine economic sectors and three firm sizes. This survey has the advantage of using a representative sample of firms, which allows us to generalize the results to the population under study. As Campbell and Kamlani (1997), we designed the survey to obtain answers for different occupational groups, in our case, managers, professionals, technicians and assistants, and unskilled workers, since the reasons for wage rigidity may differ across types of workers. Regarding the response rate, it is important to mention that we obtained responses from 1,305 firms.

The survey asked firms how likely it is they will perform certain actions during a period of economic slowdown. Then, with the survey results and using ordered *logit* models, we empirically examine the firms' responses, taking into account the firm-specific information collected for the survey.

[4] For details on the WDN firm survey, see European Central Bank, *Wage Dynamics in Europe: Final Report of the Wage Dynamics Network (WDN)*, December 2009.

The survey also asked firms why they do not reduce wages in difficult times and provided respondents with a series of reasons based on the more relevant theories, so as to test which of them explain wage rigidities in the Colombian case. We also used ordered *logit* models to examine the firms' responses in greater detail.

The results of this study point to the presence of nominal and real downward wage rigidities in Colombia.[5] According to the survey, the most important reasons why Colombian firms do not cut wages during difficult times are to prevent loss of the most productive and experienced workers, do not affect worker's effort and productivity, and do not affect worker's motivation. These reasons are related to the efficiency wage theory, particularly to the adverse selection model, the shirking model, the gift-exchange model and the fair wage-effort hypothesis. Interestingly, these results are similar to those found in the literature for developed countries.

Survey evidence also suggests that firms can resort to other alternatives to adjust costs in difficult times, besides changes in base wages, such as reducing non-statutory benefits and variable pay, laying off employees, changing the type of employment contract and hiring new workers at lower wages. The use of these strategies varies across economic sectors and occupational groups.

This paper is divided into five sections, in addition to the introduction. In the second one, we describe the survey design and sample selection. The third section analyzes the presence of downward nominal and real wage rigidities in Colombia and empirically test firms' responses to the related questions. Section four studies the reasons for preventing wage cuts and empirically tests different theories on wage rigidities. In the fifth section, we discuss alternatives other than changes in base wages that firms could use to adjust labor costs during a period of economic slowdown. The final section presents the main conclusions.

2. SURVEY DESIGN

In this paper, the analysis is based on a survey of 1,305 Colombian firms. It was designed to explore wage setting mechanisms, the nature and sources of wage rigidities, and the link between wages and prices (Iregui et al., 2009b). The survey also collects data on several characteristics of the firms

[5] This finding confirms previous microeconomic evidence of wage rigidities in Colombia; see Iregui et al. (2009a) and Iregui et al. (2010).

in question, such as the economic sector where they operate, the kind of labor contracts they use, the existence of collective agreements and different types of remuneration, among other features, which helped us to characterize the firms in the empirical analysis.

The survey has the advantage of using a representative sample of firms. This allowed us to generalize the results to the population under study: namely 39,004 small, medium and large scale enterprises,[6] which are legally constituted and belong to all economic sectors, except the public sector.[7] The firms are located in 13 cities,[8] which account for 70% of the formal employment in Colombia.

The sample selection was done by stratified random sampling, considering nine strata and obtaining a final sample of 1,305 firms. The strata correspond to the following economic sectors: agriculture, forestry and fishing; commerce; construction; electricity, gas, water and mining; manufacturing; financial services; transport, storage and communications; education and health; and other services. In addition, firm size was considered as a domain to guarantee that all sizes were represented in the final sample. It is important to mention that responses were obtained from 1,305 firms. The firms that did not answer the questionnaire, for whatever reason, were replaced by companies with similar characteristics, such as the economic sector, size and location of the firm. To do so, we used a sample surplus to maintain its representativeness within the population under study.[9]

In the design of the questionnaire, we discussed with senior specialists in survey design and human resources managers; this enriched the survey.[10] Some questions took into account the studies by Blinder and Choi (1990); Campbell and Kamlani (1997); Bewley (1999); Agell and Lundborg (1995, 2003); Franz and Pfeiffer (2006); and Copaciu et al. (2007), who studied downward wage rigidities.

[6] Firms with less than ten employees were excluded.

[7] The public sector was excluded, because the wages of public employees are set mainly by government decree, although public enterprises were included.

[8] The cities are Bogotá, Bucaramanga, Barranquilla, Cali, Cartagena, Medellín, Manizales, Pereira and their metropolitan areas. Barrancabermeja, Buga, Tuluá, Girardot and Rionegro were also included.

[9] It is important to note that the decision to replace a firm was made after making at least five phone calls to make an appointment.

[10] A Spanish version of the questionnaire is available in Iregui et al. (2009b), Appendix 4. For additional details related to the questionnaire design, see Iregui et al. (2010).

The selected firms were contacted first by telephone; those showing interest in answering the survey were sent a letter explaining the academic purpose of the study and emphasizing the confidentiality of the information provided. Once the company agreed to participate in our survey, a face-to-face interview was scheduled to apply the questionnaire. The survey was directed to human resources personnel involved with wage policies, who should be able to answer the questions for different occupational groups (managers, professionals, technicians and assistants, and unskilled workers). The survey was carried out during the first semester of 2009, when the Colombian economy was showing signs of a slowdown in economic activity, low inflation and increasing unemployment.

Finally, it is important to mention that all the results presented hereafter are generalized for the population under study (39,004 firms). The coefficients of variation were calculated for each answer; the coefficients obtained did not exceed 5%, which is an indicator of the reliability of the population estimates.

3. DOWNWARD NOMINAL AND REAL WAGE RIGIDITIES

To assess whether wages are downward rigid, we asked firms about the likelihood of performing certain actions during a period of economic slowdown, using a scale from 1 to 4, where 1 is *not at all* and 4 is *very likely*. To allow for comparisons, we calculated the mean score of the answers. Following Blinder (1991), a mean score greater than or equal to 3.0 is considered excellent and a score of less than 1.5 is very poor; a mean score greater than or equal to 2.5 is considered to be reasonably strong.

In particular, to identify downward nominal wage rigidity (DNWR), the options of either reducing or freezing base wages were considered. For downward real wage rigidity (DRWR), the alternative of increasing basic pay at a rate lower than inflation was included.[11] Table 1 shows the percentage of responses *not at all / not likely* and *likely / very likely* for each occupational position, as well as the mean scores obtained for the aforementioned options.

The results suggest the presence of DNWR, considering that, in all cases, more than 85% of the firms indicated the option of *reducing base pay*

[11] According to Colombian law, the purchasing power of the minimum wage must be maintained. Then, the previous alternatives can be considered only for base wages higher than the legal minimum wage.

TABLE 1. HOW LIKELY IS YOUR FIRM TO CARRY OUT THE FOLLOWING ACTIONS?

Occupational group	*Do not increase base wages*	*Reduce base wages*	*Pay raises below the inflation rate*
Managers			
Mean score[a]	2.33	1.52	2.13
Responses (%)			
Not at all / not likely	54.0	85.9	59.6
Likely / very likely	46.0	14.1	40.4
Professionals			
Mean score[a]	2.33	1.52	2.17
Responses (%)			
Not at all / not likely	53.8	86.4	57.9
Likely / very likely	46.2	13.6	42.1
Technicians, assistants, and unskilled workers			
Mean score[a]	2.04	1.45	1.96
Responses (%)			
Not at all / not likely	67.7	89.3	68.2
Likely / very likely	32.3	10.7	31.8

SOURCE: Authors calculations.
[a] Average score based on the following scale: 1 = not at all, 2 = not likely, 3 = likely, 4 = very likely.

was *not at all / not likely* and the mean score was 1.5, indicating a very low likelihood of occurrence. In addition, more than half the firms replied that the alternative of *not increasing base wages* was *not at all / not likely*. The option of *pay raises below the inflation rate* had a mean score of around 2.0 for all occupational groups and it is *not at all / not likely* for about 60% of the firms in the case of managers and professionals and 70% of the firms for technicians, assistants and unskilled workers, all of which provides evidence of DRWR. It is worth mentioning that the results show no important differences by firm size. However, across sectors, the results do show some variation.[12] For instance, in financial services, the alternatives of *reducing base pay* and *not increasing base wages* have a percentage of response for *not at all / not likely* that is considerably higher than in the other sectors. In the construction sector, the alternative of *pay raises below the inflation rate* has the highest response rates for *not at all / not likely* compared to all occupations (73% on average).

The answers concerning wage rigidities are consistent with the results obtained when the firms were asked about the last annual effective wage

[12] These results may be obtained from the authors upon request.

increase. Figure 2 shows the histograms of the distribution of the average nominal wage change for each occupational position between 2008 and 2009, when the country was showing signs of a slowdown in economic activity. As illustrated, none of the companies cut wages and there is a spike around the observed rate of inflation for the year 2008, 7.67%. In the case of unskilled workers, wage changes were concentrated around this value for about 60% of the firms; however, for managers, this proportion declines to about 40%. Furthermore, wage freezes are less frequent among less-skilled workers, since they might be protected by collective agreements.

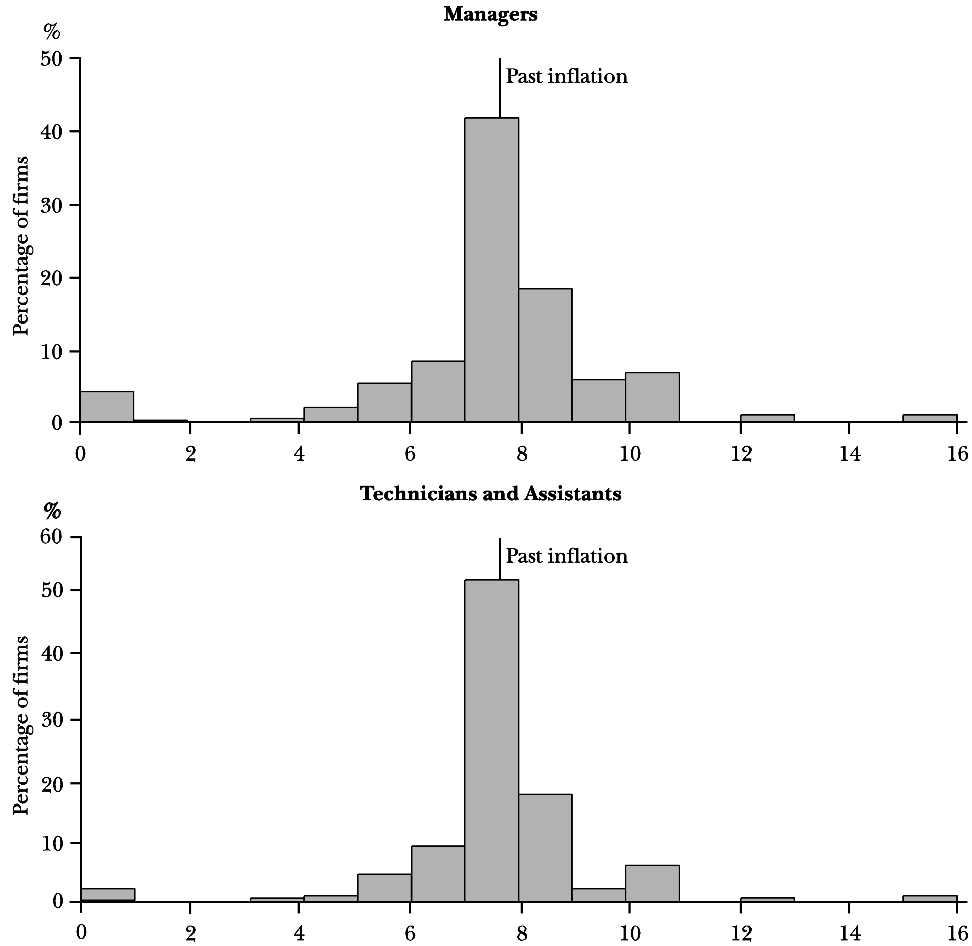
Next, to test the relevance of the firm's characteristics for the responses, we estimated ordered *logit* models for each action and occupational group. The dependent variable increases with the likelihood of carrying out such actions. It takes values from 1 to 4, where 1 = *not at all*, 2 = *not likely*, 3 = *likely* and 4 = *very likely*. The threshold parameters estimated in all the models are statistically different from one another; therefore, we maintained the four categories for the dependent variables in all the models.[13]

The explanatory variables allow for differences in economic sectors and the location of the firms (*region*); we considered trade and cities other than Bogotá (the nation's capital) as the reference categories in the regressions. Firm size also is included and is measured by the number of employees [*log (No. of employees)*]. In addition, the share of managers and professionals (*skilled workers*); the percentage of workers earning the minimum wage (*minimum wage earners*); and the share of employees with a permanent employment contract (*permanent workers*) were included to take into account the characteristics and composition of the labor force. Moreover, a dummy variable that takes the value of 1, if the firm has any form of collective agreement (*collective agreements*); and a measure of union density [*union members (%)*] were considered to evaluate the importance of collective wage agreements. Furthermore, we included dummy variables to account for the presence of flexible benefits and variable pay.[14] Finally, labor costs as a share of total costs were also included to approximate labor intensity.

[13] A Wald test was used to test the difference among the threshold parameters. The results of the tests, as well as the marginal effects for all models, may be obtained from the authors upon request.

[14] Flexible benefits correspond to a formal plan whereby employees can choose among different employer-paid benefits or take cash. Variable pay corresponds to a form of compensation that links employee payment to some measure of job performance.

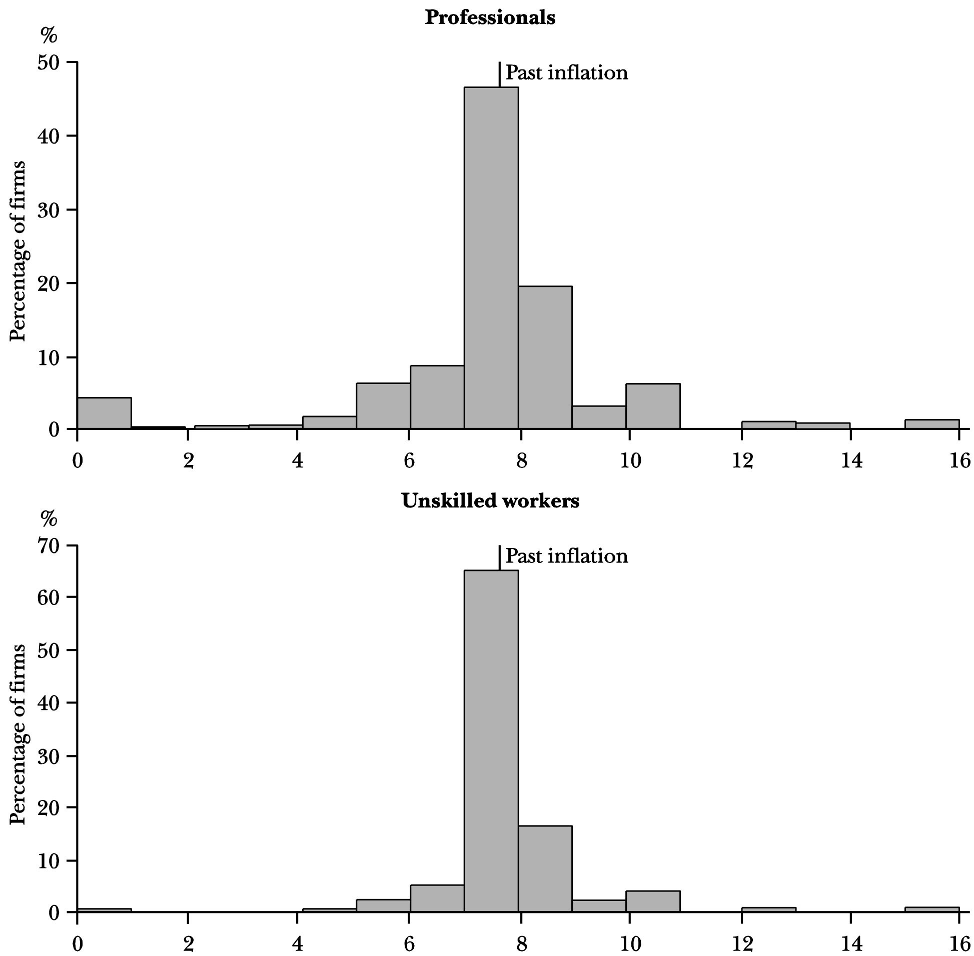
FIGURE 2. HISTOGRAMS OF THE DISTRIBUTION OF THE LAST NOMINAL WAGE INCREASE,



SOURCE: Authors' calculations.

Table 2 shows the ordered *logit* estimates for the alternatives *do not increase base wages* and *reduce base wages*. According to the results for all occupational groups, the probability that firms *do not increase base wages* in an economic slowdown increases with the share of labor costs as a portion of total costs, as expected. Moreover, this strategy in firms operating in the construction, manufacturing and financial services is less likely than for firms in the commercial sector (the reference category), where the high share of temporary workers could affect the bargaining power of employees. Regarding the composition of the labor force, in the case of managers

2009/2008



and professionals the probability that firms *do not increase base wages* decreases as the share of skilled workers increases. This could be explained by the difficulty in recruiting employees of this type, as our survey indicates. The presence of flexible benefits is statistically significant only in the case of managers, where such benefits account for approximately 15% of their remuneration. Finally, in the case of technicians, assistants and unskilled workers, as firm size and the share of minimum wage earners increase, the likelihood of not increasing base wages declines; this is also true for firms operating in agriculture, forestry and fishing sectors.

TABLE 2. HOW LIKELY IT IS FOR A FIRM NOT TO INCREASE BASE WAGES OR TO REDUCE BASE WAGES (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

	Not to increase base wages						*Reduce base wages*					
Variables	*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*		*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	−0.123	(0.217)	−0.327	(0.238)	−0.594[c]	(0.236)	−0.040	(0.238)	−0.244	(0.254)	−0.279	(0.250)
Construction	−0.805[c]	(0.234)	−0.619[b]	(0.227)	−0.529[c]	(0.211)	−0.369	(0.253)	0.120	(0.236)	0.352[a]	(0.228)
Electricity, gas, water, mining	−0.105	(0.248)	−0.414[a]	(0.253)	−0.188	(0.227)	0.487[a]	(0.290)	0.451[a]	(0.295)	0.372	(0.283)
Manufacturing	−0.396[b]	(0.199)	−0.410[b]	(0.207)	−0.511[c]	(0.188)	0.101	(0.214)	0.370[a]	(0.229)	0.288	(0.221)
Financial services	−0.764[c]	(0.305)	−0.696[c]	(0.298)	−1.316[c]	(0.316)	−0.493	(0.377)	−0.501	(0.364)	−0.643[a]	(0.388)
Transport, storage and communications	−0.031	(0.168)	−0.009	(0.183)	−0.209	(0.180)	−0.122	(0.212)	−0.119	(0.222)	0.023	(0.212)
Education and health	−0.118	(0.263)	−0.064	(0.286)	−0.350	(0.256)	0.181	(0.317)	0.222	(0.318)	−0.098	(0.311)
Other services	0.203	(0.166)	0.109	(0.185)	−0.035	(0.174)	0.467[c]	(0.213)	0.315	(0.219)	0.166	(0.210)
Region	−0.214[a]	(0.128)	−0.050	(0.134)	0.177	(0.122)	−0.311[c]	(0.137)	−0.105	(0.141)	−0.137	(0.137)

Log (No. of employees)	0.010	(0.048)	−0.049	(0.051)	−0.074[a]	(0.045)	−0.063	(0.060)	−0.072	(0.059)	−0.051	(0.056)
Skilled workers (%)	−0.006[b]	(0.003)	−0.007[c]	(0.003)	−0.002	(0.003)	−0.004	(0.003)	−0.002	(0.003)	0.004	(0.003)
Minimum wage earners (%)	0.002	(0.002)	0.003	(0.003)	−0.004[a]	(0.002)	0.002	(0.002)	0.004	(0.003)	0.001	(0.003)
Flexible benefits	0.232[b]	(0.129)	0.128	(0.135)	0.035	(0.135)	0.157	(0.147)	0.193	(0.154)	0.000	(0.151)
Variable pay	0.108	(0.129)	0.018	(0.138)	−0.090	(0.127)	0.026	(0.155)	−0.085	(0.160)	−0.075	(0.152)
Collective agreements	−0.264	(0.243)	−0.245	(0.241)	−0.181	(0.238)	0.226	(0.252)	0.154	(0.256)	0.184	(0.270)
Union members (%)	0.006	(0.005)	0.006	(0.005)	−0.002	(0.005)	−0.005	(0.005)	−0.007	(0.006)	−0.010[a]	(0.007)
Labor costs (%)	0.006[b]	(0.003)	0.007[b]	(0.003)	0.007[b]	(0.004)	0.002	(0.004)	0.006	(0.004)	0.005	(0.004)
Permanent workers (%)	0.001	(0.002)	−0.001	(0.002)	0.000	(0.002)	−0.004[b]	(0.002)	−0.005[c]	(0.002)	−0.003[b]	(0.002)
Number of observations	1,266		1,163		1,283		1,266		1,163		1,283	
Pseudo R^2	0.023		0.020		0.027		0.022		0.023		0.017	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the likelihood, ranging from 1 to 4, where 1=not at all, 2 = not likely, 3 = likely and 4 = very likely.

The results for the alternative of *reducing base wages* are also reported in table 2. For all occupational positions, we found the likelihood of reducing base wages decreases as the share of employees on permanent contract increases, which suggests these workers have more bargaining power. In the particular case of managers, firms located in Bogotá are less likely to reduce wages than in other cities of the country and firms in other services and electricity, gas, water and mining, the probability of reducing wages is higher than in the commercial sector. For technicians, assistants and unskilled workers, the likelihood of reducing wages declines as the percentage of union member's increases, suggesting that collective agreements are one of the main reasons for wage rigidity in this occupational group.

We also examined what kind of firm is more prone to increase wages at a rate less than that of inflation. In general, the results show that the probability of using this alternative decreases as the share of labor costs increases, suggesting the presence of DRWR is more likely in firms that are less labor intensive. At the sector level, firms belonging in the *other services* sector are more likely to increase wages below the inflation rate.

4. REASONS PREVENTING WAGE CUTS

In this section, we analyze the reasons why firms do not reduce base wages in difficult times and test different theories of wage rigidity. In particular, the contract theory states that companies and their employees sign long-term agreements so wages are fixed in advance, the idea being to maintain a stable real wage throughout the business cycle (Baily, 1974; Azariadis, 1975; Taylor, 1979). With the insider-outsider theory, companies are reluctant to fire their employees (insiders) and to hire unemployed workers (outsiders) at lower wages, because of the cost involved in hiring and training new workers. In addition, insiders can refuse to cooperate with new incoming employees. This increases the possibility of reducing the firm's productivity, giving insiders power to negotiate their wages (Lindbeck and Snower, 2001).

According to the efficiency wage theory, workers' productivity is a function of their wages. This theory has several versions, including the shirking model, the adverse selection model, the labor turnover model, the gift exchange model and the fair wage-effort hypothesis. With the shirking model, the cost of losing a job depends positively on the wage

(Shapiro and Stiglitz, 1984); with the adverse selection model, the most productive workers are the most likely to resign in the event of a wage reduction (Weiss, 1990); with the labor turnover model, workers' resignation rates depend negatively on the wage rate (Stiglitz 1974); with the gift exchange model, the loyalty of workers is directly related to their salary, and this loyalty leads to higher productivity (Akerlof 1982, 1984); and with the fair wage-effort hypothesis, workers' effort declines if the salary they receive is below what they perceive as a fair wage (Akerlof and Yellen, 1990).

In simple and nontechnical language, the respondents were presented with a number of reasons associated with the theories mentioned above, which explain why firms do not reduce wages (table 3). We asked the interviewees to indicate the importance of each reason based on a scale of 1 to 4, where 1 is *not important* and 4 is *very important*. The average scores obtained were ordered and t statistics were calculated for each option to test whether the mean differences between contiguous alternatives were statistically significant. In all cases, the results show the null hypothesis of equal

TABLE 3. THEORIES ASSOCIATED TO WAGE RIGIDITY

Proposed reasons	*Associated theory*
To prevent the loss of the most productive and more experienced workers	Efficiency wages (adverse selection, Weiss, 1990)
Do not affect employee's motivation	Efficiency wages (fair wage-effort hypothesis, gift exchange, Akerlof, G. A., 1984; Akerlof and Yellen, 1990)
Do not affect workers' efforts and productivity	Efficiency wages (shirking, fair wage-effort hypothesis, gift exchange, Shapiro and Stiglitz, 1984; Akerlof, G. A., 1984; Akerlof and Yellen, 1990)
Previous agreements between employees and employers	Contracts theory (Taylor, 1979; Baily; 1974; Azariadis, 1975)
Minimize costs of labor turnover	Efficiency wages (minimize turnover, Stiglitz, 1974)
Do not affect relative wages in relation to competition (outside the firm)	Keynesian theory
Legal restrictions	Contract theory (Taylor, 1979; Baily; 1974; Azariadis, 1975)
Collective agreements	Insider-outsider (insider-outsider, Lindbeck and Snower, 2001).

SOURCE: Iregui et al. (2009b).

average scores for contiguous actions is rejected, with a confidence level of 99 percent.[15]

Table 4 reports the mean scores for all occupational groups, as well as the response rates *not important / of minor importance* and *moderately important / very important* for the different reasons preventing wage cuts. The alternative with the highest mean score was *to prevent the loss of the most productive and experienced workers*. This reason receives the highest response rate as the most important explanation for not cutting wages paid to managers and professionals. This reason is related to the efficiency wage theory, specifically to the adverse selection model. Similar results were found by Campbell and Kamlani (1997) for the United States, Zoega and Karlsson (2006) for Iceland, Martins (2009) for Portugal and Copaciu et al. (2010) for Romania.

The survey also found that *do not affect worker's effort and productivity* and *do not affect worker's motivation* are *very important* reasons for not reducing base wages. These alternatives also are related to the efficiency wage theory, particularly to the shirking model, the gift exchange model and the fair wage-effort hypothesis. Despite differences in the labor market institutions, our results are similar to those found for developed countries. For instance, Bewley (1995, 1999 and 2004) found, for the United States, that employers do not cut wages because of the effect doing so might have on workers' morale and motivation. Similar evidence was found by Blinder and Choi (1990) and Campbell and Kamlani (1997) for the United States, Kaufman (1984) for the United Kingdom, Agell and Bennmarker (2002, 2007) for Sweden, Franz and Pfeiffer (2003) for Germany, Kawaguchi and Ohtake (2008) for Japan, Martins (2009) for Portugal and the Wage Dynamics Network (European Central Bank, 2009, and Babecký et al., 2009a) for different European countries.

Another *important* reason mentioned by respondents for not cutting base wages is to *prevent the loss of the firm's reputation.* For technicians, assistants and unskilled workers, as opposed to managers and professionals, strong support was found for the existence of collective agreements, which might be associated to the *insider-outsider* theory.[16] Similarly, Franz and Pfeiffer (2003) found that labor union contracts explain wage rigidities for the less skilled workers in German firms. In Sweden, the high rate

[15] These results may be obtained from the authors upon request.

[16] The insider-outsider theory considers union members as insiders who show little concern for non-members (outsiders). These insiders have power when negotiating wages.

TABLE 4. IMPORTANCE OF THE FOLLOWING REASONS IN PREVENTING WAGE CUTS

	Managers			*Professionals*			*Technicians, assistants, and unskilled workers*		
Reasons	*Mean score*[a]	*Responses not important / of minor importance (%)*	*Responses moderately important / very important (%)*	*Mean score*[a]	*Responses not important / of minor importance (%)*	*Responses moderately important / very important (%)*	*Mean score*[a]	*Responses not important / of minor importance (%)*	*Responses moderately important / very important (%)*
Collective agreements	1.90(9)	69.9	30.4	2.22(8)	56.5	43.5	3.00(5)	27.2	72.8
Legal restrictions	2.03(8)	64.4	35.6	2.03(9)	64.8	35.2	2.08(9)	62.6	37.4
Previous agreements between employees and employers	2.51(5)	43.9	56.1	2.67(5)	35.3	64.7	2.70(6)	36.1	63.9
To prevent the loss of the firm's reputation	3.14(2)	22.0	78.0	3.13(4)	21.1	78.9	3.15(4)	21.2	78.8
Do not affect employee's motivation	3.01(3)	26.8	73.2	3.21(3)	16.9	83.1	3.30(3)	14.8	85.2
Do not affect workers' efforts and productivity	2.98(4)	27.2	72.8	3.22(2)	17.1	82.9	3.33(2)	14.4	85.6
Minimize costs of labor turnover	2.48(6)	45.0	55.0	2.60(6)	40.8	59.2	2.61(7)	39.7	60.3
To prevent the loss of the most productive and more experienced workers	3.16(1)	21.5	78.5	3.34(1)	14.0	86.0	3.35(1)	14.9	85.1
Do not affect relative wages in relation to competition (outside the firm)	2.28(7)	53.2	46.8	2.28(7)	51.7	48.3	2.28(8)	54.2	45.8

SOURCE: Authors' calculations.

NOTE: The numbers in parentheses correspond to the order obtained by each action.

[a] Average scores based on the following scale: 1 = not important, 2 = of minor importance, 3 = moderately important, 4 = very important.

of unionization explains the wage rigidity in all positions (Agell and Bennmarker, 2002, 2007).[17] In Colombia, when firms are classified by payroll size, this option receives more support in large firms than in small ones, possibly because of the fact that collective agreements are more prevalent in larger firms.[18] Across sectors, this option obtains the highest response rates in electricity, gas, water and mining and manufacturing, where the number of firms with collective agreements (26.1% and 19.6% respectively) is above average (9.3%).

Other reasons receive less support in explaining why firms do not cut wages. Moderate support was found for *minimize costs of labor turnover*, especially in large firms and in the *other services* sector. However, in the construction sector this option obtains the lowest response rate among all sectors, possibly because of an excess of labor supply in this sector. As mentioned by Campbell and Kamlani (1997) and Agell and Bennmarker (2002), firms do not reduce wages to avoid an increase in the number of resignations. According to our survey, a better wage offer is one of the main reasons why workers resign, which might indicate that firms perceive the risk of voluntary turnover as a wage-policy constraint.

Then, we controlled for factors that might explain wage rigidities in the country by estimating ordered *logit* models. The dependent variable takes values from 1 to 4, where 1 = *not important*, 2 = *of minor importance*, 3 = *moderately important*, and 4 = *very important*. As before, we used the same set of benchmark regressors and kept four categories for the dependent variable in all the models, since the threshold parameters are statistically different from one another.

The results for the reason rated as the most important for not cutting wages, namely to *prevent the loss of the most productive and more experienced workers* are reported in table 5. In the case of managers, the main findings indicate the size of the firm; its geographic location and the sector where it operates affect the probability of rating this reason as important. In particular, greater support for the adverse selection model is found among larger firms and those operating in the *other services* sector. On the contrary, less support is found among firms located outside the nation's capital and those operating in construction, manufacturing, financial services

[17] In Sweden, the union density rate was 75.1% in 2006; in Germany, it was 14.6% (data available at ⟨http://stats.oecd.org/Index.aspx?DatasetCode=U_D_D⟩). In Colombia, this rate was 3.4% in 2007 (Guataquí et al., 2009).

[18] According to the results of our survey, 35% of the large firms have collective agreements as opposed to only 3% of the small firms.

and education and health, compared to the trade sector. For professionals, the probability of rating this reason as important is statistically significant only for firms involved in transport, storage and communications and *other services;* however, for technicians, assistants and unskilled workers, it is significant only for firms involved in transport, storage and communications.

TABLE 5. IMPORTANCE OF THE FOLLOWING REASONS IN PREVENTING WAGE CUTS (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

Explanatory variables / *Dependent variable and occupational groups*	*To prevent the loss of the most productive and more experienced workers*					
	Managers		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	0.091	(0.225)	0.307	(0.225)	0.026	(0.218)
Construction	–0.74[c]	(0.210)	–0.065	(0.216)	–0.171	(0.221)
Electricity, gas, water, mining	0.374	(0.282)	0.241	(0.289)	0.195	(0.282)
Manufacturing	–0.491[c]	(0.217)	0.140	(0.226)	0.207	(0.216)
Financial services	–0.829[c]	(0.293)	0.118	(0.347)	–0.043	(0.344)
Transport, storage and communications	–0.333[a]	(0.195)	0.586[c]	(0.213)	0.391[b]	(0.206)
Education and health	–0.458[a]	(0.260)	0.388	(0.283)	–0.060	(0.262)
Other services	0.444[c]	(0.191)	0.452[c]	(0.203)	0.033	(0.184)
Region	–0.729[c]	(0.132)	–0.190	(0.142)	–0.165	(0.138)
Log (No. of employees)	0.218[c]	(0.055)	0.066	(0.059)	–0.015	(0.056)
Skilled workers (%)	0.002	(0.003)	–0.001	(0.003)	–0.004	(0.003)
Minimum wage earners (%)	–0.002	(0.003)	–0.001	(0.003)	–0.003	(0.003)
Flexible benefits	0.069	(0.148)	0.145	(0.154)	0.196	(0.147)
Variable pay	0.175	(0.133)	0.215	(0.148)	0.159	(0.144)
Collective agreements	–0.086	(0.283)	–0.228	(0.299)	–0.380	(0.279)
Union members (%)	0.001	(0.006)	0.001	(0.007)	–0.001	(0.005)
Labor costs (%)	0.001	(0.004)	0.003	(0.004)	0.006	(0.004)
Permanent workers (%)	0.001	(0.002)	0.001	(0.002)	0.000	(0.002)
Number of observations	1,266		1,163		1,283	
Pseudo R^2	0.043		0.011		0.009	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the importance, ranging from 1 to 4, where 1 = not important, 2 = of minor importance, 3 = moderately important and 4 = very important.

For the alternatives *do not affect employee's motivation* and *do not affect worker's effort and productivity*, the results indicate the probability that the firms rate each of these reasons as important increases with the number of employees. Agell and Bennmarker (2007) point out that wage rigidity might be an issue in larger firms because of shirking, since it is more difficult for them to supervise workers' effort. In addition, the importance of these reasons increases for firms in the *other services* sector, which includes highly specialized activities that require a particular expertise.[19] On the contrary, the importance of these alternatives is less for firms located in Bogotá compared to the rest of the country. In the case of managers, the economic sector where the firm operates could significantly increase or decrease the probability of rating these two alternatives as important, compared to the commercial sector. For instance, the probability reduces for firms in construction, manufacturing and financial services, whereas it increases for firms involved in electricity, gas, water and mining (table 6).

Similarly, as can be seen in table 7, for the reasons *minimize costs of labor turnover* and *do not affect relative wages in relation to competition (outside the firm)*, the size of the firm, its location and economic sector are significant in explaining why firms rate these reasons as important in preventing wage cuts. It is worth mentioning that in order to evaluate the explanatory power of collective agreements as a reason for preventing wage cuts, an ordered *logit* model was also estimated (table 8). Only in the case of technicians, assistants and unskilled workers was the share of unionized workers found to be positive and highly significant; this is indicative of the bargaining power these workers might have. In addition, the results show that, for most sectors, the coefficients are negative and significant with respect to the commercial sector where union density is very low (according to our survey, only 2.2% of the firms in this sector have unions).

Regarding the reasons associated with the contract theory, *legal restrictions* and *previous agreements between employees and employers* (tables 8 and 9, respectively), the results show that firms located in Bogotá are more likely to consider these reasons as an explanation for wage rigidity. In the

[19] This sector includes activities such as software consultancy and supply; maintenance and repair of office; accounting and computing machinery; research and experimental development in natural sciences, engineering, social sciences and humanities; legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy; and advertising, among other activities.

particular case of previous agreements, the coefficient of the share of employees who have a permanent contract is negative and highly significant. As suggested by Agell and Benmarker (2007), the bargaining power of these workers might increase as the share of employees with more secure jobs increases.

Finally, another reason for avoiding wage reductions was *to prevent the loss of the firm's reputation*. This reason is important for firms in *other services* and transport, storage and communications, because these sectors might employ specialized workers and firms do not want their wage policy to be a deterrent for future employees (table 9).

4. 1. Complementarity among Theories on Wage Rigidities

Summers (1988) and Agell and Bennmarker (2007) point out that different sources of wage rigidity can operate at the same time, reinforcing one another. To explore the possible interaction between different theories, we computed Spearman rank correlations between the reasons for preventing wage cuts (table 10).

The results show the reasons associated with the efficiency wage theory are highly correlated for all occupational groups. Specifically, in all cases, the highest observed correlation is between *do not affect employee's motivation* and *do not affect worker's effort and productivity*. The former also is highly correlated with the reasons *prevent the loss of the most productive and more experienced workers* and *minimize costs of labor turnover*, which could indicate that firms prefer to keep their employees motivated, so as to avoid losing their most valuable workers and incurring the cost to train new workers. It is also worth mentioning that the presence of collective agreements is highly correlated with the reasons associated with the contract theory, given the bargaining power unions have to set long term contracts between firms and workers.

5. FIRMS' OTHER RESPONSES TO AN ECONOMIC SLOWDOWN

Besides considering changes in base wages, we examined other alternatives firms could use to adjust labor costs during a period of economic slowdown. According to Babecký et al. (2009b) and Fabiani et al. (2010), the use of alternative strategies has gained importance due to the existence of wage rigidities that make it difficult to cut wages to adjust the labor

TABLE 6. IMPORTANCE OF THE FOLLOWING REASONS IN PREVENTING WAGE CUTS (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

Explanatory variables / *Dependent variable and occupational groups*	*Do not affect employee's motivation*						*Do not affect workers' efforts and productivity*					
	Managers		*Professionals*		*Technicians, assistants and unskilled workers*		*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	0.045	(0.228)	0.160	(0.224)	–0.176	(0.209)	–0.175	(0.224)	0.078	(0.223)	–0.068	(0.218)
Construction	-0.717^{c}	(0.227)	–0.076	(0.221)	–0.176	(0.218)	-0.818^{c}	(0.234)	0.028	(0.214)	–0.127	(0.216)
Electricity, gas, water, mining	0.466^{b}	(0.259)	0.149	(0.269)	–0.010	(0.273)	0.447^{a}	(0.252)	0.181	(0.266)	0.156	(0.282)
Manufacturing	-0.701^{c}	(0.196)	–0.213	(0.221)	–0.235	(0.213)	-0.779^{c}	(0.193)	0.048	(0.221)	–0.128	(0.207)
Financial services	-0.906^{c}	(0.308)	–0.315	(0.337)	–0.338	(0.334)	-1.088^{c}	(0.304)	–0.170	(0.350)	–0.263	(0.360)
Transport, storage and communications	0.090	(0.196)	0.677^{c}	(0.209)	0.501^{c}	(0.198)	–0.117	(0.193)	0.810^{c}	(0.208)	0.595^{c}	(0.209)
Education and health	–0.337	(0.271)	–0.082	(0.266)	–0.185	(0.257)	–0.178	(0.287)	0.047	(0.286)	–0.211	(0.264)
Other services	0.981^{c}	(0.192)	0.582^{c}	(0.197)	0.093	(0.185)	0.889^{c}	(0.191)	0.585^{c}	(0.192)	0.190	(0.187)
Region	-0.908^{c}	(0.136)	-0.399^{c}	(0.139)	-0.284^{b}	(0.135)	-1.025^{c}	(0.135)	-0.379^{c}	(0.140)	-0.328^{c}	(0.140)

Log (No. of employees)	0.211[c]	(0.056)	0.153[c]	(0.054)	0.084[a]	(0.053)	0.220[c]	(0.055)	0.155[c]	(0.056)	0.091[a]	(0.054)
Skilled workers (%)	0.003	(0.003)	0.004	(0.003)	0.001	(0.003)	0.001	(0.003)	0.003	(0.003)	0.000	(0.003)
Minimum wage earners (%)	0.000	(0.003)	0.000	(0.003)	–0.001	(0.003)	0.001	(0.003)	0.000	(0.003)	–0.001	(0.003)
Flexible benefits	–0.052	(0.143)	0.019	(0.144)	0.055	(0.141)	–0.042	(0.141)	0.187	(0.146)	0.107	(0.144)
Variable pay	0.297[b]	(0.134)	0.180	(0.144)	0.207	(0.137)	0.167	(0.130)	0.089	(0.142)	0.063	(0.138)
Collective agreements	0.190	(0.257)	–0.032	(0.238)	0.057	(0.237)	0.221	(0.276)	–0.091	(0.253)	–0.184	(0.243)
Union members (%)	–0.002	(0.007)	0.002	(0.006)	–0.001	(0.005)	–0.002	(0.006)	–0.003	(0.006)	–0.005	(0.006)
Labor costs (%)	–0.006[a]	(0.003)	–0.001	(0.004)	0.000	(0.004)	–0.007[b]	(0.003)	–0.002	(0.004)	0.002	(0.004)
Permanent workers (%)	0.002	(0.002)	0.003[b]	(0.002)	0.001	(0.002)	0.003[b]	(0.002)	0.004[b]	(0.002)	0.002	(0.002)
Number of observations	1,266		1,163		1,283		1,266		1,163		1,283	
Pseudo R^2	0.062		0.020		0.011		0.068		0.019		0.012	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the importance, ranging from 1 to 4, where 1 = not important, 2 = of minor importance, 3 = moderately important and 4 = very important.

TABLE 7. IMPORTANCE OF THE FOLLOWING REASONS IN PREVENTING WAGE CUTS (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

Dependent variable and occupational groups / *Explanatory variables*	*Minimize costs of labor turnover*						*Do not affect relative wages in relation to competition (outside the firm)*					
	Managers		*Professionals*		*Technicians, assistants and unskilled workers*		*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	–0.239	(0.225)	–0.258	(0.245)	–0.455[b]	(0.229)	–0.201	(0.234)	–0.062	(0.250)	–0.202	(0.227)
Construction	–0.820[c]	(0.209)	–0.711[c]	(0.205)	–0.519[c]	(0.199)	–0.415[b]	(0.204)	–0.232	(0.201)	–0.125	(0.191)
Electricity, gas, water, mining	0.194	(0.266)	–0.110	(0.286)	–0.041	(0.276)	0.381	(0.253)	0.244	(0.269)	0.336	(0.243)
Manufacturing	–0.889[c]	(0.193)	–0.598[c]	(0.202)	–0.471[c]	(0.194)	–0.716[c]	(0.189)	–0.558[c]	(0.200)	–0.461[c]	(0.191)
Financial services	–1.009[c]	(0.347)	–0.870[c]	(0.308)	–0.728[c]	(0.282)	–0.983[c]	(0.353)	–1.120[c]	(0.333)	–0.881[c]	(0.341)
Transport, storage and communications	–0.496[c]	(0.184)	–0.144	(0.189)	0.011	(0.179)	–0.516[c]	(0.190)	–0.474[c]	(0.208)	–0.324[a]	(0.193)
Education and health	–0.188	(0.273)	–0.072	(0.270)	–0.052	(0.256)	–0.136	(0.241)	–0.154	(0.234)	0.062	(0.226)
Other services	0.753[c]	(0.184)	0.574[c]	(0.195)	0.442[c]	(0.184)	0.517[c]	(0.192)	0.461[c]	(0.197)	0.616[c]	(0.184)
Region	–0.718[c]	(0.133)	–0.488[c]	(0.141)	–0.321[c]	(0.132)	–0.765[c]	(0.129)	–0.715[c]	(0.135)	–0.676[c]	(0.126)

Log (No. of employees)	0.185[c]	(0.052)	0.159[c]	(0.053)	0.120[c]	(0.047)	0.227[c]	(0.057)	0.237[c]	(0.055)	0.134[c]	(0.050)
Skilled workers (%)	0.001	(0.003)	0.001	(0.003)	0.000	(0.003)	0.003	(0.003)	0.004	(0.003)	–0.001	(0.003)
Minimum wage earners (%)	0.001	(0.002)	0.002	(0.003)	0.001	(0.002)	–0.001	(0.002)	0.000	(0.003)	–0.004	(0.002)
Flexible benefits	0.061	(0.139)	0.158	(0.144)	0.176	(0.138)	–0.105	(0.130)	–0.125	(0.139)	–0.109	(0.130)
Variable pay	0.178	(0.132)	0.132	(0.138)	0.087	(0.130)	0.170	(0.137)	0.141	(0.140)	0.076	(0.131)
Collective agreements	0.189	(0.266)	–0.028	(0.271)	–0.148	(0.260)	0.291	(0.222)	0.218	(0.236)	0.317	(0.223)
Union members (%)	0.002	(0.006)	0.005	(0.006)	0.006	(0.006)	0.001	(0.005)	0.002	(0.005)	0.001	(0.005)
Labor costs (%)	–0.006	(0.004)	–0.003	(0.004)	–0.001	(0.004)	0.003	(0.004)	0.002	(0.004)	0.002	(0.004)
Permanent workers (%)	–0.001	(0.002)	–0.001	(0.002)	–0.001	(0.002)	0.002	(0.002)	0.002	(0.002)	0.001	(0.002)
Number of observations	1,266		1,163		1,283		1,266		1,163		1,283	
Pseudo R^2	0.055		0.036		0.024		0.048		0.043		0.034	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the importance, ranging from 1 to 4, where 1 = not important, 2 = of minor importance, 3 = moderately important and 4 = very important.

TABLE 8. IMPORTANCE OF THE FOLLOWING REASONS IN PREVENTING WAGE CUTS (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

Dependent variable and occupational groups / *Explanatory variables*	*Collective agreements*						*Legal restrictions*					
	Managers		*Professionals*		*Technicians, assistants and unskilled workers*		*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	–0.898	(0.784)	–1.800[c]	(0.731)	–1.638[c]	(0.709)	–0.188	(0.222)	–0.191	(0.236)	0.011	(0.220)
Construction	–0.573	(0.952)	–2.302	(0.788)	–2.080	(1.365)	–0.829[c]	(0.221)	–0.817[c]	(0.222)	–0.790[c]	(0.215)
Electricity, gas, water, mining	–1.217	(0.863)	–1.116[c]	(0.788)	–0.008	(0.800)	–0.101	(0.236)	–0.192	(0.245)	–0.162	(0.236)
Manufacturing	–1.065[a]	(0.684)	–1.530[c]	(0.598)	–1.201[b]	(0.586)	–0.931[c]	(0.194)	–0.933[c]	(0.201)	–0.787[c]	(0.189)
Financial services	–0.989	(0.947)	–1.695[b]	(0.799)	–1.539[b]	(0.820)	–0.839[c]	(0.349)	–1.014[c]	(0.353)	–0.951[c]	(0.333)
Transport, storage and communications	–1.325[a]	(0.797)	–1.695[c]	(0.690)	–1.870[c]	(0.753)	–0.522[c]	(0.196)	–0.682[c]	(0.210)	–0.442[c]	(0.191)
Education and health	0.307	(0.999)	–0.142	(0.981)	–1.716[a]	(1.067)	–0.262	(0.283)	–0.366	(0.295)	–0.375	(0.273)
Other services	–0.944	(0.863)	–2.341[c]	(0.756)	–2.180[c]	(0.843)	–0.090	(0.190)	–0.189	(0.205)	–0.292	(0.193)
Region	–0.749[b]	(0.407)	–0.154	(0.386)	–0.605[a]	(0.372)	–0.678[c]	(0.130)	–0.633[c]	(0.134)	–0.652[c]	(0.124)

Log (No. of employees)	−0.393[c]	(0.155)	−0.240	(0.173)	0.410[c]	(0.180)	0.060	(0.055)	0.085	(0.057)	0.043	(0.052)
Skilled workers (%)	−0.021[a]	(0.013)	−0.024[b]	(0.012)	−0.009	(0.012)	0.001	(0.003)	0.000	(0.003)	0.002	(0.003)
Minimum wage earners (%)	0.002	(0.007)	−0.009	(0.006)	−0.005	(0.006)	−0.002	(0.002)	−0.001	(0.003)	−0.001	(0.002)
Flexible benefits	0.310	(0.429)	0.369	(0.399)	−0.398	(0.415)	0.110	(0.138)	0.141	(0.144)	0.139	(0.139)
Variable pay	−0.129	(0.392)	−0.344	(0.479)	−0.109	(0.398)	0.232[a]	(0.140)	0.172	(0.147)	0.183	(0.135)
Collective agreements							0.313	(0.224)	0.350	(0.229)	0.392[a]	(0.231)
Union members (%)	−0.005	(0.006)	0.002	(0.005)	0.014[c]	(0.005)	0.004	(0.004)	0.003	(0.004)	0.003	(0.004)
Labor costs (%)	0.001	(0.008)	−0.001	(0.009)	−0.003	(0.010)	0.000	(0.004)	−0.001	(0.004)	−0.001	(0.004)
Permanent workers (%)	0.003	(0.006)	0.004	(0.006)	0.000	(0.005)	−0.002	(0.002)	−0.002	(0.002)	0.000	(0.002)
Number of observations	182		175		187		1,266		1,163		1,283	
Pseudo R^2	0.079		0.064		0.110		0.035		0.035		0.031	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the importance, ranging from 1 to 4, where 1 = not important, 2 = of minor importance, 3 = moderately important and 4 = very important.

TABLE 9. IMPORTANCE OF THE FOLLOWING REASONS IN PREVENTING WAGE CUTS (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

Dependent variable and occupational groups / *Explanatory variables*	*Previous agreements between employees and employers*						*To prevent the loss of the firm's reputation*					
	Managers		*Professionals*		*Technicians, assistants and unskilled workers*		*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	−0.178	(0.233)	−0.238	(0.231)	−0.154	(0.201)	−0.001	(0.237)	0.085	(0.240)	−0.289	(0.222)
Construction	−0.748^{c}	(0.208)	−0.327^{a}	(0.210)	−0.296	(0.207)	−0.076	(0.230)	0.000	(0.234)	0.058	(0.224)
Electricity, gas, water, mining	−0.073	(0.257)	−0.596^{b}	(0.270)	−0.499^{b}	(0.264)	0.129	(0.249)	0.026	(0.251)	0.051	(0.231)
Manufacturing	−0.650^{c}	(0.189)	−0.218	(0.211)	−0.206	(0.206)	−0.085	(0.203)	−0.141	(0.215)	−0.126	(0.208)
Financial services	−0.298	(0.265)	0.155	(0.274)	0.361	(0.280)	0.204	(0.315)	0.083	(0.340)	−0.051	(0.302)
Transport, storage and communications	−0.241	(0.194)	0.476^{c}	(0.213)	0.394^{b}	(0.186)	0.503^{c}	(0.195)	0.550^{c}	(0.209)	0.488^{c}	(0.193)
Education and health	−0.057	(0.266)	0.025	(0.257)	−0.071	(0.234)	0.330	(0.264)	0.449^{a}	(0.272)	0.284	(0.261)
Other services	0.505^{c}	(0.191)	0.186	(0.191)	−0.104	(0.180)	0.578^{c}	(0.180)	0.528^{c}	(0.186)	0.336^{b}	(0.181)
Region	−0.830^{c}	(0.133)	−0.299^{c}	(0.133)	−0.163	(0.120)	−0.173	(0.133)	−0.133	(0.138)	−0.074	(0.130)

Log (No. of employees)	0.007	(0.052)	−0.064	(0.050)	-0.099^{b}	(0.049)	−0.055	(0.050)	−0.037	(0.054)	−0.025	(0.049)
Skilled workers (%)	−0.001	(0.003)	0.000	(0.003)	−0.001	(0.003)	−0.001	(0.003)	0.000	(0.003)	−0.001	(0.003)
Minimum wage earners (%)	0.001	(0.002)	0.001	(0.002)	−0.003	(0.002)	0.000	(0.002)	0.002	(0.003)	0.000	(0.002)
Flexible benefits	0.156	(0.134)	0.227^{a}	(0.141)	0.228^{a}	(0.138)	0.162	(0.131)	0.223^{a}	(0.140)	0.204	(0.136)
Variable pay	0.092	(0.131)	0.040	(0.140)	−0.018	(0.133)	−0.067	(0.136)	−0.053	(0.148)	−0.037	(0.134)
Collective agreements	0.343^{a}	(0.212)	0.107	(0.224)	0.304	(0.229)	−0.103	(0.234)	−0.166	(0.239)	−0.017	(0.232)
Union members (%)	0.005	(0.006)	0.009^{a}	(0.005)	0.014^{c}	(0.005)	−0.001	(0.005)	0.000	(0.005)	−0.002	(0.004)
Labor costs (%)	−0.002	(0.003)	0.005	(0.004)	0.002	(0.003)	0.002	(0.004)	0.001	(0.004)	0.002	(0.004)
Permanent workers (%)	-0.004^{c}	(0.002)	-0.004^{c}	(0.002)	−0.002	(0.002)	−0.002	(0.002)	-0.003^{a}	(0.002)	-0.003^{a}	(0.002)
Number of observations	1,266		1,163		1,283		1,266		1,163		1,283	
Pseudo R^2	0.040		0.014		0.015		0.011		0.013		0.009	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the importance, ranging from 1 to 4, where 1 = not important, 2 = of minor importance, 3 = moderately important and 4 = very important.

TABLE 10. SPEARMAN RANK CORRELATIONS BETWEEN REASONS FOR PREVENTING WAGE CUTS

Reasons	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
A. Managers									
Legal restrictions (1)	1.000								
Previous agreements between employees and employers (2)	0.377[a]	1.000							
To prevent the loss of the firm's reputation (3)	0.092[a]	0.298[a]	1.000						
Do not affect employee's motivation (4)	0.239[a]	0.363[a]	0.398[a]	1.000					
Do not affect workers' efforts and productivity (5)	0.265[a]	0.381[a]	0.356[a]	0.818[a]	1.000				
Minimize costs of labor turnover (6)	0.349[a]	0.371[a]	0.222[a]	0.497[a]	0.553[a]	1.000			
To prevent the loss of the most productive and more experienced workers (7)	0.215[a]	0.350[a]	0.327[a]	0.619[a]	0.608[a]	0.473[a]	1.000		
Do not affect relative wages in relation to competition (outside the firm) (8)	0.303[a]	0.365[a]	0.207[a]	0.401[a]	0.420[a]	0.530[a]	0.394[a]	1.000	
Collective agreements (9)	0.255[a]	0.337[a]	0.062	–0.060	0.048	0.018	–0.010	0.057	1.000
B. Professionals									
Legal restrictions (1)	1.000								
Previous agreements between employees and employers (2)	0.229[a]	1.000							
To prevent the loss of the firm's reputation (3)	0.048	0.399[a]	1.000						
Do not affect employee's motivation (4)	0.069	0.256[a]	0.524[a]	1.000					

Do not affect workers' efforts and productivity (5)	0.064	0.323[a]	0.517[a]	0.773[a]	1.000				
Minimize costs of labor turnover (6)	0.299[a]	0.236[a]	0.281[a]	0.360[a]	0.371[a]	1.000			
To prevent the loss of the most productive and more experienced workers (7)	0.023	0.311[a]	0.468[a]	0.563[a]	0.567[a]	0.332[a]	1.000		
Do not affect relative wages in relation to competition (outside the firm) (8)	0.300[a]	0.188[a]	0.197[a]	0.230[a]	0.224[a]	0.454[a]	0.213[a]	1.000	
Collective agreements (9)	0.354[a]	0.337[a]	0.107	–0.013	0.048	0.032	0.097	0.011	1.000
C. Technicians, assistants, and unskilled workers									
Legal restrictions (1)	1.000								
Previous agreements between employees and employers (2)	0.134[a]	1.000							
To prevent the loss of the firm's reputation (3)	–0.028	0.382[a]	1.000						
Do not affect employee's motivation (4)	–0.019	0.266[a]	0.577[a]	1.000					
Do not affect workers' efforts and productivity (5)	0.007	0.303[a]	0.566[a]	0.759[a]	1.000				
Minimize costs of labor turnover (6)	0.152[a]	0.185[a]	0.330[a]	0.316[a]	0.310[a]	1.000			
To prevent the loss of the most productive and more experienced workers (7)	–0.013	0.304[a]	0.484[a]	0.558[a]	0.601[a]	0.329[a]	1.000		
Do not affect relative wages in relation to competition (outside the firm) (8)	0.184[a]	0.114[a]	0.220[a]	0.209[a]	0.192[a]	0.431[a]	0.211[a]	1.000	
Collective agreements (9)	0.364[a]	0.310[a]	–0.087	0.018	0.036	0.040	0.085	0.036	1.000

SOURCE: Authors' calculations.

NOTE: [a] Denotes statistical significance at 1%. In panel a, the number of observations is 1,267, except for action (9), where the number 183. In panel b, the number of observations is 1,164, except for action (9), where de number is 176. In panel c, the number of observations 1,284, except for action (9), where the number of observations is 188.

market. In particular, we included options related to remuneration for employees, other than base wages, and the firm's personnel. The former includes the reduction of variable pay and non-statutory benefits,[20] while the latter considers changes in the type of employment contract, laying off employees, hiring of workers at lower wages and not hiring anyone (table 11).

The survey shows that, in all cases, around 30% of the firms consider the option of *reducing non-statutory benefits* and *reducing variable pay* as *likely / very likely*. The option of *laying off employees* is more common in the case of technicians, assistants and unskilled workers than in the case of managers and professionals, which suggests that firms are more reluctant to fire more skilled workers.[21] According to our survey, firms that found it difficult to fill vacancies argued the main reason was the lack of candidates with the required profile, especially in the case of managers.

The alternative of a *change the type of employment contract* is also *likely / very likely* for about 30% of the firms. At the sector level, in agriculture, forestry and fishing the options of *hiring new workers at lower wages* and *laying off employees* have higher response rates for *not at all / not likely* than the other sectors with respect to professionals and technicians, assistants and unskilled workers. In the construction sector, the alternative of *reducing variable pay* has the highest response rates for *not at all / not likely*, in all occupations (83% on average). Lastly, in the case of agriculture, forestry and fishing, the alternative of *hiring new workers at lower wages* has the highest response rate for *not at all / not likely,* in all occupations (80% on average).

The strategies to adjust labor costs in a period of economic slowdown are not mutually exclusive and firms could use more than one option. To evaluate the link between the different alternatives, Spearman rank correlations were calculated for the pairing of the different strategies (table 12). As expected, *laying off employees* and *hiring new workers at lower wages* have one of the highest correlation coefficients for all occupational positions, suggesting that some firms could use turnover to adjust labor costs. Similarly, the strategy of *changing the type of employment contract* is highly correlated with the options of *laying off employees* and *hiring new workers at lower wages,* which might indicate that firms could deal with a difficult economic situation by recruiting workers under a different type of contract and at

[20] Non-statutory benefits are determined either by collective agreements or set at the discretion of the employer.

[21] In fact, the mean score obtained with respect to this strategy is the highest for professionals and technicians, assistants and unskilled workers.

TABLE 11. HOW LIKELY IS YOUR FIRM TO CARRY OUT THE FOLLOWING ACTIONS?

Occupational group	*Change the type of employment contract*	*Do not hire anyone*	*Lay off employees*	*Hire new workers at lower wages*	*Reduce non–statutory benefits*	*Reduce variable pay*	*Do nothing*
Managers							
Mean score[a]	1.64	2.18	1.93	1.83	1.84	1.90	2.00
Responses (%)							
Not at all / not likely	81.2	58.2	70.8	73.6	70.5	68.9	78.6
Likely / very likely	18.8	41.8	29.2	26.4	29.5	31.1	21.4
Professionals							
Mean score[a]	1.86	2.21	2.20	2.14	1.82	1.90	1.76
Responses (%)							
Not at all / not likely	72.2	56.6	59.6	59.3	70.5	71.0	87.7
Likely / very likely	27.8	43.4	40.4	40.7	29.5	29.0	12.3
Technicians, assistants, and unskilled workers							
Mean score[a]	1.93	2.08	2.34	2.14	1.75	1.90	1.77
Responses (%)							
Not at all / not likely	68.8	63.3	53.4	60.9	74.0	73.0	87.0
Likely / very likely	31.2	36.7	46.6	39.1	26.0	27.0	13.0

SOURCE: Authors' calculations.
[a] Average score based on the following scale: 1 = not at all, 2 = not likely, 3 = likely, 4 = very likely.

a lower wage. Another pair with high correlations is *reducing non-statutory benefits* and *reducing variable pay*. Similar results for Europe were obtained by Babecký et al. (2009b), who emphasized the complementary nature of these two strategies.

TABLE 12. SPEARMAN RANK CORRELATIONS BETWEEN STRATEGIES TO FACE A SLOWDOWN IN ECONOMIC ACTIVITY

Actions	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
A. Managers						
Change the type of employment contract (1)	1.000					
Do not hire anyone (2)	0.277[a]	1.000				
Lay off employees (3)	0.418[a]	0.427[a]	1.000[a]			
Hire new workers at lower wages (4)	0.425[a]	0.313[a]	0.491[a]	1.000		
Reduce non-statutory benefits (5)	0.318[a]	0.320[a]	0.317[a]	0.336[a]	1.000	
Reduce variable pay (6)	0.307[a]	0.286[a]	0.292[a]	0.315[a]	0.458[a]	1.000
B. Professionals						
Change the type of employment contract (1)	1.000					
Do not hire anyone (2)	0.094[a]	1.000				
Lay off employees (3)	0.376[a]	0.306[a]	1.000			
Hire new workers at lower wages (4)	0.418[a]	0.104[a]	0.432[a]	1.000		
Reduce non-statutory benefits (5)	0.144[a]	0.303[a]	0.153[a]	0.134[a]	1.000	
Reduce variable pay (6)	0.247[a]	0.214[a]	0.177[a]	0.148[a]	0.456[a]	1.000
C. Technicians, assistants, and unskilled workers						
Change the type of employment contract (1)	1.000					
Do not hire anyone (2)	0.068	1.000				
Lay off employees (3)	0.346[a]	0.221[a]	1.000			
Hire new workers at lower wages (4)	0.423[a]	0.053	0.382[a]	1.000		
Reduce non-statutory benefits (5)	0.125[a]	0.305[a]	0.133[a]	0.146[a]	1.000	
Reduce variable pay (6)	0.179[a]	0.258[a]	0.170[a]	0.177[a]	0.470[a]	1.000

SOURCE: Authors' calculations.

NOTE: [a] All correlations are significant at the 1% level. In panel a, number of observations is 1,267, except for actions (5) and (6), where the number of observations are 947 and 678, respectively. In panel b, number of observations is 1,164, except for actions (5) and (6), where the number of observations are 874 and 622, respectively. In panel c, number of observations is 1,284, except for actions (5) and (6), where the number of observations are 955 and 673, respectively.

To analyze the determinants of the different strategies, ordered *logit* models were estimated using the same set of regressors as in the previous models. With regard to the likelihood of reducing non-statutory benefits, the results indicate that the probability of cutting them increases in firms with flexible benefits. On the contrary, the likelihood is lower in firms located in Bogotá and in firms operating in construction and financial services. In addition, the probability reduces as the percentage of workers with permanent contracts increases. As mentioned earlier, workers' bargaining power might increase as the share of employees with more protected jobs increases. The strategy of *reducing variable pay* is less likely in firms operating in construction, manufacturing and financial services, where our survey shows that variable pay is more widespread (nearly 75% of the firms use this type of remuneration) (table 13).

The next alternatives are related to the type of labor contract and changes in company personnel. Regarding a *change in the type of employment contracts*, in general, we find the likelihood of using this strategy decreases as the share of permanent workers and the size of the firm increase; this is also the case with the presence of collective agreements. On the contrary, the probability of changing employment contracts increases in firms with flexible benefits. Moreover, the results show the likelihood of *not hiring anyone* increases with the presence of collective agreements and with firm size. Conversely, the probability reduces with higher labor costs and in firms located in Bogotá. At the sector level, firms belonging to construction, manufacturing, financial services, and transport, storage and communications are less likely not to hire anyone (table 14).

The alternative of *laying off workers* is less likely in Bogotá and in firms in agriculture, forestry and fishing and more likely in firms with flexible benefits and those operating in transport, storage and communications. For technicians, assistants and unskilled workers, the presence of collective agreements reduces the probability of *laying off workers* (table 15).

The main determinants of the possibility of *hiring new workers at lower wages* differ among occupational groups. In the case of managers, the most important explanatory variables are labor intensity, the presence of variable pay and firm size. For professionals, the existence of flexible benefits, the location of the firm and the sector where the firm operates are the most significant determinants. Finally, for technicians, assistants and unskilled workers, the share of minimum wages earners and the share of employees on a permanent contract are significant explanatory factors, besides sector and location of the firm (table 15).

TABLE 13. HOW LIKELY IT IS FOR A FIRM TO REDUCE BENEFITS OR TO REDUCE VARIABLE PAY (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

Dependent variable and occupational groups / *Explanatory variables*	*Reduce non-statutory benefits*						*Reduce variable pay*					
	Managers		*Professionals*		*Technicians, assistants and unskilled workers*		*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	0.366	(0.277)	0.108	(0.292)	0.063	(0.251)	0.021	(0.336)	−0.197	(0.356)	−0.053	(0.312)
Construction	−0.544[b]	(0.284)	−0.507[a]	(0.292)	−0.701[c]	(0.266)	−0.469[a]	(0.293)	−0.863[c]	(0.315)	−0.779[c]	(0.304)
Electricity, gas, water, mining	0.184	(0.299)	−0.005	(0.296)	−0.011	(0.284)	0.325	(0.380)	0.346	(0.363)	0.324	(0.352)
Manufacturing	−0.122	(0.225)	−0.210	(0.243)	−0.137	(0.230)	−0.540[b]	(0.262)	−0.442[a]	(0.269)	−0.685[c]	(0.261)
Financial services	−1.052[b]	(0.461)	−0.885[b]	(0.428)	−1.128[c]	(0.482)	−0.793[b]	(0.421)	−1.237[c]	(0.438)	−1.140[c]	(0.405)
Transport, storage, communications	−0.147	(0.218)	−0.247	(0.225)	−0.216	(0.217)	−0.127	(0.264)	−0.206	(0.282)	0.061	(0.278)
Education and health	0.103	(0.301)	−0.008	(0.315)	−0.206	(0.308)	0.167	(0.430)	0.226	(0.433)	0.198	(0.436)
Other services	0.183	(0.231)	0.113	(0.243)	0.014	(0.233)	0.188	(0.236)	0.128	(0.252)	0.312	(0.260)
Region	−0.532[c]	(0.157)	−0.350[b]	(0.168)	−0.351[b]	(0.159)	−0.232	(0.179)	0.007	(0.183)	−0.081	(0.177)

Log (No. of employees)	0.058[a]	(0.057)	0.080	(0.062)	0.038	(0.056)	–0.070	(0.073)	–0.030	(0.070)	–0.029	(0.065)
Skilled workers (%)	0.002	(0.003)	0.002	(0.004)	0.001	(0.004)	0.002	(0.004)	0.001	(0.004)	–0.005	(0.004)
Minimum wage earners (%)	–0.002	(0.003)	–0.001	(0.003)	–0.006[b]	(0.003)	0.000	(0.003)	0.001	(0.004)	–0.004	(0.004)
Flexible benefits	0.519[c]	(0.152)	0.417[c]	(0.157)	0.272[b]	(0.150)	0.234	(0.172)	0.365[b]	(0.187)	0.239	(0.182)
Variable pay	0.272[a]	(0.161)	0.241	(0.168)	0.301[b]	(0.160)						
Collective agreements	0.194	(0.239)	0.108	(0.264)	–0.160	(0.263)	1.052[c]	(0.288)	0.566[b]	(0.323)	0.328	(0.323)
Union members (%)	–0.005	(0.005)	0.002	(0.005)	–0.002	(0.005)	–0.006	(0.007)	–0.004	(0.006)	–0.006	(0.007)
Labor costs (%)	–0.001	(0.005)	0.000	(0.005)	–0.002	(0.005)	–0.001	(0.004)	–0.001	(0.005)	–0.001	(0.005)
Permanent workers (%)	–0.003[a]	(0.002)	–0.004[a]	(0.002)	–0.002	(0.002)	–0.001	(0.002)	–0.003	(0.003)	0.001	(0.002)
Number of observations	946		873		954		677		621		672	
Pseudo R^2	0.039		0.028		0.028		0.024		0.028		0.029	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the likelihood, ranging from 1 to 4, where 1 = not at all, 2 = not likely, 3 = likely and 4 = very likely.

TABLE 14. HOW LIKELY IT IS FOR A FIRM TO CHANGE THE TYPE OF EMPLOYMENT CONTRACT OR NOT TO HIRE ANYONE (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

Dependent variable and occupational groups / *Explanatory variables*	*Change the type of employment contract*						*Not to hire anyone*					
	Managers		*Professionals*		*Technicians, assistants and unskilled workers*		*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	−0.311	(0.248)	-0.409^{a}	(0.251)	−0.334	(0.234)	−0.103	(0.218)	−0.096	(0.223)	-0.454^{b}	(0.226)
Construction	-0.570^{c}	(0.240)	0.054	(0.215)	−0.035	(0.206)	-0.455^{b}	(0.227)	-0.479^{b}	(0.230)	-0.559^{c}	(0.219)
Electricity, gas, water, mining	−0.001	(0.287)	−0.193	(0.319)	-0.473^{a}	(0.289)	0.181	(0.272)	−0.180	(0.280)	−0.048	(0.255)
Manufacturing	-0.374^{b}	(0.199)	0.304	(0.200)	0.208	(0.193)	-0.617^{c}	(0.193)	-0.729^{c}	(0.199)	-0.668^{c}	(0.198)
Financial services	−0.503	(0.350)	0.442	(0.309)	0.231	(0.308)	-0.603^{b}	(0.299)	-0.603^{b}	(0.303)	-0.703^{c}	(0.315)
Transport, storage, communications	−0.018	(0.200)	0.428^{b}	(0.214)	0.401^{b}	(0.195)	-0.516^{c}	(0.188)	-0.556^{c}	(0.204)	-0.449^{c}	(0.191)
Education and health	−0.018	(0.302)	0.327	(0.279)	0.200	(0.257)	−0.195	(0.285)	−0.388	(0.301)	-0.480^{a}	(0.276)
Other services	0.215	(0.186)	−0.053	(0.194)	-0.341^{b}	(0.188)	0.328^{a}	(0.185)	0.228	(0.195)	0.058	(0.178)
Region	-0.289^{b}	(0.136)	0.245^{a}	(0.136)	0.418^{c}	(0.127)	-0.400^{c}	(0.130)	-0.370^{c}	(0.136)	-0.248^{b}	(0.128)

Log (No. of employees)	−0.023	(0.054)	−0.140[c]	(0.051)	−0.109[c]	(0.047)	0.195[c]	(0.047)	0.175[c]	(0.050)	0.173[c]	(0.048)
Skilled workers (%)	0.000	(0.003)	−0.003	(0.003)	−0.002	(0.003)	0.004	(0.003)	0.004	(0.003)	0.006[b]	(0.003)
Minimum wage earners (%)	−0.001	(0.003)	0.000	(0.003)	0.001	(0.002)	0.001	(0.002)	0.002	(0.003)	0.000	(0.002)
Flexible benefits	0.228[a]	(0.140)	0.431[c]	(0.146)	0.297[b]	(0.144)	0.173[a]	(0.134)	0.115	(0.140)	0.083	(0.135)
Variable pay	0.198	(0.142)	−0.035	(0.145)	−0.061	(0.137)	0.202	(0.129)	0.201	(0.136)	−0.021	(0.129)
Collective agreements	−0.177	(0.265)	−0.416[a]	(0.268)	−0.436[a]	(0.255)	0.655[c]	(0.232)	0.636[c]	(0.227)	0.767[c]	(0.221)
Union members (%)	0.002	(0.005)	0.002	(0.004)	0.000	(0.005)	0.002	(0.005)	0.004	(0.005)	−0.003	(0.005)
Labor costs (%)	0.001	(0.005)	0.002	(0.004)	0.005	(0.003)	−0.008[c]	(0.003)	−0.008[c]	(0.003)	−0.007[c]	(0.003)
Permanent workers (%)	−0.006[c]	(0.002)	−0.005[c]	(0.002)	−0.002	(0.002)	0.000	(0.002)	0.000	(0.002)	0.001	(0.002)
Number of observations	1,266		1,163		1,283		1,266		1,163		1,283	
Pseudo R^2	0.021		0.017		0.016		0.036		0.033		0.025	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the likelihood, ranging from 1 to 4, where 1 = not at all, 2 = not likely, 3 = likely and 4 = very likely.

TABLE 15. HOW LIKELY IT IS FOR A FIRM TO LAY OFF EMPLOYEES OR TO HIRE NEW WORKERS AT LOWER WAGES (ORDERED *LOGIT* ESTIMATES, WEIGHTED)

Dependent variable and occupational groups / *Explanatory variables*	*Lay off employees*						*Hire new workers at lower wages*					
	Managers		*Professionals*		*Technicians, assistants and unskilled workers*		*Managers*		*Professionals*		*Technicians, assistants and unskilled workers*	
Agriculture, forestry, fishing	-0.424^{b}	(0.234)	-0.625^{c}	(0.239)	-0.456^{b}	(0.226)	–0.167	(0.236)	-0.508^{b}	(0.232)	-0.357^{a}	(0.215)
Construction	–0.128	(0.223)	0.288	(0.210)	0.225	(0.201)	–0.259	(0.225)	0.442^{b}	(0.216)	0.452^{b}	(0.208)
Electricity, gas, water, mining	0.135	(0.251)	–0.423	(0.279)	–0.360	(0.265)	0.292	(0.268)	0.224	(0.263)	–0.093	(0.255)
Manufacturing	-0.342^{a}	(0.193)	0.079	(0.192)	0.054	(0.186)	–0.273	(0.187)	0.366^{b}	(0.188)	0.518^{c}	(0.187)
Financial services	–0.446	(0.323)	0.119	(0.298)	0.095	(0.259)	-0.533^{a}	(0.347)	0.524	(0.366)	0.719^{b}	(0.335)
Transport, storage, communications	0.084	(0.194)	0.517^{c}	(0.205)	0.376^{b}	(0.199)	0.266	(0.193)	0.715^{c}	(0.202)	0.817^{c}	(0.190)
Education and health	–0.128	(0.272)	0.140	(0.270)	0.061	(0.255)	0.308	(0.272)	0.901^{c}	(0.273)	0.486^{b}	(0.233)
Other services	0.324^{b}	(0.173)	0.123	(0.180)	–0.103	(0.179)	0.565^{c}	(0.187)	0.312^{a}	(0.187)	0.181	(0.181)
Region	-0.635^{c}	(0.133)	-0.329^{c}	(0.136)	-0.246^{b}	(0.122)	–0.177	(0.129)	0.455^{c}	(0.136)	0.679^{c}	(0.122)

Log (No. of employees)	0.091[b]	(0.048)	−0.008	(0.050)	−0.033	(0.045)	0.146[c]	(0.052)	−0.026	(0.053)	−0.020	(0.044)
Skilled workers (%)	0.003	(0.003)	0.006[a]	(0.003)	0.002	(0.003)	−0.001	(0.003)	−0.003	(0.003)	−0.002	(0.003)
Minimum wage earners (%)	0.001	(0.002)	0.001	(0.003)	0.000	(0.003)	−0.002	(0.002)	−0.002	(0.003)	−0.007[c]	(0.002)
Flexible benefits	0.172	(0.141)	0.502[c]	(0.142)	0.417[c]	(0.136)	0.160	(0.134)	0.269[b]	(0.143)	0.179	(0.139)
Variable pay	0.215[a]	(0.137)	0.066	(0.140)	0.006	(0.128)	0.309[b]	(0.138)	0.238[a]	(0.148)	0.109	(0.137)
Collective agreements	−0.019	(0.226)	−0.176	(0.227)	−0.384[b]	(0.224)	0.377[a]	(0.227)	0.130	(0.244)	−0.081	(0.239)
Union members (%)	0.010[c]	(0.005)	0.008	(0.005)	0.008	(0.005)	−0.007[a]	(0.005)	−0.007	(0.005)	−0.006	(0.005)
Labour costs (%)	−0.001	(0.004)	0.001	(0.004)	−0.001	(0.003)	−0.009[b]	(0.004)	−0.004	(0.004)	−0.006[a]	(0.003)
Permanent workers (%)	−0.002	(0.002)	−0.003[a]	(0.002)	−0.002	(0.002)	−0.003[a]	(0.002)	−0.002	(0.002)	−0.003[b]	(0.002)
Number of observations	1,266		1,163		1,283		1,266		1,163		1,283	
Pseudo R^2	0.026		0.017		0.011		0.028		0.021		0.034	

SOURCE: Authors' calculations.

NOTES: Robust standard errors in parentheses. [a], [b] and [c] denote statistical significance at 10, 5 and 1 percent, respectively. The dependent variable increases with the likelihood, ranging from 1 to 4, where 1 = not at all, 2 = not likely, 3 = likely and 4 = very likely.

6. CONCLUSIONS

This paper uses data from a wage setting survey of 1,305 Colombian firms to explore the nature and source of wage rigidities. Our sample is fully representative of the population under study and includes nine economic sectors, three firm sizes and three occupational groups.

The survey provides evidence of nominal and real downward wage rigidities in Colombia. The results show that during difficult times firms would be more willing to freeze wages and to increase them below the inflation rate as opposed to cutting wages. The most important reasons why Colombian firms do not reduce wages during difficult times are to prevent the loss of the most productive and experienced workers, to not affect the worker's effort and productivity and to not affect the worker's motivation, all of which are associated with the efficiency wage theory. In summary, these results suggest downward wage rigidity in Colombia could be explained by the efficiency wage theory. It is worth mentioning that the reasons associated with the different versions of the efficiency wage theory are highly correlated.

Ordered *logit* regressions were used to determine what factors are related to wage rigidities. The findings indicate that permanent contracts impose more wage rigidity than other types of contracts, since workers are more protected by labor legislation. In addition, workforce composition and labor intensity play an important role in explaining of wage rigidities. For less skilled workers, the presence of collective agreements increases wage rigidity. Regarding the reasons preventing wage cuts, we found the sources of wage rigidity differ according to economic sector, firm location and firm size. For example, greater support for the adverse selection model and the shirking model is found among large firms and in those operating in the *other services* sector, which is comprised of specialized workers.

Survey evidence also suggests firms could use other alternatives to adjust costs in difficult times, since wage cuts are not usual. These alternatives include reducing non-statutory benefits and variable pay, laying off employees, changing the type of employment contract and hiring new workers at lower wages. The use of these strategies varies across economic sectors and occupational groups.

Finally, this paper contributes to a better understanding of wage rigidities and their sources at the firm level in Colombia. This is important for the monetary policy transmission process in a context of low inflation and high unemployment. In addition, the results help to improve the microfoundation of macroeconomic models used in monetary policy decisions.

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