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Nicoletta BERARDI
Banque de France

Erwan GAUTIER
Université de Bretagne Occidentale
Banque de France

Hervé LE BIHAN
Banque de France

Berardi: nicoletta.berardi@banque-france.fr
Gautier: erwan.gautier@univ-brest.fr
Le Bihan: herve.lebihan@banque-france.fr

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Résumé

A partir de données individuelles de prix couvrant la crise de 2008-2009, nous présentons des nouveaux faits sur la rigidité des prix en France: (i) chaque mois, 17% des prix sont modifiés contre 23% aux Etats-Unis. Quand les soldes sont exclus, seulement 14% des prix sont modifiés contre 15% aux Etats-Unis; (ii) la distribution des changements de prix présente une dispersion importante avec beaucoup de petits et de très grands changements de prix; (iii) les hausses de prix sont plus fréquentes en Janvier et Septembre même après avoir contrôlé par les soldes; (iv) les changements de prix associés aux soldes et remplacements de produits sont moins corrélés l'inflation que les autres changements de prix; (v) l'inflation mensuelle est corrélée aux fréquences de hausses et de baisses de prix. Les variations de l'ampleur des changements de prix dans le temps est principalement expliquée par les soldes et les remplacements; (vi) au cours de la crise de 2008-2009, les caractéristiques de l'ajustement des prix ont été peu modifiées: la fréquence, l'ampleur moyenne et la variance des baisses de prix ont légèrement augmenté.

Codes JEL : E31, D40, L11
Mots-clé : rigidité des prix, inflation, prix la consommation, soldes et promotions, remplacements de produit

Abstract

Using micro price data covering the Great Recession period, we document new facts on price rigidity in France: (i) each month, 17% of prices are changed versus 23% in the United States. When sales are excluded, only 14% of prices are modified in France versus 15% in the United States; (ii) the distribution of price changes is dispersed with a lot of large and very small price changes; (iii) price increases are more frequent in January and September, even after controlling for sales; (iv) price changes related to sales and product replacements are less driven by inflation variations than regular price changes; (v) the monthly inflation rate is correlated to the frequencies of price decreases and increases. The volatility in the sizes of price increases and decreases is mainly due to sales and promotions; (vi) during the Great Recession, the patterns of price adjustment were only slightly modified: the frequency, average size and dispersion of price decreases increased a little.

JEL codes: E31, D40, L11
Keywords: price stickiness, inflation, consumer prices, sales, product substitution

1 Introduction

How prices are set has a lot of crucial macroeconomic implications especially for the real effects of monetary policy or the welfare consequences of business cycles. Over the past decade, several empirical studies have provided evidence on micro price rigidity for more than 50 countries. This progress was made possible because large data sets of individual prices (consumer price index (CPI) individual data, scanner data...) were made available to researchers. Using price quotes collected for the CPI calculation, seminal studies by Bils and Klenow [2004], Klenow and Kryvtsov [2008] and Nakamura and Steinsson [2008] have provided basic findings on price rigidity for the United States whereas Dhyne et al. [2006] have summarized European evidence.[1] A recent strand of the US literature has emphasized the relevance of a new set of patterns, such as the influence of sales, of product replacements or the shape of the distribution of price changes (in particular its fat tails and the large proportion of small price changes). These patterns have important consequences for the real effects of monetary policy (see for instance, Nakamura and Steinsson [2010a], Kehoe and Midrigan [2010] for sales, and Costain and Nakov [2011], Midrigan [2011] or Golosov and Lucas [2007] for the distribution of price changes). Our paper adds to the literature on price rigidity along three dimensions. First, we provide new facts on patterns of price rigidity that so far have been little documented for European countries in particular the impact of sales and product replacements on price rigidity indicators. Second, we provide a detailed comparison of the degree of price rigidity between France and the United States. Finally, we document the impact of the Great Recession on price setting behavior.

For that purpose, we use a new release of CPI price quotes collected in France. Our data set consists of more than 11 million monthly price quotes collected by the national statistical office in order to compute the French CPI. Our data are available from April 2003 to April 2011, extending the period covered by the previous study by Baudry et al. [2007] (July 1994 - February 2003). Prices are collected for more than 700,000 individual products identified at the outlet level. The sample contains prices for more than 3,500 types of goods and services, allowing the construction of indicators of price rigidity that are representative of the non-farm business economy.

Our first contribution is to provide new findings on price rigidity indicators including or not sales and temporary promotions. Sales were shown to have strong implications for price rigidity assessment in the United States (see for instance Kehoe and Midrigan

[1] For recent surveys of these findings, see Klenow and Malin [2010], Smets and Mackowiak [2009] or Nakamura and Steinsson [2013]

[2010]). Moreover, a growing recent literature examines the determinants of sales and promotions in the United States and their aggregate implications (Anderson et al. [2012], Coibion et al. [2012], Kehoe and Midrigan [2010], and Guimaraes and Sheedy [2011]). However, little evidence has been made available for European countries.[2] We find that the frequency of price changes when we exclude sales is a little less than 15% (versus 17% when they are included). We also obtain that aggregate inflation has a smaller impact on price changes associated to sales than on regular price changes. Considering the distribution of price changes, excluding sales leads to a decrease in the average absolute size of price changes from 9.5% to 5.5%. When sales are included, the share of small price changes is large: almost 25% of price changes are smaller than 2% in absolute values. When sales are excluded, the proportion of large price changes decreases whereas the proportion of price changes less than 2% in absolute values increases. Midrigan [2011] shows that those features of the data may have strong implications for the persistence of monetary shocks. Following Klenow and Kryvtsov [2008], we also decompose the monthly fluctuations of inflation into an extensive margin (frequency of price changes) and an intensive margin (size of price changes): almost 75% of monthly inflation variations are due to sales. When sales are excluded, the frequencies of price increases and decreases are the most important contributions to inflation. In particular, when we exclude sales and promotions, there is still a peak of inflation in January; this peak is mostly explained by an increase in the frequency of price increases (especially in services).

The importance of product replacements has been stressed in a recent contribution by Nakamura and Steinsson [2008] who argue that product replacement provide an opportunity for changing prices. We compute new price rigidity indicators assuming that forced product substitutions are not the end of a price trajectory. Extending our sample to product substitution-related price changes increases the frequency and the average absolute size of price changes: the frequency including substitutions is about 19.3% and the average absolute size is closer to 11%. Overall, substitutions have a positive impact on average monthly inflation rate (0.02 when product substitutions are excluded and 0.09 when they are included) but they only sightly contribute to the fluctuations of inflation.

Our second contribution consists of a detailed comparison of the degree of price rigidity between France and the United States. Using American and European results, Klenow and Malin [2010] conclude that prices appear as more flexible in the United States than in France. In this paper, we investigate in more details the differences in price rigidity

[2] In some countries like Germany, Italy or Spain, sales prices were not available in micro data sets (see Dhyne et al. [2006]). Baudry et al. [2007] provide some results on the frequency of price changes excluding sales as robustness checks.

between France and the United States. We construct a bridge table to match European and US classifications of products, we identify products that are available in both French and US micro price data sets and we control for differences in CPI weight structures between France and the United States. On the common sample of products (65% of CPI weights), when sales are included, the frequency of price changes is higher in the United States than in France (23% of price changes in the United States versus 17% in France). However, when sales are excluded, the difference shrinks: 14.4% of price changes in France versus 15.1% in the United States. Similarly, the average size of price changes is larger in the United States than in France (14.9% versus 10.2% for price increases and -18.5% versus -12.7% for price decreases) but when sales are excluded, the difference drops substantially: the average size of price increases (resp. decreases) is about 6% (resp. -9%) in France versus 9% (resp. -12%) in the United States.

Our last contribution is to document micro price setting behavior during the Great Recession. Most of empirical results on price rigidity were obtained on data collected in the 90s or in this first years of 2000s. During this period, GDP growth and inflation were quite stable in Europe and in the United States. However, patterns of price rigidity may be different when the economic environment becomes unstable. Gagnon [2009] on Mexican data during the peso devaluation or Wulfsberg [2010] on Norwegian data during the 70s provide evidence on price setting features in unstable economic environments. During the recent Great Recession, GDP growth dramatically decreased whereas the variations of the inflation rate were mainly due to decreasing then increasing energy prices and core inflation remains rather stable ([ECB, 2012]). We assess to which extent the Great Recession had an impact on microeconomic price adjustment behavior. To our knowledge, little is known about micro price setting features during that period especially in European countries.[3] We find that the broad patterns of price adjustment remained mainly unchanged during the recent crisis, which sheds some light on the relative inflation stability during the Great Recession. We show that the Great Recession had a significant positive but small impact on the frequency of price decreases and a negative impact on the size of price decreases. We also find that the variance of price increases increased somewhat during the Great Recession, which may reflect the increasing variance of economic shocks. Finally, we do not find that price changes associated with sales were more frequent during the Great Recession but provide evidence of more price changes due to product replacements.

The paper is organized as follows. A description of the data is provided in section 2.

[3] Bergen and Vavra [2012] document some findings on price distributions during recessions in the United States.

Section 3 provides cross-sectional evidence on the frequency and size of price changes for the recent period. We also document the influence on price rigidity of removing sales, and of considering product replacements as ends of price trajectories or not. We analyze the patterns of the distribution of price changes. We compare our findings with US results. Section 4 presents time-series evidence on the frequency and size of price changes and investigates the impact of the Great Recession on price rigidity indicators. We also explore the impact of sales and product substitution on the fluctuations of the monthly inflation rate. Finally, we provide detailed evidence on the seasonality of price changes and the contribution of sales to this seasonality. Section 5 concludes by summarizing our main results and discussing some of their macroeconomic implications.

2 Data

The data are taken from a longitudinal data set of monthly price quotes collected by the Institut National de la Statistique et des Études Économiques (INSEE) in order to compute the French CPI.[4]

2.1 Price quotes

The sample contains monthly CPI records from April 2003 to April 2011 and each record is related to a precisely defined product sold in a particular outlet. The raw data set contains more than 11 million price quotes and covers about 65% of the CPI weights.[5] Those data contain prices for more than 3,500 goods and services, sold in more than 30,000 outlets in more than 100 locations. This large coverage of our data set allows us to calculate indicators of price rigidity that are representative of the whole non-farm business economy. We aggregate product categories into four sectors: food, manufacturing goods (durables, clothing, and other manufacturing goods), energy, and services.

With each individual price quote (*i.e.* the exact price level of the product), the following additional information is recorded: the year and month of the record, and the type of price record (*e.g.* sale price). It is possible to track the price variation of an individual product, (*i.e.*, a particular product, of a particular brand and quality, sold in a particular outlet) using a single identification number. The sequence of records corresponding to one individual product is called price trajectory. The individual products are characterized

[4]The methodology of data collection is described in Caillaud [1999], and also in Lequiller [1997].

[5]Some categories of goods and services are not available in our sample: centrally collected prices, among which car prices and administered prices (*e.g.* tobacco) or public utility prices (*e.g.* electricity), as well as other types of products such as fresh food or rents.

by the packaging quantity[6], the category of product, the outlet where it is sold and its type (*e.g.* supermarket, traditional store, etc).

To produce aggregate measures of the frequency or size of price changes, we compute all statistics using CPI weights. Products categories (6-digit COICOP) are the lowest level for which these CPI weights are available to us. There are a little less than 300 product categories in the dataset. Although available CPI weights are not defined at the store/product level, the statistical office designs the list of outlets present in the sample to be representative in terms of market shares. Moreover, weights of CPI categories change every year. To control for possible changes in the composition structure of the CPI, we use average weights of CPI categories over the sample. Our benchmark procedure for computing aggregate statistics from individual observations is as follows. The weight of an individual observation is set equal to the average weight of the CPI category over the period 2003-2011 (with weight set to zero at times when a product is not included in the CPI basket), divided by the number of observations in the category. This procedure gives the same importance in aggregation to all items belonging to the same category.

2.2 Sales and promotions

Our dataset contains a variable that identifies whether a price corresponds to sales, either in the form of seasonal sales or temporary promotional discounts.[7] These two kinds of sales are different in France and their regulation changed a little during our sample period.[8] Temporary promotional discounts are allowed at any time during the year but the seller cannot sell its product below costs and must deliver the discounted product during all the promotion period. Seasonal sales are subject to administrative restrictions: they are restricted to specific time periods and price posting is subject to precise regulations. Contrary to temporary discounts, selling below cost is allowed during seasonal sales. The definition of sales periods are administered: with very small variations, one from beginning of January to mid-February and another one from end of June to end of July. Before 2009 seasonal sales were allowed twice a year for a six-week period each. From 2009, a new law (Loi de Modernisation de l'Économie) slightly modified the regulation on sales, it reduced the durations of fixed periods of sales from six to five weeks and introduced a flexible period of sales (two weeks or two periods of one week) which can be freely set by stores. To compute our price rigidity indicators, we consider two alternative

[6]When relevant, we divide prices by the indicator of quantity sold in order to recover a consistent price per unit.

[7]Field agents are instructed to flag a price as a seasonal sale or a temporary promotional discount if this is indicated next to the price when it is collected.

[8]Contrary to the United States, United Kingdom, or Germany, sales are regulated in France.

assumptions. First, we includes sales-related price changes: we use all price records without modifying them. Second, following Nakamura and Steinsson [2008], we exclude sales-related price changes: we consider that a price quote flagged by Insee as "seasonal sales" or "promotion" corresponds to a temporary price adjustment and we replace the price by the last regular price. Thus, to compute price rigidity statistics without sales, we exclude any price decrease implied by sales, as well as the subsequent price increase that generally follows.

2.3 Product replacement

If in an outlet a given product is definitively substituted by a similar one of another brand or of a different quality the substitution is tagged. The statistical agency may no longer record the price of a given product in a given outlet, either because the product is no longer sold by the outlet or, more rarely, because the outlet itself closes (attrition/forced replacement), or because the statistical institute may decide to discard a product or an outlet in order to keep the sample of items representative of the structure of consumption (voluntary replacement).[9] When product substitution occurs, we may assume that a new price trajectory starts. As a result the price changes occurring when products are replaced are discarded from the sample. This approach has typically been followed in European empirical studies on price rigidity (for instance, Dhyne et al. [2006]). However, alternative assumptions may be relevant to characterize the implied price dynamics. Figure 1 summarizes the different possible assumptions on product replacements and their consequence for price trajectories. The first possibility is to consider that a new price trajectory starts with product substitution. In a second and third cases, the previous price trajectory is assumed to continue, respectively not taking and taking into account the potential quality adjustment. A key feature of our data is that we also know which product substitutes the old one and, when relevant, the coefficient of quality adjustment.[10] Consequently, we can assess whether the price adjustment characteristics are different when we consider that a price trajectory continues with the replacing product. The implications of assuming that a price trajectory continues despite product replacement are particularly relevant in the analysis of some sectors where substitution are frequent, like clothing and durables sectors. In the rest of the paper, when we assume that price trajectories are stopped by a product replacement we refer as "excluding product substitutions" and

[9] We cannot distinguish between forced and voluntary replacement. The statistical office however deals with them in a different way.

[10] Baudry et al. [2007] consider product replacements as price changes but they do not observe the new product that substitutes the old one.

when we consider that price trajectories continue after a product replacement, we refer as "including product substitutions".[11]

[Insert Figure 1]

2.4 Comparing France and the United States

One aim of this paper is to compare the average frequency and size of price changes in France to those in the US. For that, we need to control (at least) for possible differences in the coverage of products between French and US micro data sets and for differences in the weighting structure of both price indices. Here, we use the detailed results obtained by Nakamura and Steinsson [2008] on the frequency of price changes, increases and decreases calculated at the product level for the period 1998-2005 (including or not sales and including or not substitutions) and the average size of log-price increases and decreases at the product level for the period 1998-2005.[12] We compute the same indicators at 6-digit COICOP product level for France. The product classification used to compute the CPI in the United States is different from the one used in Europe, the COICOP (Classification of Individual Consumption According to Purpose).[13] For France, we have information for products at level 6 of the COICOP (304 different products) whereas Nakamura and Steinsson [2010b] report statistics for each Entry Level Item (ELI) code (a product classification structure which, after the 1998 revision, consists of 278 different products for the CPI construction). Using available information, we build a bridge table between COICOP and ELI product classification to compare our aggregate results. For that, we map every given ELI product code to one or more 6-digit COICOP products. Besides, to control for differences in the weighting structures between US and France, we use this bridge table to apply the US weight structure to our French data.[14] We are then able to compute French indicators of price rigidity using the US weight structure. An important restriction to our comparison exercise is that individual prices for categories of products are not available in our French dataset whereas they are available for the United States. In particular, prices for fresh food, tobacco, drugs and medical services, some transport services and cars, postal and telephone services and electricity are not present in our micro data set since most of them are centrally collected. Overall, we are able to match about 65% of US products (in terms of CPI weights) to French products.

[11]For further details on data treatment, see also Appendix or Baudry et al. [2004].

[12]Tables 20 and 22 from their supplementary material see Nakamura and Steinsson [2010b]

[13]See for instance Lane and Schmidt [2006] for a discussion of the difference between US and European CPI

[14]This bridge table is available upon request.

We are able to build comparable aggregate statistics for both US and France that cover in both cases about 65% of the CPI weights.

3 Cross-Sectional Evidence on Price Adjustment

Price rigidity is often approximated in macroeconomic models by the frequency of price changes. In this section, we present new results for France on the frequency and size of price changes, with a concern on the sensitivity of results about the assumptions about sales and product replacements. Moreover, we provide new facts on the distribution of price changes. We compare our findings to recent US results obtained on CPI price data.

3.1 Frequency of price changes

Table 1 provides the main statistics on the frequency of price changes and comparisons with findings from the United States, as reported by Nakamura and Steinsson [2008]. The average monthly frequency of price changes in France is about 17% on the period 2003-2011 in the baseline case when price changes related product replacements are disregarded but price changes related to sales are included. The average price duration is about a year[15] while the median is close to 8 months. Consumer prices appear much more flexible in the United States, since Nakamura and Steinsson [2008] find that the frequency of price changes is 26.5% over the period 1998-2005. However, when computing the frequencies for both countries restricting to the sample of products available in both datasets, and using the US weight structure, the difference is smaller: each month, 16.8% of prices change in France versus 22.7% in the United States. Products whose prices are modified quite frequently like fresh food, cars or electricity are not available in the French data set, which explains at least partly this smaller difference in the frequencies of price changes. The share of price increases is close to 60% in France but about 55% in the United States.

[Insert Table 1]

One important pattern of price rigidity is the large degree of sectoral heterogeneity.[16] Table 2 shows the frequency of price changes for the four major groups of products we consider. Prices in the energy sector are modified very often (77% on average each month) whereas the frequency of price changes for manufactured goods lies between 15.4% for durables, and 11% for clothing and other manufacturing goods. The frequency of price

[15] The mean duration is calculated averaging the inverse of price change frequency at product level.

[16] A recent macroeconomic literature shows the relevance of sectoral heterogeneity in the frequency of price changes for the real effects of monetary policy (see for instance Carvalho [2006]).

changes is very low for services (about 7%). Looking at the share of price decreases, the proportions of price decreases are close to 40% in food, other manufacturing goods and energy sectors whereas they are higher for durables and clothing (55 to 60 %). On the contrary, in services, price decreases are rare (only 20% of price changes). Similar findings were obtained for the United States (Nakamura and Steinsson [2008]).

[Insert Table 2]

Many empirical studies emphasize that sales are widespread in the United States. A widely spread conjecture is that the extent of sales is an important factor behind the differential in price flexibility between the US and Europe. We now document some basic facts on the frequency of sales in France and their impact on the frequency of price changes. A little more than 2% of price quotes are flagged by Insee as sales or promotions.[17] The proportion of seasonal sales is 0.5% and the proportion of temporary promotional discounts amounts to 1.6%. Sales are much less frequent in France than in the United States: Klenow and Kryvtsov [2008] find that about 11% of price records are sales and Nakamura and Steinsson [2008] 7.4% (Table 1). Sales and promotions are concentrated in some sectors (Table 2). About 6% of price quotes in the clothing and durables sectors are promotions or sales, 3% for food products and a little less than 2% for other manufacturing goods. Almost no price quotes are promotions or sales in energy or services. This sectoral heterogeneity is very similar to that found in the United States even if the proportion of price quotes concerned by sales or promotions are much larger. If we disregard sales-related prices (i.e. when a price is flagged as in sales or promotions, we replace it by the last "regular" price), the frequency of price changes in France is much lower than when sales are included: 14.8% of prices are modified each month and the proportion of price increases increases a little (from 60.7% to 63.5%)[18]. In the United States, Nakamura and Steinsson [2008] find that after excluding sales, the frequency of price changes decreases by almost 5 percentage points from 26.5% to 21.1%. When we in addition restrict to products available in both datasets and use the US weight structure, the difference between the United States and France further shrinks: the frequency of price changes is 14.4% in France and 15.1% in the United States.[19] The proportion of price increases is in that case similar, close to 60%, in both countries.

[17] Baudry et al. [2004] provide a similar proportion of sales for the period 1994-2003 (Table 1) but the figure is unweighted.

[18] Baudry et al. [2007] find a frequency of price changes of 13.9% when excluding sales for the period 1994-2003

[19] As robustness checks, we run the same comparison but excluding observations between 2008 and 2010 for France (where inflation varies more) and also if we exclude gasoline prices for both countries, the difference remains similar.

Nakamura and Steinsson [2012] recently illustrated the role played by product replacements in price dynamics and their macroeconomic effects.[20] In France, about 3.7% of price quotes correspond to a product substitution (Table 1). A similar figure is obtained on US CPI data (3% and 3.4% of price quotes are product replacements according to respectively Klenow and Kryvtsov [2008] and Bils and Klenow [2004]). When we include price adjustments associated with product substitutions, the consequences for the characteristics of price dynamics are sizable. The frequency of price change increases by 2 percentage points, from 17.2% to 19.3%. Correcting by quality adjustment affects only marginally the frequency of price change (19.4%). This is consistent with what is found on US data: considering price changes at product substitution increases the frequency of price changes by 1 to 2.5 percentage points: from 26.5% to 27.7% for Nakamura and Steinsson [2008] and from 23.6% to 26.1% for Bils and Klenow [2004].[21] On the common sample of products and using the US weight structure, we find similar differences between the US and France: including sales and substitutions, the frequency of price changes is 19.1% in France and 24.1% in the United States whereas when we exclude sales but include substitutions, the frequency of price changes is 16.8% in France and 17.1% in the US. The incidence of product substitution is strongly heterogeneous across products and especially widespread in the manufacturing industry. In particular, almost 10% of clothing and about 11% of durables price records are product replacements. Comparable findings are obtained by Nakamura and Steinsson [2008] on US data: 10% of price quotes in the clothing sector, and 5% of price quotes for furniture and entertainment products are product replacements. In France, for food, services or energy, the substitution rates are much lower (close or less to 2%). The frequency of price changes is larger when we consider product substitutions as price changes, it increases for clothing and durables respectively by 5.9 and 6.6 percentage points (from 11% and 15% to 17% and 21%). When product replacement occurs, 26% of prices do not change, 44% increase, and 30% decrease.

3.2 The distribution of price changes

The recent macroeconomic literature on price rigidity emphasizes some important results on the distribution of price changes: the average price changes are quite large, small

[20]Nakamura and Steinsson [2010a] suggest that the cost of price adjustment is low at product replacement, consequently a firm may wait for a predetermined product replacement to change its price.

[21]Baudry et al. [2004] find that when product replacements are included the frequency of price changes increases from 16.2 to 18.9%; however, they consider that all product replacements are price changes (because the new product was not observable) whereas price changes are not systematic when products are replaced.

price changes are as frequent as large ones (Klenow and Malin [2010]). Those empirical results have spurred some theoretical models of price rigidity (see for instance Costain and Nakov [2011], Golosov and Lucas [2007], Klenow and Kryvtsov [2008] or Midrigan [2011]). We provide here new stylized facts on the distribution of price changes in France and compare them to US results and previous evidence from Euro area countries.

Table 3 reports our basic findings on the size of price changes. The average size of price changes is rather large: 9.2% for price increases and -9.7% for price decreases while the median is much smaller 3.8% for price increases and -4.9% for price decreases. Klenow and Kryvtsov [2008] and Nakamura and Steinsson [2008] obtain larger price changes (more than 11%).

[Insert Table 3]

To perform an accurate comparison of France and United States, we follow the same approach as Nakamura and Steinsson [2008]: we compute the average size of log-price changes by product, then we compute (using product weights) the aggregate average price increase and decrease. With this aggregation approach, the average size of price increase is 10.2% in France and 14.9% in the United States whereas for price decreases, the average price change is -12.7% in France and -18.5% in the United States (Table 4). Overall, price changes are more frequent and larger in the United States compared to France. As stressed by earlier studies, the average size of price changes is large compared to the typical inflation rate, suggesting price changes do not simply correspond to inflation indexation, but incorporate idiosyncratic shocks with large variance.

[Insert Table 4]

Table 5 reports results on the sectoral heterogeneity of the size of price changes. The sectoral heterogeneity of the average size of price changes is quite substantial. The average absolute size of price changes are large for durables and clothing (respectively about 30% and more than 10%). On the contrary, price changes in the energy sectors are much smaller, less than 4% in absolute values. For food and other manufacturing goods, the size of price changes is on average about 10% in absolute values.

[Insert Table 5]

Two important and related facts are discussed by the US empirical literature on price rigidity (including Klenow and Kryvtsov [2008], Midrigan [2011] or Eichenbaum et al. [2012]): the distribution of price changes has fat tails (*i.e.* large price changes are quite frequent) and the proportion of small price changes is large. We now provide related results on the distribution of price changes for France.[22] Figure 2 plots the weighted distribution of all non-zero price changes. The mode of the distribution is between 1 and 3% and the distribution is a little asymmetric for small price changes. The distribution also has two modes, with relatively few price changes between 0 and 1%. On the negative part of the distribution, the mode is -1%. Finally, the distribution of price changes has noticeable peaks at large price increases and decreases in absolute values. These reflect sales, with clusters of price changes at values -20, -30, -40, -50% and 25%, 33% and 50%.

[Insert Figure 2]

Tables 3 and 5 also report statistics on the distribution of price changes. The proportion of small prices is quite large in France: 12.5% of price changes in absolute values are below 1% and a little more than a quarter of price changes are below 2%. The lower quartile of the distribution is a little less than 2% in absolute values. By comparison, Klenow and Kryvtsov [2008] on US price data find that 25% of price changes are below 2.5% in absolute values and Vermeulen et al. [2012] find that a quarter of price increases and decreases in absolute values are smaller than 1.5% on producer prices. Eichenbaum et al. [2012] recently challenge this result for the United States and show that when some products like cigarettes, gas services, electricity, telephone services or new cars are excluded the proportion of price changes less than 1% is less than 5%. However, in our case, most of those problematic products have been already excluded (in particular, telephone services, electricity, gas, new cars or cigarettes). The abundance of small price changes is at odds with the predictions of simple models of price rigidity where small price changes would be rare. However, small price changes are more frequent in some specific sectors. In particular, in energy[23] and other manufacturing goods, the proportion of price changes less than 2% in absolute value is close or larger than 30% whereas in durables or clothing sectors, this proportion is close or less than 10%.

Large price changes are also common: the higher quartile of the distribution is close to 8% for price increases and 12.5% in absolute value for price decreases. Golosov and Lucas [2007] and Midrigan [2011] show that the amount of large price changes cannot be explained within a simple menu cost model and that large idiosyncratic shocks are necessary. Large price changes are more frequent in durables and clothing sector where the upper quartile of the price change distribution is larger than 20%. On the contrary,

[22] Alvarez et al. [2013] document in details these patterns and investigate their macroeconomic consequences

[23] See for example Gautier and Le Saout [2012] for gasoline prices at higher frequency.

in energy, services and other manufacturing goods, the distribution of price changes is less dispersed, the standard deviation of the distribution is lower than in other sectors and the 75th percentile of the distribution is also quite low.

The sizes of price changes are larger in absolute value during sales. The average size of price decreases (in log difference) during sales is about -30% (versus 10% overall). This is in line with Nakamura and Steinsson [2008] who find a median size of price change of 29.5% in absolute value. Price changes during seasonal sales are larger than those during promotional discounts (about -35% versus -20% on average). Sectoral heterogeneity is more limited as far as the size of price changes is concerned. Largest price decreases during sales are observed in the clothing sector (-46% on average). Sales have a large contribution to the average size of price changes (Table 3). When we consider only non-sales prices, the average size of price increases is 5.3% and the average size of price decreases is -5.8% whereas the median price change in absolute value is a little larger than 3%. To compare French and US results, we compute the average size of log-price changes for France and United States excluding sales. The average size of price increase is 6.4% in France and 9.2% in the United States whereas for price decreases, the average price change is -9.1% in France and -12.0% in the United States (Table 4). As in the case of frequencies, sales contribute a lot to the difference in the average size of price changes between France and the United States. The dispersion of the price change distribution excluding sales is half of the dispersion of the benchmark distribution of price changes. In particular, the number of large price increases and decreases drops substantially when excluding sales: the 75th percentile of price decreases is -7.4%. Some sectors are especially impacted by the exclusion of sales, namely manufacturing goods and to a lesser extent food products. The sectoral heterogeneity in the size of price changes is substantially reduced (Table 5).

We now consider the influence of including price changes related to product replacements. The average price increases and decreases are larger when product replacements are included in the sample of price changes.The average price increase rises by a little more than 2 percentage points (from 9.2% to 11.5%) and the average price decrease drops by only 0.9 percentage points (from -9.7% to -10.6%). The median price increase and decrease are both larger in absolute values (4.2% for price increases and -5.7% for price decreases) (Table 3). The price change distribution is even more dispersed. Finally, the share of large price changes is larger, in particular ine the case of price increases: the 75th percentile increases from 7.8% to 10% in absolute values. The impact of product substitutions is large in manufacturing goods: for durables and other manufacturing goods, replacements have a positive impact on the average absolute price change whereas for clothing the effect is more ambiguous because of replacements after sales. When we consider product replacements as price changes for non-sales prices, the average size of price changes in absolute values is close to 7.5%. The share of small price changes is almost equal to what is found on the whole price change distribution (Table 3).

4 Time-Series Evidence on Price Adjustment

Inflation results from the aggregation of individual price adjustment behaviors: at a given time, inflation may increase because more firms change their prices (the extensive margin) or because firms change their prices by a larger amount (the intensive margin). We here investigate how these two dimensions of individual behavior of price adjustment contribute to inflation dynamics over time. Meanwhile, we document the impact of sales and substitutions on inflation. Moreover, we analyze the stability of price adjustment behavior during the recent crisis.

4.1 Decomposition of inflation variations

Following Klenow and Kryvtsov [2008] as well as Gagnon [2009] and Wulfsberg [2010], we decompose the inflation rate into an extensive margin (the frequency of price changes) and an intensive margin (the mean size of price changes). The inflation rate can be written as the product of the frequency of price changes by the average size of price changes:

$$\pi_t = F_t \cdot dp_t \tag{1}$$

where π_t is our approximation of the weighted monthly inflation rate using our micro-data, F_t is the weighted monthly frequency of price changes, and dp_t is the weighted average size of all non-zero price changes (here in first differences of log-prices between month t and $t-1$, see also Appendix). This approximation can be further decomposed by considering separately price increases and price decreases:

$$\pi_t = F_t^+ \cdot dp_t^+ + F_t^- \cdot dp_t^- \tag{2}$$

where F_t^+ and F_t^- are respectively the frequency of price increases and the frequency of price decreases, and dp_t^+ and dp_t^- are the average size of price increases and the average size of price decreases (calculated as the first difference in log-prices between month t and $t-1$). We can then compute the relative contribution of the frequencies and the sizes of price changes to the monthly inflation rate. For that, we consider deviations of inflation

$\widetilde{\pi}_t$ from its average over time $\overline{\pi}$ and we can write the inflation rate as:

$$\pi_t = \widetilde{\pi}_t + \overline{\pi} \tag{3}$$

Then, we consider deviations from their average over time of frequencies and sizes of price changes and the decomposition of inflation can be rewritten as:

$$\widetilde{\pi}_t + \overline{\pi} = \left(\overline{F}^+ + \widetilde{F}_t^+\right) \cdot \left(\overline{dp}^+ + \widetilde{dp}_t^+\right) + \left(\overline{F}^- + \widetilde{F}_t^-\right) \cdot \left(\overline{dp}^- + \widetilde{dp}_t^-\right) \tag{4}$$

Rearranging terms, it is possible to exhibit the contributions of the frequency and the size of price changes to the variations of the monthly inflation rate:

$$\widetilde{\pi}_t = \underbrace{\left(\widetilde{F}_t^+ \cdot \overline{dp}^+ + \widetilde{F}_t^- \cdot \overline{dp}^-\right)}_{frequency\ contribution} + \underbrace{\left(\overline{F}^+ \cdot \widetilde{dp}_t^+ + \overline{F}^- \cdot \widetilde{dp}_t^-\right)}_{size\ contribution} + \underbrace{\left(\widetilde{F}_t^+ \cdot \widetilde{dp}_t^+ + \widetilde{F}_t^- \cdot \widetilde{dp}_t^-\right)}_{residual} \tag{5}$$

We run this decomposition using our data set of individual price quotes (excluding energy) and we consider different cases concerning sales and product replacements. In our benchmark exercise, sales are included and product replacements are not considered as price changes. Then, we run similar decomposition exercises excluding or not sales and excluding or not product substitutions.

[Insert Table 6]

Table 6 reports some summary statistics on the inflation rate obtained when we decompose inflation between frequencies and sizes of price increases and decreases. In the benchmark case where sales are included and replacements excluded, the correlation between our recomposed monthly inflation rate and the monthly inflation rate published by Insee (excluding energy) is large (0.85).[24] Correlation coefficients are much lower when sales are excluded and become even negative (-0.15). In the benchmark exercise, the average monthly inflation rate is small (0.02 versus 0.12 in actual aggregate data) and the standard deviation of inflation a little larger than what is observed in actual data (0.41 versus 0.26).

[Insert Table 7]

Table 7 reports the correlations between monthly inflation (excluding energy) and the frequency and size of price changes. The monthly inflation rate is highly negatively

[24]We recall that our sample covers 65% of the CPI weights, in particular rents or tobacco or fresh food are excluded from our sample. It may explain part of the difference we obtain between our recomposed inflation rate and the actual inflation rate (excluding energy).

correlated with the frequency of price changes and the average size of price increases and decreases: correlation coefficients are larger than 0.6 in absolute values. Figure 3 shows the contributions of frequencies of price increases and decreases and the contributions of the size of price increases and decreases to monthly inflation deviations from its average. Inflation variations are mostly explained by its size contribution, while the contribution of the extensive margin is much lower. The large contribution of the intensive margin to inflation variations seems mostly driven by large movements in the size of price changes due to seasonal sales.

[Insert Figure 3]

When we replace sales prices by the last non-sales prices, we find that the average inflation rate increases from 0.02% to 0.09% (because the frequency of price decreases is lower) whereas the volatility of the inflation rate is divided by almost 4 (Table 6). Variations of the monthly inflation rate are mostly due to the large seasonal movements of prices implied by sales. Inflation excluding sales prices is highly correlated with the frequency of price changes (0.63). This correlation comes from a large positive correlation with the frequency of price increases (0.78) and a much lower negative frequency of price decreases (-0.19) (Table 7). Nakamura and Steinsson [2008] obtain similar results on US data. The larger correlation with the frequency of price increases can be explained by a positive inflation trend which makes the distribution of relative prices asymmetric. The correlation between inflation and size is very small and non significant any more. Figure 4 plots the contributions of the frequency and size of price changes when sales are excluded. The contribution of the frequency of price increases and decreases is much larger than the contribution of size to inflation fluctuations. Moreover, Figure 3 also shows the specific January effect even when sales are excluded (see below): in January, the peak in the frequency of price increases has a clear positive significant effect on the monthly inflation rate.

[Insert Figure 4]

When product replacements are considered as price changes, the average inflation rate increases from 0.02% to 0.13% and becomes very close to the actual average inflation monthly rate (0.12%) (Table 6). If product substitutions are considered as price changes, both the frequency of price changes and the size of price changes increase, which contributes positively and significantly to the level of average inflation. As Figure 5 shows, the difference between the reconstructed monthly inflation when considering product replacement (bold line) and when disregarding it (dotted line) is significant and stable over time (excluding or including sales). The contribution of product replacement to monthly inflation variations is however limited: when product substitutions are included, inflation volatility increases only to a limited extent (from 0.41 to 0.43). The correlations between inflation and frequencies and average sizes of price changes are similar to the benchmark case, where product substitutions are not taken into account. When we consider inflation without sales but including product substitutions, we find that product substitution again positively and significantly contributes to the level of average inflation (which increases from 0.09 to 0.14). Figure 5 shows that the difference is also very stable over time. However, the standard deviation of our recomposed inflation rate is only 0.11, independently on product substitution assumptions.

[Insert Figure 5]

4.2 The seasonality of price changes

The decomposition of inflation variations shows the relevance of seasonal movements in the monthly inflation rate. Olivei and Tenreyro [2007] and Olivei and Tenreyro [2010] obtain that the seasonality of wage setting patterns may have an impact on the effects of the monetary policy. We now document the seasonality of the frequency and size price changes and in particular assess the contribution of sales and replacements to this seasonality.

[Insert Figure 6]

Figure 6 plots the average frequency of price changes, increases and decreases by month of the year. Like in the United States, the frequency of price changes decreases slowly over the months within the year. The frequency of price changes shows a significant peak in January (close to 25%), two smaller peaks in July and September (about 18%) and a through in December when 14.2% of price changes are modified on average. The seasonal pattern of the frequency of price changes mainly comes from the seasonality of price increases: the frequency of price increases is 15.3% in January, close to 12% between February and April, about 10% between May and September and then below 9% during the fourth quarter. The frequency of price decreases also exhibits a peak in January (8.5%). Moreover, price decreases are more likely in February, July and during the fourth quarter of the year where the frequency of price decreases is close to 7%, presumably reflecting seasonal sales especially in the clothing and durable sectors. Figure 7 represents the frequency of price changes, increases and decreases by month of the year for our six groups of products. All sectors, except in energy and food, exhibit a peak in the frequency of price changes in January. The peak is very marked in services: the frequency of price changes is above 15% in January versus less than 7% the rest of the year. In manufacturing goods sector (in particular clothing) the frequency of price decreases has noticeable peaks in January and July, while that of price increases has peaks in February and August. In services, another peak in the frequency of price increases appears in September.

[Insert Figure 7]

Sales contribute significantly to the seasonal movements in the frequency of price changes. In France, sales are regulated and occur by law mostly in January-February and June-July: more than 50% of sales prices are observed in January-February and 39% in July. Promotions are less seasonal but are more frequent in March-April and in November-December (a little more than 9% on average during those months). The seasonality of sales and promotions is quite similar in the United States even if the frequency of sales does not decrease so much after January and July in the US (Nakamura and Steinsson [2008]). Figure 8 plots the frequencies of price changes, increases and decreases by month and compare them to the ones when sales are included. When we compute the frequency of price changes excluding sales, the seasonal pattern of the frequency of price changes is quite modified: the frequency of price decreases becomes flat, slightly increasing at the end of the year whereas the frequency of price increases is now more decreasing over the months of the year. Overall, the frequency of price changes exhibits a large peak in January mostly due to seasonal price increases and a smaller one in September (mainly due to services) whereas the frequency of price changes is more clearly decreasing over the months of the year.

[Insert Figure 8]

Product substitutions are less seasonal than sales. They are somewhat more frequent in February-March and September-October (slightly more than 4% of product substitutions are observed during those months versus less than 3.5% in the other months of the year). Similarly, for the United States, Nakamura and Steinsson [2010a] find the highest substitution rates in February and September. The lowest proportion of product replacement is obtained in July (2.6% of prices are product replacements). The seasonality of replacements mirrors the seasonality of product replacements in manufacturing good sector.[25] In services, most product replacements are observed in January. Overall,

[25]For clothing, 15% of observations are replacements in March, 17.3% in September, and 12.6% in October, while only 2.7% and 1.7% in January and July. Product substitution of durables takes place mostly in February and September (almost 9.5% of observations).

the seasonal patterns of the frequency of price changes are not modified by considering product substitutions as price changes or not (see Figure 8).

[Insert Figure 9]

Figure 9 shows the average size of price increases and decreases by month of the year. The size of price changes also has strong seasonal patterns. Price decreases are larger in January and July: the average price decrease is around -14% versus -9.7% on average. Price increases are larger than usual in the periods February-March and August-September: the average price increases is then larger than 10% versus 9.2% on average. When we consider only non-sales prices, the seasonality of the size of price changes almost disappears: over the months of the year, the size of price increases only varies between 4.9% and 5.8% whereas the size of price decreases varies between -4.9% and -6.5%. When including product substitutions as price changes and including sales, the seasonal patterns of the size of price changes are reinforced. In particular, the average price increases after sales are larger than when excluding product replacements.

4.3 Inflation Fluctuations Before and During the Great Recession

We here examine other determinants of the frequency and size of price changes. The recent period was characterized by quite large shocks: increase in the volatility and the level of oil price and also the Great Recession. Figure 10 presents the evolution of overall inflation and overall inflation excluding energy during the period 2003-2011. Between 2003 and 2006 inflation was relatively stable, around 2% on average. Then, it increased between 2007 and 2008, reaching more than 3.5%, dropped to negative values in 2009 and it eventually went back to 2% in the period 2010-2011. While the fall of inflation corresponds to the recession (GDP growth was -1.5% in the first quarter of 2009), it also reflects the volatility of energy prices. Indeed, excluding energy, inflation appears much more stable over the decade. A simple Phillips curve would predict that inflation may vary for three reasons: a modification in inflation expectations, variations in the marginal costs or variations (or asymmetry) in the degree of price rigidity. Movements in the frequency of price changes over time can be related to a modification in the degree of price rigidity. Variations of the size of price changes may mirror movement in the marginal costs. To understand variations in the inflation rate, we here analyze the determinants and the stability of the frequency and the size of price changes over time.

[Insert Figure 10]

Figure 11 shows the evolution of the frequency of price changes, distinguishing price increases and decreases. Using the frequency of price changes computed by Baudry et al. [2007], we plot the frequency of price changes from August 1994 to April 2011. Abstracting from the seasonal patterns, the frequency of price changes is rather stable between 15% and 20% on the period 1994-2011. Its main fluctuations are due to movements in commodity prices (in particular in the periods 1999-2000 and 2008-2009), changes in VAT in 1994 and in 2000 or euro cash changeover in January 2002. However, variations in the frequencies of price increases and decreases are stronger with a clear negative correlation (see also Table 7). Moreover, this increase in the frequency of price changes is contemporaneous to the Great Recession: the frequency of price changes is a little less than 17% between 2003 and 2008 and about 18% after 2008 and the beginning of the recession. On average, the frequency of price changes is a little larger in the recent period compared to the 1994-2003 period: Baudry et al. [2007] obtained that it was 16.2% in the preceding decade (1994-2003)[26] (versus 17.2% for the 2003-2011 period).

[Insert Figure 11]

Figure 12 shows the average and the median sizes of price changes over time for the period 1994-2011, we distinguish price increases and decreases. Like for frequency, we use results from Baudry et al. [2007] to extend our observation period. The average sizes of price decreases and increases show large seasonal variations but no long term trend; the median price increase and decrease are rather stable over time. However, after 2008, the variations of the average size of price increases are larger and the standard deviation of price changes increases. For instance before 2008, the standard deviation of price increases is a less than 13 while it is 14 between 2008 and 2011. When we exclude sales, the standard deviation is smaller but a similar difference is observed between the two periods. Turning to price decreases, their standard deviation is roughly constant over the period 2003-2011 when sales are included. This standard deviation displays an increase over time when sales are excluded. Bergen and Vavra [2012] provide similar evidence for the United States, and argue that this increase in the volatility of price increases reflects an increase in the variance of shocks and macroeconomic uncertainty.

[Insert Figure 12]

[26] As a robustness check, we control for the weight structure since it can have been modified between the two periods 1994-2003 and 2003-2011. When we use the 1994-2003 structure of weights to compute the frequency of price changes on the period 2003-2011, the frequency of price changes slightly increases from 17.2% to 17.5%.

To investigate the effect of inflation and the impact of the Great Recession on price rigidity, we estimate Tobit type II models, both for price increases and price decreases, on individual price change data. We examine the sensitivity of the result to considering or not product replacements as price changes and including or not sales. One motivation is that a recent literature suggests that price changes associated with sales have different determinants than regular price changes. The microeconometric models we estimate in a first stage explain the probability of price changes. In a second stage an equation for the size of price changes. A first equation explains the price change decision:

$$y^*_{it} = \alpha + \beta\pi_{it} + \gamma x_t + \delta_y + \mu_m + \theta_p + u_{it} \tag{6}$$

where i denotes the product-outlet pair, t the date, y^*_{it} is an unobservable latent variable driving the decision of price increase (or decrease), π_{it} is the cumulative inflation rate at the 4-digit product level since the last price change of outlet i[27], x_t is a dummy variable for economic slowdowns or recessions.[28] δ_y, μ_m and θ_p are dummy variables for years, months and products at 6-digit level. When $y^*_{it} > 0$, then price in outlet i at date t increases (or decreases). When $y^*_{it} < 0$ then price in outlet i at date t remains unchanged. We observe a variable equal to one when a price is increased (resp. decreased) and zero otherwise. Using this first equation, we explain the probability of price changes. When prices are increased (or decreased) (i.e. when $y^*_{it} > 0$), a second equation accounts for the size of price change controlling for the selection effect, i.e. the fact that the determinants of the first stage regression did actually trigger a price change:

$$dp^*_{it} = a + b\pi_{it} + cx_t + d_y + e_p + \epsilon_{it} \tag{7}$$

where u_{it} and ϵ_{it} are i.i.d and correlated, dp^*_{it} is an unobservable latent variable for the size of price increase (or decrease). If $y^*_{it} > 0$, the size of price change is given by $dp^*_{it} = dp_{it}$ and if $y^*_{it} < 0$, $dp_{it} = 0$. For identification reasons, we include monthly dummies in the price change decision equation and not in the equation explaining the size of price changes. We assume that the month of the year is crucial for outlet in their price decision (because of annual contracts, holidays...), the month of the year modifies the timing of the price change but has no specific effect on the size of price changes. We estimate this model using a Heckman–type two-step procedure.

[27] We underline that cumulative inflation varies between outlets and over time, which is an important source of identification in our exercise.

[28] We here use a monthly business indicator constructed by the Banque de France from survey data. We define a dummy variable equal to one when this indicator is below its average over time, zero otherwise. The following economic slowdowns are the year 2003 and mid–2008 to end 2009.

Table 8 reports results of our Tobit models obtained separately for price decreases and price increases, including or not sales, including or not product replacements.

[Insert Table 8]

First, in all cases, cumulative product-level inflation has a significant positive effect on the probability of price increases and a significant negative effect on the probability of price decreases. As expected, the effect of cumulative inflation is in almost all cases positive and significant on the size of price decreases and increases. Using related regressions, Nakamura and Steinsson [2008] find similar evidence for probability of price changes but do not obtain significant effects for the size of price changes. In the sample excluding sales, the coefficients related to cumulative inflation increase substantially; for instance for price increases and excluding substitutions, the coefficients more than double. Cumulative inflation has a larger impact on the probability and size of price changes when sales are excluded. This suggests that price changes related to sales are less responsive than regular price changes to cumulative inflation, and more generally, to macroeconomic information. Contrary to results obtained by Klenow and Willis [2007], sales do not seem to reflect recent developments on aggregate prices but they may depend more on idiosyncratic shocks. Anderson et al. [2012] provide similar conclusions using micro data from a US retailer. When price changes related to replacements are included, the coefficients are smaller than when product replacements are excluded. For instance, for price increases when sales are excluded, we find that regression coefficients are divided by more than two when we consider product substitutions as price changes. This result suggests that product substitutions are not driven by inflation developments but more likely by other long-term firm decisions like product development cycle or seasonality of demand. This last result is consistent with those obtained by Klenow and Willis [2007] on US data using similar regressions.

Turning to the impact of recessions on the probability and the size of price changes, this effect is found to be very limited in the case of price increases. In the sample excluding sales, the effect of recessions on the probability of price increases is not significant, whereas when sales are included this effect becomes positive and significant. When sales are excluded, recessions have a negative although small effect on the size of price increases. The impact of recessions is larger in the case of price decreases: recessions have a positive and significant effect on the probability of price decreases. When sales are excluded, recessions have also a negative significant effect on the size of price decreases. However, for both probability and size of price decreases, recessions have a rather small impact. Like for cumulative inflation, sales do not seem to reflect macro information on real activity. When sales are excluded, for price decreases, the coefficients related to the recession dummy are larger in the decision equation and are (as expected) negative in the equation for the size of price changes. Price changes related to sales do not seem to respond to recession episodes. Coibion et al. [2012] provides similar evidence in the United States. Finally, when we include in the sample price changes related to product replacements, the coefficients associated to the recession dummy increase a little. This might suggest that product replacements are partly driven by fluctuations of real activity and in particular by recessions.[29]

5 Conclusion

To conclude, we summarize our main stylized facts and discuss some of their possible macroeconomic implications.

First, for the available common sample of products (representing 65% of CPI weights) and using US weighting structure, we find that the frequency of price changes is higher in the United States than in France (22.6% versus 16.8%). When sales are excluded however, the difference is very limited (15.1% in the United States versus 14.4% in France). Incorporating price changes related to product replacements has rather similar consequences in France and in the United States: the estimated frequency of price changes in both countries is increased by about 2 percentage points. Similar results are obtained regarding the average size of price changes. Price changes are larger in the United States but when sales are excluded the difference appears much smaller. Those results raise two concerns for macro models. First, they emphasize again the need of a better understanding of the determinants of sales and whether the presence of sales has macro implications. In particular, Kehoe and Midrigan [2010] suggest that the actual degree of price stickiness is mainly driven by the frequency of regular price changes. Second, to the extend that prices are more sticky in France than in the United States, it is important to determine whether structural differences in costs of adjustments, or differences in the volatility of micro or aggregate shocks stand behind this contrast. If prices are structurally more sticky in France, one should for instance expect larger real effects of monetary policy than in the United States.

A second set of noticeable facts relates to the distribution of price changes. The shares both of small and of large price changes is substantial. This fact is robust to taking into account sales and substitutions, although the sizes of price increases and

[29]For robustness check, we also ran the same regressions excluding energy products, and found similar results.

decreases are strongly reduced when we exclude sales. The average price change is about 9.5% in absolute values when sales are included and about 5% when they are excluded. Product replacements increase a little the size of price changes. The distribution of price changes is quite dispersed and leptokurtic, which is consistent with what has been obtained by Midrigan [2011] for instance. The large size of price changes suggests a large variance in idiosyncratic shocks, whereas the extent of small price changes suggest more complicated forms of adjustment costs than in the basic menu cost model (as suggested by Midrigan [2011] or Costain and Nakov [2011]). A recent theoretical literature emphasizes that designing macroeconomic models able to reproduce those facts alters the monetary policy responses to shocks (see for instance Alvarez et al. [2013]).

Our third finding is the large seasonality of price changes even after controlling for sales. About 25% of prices are modified in January (versus 17% on average). Wen sales are excluded, 20% of prices are modified in January and almost 16% in September (versus less than 15% on average). We find that this "January effect" on the frequency of price changes contributes a lot to variations of the monthly inflation rate. This is in line with predictions of Taylor contract models or could be explained by a strong degree of synchronization of price changes. When sales are excluded, the average sizes of price increases and decreases are not seasonal and are very flat over the months of the year. Olivei and Tenreyro [2007] and Olivei and Tenreyro [2010] show that seasonality in wage-setting may have important consequences for the real effects of monetary policy which would depend on the quarter where a shock occurs. One can expect similar macroeconomic consequences for prices since regular prices appear - at least - as seasonal as wages.

Fourth, we find that the volatility of size of price increases and decreases is mainly due to sales and promotions. However, excluding sales, the monthly inflation rate is mainly explained by movements in the frequencies of price decreases and increases. The strong correlation of frequencies of price increases and decreases with inflation is quite consistent with predictions of menu-cost models. We also find that price changes associated with sales and product replacements do not have the same determinants as regular price changes. In particular, they are not driven by macroeconomic information as captured by inflation variations but presumably respond to idiosyncratic shocks and other long-term firm decisions. This result could be quite consistent with predictions of rational inattention models where firms' price decisions are more driven by idiosyncratic shocks than macro ones (Mackowiak and Wiederholt [2009]).

A last finding of this paper is the impact of the Great Recession on price rigidity. We find only small changes in price adjustment patterns during the recent crisis: the frequency and the (absolute) size of price decreases slightly increase during recessions.

Moreover, the dispersion of the price change distribution also increased, which is quite consistent with some recent US findings. Finally, recessions in France have no impact on sales, but have a little positive effect on product substitutions. The stability of the frequency of price changes during the Great Recession raises the question of whether if merely reflects price stickiness, or whether it can be explained by some increased rigidity in marginal costs in the recent period.

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Table 1: Frequency of price changes

	France 2003-2011	US 1998-2005	France US weights	US US weights
Including sales, excluding substitutions				
Frequency of price changes	17.2	26.5	16.8	22.7
% of price increases	60.7	57.0	59.9	53.6
Excluding sales, excluding substitutions				
Frequency of price changes	14.8	21.1	14.4	15.1
% of price increases	63.5	64.9	62.5	60.9
Including sales, including substitutions				
Frequency of price changes	19.3	27.7	19.1	24.1
% of price increases	57.0	-	-	-
Excluding sales, including substitutions				
Frequency of price changes	16.9	22.8	16.8	17.1
% of price increases	62.4	-	-	-
% of sales	2.1	7.4	-	-
% of substitutions	3.7	2.8	-	-

Note: Frequency of price changes are weighted proportion of price changes on all price records; % of sales is the weighted proportion of sales and promotions among all observations; % of substitutions is the weighted proportion of product replacements among all price records; US results are from Nakamura and Steinsson [2008] and Nakamura and Steinsson [2010b]. In columns 'US weights', we compute aggregate frequencies of price changes using product level frequencies for products available in US and French data set and using the US weight structure.

Table 2: Frequency of price changes by sector

	Food	Manufacturing goods			Energy	Services
		Durables	Clothing	Other manuf.		
Including sales, excluding substitutions						
Frequency of price changes	19.5	15.4	11.2	11.7	77.0	6.7
% of price increases	56.4	42.9	44.6	65.0	60.8	79.1
Excluding sales, excluding substitutions						
Frequency of price changes	15.9	9.5	1.7	9.7	76.9	6.5
% of price increases	58.5	43.2	58.8	69.1	60.7	81.5
Including sales, including substitutions						
Frequency of price changes	20.6	21.9	17.0	14.1	77.1	8.0
% of price increases	56.3	48.4	57.1	63.8	60.7	77.5
Excluding sales, including substitutions						
Frequency	17.1	16.6	8.2	12.3	77.0	7.8
% of price increases	57.9	48.7	55.6	66.1	60.8	78.6
% of sales	3.0	5.5	6.1	1.8	0.1	0.2
% of substitutions	2.2	9.7	10.8	4.0	0.7	2.0

Note: Frequency of price changes are weighted proportion of price changes on all price records; % of sales is the weighted proportion of sales and promotions among all price records; % of substitutions is the weighted proportion of product replacements among all price records.

Table 3: Size of price changes

	Incl. sales Excl. subst.	Excl. sales Excl. subst.	Incl. sales Incl. subst.	Excl. sales Incl. subst.
Price increases				
Mean	9.2	5.3	11.5	7.7
Std	18.9	8.5	23.1	16.0
Lower quartile	1.9	1.7	2.0	1.9
Median	3.7	3.2	4.2	3.7
Higher quartile	7.8	5.9	10.0	7.3
Price decreases				
Mean	-9.7	-5.8	-10.6	-7.6
Std	11.9	6.8	12.4	9.4
Lower quartile	-12.5	-7.4	-14.3	-9.6
Median	-4.9	-3.5	-5.7	-4.3
Higher quartile	-1.9	-1.6	-2.1	-1.8
% of absolute price change less than 2%				
	26.7	31.1	24.4	27.8
% of absolute price change less than 1%				
	12.5	14.6	11.5	13.2

Note: The statistics on the size of price changes are all weighted using CPI disaggregated weights on the period 2003-2011. Individual sizes of price changes are here calculated in percentage, and only non-zero price changes are considered.

Table 4: Size of price changes: France - United States

	France	United States
Price increases		
Including sales	10.2	14.9
Excluding sales	6.4	9.2
Price decreases		
Including sales	-12.7	-18.5
Excluding sales	-9.1	-12.0

Note: The statistics on the size of price changes (log-differences) are all weighted using US ELI disaggregated weights. Average price changes are first calculated at product level (on the period 1998-2005 for the United States (Nakamura and Steinsson [2010b]) and on the period 2003-2011 for France) and then aggregate using US weight structure to obtain the average size of price changes.

Table 5: Size of price changes by sector

	Price increases				Price decreases			
	Mean	Q1	Median	Q3	Mean	Q1	Median	Q3
Including sales, excluding substitutions								
Food	9.7	2.0	4.4	10.1	-8.8	-11.8	-4.9	-1.9
Manufacturing sector								
Durables	16.1	3.7	10.6	22.5	-13.3	-19.1	-11.1	-6.1
Clothing	60.8	25.0	42.9	100.0	-33.6	-50.0	-30.0	-21.3
Other manuf.	9.6	1.7	3.5	9.1	-11.9	-19.2	-6.8	-2.0
Energy	3.8	1.7	3.0	5.0	-3.9	-5.1	-2.9	-1.5
Services	7.0	2.0	3.6	7.5	-11.3	-16.4	-8.5	-3.1
Excluding sales, excluding substitutions								
Food	5.7	1.7	3.5	6.8	-5.5	-7.3	-3.4	-1.5
Manufacturing sector								
Durables	8.9	2.0	5.3	11.1	-9.7	-13.3	-8.2	-4.1
Clothing	15.9	2.2	5.6	14.5	-18.7	-30.0	-14.3	-4.0
Other manuf.	5.6	1.5	3.0	6.0	-7.2	-9.7	-4.0	-1.4
Energy	3.8	1.7	3.0	5.0	-3.8	-5.1	-2.9	-1.5
Services	6.5	2.0	3.5	7.1	-10.4	-14.6	-7.7	-2.7
Including sales, Including substitutions								
Food	10.5	2.0	4.7	11.1	-9.3	-12.6	-5.2	-2.0
Manufacturing sector								
Durables	20.0	5.1	12.5	25.0	-14.2	-20.0	-11.4	-6.3
Clothing	48.4	12.5	33.4	66.7	-28.1	-40.0	-28.8	-14.8
Other manuf.	12.9	2.0	4.2	12.9	-12.9	-20.0	-8.0	-2.5
Energy	3.8	1.7	3.1	5.0	-3.9	-5.2	-2.9	-1.5
Services	8.8	2.1	3.9	8.7	-12.6	-17.3	-9.1	-3.6
Excluding sales, Including substitutions								
Food	6.9	1.8	3.7	7.6	-6.5	-8.3	-3.8	-1.6
Manufacturing sector								
Durables	16.8	3.6	9.1	20.0	-12.5	-16.7	-9.8	-5.0
Clothing	22.2	5.6	12.7	25.4	-17.3	-24.6	-13.5	-7.1
Other manuf.	9.6	1.8	3.6	8.9	-10.0	-13.5	-5.6	-1.9
Energy	3.8	1.7	3.0	5.0	-3.9	-5.2	-2.9	-1.5
Services	8.4	2.1	3.8	8.3	-12.0	-16.7	-8.6	-3.3

Note: The statistics on the size of price changes are all weighted using CPI disaggregated weights. Individual sizes of price changes are here calculated in percentage, and only non-zero price changes are considered.

Table 6: Recomposing aggregate monthly inflation

	Incl. sales Excl. subst.	Excl. sales Excl. subst.	Incl. sales Incl. subst.	Excl. sales Incl. subst.	Monthly Inflation
Average inflation	0.02	0.13	0.09	0.14	0.12
Standard Deviation	0.41	0.43	0.11	0.11	0.26
Corr. with actual inflation	0.85	0.84	-0.15	-0.16	1

Note: We recompose monthly inflation rates using all individual price quotes (excluding energy) and under different hypotheses on sales and product replacements. We compare the average and standard deviation of recomposed inflation rates to the monthly inflation rate published by Insee (overall index excluding energy)

Table 7: Correlation between inflation, frequency and size of price changes

	Correlation coefficients (p-value)			
	Incl. sales Excl. subst.	Excl. sales Excl. subst.	Incl. sales Incl. subst.	Excl. sales Incl. subst.
Frequency of price changes	-0.30	-0.14	0.63	0.59
	(0.00)	(-0.17)	(0.00)	(0.00)
Freq. increases	-0.10	0.03	0.78	0.78
	(0.35)	(0.74)	(0.00)	(0.00)
Freq. decreases	-0.63	-0.48	-0.19	-0.21
	(0.00)	(0.00)	(0.06)	(0.04)
Size of price changes	0.98	0.99	0.93	0.92
	(0.00)	(0.00)	(0.00)	(0.00)
Size increases	0.72	0.77	0.01	-0.21
	(0.00)	(0.00)	(0.95)	(0.04)
Size decreases	0.69	0.65	0.03	0.07
	(0.00)	(0.00)	(0.78)	(0.51)

Note: We recompose monthly inflation rates using all individual price quotes (excluding energy) and under different hypotheses on sales and product replacements. We compute the correlation coefficients between the recomposed monthly inflation rate and the frequency/size of price changes/increases/decreases. Size of price changes are here calculated as the weighted average of log differences.

Table 8: Probability and size of price changes on inflation and recession - Tobit models

	Probability		Size		N. obs
	Cum. inflation	Recession	Cum. inflation	Recession	
Price increases					
Sales and no subst.	0.121***	0.008***	0.046***	0.000	6,111,695
	(0.004)	(0.002)	(0.003)	(0.001)	
No sales and no subst.	0.340***	-0.002	0.106***	-0.002***	5,496,879
	(0.008)	(0.003)	(0.002)	(0.000)	
Sales and subst.	0.050***	0.014***	0.036***	0.001**	8,203,667
	(0.003)	(0.002)	(0.002)	(0.001)	
Subst. and no sales	0.105***	0.003	0.053***	-0.002***	7,915,784
	(0.004)	(0.003)	(0.002)	(0.000)	
Price decreases					
Sales and no subst.	-4.522***	0.018***	0.285***	0.001	6,111,695
	(0.015)	(0.003)	(0.022)	(0.001)	
No sales and no subst.	-6.396***	0.019***	0.666***	-0.003***	5,496,879
	(0.032)	(0.003)	(0.020)	(0.000)	
Sales and subst.	-0.410***	0.018***	-0.042***	-0.000	8,203,667
	(0.007)	(0.003)	(0.002)	(0.001)	
Subst. and no sales	-3.617***	0.032***	0.592***	-0.006***	7,915,784
	(0.020)	(0.003)	(0.017)	(0.001)	

Note: The table reports the parameter estimates from the Tobit models. "Cum. inflation" is the cumulative inflation rate since the last price change in a given outlet i (4-digit product level) and "Recession" is a dummy variable equal to 1 when the French industry experiences an economic slowdown or a recession. Year, month and product (6-digit product level) controls are included. *** significant at 1%, ** significant at 5%, * significant at 10%. Standard deviations of estimates are reported in brackets.

Figure 1: Three different hypotheses on product substitution and price trajectory

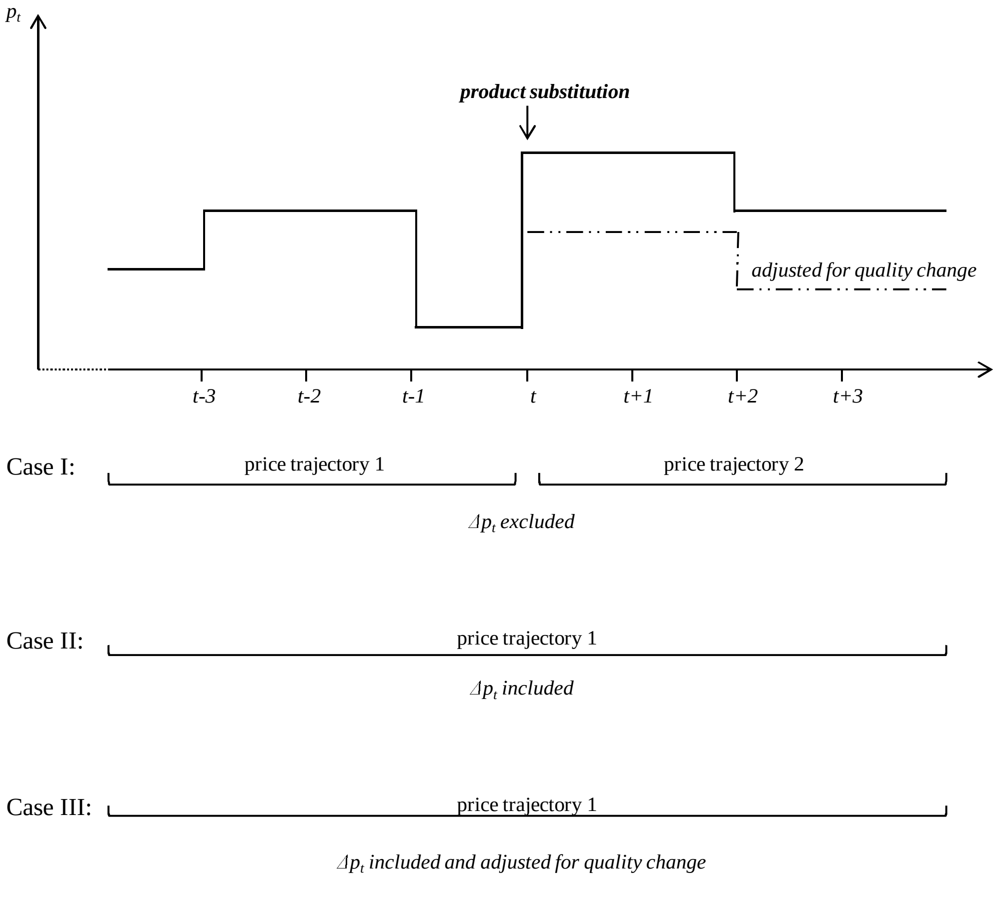
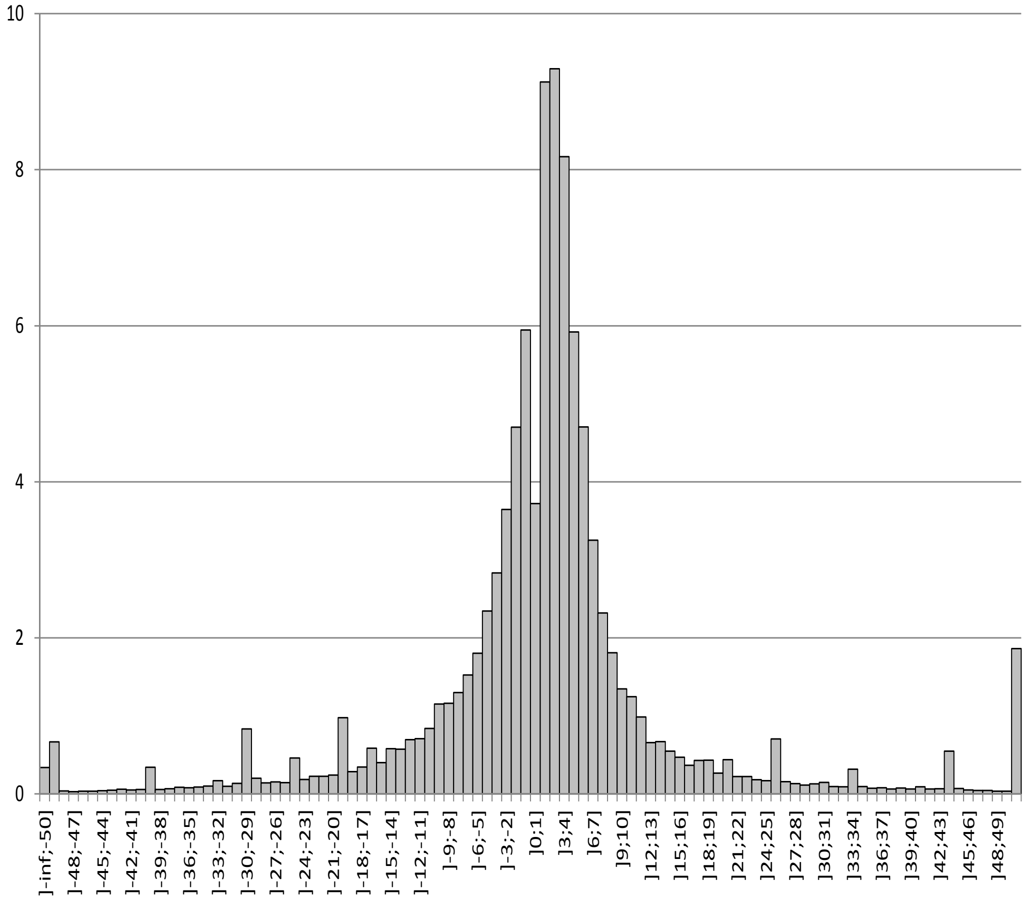
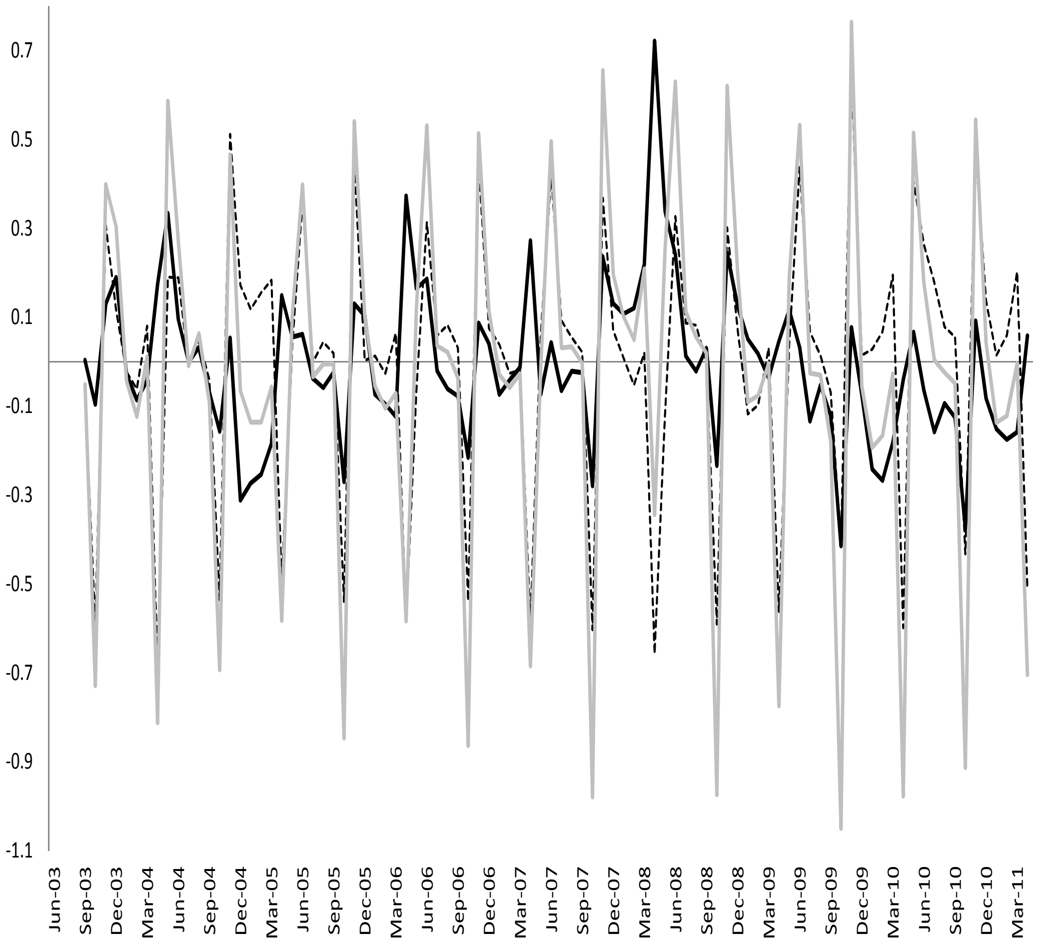


Figure 2: Distribution of non-zero price changes



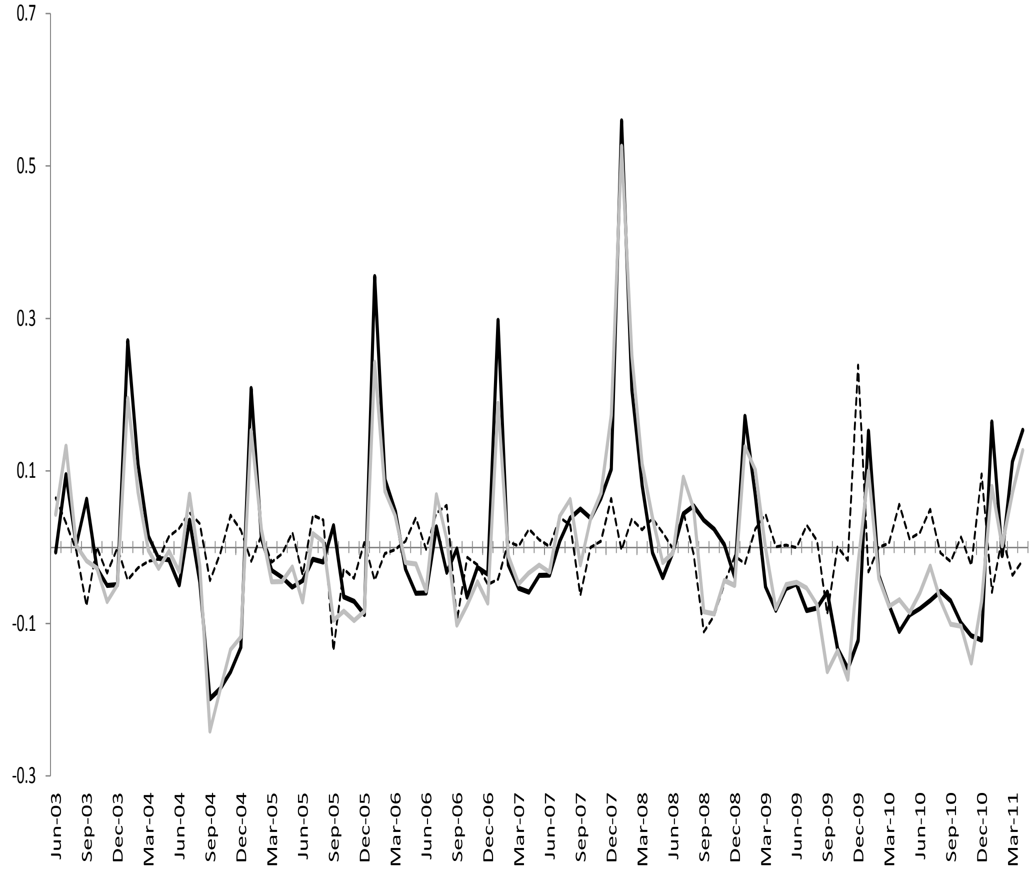
Note: all prices changes different from zero, calculated in percentage, including sales and excluding product substitutions. Period 2003-2011

Figure 3: Contributions of the frequency and of the size of price changes to inflation - All prices



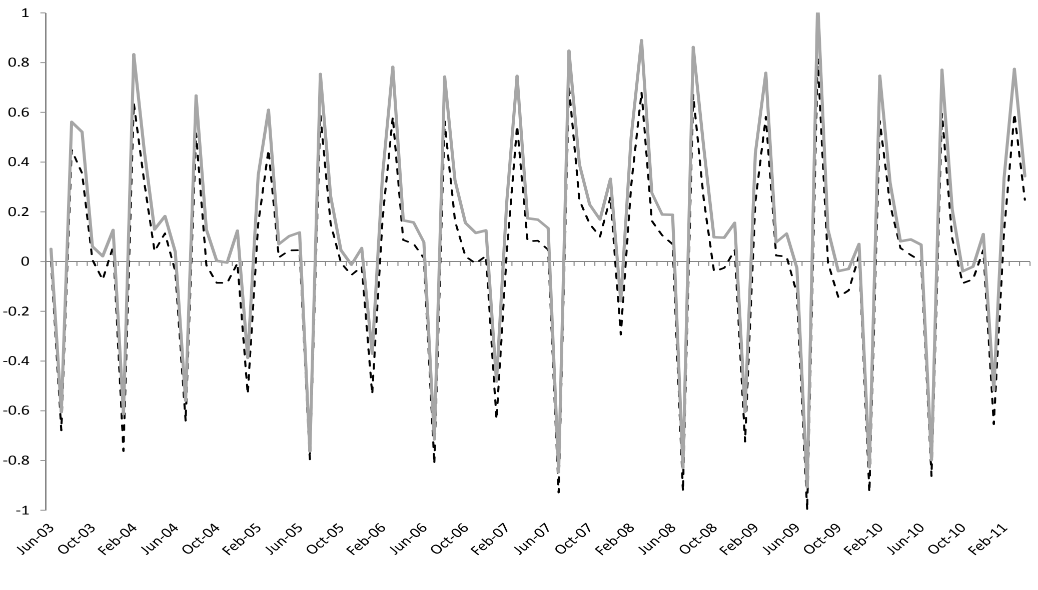
Note: gray line: deviations of the monthly rate of inflation from its average over time (excluding energy), excluding replacements and sales included. Black line: contribution of the frequencies of price increases and of price decreases to the deviations of monthly inflation over time. Black dashed line: contribution of the average sizes of price increases and of price decreases to the deviations of monthly inflation over time.

Figure 4: Contributions of the frequency and of the size of price changes to inflation - Non-sales prices

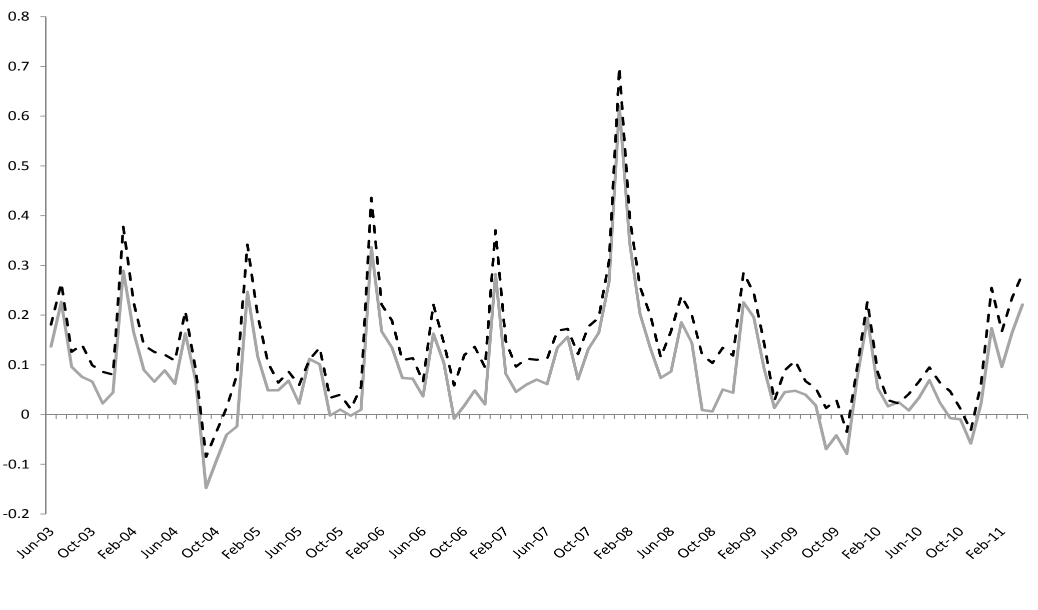


Note: gray line: deviations of the monthly rate of inflation from its average over time (excluding energy), excluding replacements and sales are excluded. Black line: contribution of the frequencies of price increases and of price decreases to the deviations of monthly inflation over time. Black dashed line: contribution of the average sizes of price increases and of price decreases to the deviations of monthly inflation over time.

Figure 5: Monthly inflation including or excluding product replacements



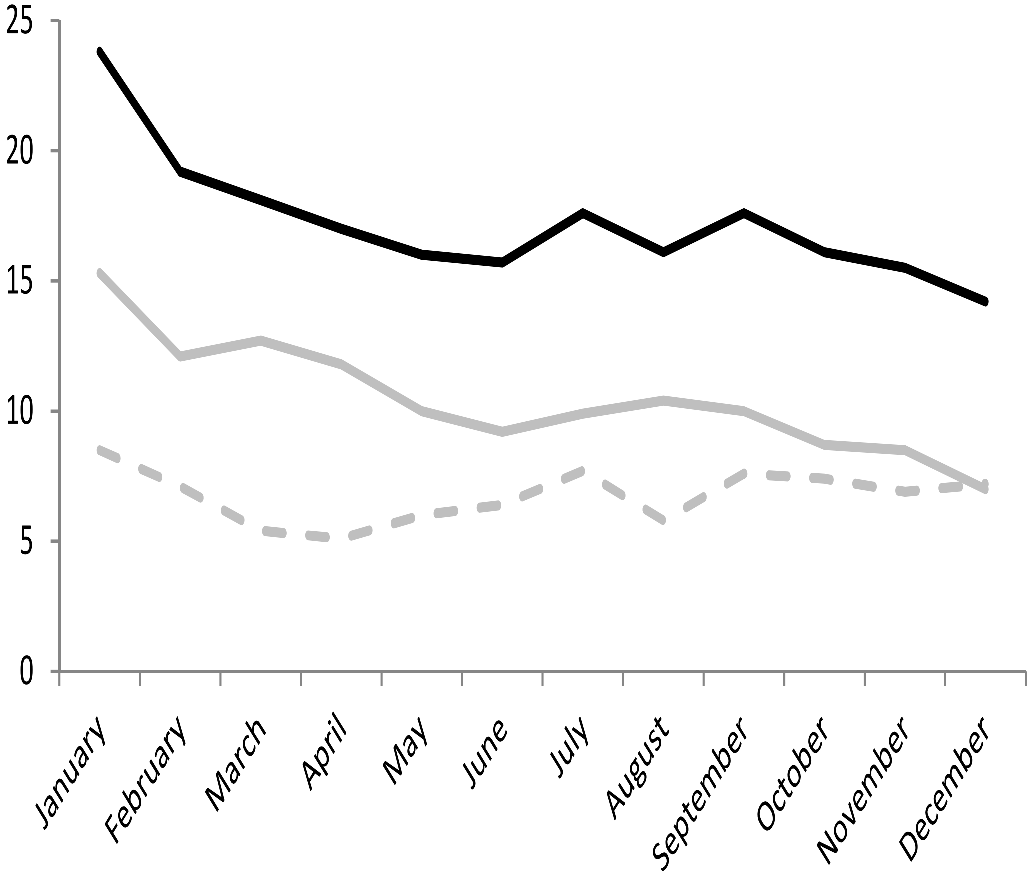
(a) Including sales



(b) Excluding sales

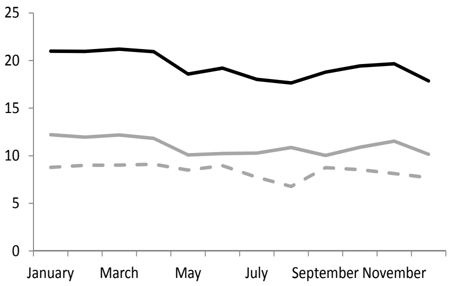
Note: gray line: deviations of the monthly rate of inflation from its average over time (excluding energy), excluding replacements. Black dashed line: deviations of the monthly rate of inflation from its average over time (excluding energy), including replacements.

Figure 6: Seasonality of the frequency of price changes

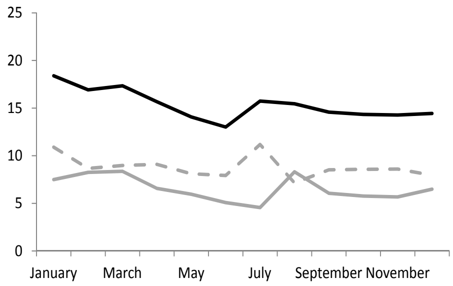


Note: black: frequency of price changes, gray: frequency of price increases and dashed gray: frequency of price decreases

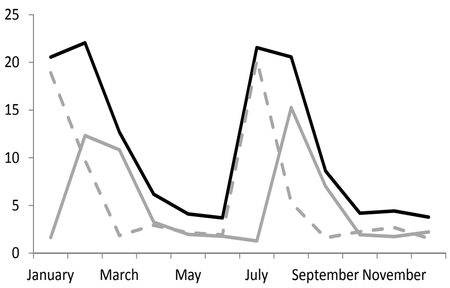
Figure 7: Seasonality of the frequency of price changes - by sector



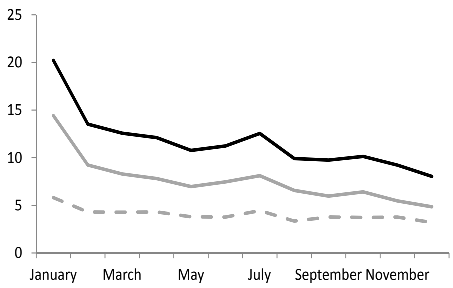
(a) Food



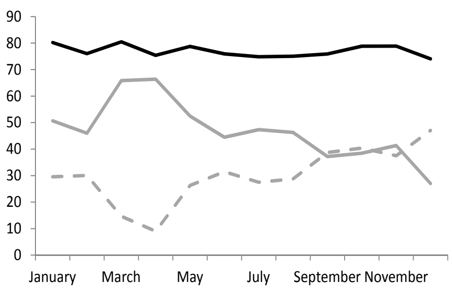
(b) Durables



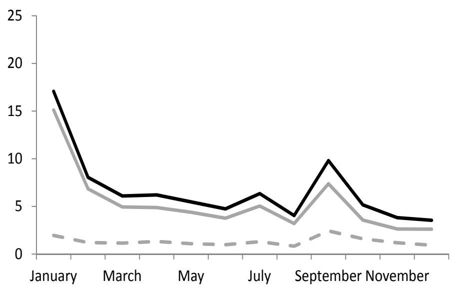
(c) Clothing



(d) Other Manuf.



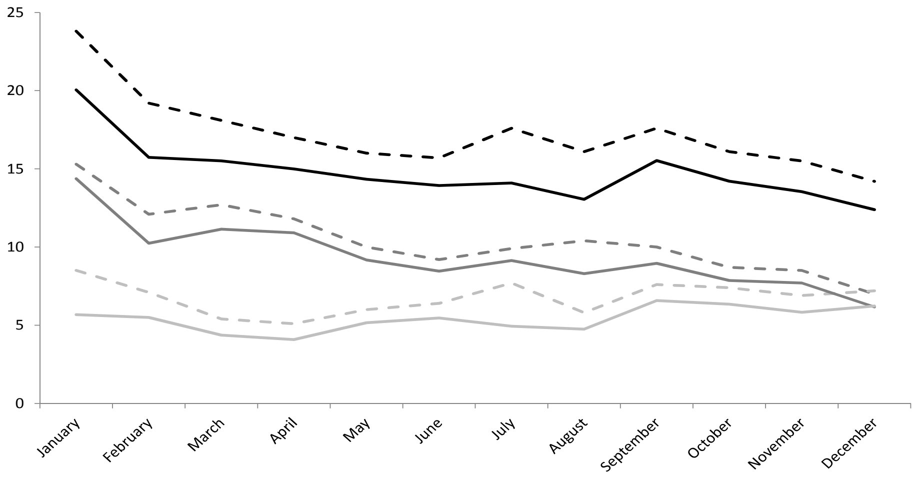
(e) Energy



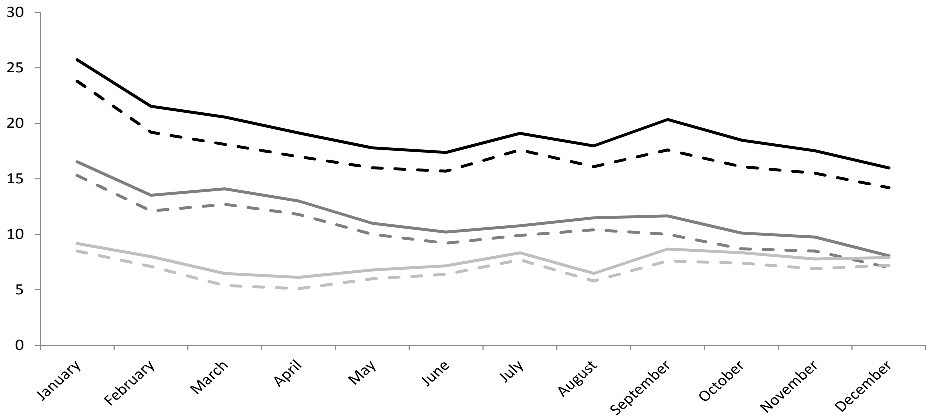
(f) Services

Note: black: frequency of price changes, gray: frequency of price increases and dashed gray: frequency of price decreases

Figure 8: Seasonality of the frequency of price changes - Sales and substitutions



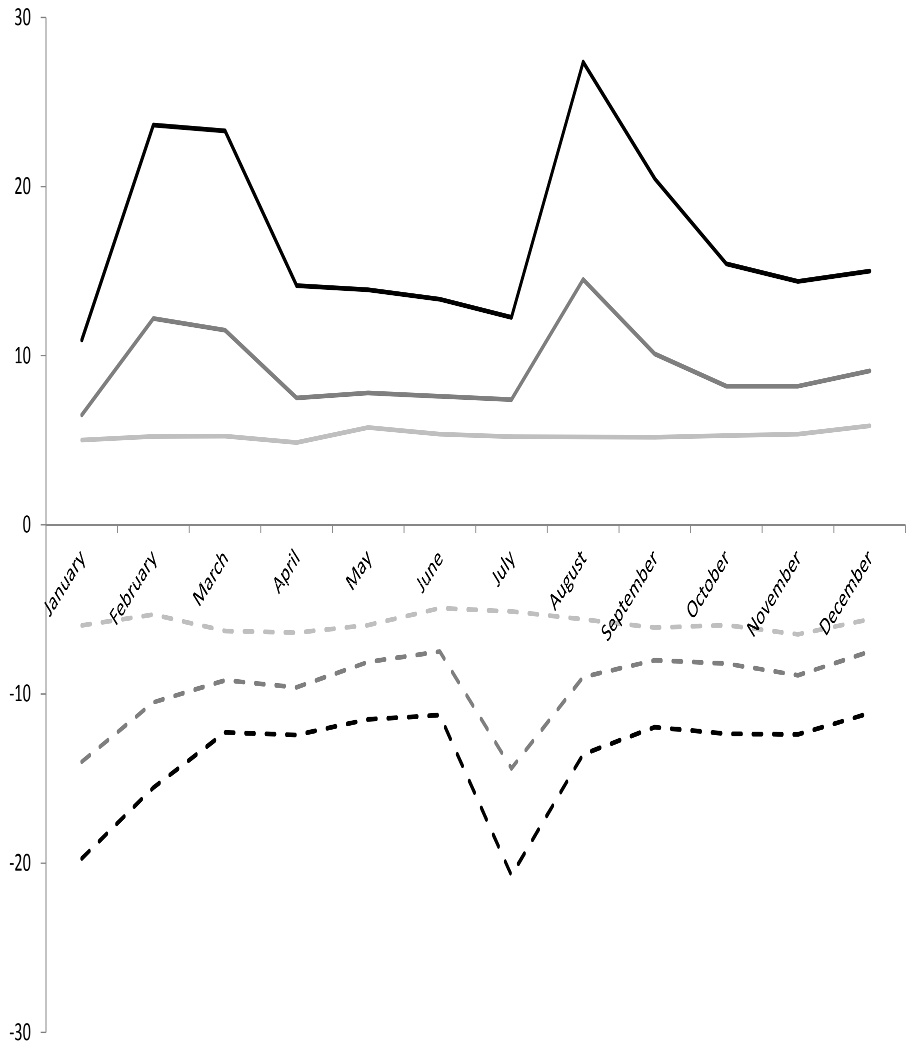
(a) Sales



(b) Substitution

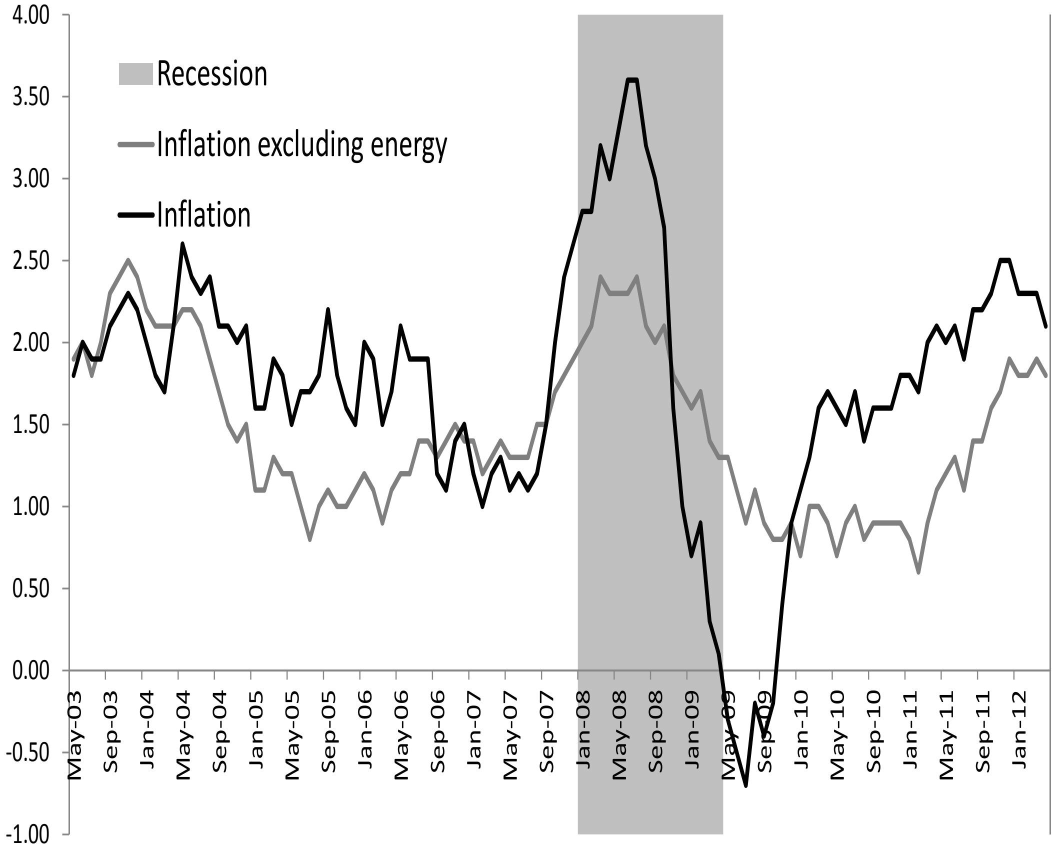
Note: black: frequency of price changes, dark gray: frequency of price increases and light gray: frequency of price decreases; dashed lines: including sales or excluding substitutions; continuous lines: excluding sales or including substitutions

Figure 9: Seasonality of the size of price changes



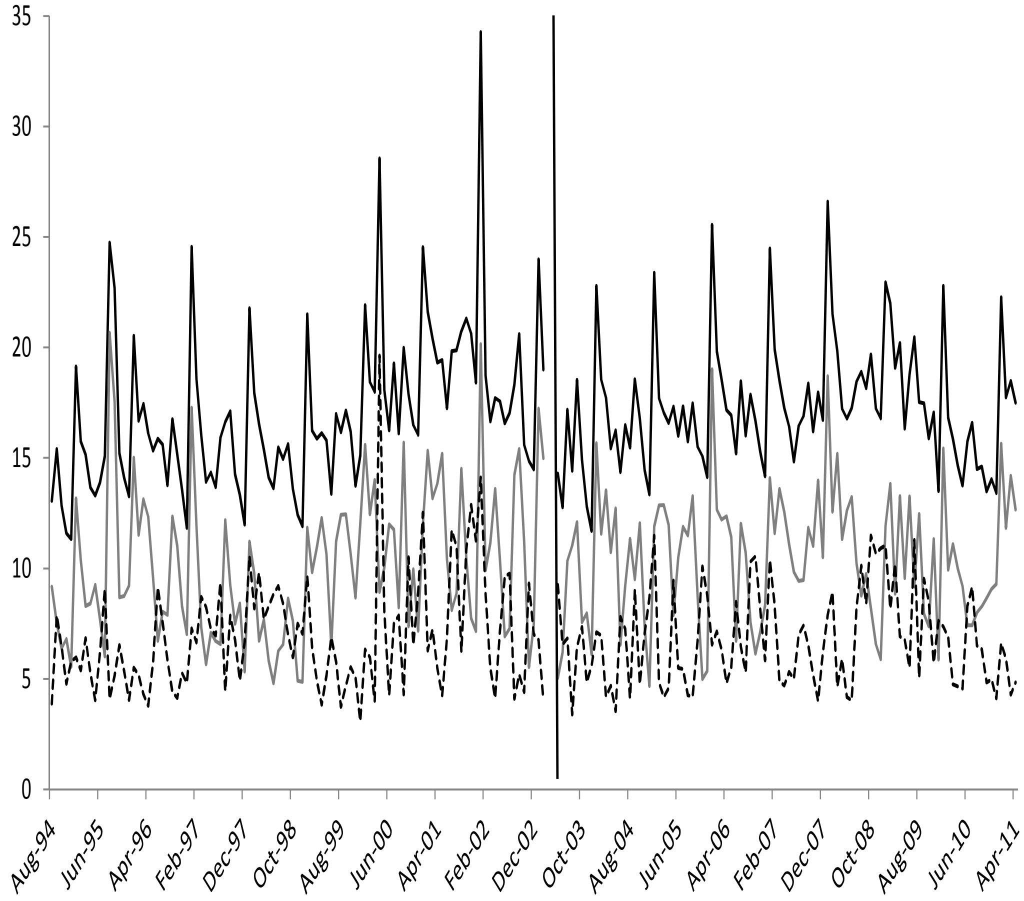
Note: dashed line: price decreases and continuous line: price increases; black: weighted average size of price increases or decreases including sales and substitutions, dark gray: weighted average size of price increases or decreases including sales and excluding substitutions and light gray: weighted average size of price increases or decreases excluding sales and excluding substitutions (in percent).

Figure 10: Overall inflation and overall inflation excluding energy (in %)



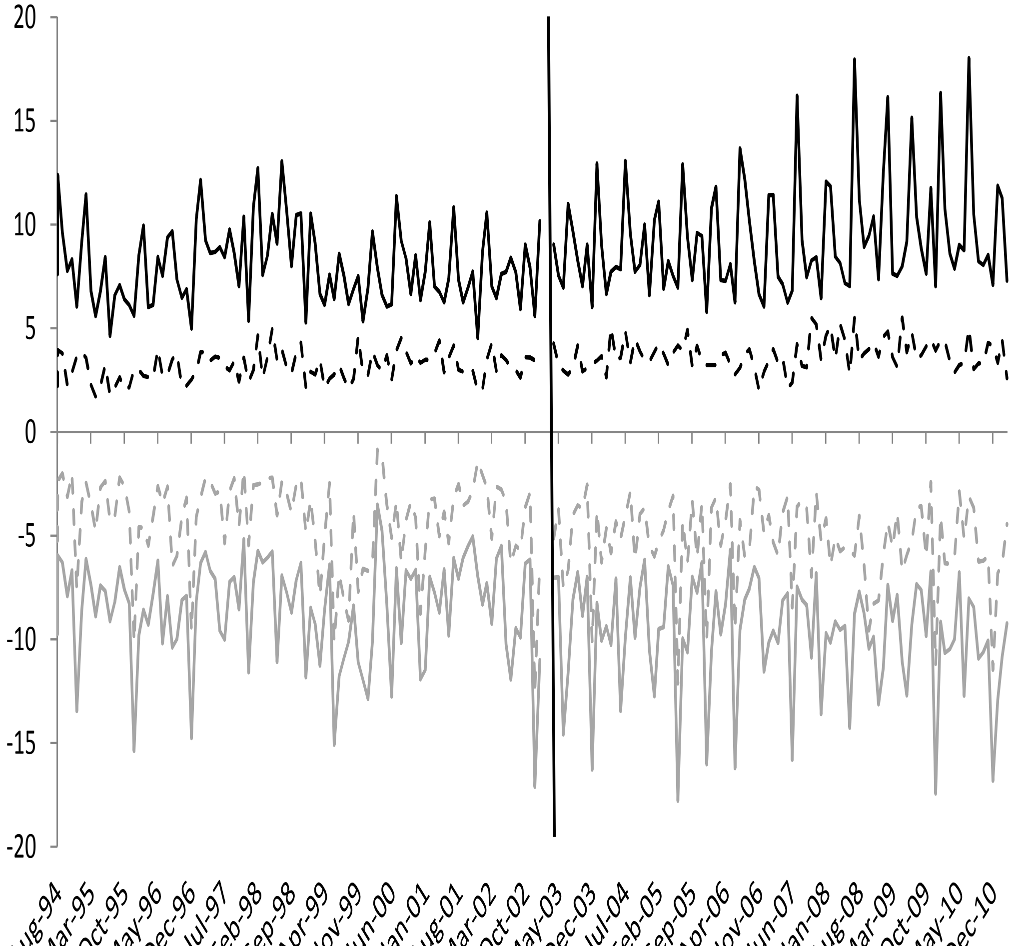
Note: Inflation rates are calculated as annual variations of CPI (overall) and CPI (overall excluding energy). Recession means that quarterly growth of GDP is negative during at least 2 quarters.

Figure 11: Frequency of price changes, increases and decreases over time



Note: Black line: Monthly weighted frequency of price changes. gray line: Monthly weighted frequency of price increases. Black dashed line: Monthly weighted frequency of price decreases.

Figure 12: Average and median size of price increases and decreases over time



Note: Black line: Average weighted size of price increases, Dashed black line: median weighted size of price increases. gray line: Average weighted size of price decreases, Dashed gray line: median weighted size of price decreases.

Appendix - Data treatment

5.1 Unit price

To take into account potential variation in the quantity corresponding to a price record, we calculated the unit price of items dividing the price by the quantity. Notice that changes in the unit of measurement or more in general measurement error may affect quantity. For instance, the packaging of a bottle of olive oil may change from 1l to 750ml. If this change in quantity is recorded as $q_{t-1} = 1$ and $q_t = 0.75$ then dividing the recorded price by quantity is sufficient. However, it may happen that the latter change is recoded as $q_{t-1} = 1$ and $q_t = 750$. Thus, to correct for potential changes in the unit of measure of quantity, we followed three rules:

1. if the quantity in t was greater or equal than 10 times, or less or equal to 1/10 of the modal quantity for an item, and if at the same time the price was between 0.9 and 1.1 of the modal price, then we substituted the quantity in t with the modal quantity for the item.

2. if the quantity in t was greater or equal than 50 times the modal quantity for an item and if at the same time the price was less or equal than the modal price, then we substituted the quantity in t with the modal quantity for the item.

3. if the quantity in t was the same as in $t-1$, at least doubled or halved with respect to $t+1$, and the price was exactly the same as the price in $t+1$ and if at the same time the price was tagged as a normal observation, a replacement, or a temporary absence, then we substituted the quantity in t with the modal quantity for the item.

5.2 Type of price record and carry-forward procedure

To compute the CPI, missing values are not allowed by the INSEE procedure in the recording of individual prices for a given individual product. However, in some cases, the price of a product cannot be observed. The value recorded is then the outcome of an imputation procedure (see Turvey [1999]) and it is labeled as a pseudo-price. The other two other types of prices are 'regular price' records and 'seasonal sale or temporary discount' records.

It is important to be more specific about pseudo prices, since we have chosen for some categories of pseudo prices to depart from the INSEE imputation procedure. Failure to observe a price can result from a variety of situations, calling for different procedures to assign a pseudo price. First, some products are seasonal by nature and their price is not posted all year round (*e.g.* ski gloves may not be sold during summer). These kinds of pseudo prices account for 7.7% of price quotes, and appear mainly in the clothing sector. Secondly, some prices fail to be observed because the prices of some products, mainly durable goods, are collected only at a quarterly frequency (0.4% of records). For these two categories of missing observations, the INSEE generally implements the carry-forward procedure: the unobserved price of the item is assumed to be the same as when it was last observed.[30] We have adopted the same convention.

A third cause for the non-observation of prices is that a product is temporarily absent in an outlet, or that an outlet is temporarily closed or that a collector absent (summing up to 6.5% of price quotes).[31] In that case, the INSEE evaluates the missing price according either to the carry-forward procedure, or preferably by using extrapolation or by computing a replacement price. The extrapolation procedure relies on adjusting the previous price by using the rate of change of the price index for the product in the same geographical area. The replacement procedure implies recording the observed price of a similar product in the same outlet, or in another outlet. Although both these procedures are appropriate for producing a real-time unbiased aggregate CPI, they do not suit our purpose. Indeed, the two imputation procedures just described are likely to impute a pseudo price different from the previous price record and this potential price change is not relevant for the purpose of studying individual price-change patterns.

We replaced most of the pseudo prices using the carry-forward procedure: whenever a price is not available at date t, then we replace the pseudo price with the last normal price observed.

One possible case where our procedure might create a downward bias on the estimated frequency of price changes is when the product was unavailable on the precise day the collector visited the outlet, but was present on other days in the month with a price different from P, say P'. We can however reasonably think that this is not very frequent and therefore the bias small. Another case where the carry-forward procedure may imply an overestimation of price duration is when an item is out of season and thus a pseudo price is reported for several months, while in one fifth of the cases a replacement follows. Therefore, we check the robustness of our results when we do not apply the carry-forward procedure to pseudo prices resulting from the absence of the product out of season.

[30] Fresh foods, which are a kind of seasonal product, undergo a different statistical treatment based on a rolling basket, but they are not included in our data set.

[31] Other rare cases where the observation is considered a pseudo price are: product to be replaced the following month and temporary replacement in the same or different outlet, summing up to 0.4% of price quotes. Note that should an item in a given outlet be missing for more than two consecutive months, it is replaced by another item in the CPI basket. This follows a Eurostat convention (EC regulation 1749/96) which aims at reducing the number of imputed prices.

Our strategy is partly supported by the observation that when the price at date t, P_t, is a pseudo price, then $P_{t+1} = P_{t-1}$ is *a posteriori* observed 3/4 of the times. Notice that the main reason allowing our treatment to be different from that adopted by INSEE is that the statistical office has to evaluate prices in real time (at date t) and by definition cannot use information dated $t + 1$.

5.3 Price changes

A price change (ΔP_t) may be calculated as logarithmic difference, *i.e.* $lnP_t - lnP_{t-1}$, or rate of change, *i.e.* $(P_t/P_{t-1}) - 1$. The former is usually preferred because it has more convenient aggregation properties than the latter. Moreover, rates of change don't measure increases and decreases symmetrically. To understand why, just consider a simple example where a price moves from 1 to 2 and back to 1 in consecutive months. Between the first and second months, the price increase rate is 100%, but in the following month the price decrease rate is only 50%. If you averaged these two rates of change you would come to the conclusion that the average price increase was 25%, while in fact the price returned back to its initial level and there was no price growth in the end. However, it may still be interesting to look at rates of change in some occasions, as they represent what consumers see or compute when evaluating price changes.

Sometimes price changes are extreme. One reason why this may happen is that an item price may go basically to 0 in certain moments. For instance, street parking in France is usually free in August. In these cases the INSEE records a symbolic price, to avoid the price variation to be infinite. Still, the average price change of an hour parking in the street is about 1800% between August and September (versus 24% in the other months), a magnitude of variation that we are not interested in explaining, since it simply results from regulation. In what follows we thus exclude price changes that are likely to be due to measurement errors or to specific price dynamics, restricting price changes to be between -80% and 500%.

5.4 Censoring and product substitution

An important issue to be addressed when measuring durations of price spells is that of censoring. Censoring is an important phenomenon in individual CPI data, because the median number of spells of an individual product price trajectory is four and typically, the first and last spells are censored. There are different types of censoring; we present the terminology adopted in this paper below.

One reason for censoring is that the observational period of prices is fixed. *Fixed* censoring means that we know nothing about the price before April 2003 (the price trajectory is left-fixed censored) and after April 2011 (the price trajectory is right-fixed censored). In our dataset slightly more than 4% of spells are left-fixed-censored and about 1% are right-fixed-censored.

Within the observational period, spell censoring is due to the fact that the (calendar) time of the beginning of the first price spell and/or the end of the last spell of an individual product price trajectory are not observed (the spell is left-censored in the first case and right-censored in the second one). Indeed, it cannot be assumed that the price was set on the precise month when a product was included in or excluded from the CPI basket, or when an individual product started or stopped being observed in a particular outlet.

A particular case of right-censoring is when an item disappears from the sample and is replaced by another one. The statistical agency may no longer record the price of a given product in a given outlet, either because the product is no longer sold by the outlet or, more rarely, because the outlet itself closes (attrition/forced replacement), or because the statistical institute may decide to discard a product or an outlet from the set of recorded price quotes in order to keep the sample of items representative of the structure of consumption (voluntary replacement).

We cannot distinguish between forced and voluntary replacement. The statistical office deals with them in a differ Voluntary replacement takes place at the end of the year. The statistical office collects the price of the substituting product before and after the replacement in the basket takes place. Therefore, the introduction of the new product has no impact on the inflation index in January. Forced replacement concerned unscheduled substitution, which may be with an 'equivalent' or 'different' product. In the first case, the price difference is considered as a simple price change. In the second one, the characteristics of the products differ to some extent. Thus, price variation at the moment of substitution is often imputed based on price changes of similar products. Otherwise, the statistical office explicitly evaluates the quality change (for instance, with a hedonic price model) and correct the price difference by the quality coefficient change.

When product substitution occurs (more than 500 thousand times in our data) different hypotheses can be made on the implied price dynamics. A first hypothesis is to consider each case of replacement as indicating the end of a price trajectory. Following this approach, like Baudry et al. [2007], 12.20% of spells are left-censored and 14.80% are right-censored within the period of observation. Moreover, almost a sixth of price spells (around 15.27% of spells) are both left- and right-censored within the period of observation. Taking into account fixed censoring as well, 14.64% of spells are left-censored, 14.64% are right-censored, and 16.69% are both left- and right-censored.

Another approach is however feasible thanks to the fact that we know which item substitutes a disappeared one. We can contrast the price of the replacing item with the one of the disappeared good that it substituted. Moreover, we can adjust this price change by the change in quality, as provided by the statistical office. These two cases imply that product substitution does not generate a new price trajectory. With this second approach 2.93% of spells are left-censored (2.92% when adjusted for quality), 5.83% are right-censored (5.79% when adjusted for quality), and only 0.54% are both left- and right-censored within the period of observation (0.53% when adjusted for quality). Finally, considering also fixed censoring, 7.02% of spells are left-censored (6.99% when adjusted for quality), 7.02% are right-censored (6.98% when adjusted for quality), and 0.31% are both left- and right-censored (0.60% when adjusted for quality).

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