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EUROSYSTEM INFLATION
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CONSUMER PRICE BEHAVIOUR IN ITALY

EVIDENCE FROM MICRO CPI DATA

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The Eurosystem Inflation Persistence Network

This paper reflects research conducted within the Inflation Persistence Network (IPN), a team of Eurosystem economists undertaking joint research on inflation persistence in the euro area and in its member countries. The research of the IPN combines theoretical and empirical analyses using three data sources: individual consumer and producer prices; surveys on firms' price-setting practices; aggregated sectoral, national and area-wide price indices. Patterns, causes and policy implications of inflation persistence are addressed.

The IPN is chaired by Ignazio Angeloni; Stephen Cecchetti (Brandeis University), Jordi Galí (CREI, Universitat Pompeu Fabra) and Andrew Levin (Board of Governors of the Federal Reserve System) act as external consultants and Michael Ehrmann as Secretary.

The refereeing process is co-ordinated by a team composed of Vítor Gaspar (Chairman), Stephen Cecchetti, Silvia Fabiani, Jordi Galí, Andrew Levin, and Philip Vermeulen. The paper is released in order to make the results of IPN research generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the author's own and do not necessarily reflect those of the Eurosystem.

CONTENTS

Abstract

This paper investigates the behaviour of consumer prices in Italy by looking at micro data in the attempt to obtain a quantitative measure of the unconditional degree of price rigidity in the Italian economy. The analysis focuses on the monthly frequency of price changes and on the duration of price spells, also with reference to different types of products and outlets. Prices tend to remain unchanged on average for around 10 months; duration is longer for non-energy industrial goods and services and much shorter for energy products. Price changes are more frequent upward than downward, in larger stores than in traditional ones. When the geographical location of outlets is accounted for, price changes display considerable synchronisation, in particular in the service sector.

Key words: consumer prices, nominal rigidity, frequency of price change.

JEL classification: D21, D40, E31.

Non-technical summary

This paper investigates the characteristics of consumer price changes in Italy by analysing prices at the most disaggregated level, namely items of a specific brand sold in a specific outlet. The database consists of 750,000 elementary price quotes in the Italian CPI basket between January 1996 and December 2003. The methodological approach is mainly of a descriptive nature; we analyse the frequency of price changes to obtain a measure of the unconditional degree of nominal price rigidity in the Italian economy. We provide a first interpretation of the results in terms of existing pricing models, but we leave a more formal investigation for future research.

The empirical analysis is based on both a duration approach, directly tracking the number of months for which a price remains unchanged, and a frequency approach, computing the proportion of price quotes that change in a given period. We use a variety of empirical strategies to assess the robustness of the results with respect to the treatment of *censored* observations. The problem of censoring reflects the fact that in the process of price collection the true time of beginning (ending) of the first (last) price spell might not correspond to the one observed in the dataset, as it comes before (after) the first (last) price observation.

The average duration of price spells, which captures how long prices tend to remain unchanged, is between 6 and 10 months, depending the way *censored* observations are treated. However, we find that price setting is very heterogeneous across product categories: average price duration is much longer for non-energy industrial goods and services (14 and 15 months, respectively) while it is very short for energy products (2 months). Including in the sample the years 2002-03 lowers our estimates of duration for all sectors, since the euro cash changeover induced a larger than average number of price adjustments in the first half of 2002.

On average each month 9% of prices are changed, which corresponds to an implied average duration of 9-11 months. Again, results are rather heterogeneous across products: at the two extremes, energy prices change every month and services prices last almost two years.

As to the size and the direction of price changes, our results indicate that there are more price increases than decreases: on average, each month around 7% of price changes are increases, while the share of decreases is about 4%. The asymmetry is most pronounced for services and non-energy industrial goods, for which increases are respectively three and two times more frequent than decreases. Furthermore, the size of price changes is substantial, on average greater than the average inflation prevailing in the years considered in the sample. The size of price increases and decreases is approximately the same, a symmetry that broadly holds for all components.

As for type of outlet, traditional outlets tend to change the price of non-energy industrial goods and food products significantly less frequently than large stores (7% *versus* 11%). Price changes tend to be more symmetrical in mass than in traditional retailing.

In general, synchronisation of price changes is rather low the aggregate level. However, the results show that properly accounting for the geographical dimension of the data this finding is perfectly compatible with higher synchronisation rates computed within a given city.

In a regression analysis we investigate the main factors (average inflation, seasonal factors, attractive pricing thresholds, indirect tax changes) determining variations over time in the frequency and size of price changes. Frequency is positively related to the headline inflation rate and to the increase in VAT rates in October 1997 and negatively related to the share of attractive prices; seasonal effects are present. As for the size of price changes, none of the considered factors seems to significantly affect it.

Finally, the probability of changing prices is positively correlated with the increase in VAT rate and with average inflation; it is negatively correlated with the share of attractive prices and with the duration of the price spell. Seasonal and sector dummies are always significant.

1. INTRODUCTION

In this paper we investigate the behaviour of consumer prices in Italy using micro data. We assess a few characteristics of price changes, in particular their frequency (monthly percentage of price changes), with reference to different items and types of outlets, to produce a quantitative measure of the unconditional degree of nominal price rigidity in the Italian economy.

Numerous theoretical models postulate nominal price stickiness, but the empirical evidence is rather limited. For Italy there are two studies. The first (Fabiani *et al.*, 2003) investigates the topic by applying a methodological approach initially developed by Ball and Mankiw (1994) based on analysis of the statistical properties of the cross-sectional distribution of sectoral price changes and of the relationships between its moments. The second (Fabiani *et al.*, 2004) is based on qualitative information collected directly by questionnaire from a sample of Italian firms, along the lines of the seminal work of Blinder (1994) and Blinder *et al.* (1998) for the US, and Hall *et al.* (2000) for the UK.

Here we take a different approach. We investigate nominal price rigidity by analysing price behaviour at the elementary level, namely a specific item and brand, sold in a given outlet. We exploit both the cross-sectional and the time series dimensions. The database consists of 750,000 elementary price quotes for 48 items in the Italian CPI basket between January 1996 and December 2003.

Similar studies have been done for other countries, though with few exceptions (e.g. Bils and Klenow, 2002) they are based on a much smaller set of products (Lach and Tsiddon, 1992, 1996; Cecchetti, 1986; Ratfai, 2004). More recently, in the framework of a Eurosystem research project, the *Inflation Persistence Network* (IPN), studies using common methodologies and similar databases have been performed for most euro area countries. Those already completed – Aucremanne and Dyhne (2004) for Belgium, Baudry *et al.* (2004) for France, Dias *et al.* (2004) for Portugal, Jonker *et al.* (2004) for the Netherlands and Alvarez and Hernando (2004) for Spain – are the natural reference for the analysis performed here.

The paper is structured as follows. The second section discusses the main characteristics of our database. Section 3 defines the main statistics on which our empirical analysis of the characteristics of price behaviour is based; the issue can be approached by adopting either a frequency or a duration approach. Section 4 presents the empirical results. Section 5 concludes.

2. THE DATASET

We use the monthly data collected by the Italian National Statistical Institute (Istat) to compute the Italian Consumer Price Index (CPI). These are the prices actually observed by the surveyors when they visit stores. Overall, for each month the Istat dataset averages 300,000 price quotes for some 550 COICOP product categories, which are mainly collected by surveyors in 85 municipalities throughout Italy and, for a subset of products, directly by the Central Bureau of Istat.

2.1 Sample coverage

We have used only a fraction of the complete Istat dataset, for the period January 1996-December 2003. Geographically, we focused only on the 20 regional capitals and disregarded data regarding the rest of the country used in computing the official overall index. In terms of product coverage, we included only 48 of around 500 categories, thus accounting for not quite 20% of the CPI basket in terms of the product weights in the *Classification of Individual Consumption by Purpose* (COICOP; Table 1). This subset was selected in agreement with the other central banks of

the euro area doing similar research within the IPN, to ensure some cross-country comparability. By restricting analysis to a subset of the CPI we lose in terms of coverage but gain in accuracy and more careful preliminary treatment of the data.

The representativeness of our sub-sample can be assessed in several ways. First, we compare the general CPI and the index only for the elementary prices for the 48 goods and services we survey.[1] As is shown in Figure 1, inflation trends are well captured by our sub-sample especially if the re-scaled weights are used. The differences are most pronounced in 1999, 2000 and 2002, largely because of developments in energy prices. The correlation coefficient between the two series, computed over the years 1997-2003, is equal to 0.85.

Second, to check the robustness of our results with respect to the geographical selection, we compare the national consumer price inflation with inflation calculated by aggregating the CPIs for the 20 regional capitals[2]; we find that the latter represents national inflation trends quite well.

Finally, we compute the monthly inflation rate on the basis of the elementary prices in our dataset. Figure 2 confirms that our "reconstructed CPI" closely mirrors that based on aggregation of the official Istat indices for the same 48 items. The correlation coefficient between the two series is equal to 0.92.

All in all, this evidence suggests that our sub-sample of elementary prices captures developments on those same items in the overall CPI; more important, it tracks headline inflation quite well.

The items in our dataset are classified according to two different criteria. One is the standard classification into the categories of expenditure typically used by Statistical Institutes (COICOP). The second is the five-category breakdown used by the Eurosystem: non-energy industrial goods, processed food, services (the so-called "core components"), unprocessed food, and energy products.

The proportion of processed food products and, in particular, of non-energy industrial goods in our sub-sample is lower than in the overall CPI basket (Table 2), while that of services is higher. With reference to the COICOP classification, the percentage of items under "Food and non-alcoholic beverages" is lower than in the overall CPI basket, whereas that of "Restaurants and hotels" is higher (Table 2). Finally, three important categories of expenditure – "Health", "Communication" and "Education" – are not represented in our sub-sample; these are the categories that show the greatest incidence of regulated prices, which we decided not to consider.

2.2 The information available in the dataset

Crucial to our study is characterising the elementary price records that underlie the empirical analysis. This hinges on the "non-price" information (metadata) collected together with the price quotes. The Istat dataset has a wealth of information pertaining not only to prices, but also to the type of product and of outlet as well as to the causes of possible replacements.

By product we denote each of the items included in the CPI classification and in our sub-sample. Take, as an example, "Coffee". For each product, several price quotes are available, each referring to a specific variety and brand, sold in a specific outlet. Accordingly, by elementary product we denote a specific variety and brand of the product, sold in a specific outlet, in a given town. Each elementary product has an elementary price quote at a particular time *t*. In terms of our

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[1]   In order to aggregate our elementary data, in principle we can rely on two different sets of weights. In one, each item has the same weight as in the overall CPI basket; in the second, these weights are re-scaled to sum up to the overall weight of all the items included in the same category of expenditure. For instance, if only 2 out of 11 unprocessed food products are considered in the sub-sample, under the first option the sub-index "unprocessed food" in our sub-sample will have a weight given by the sum of the two items, and this can differ substantially from its weight in the overall basket. Under the second weighting scheme, each weight is re-scaled so that the overall importance of unprocessed food in our sub-sample is equal to that in the overall index (i.e., the selected products are assumed to be fully representative of all unprocessed food goods).

[2]   Up to the end of the nineties Istat computed, for regional capitals, the index of consumer prices for worker and employee households, whose evolution mirrors that of the CPI.

example, by elementary price quote we mean the price of, say, a "1 kilogram package of coffee, of brand X, sold at time t in store Y, located in town Z".[3] In our analysis it is crucial to follow the exact same elementary price quote through time; this is possible using the information associated with each quote (metadata), summarised in Table 3.

Our dataset includes 750,000 elementary price quotes (8,000 quotes each month). Most of the quotes cover the entire period from January 1996 to December 2003.[4] Istat's sampling procedure aims at maintaining within a given base period[5] a balanced sample of product price quotes. For example, in the collection of price quotes for "packaged coffee" for the city of Turin, Istat may collect 30 different elementary quotes for every month in a given base period (e.g. between December 2001 and December 2002). This method requires the "forced" replacement of some products when, say, the brand in question happens to be unavailable on shelves.[6] Forced replacements are not to be confused with replacements due to the standard turnover of outlets and products that can occur at each base-year change and due to a rotation in the sample ("optional" replacement; see below).

The metadata at our disposal is sufficiently rich to detect product replacements, which occur for various reasons:

(1) a specific product is no longer sold in a given store (a new brand of coffee is now sold);

(2) the product is temporarily unavailable on shelves; in this case the previous month's price quote is imputed, but such imputation can only last for at most two consecutive months;

(3) the shop has closed;

(4) the periodical rotation of outlets that occurs when Istat re-bases the CPI.

The first three are forced replacement. In these cases the surveyor replenishes the sample by collecting the price of an elementary product with similar characteristics (for instance, another brand of coffee in the same shop); if a shop was closed, another outlet with similar characteristics in the same area is included. The fourth case instead leads to an optional replacement, since Istat deliberately introduces a change to maintain a representative of sample.

From the metadata we know that a replacement has occurred, but we cannot tell whether it was forced (reasons 1, 2 and 3 above) or optional (reason 4). As will become clear in the empirical section, this requires us to make some auxiliary assumptions when dealing with the problem of censored observations[7].

Some of our products – essentially clothing and footwear – are subject to significant price swings due to temporary sales or other special offers. Since January 2002 Istat has been following the EC Regulation on the treatment of sales prices in the HICP, which requires collection also of the prices subject to temporary reductions. But for the national CPI Istat has continued to disregard reductions lasting less than a month. So after 2001 the observations for products on sale have

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[3]   At this level of disaggregation, the elementary price quotes are not associated with specific weights in the basket. Istat, in computing the CPI, aggregates elementary price quotes for each good or service, collected in different stores in a given town, first in the so-called "elementary aggregate index"; namely, for each municipality and for each product, the geometric mean of the ratios between each current quote and the base-period quote is used to calculate the "municipal product index". Then, using a provincial weight structure, Istat applies weighted arithmetic averages to produce "national product indices". Finally, the CPI results from a weighted average of the national product indices, where the weights are derived from the yearly Survey of Final Household Consumption.

[4]   To compare prices over time with the euro cash changeover, we converted into euro all prices before January 2002. When comparing prices between January 2002 and December 2001, figures were rounded to the 2nd decimal place, as required by Eurostat regulations.

[5]   The base period for the CPI is annual, from December to December.

[6]   Istat signals replacements with various flags, according to the type of replacement enacted by the price collector (variety-brand-size-outlet). If the product package size changes (for instance from ½ to 1 kilogram) we consider the product to be the same and, accordingly, we use the collected price per unit instead of the actual package price.

[7]   The problem of censoring arises when the "true" time of beginning (ending) of the first (last) price spell does not correspond to the one observed in the dataset, since it occurs before (after) the first (last) price collection. A detailed discussion of censoring is in Section 4.1.

included both full price and sales price for each month. For meaningful intertemporal comparisons, we have ignored sales prices. This may produce downward bias in the estimate of the frequency of price changes.

We selected products that would always be available throughout the year. Thus in categories with strong seasonal dependence, such as clothing or unprocessed food, we took only highly standardised items (e.g. men's shirts, fresh tomatoes), in stock all year long.

As for type of outlet, around 60% of our elementary price quotes come from traditional stores, such as corner shops and other small sized stores (Table 4); this share is in line with that of the whole CPI basket.

Finally, of our 48 items: (i) none of the prices is regulated, with the partial exception of "taxis", for which fares are usually set by the local municipality; hence, only one price per town is collected; (ii) the periodicity of data collection can be either monthly, quarterly or twice a month; around 75% of the elementary quotes are monthly (Table 4). For prices observed quarterly, Istat leaves the price unchanged except in observation months ("carry forward" approach); for those collected twice a month (products with high price variability, such as some unprocessed food and energy products) an average monthly price is computed.

2.3 Basic definitions

We follow the notation introduced by Baudry *et al*. (2004) to provide the basic definitions underlying our empirical analysis. We define:

- Elementary price quote: $P_{jl,t}$, for product j (j =1,.., n_j, where n_j is the total number of products; in our analysis n_j=48), sold in a specific outlet l (l = 1,…, n_l) and observed at time t (t= 1,…T). An elementary product is therefore defined by the pair (j,l).

- Price spell: an uninterrupted sequence of unchanged price quotes associated with the elementary product (j,l), that is the sequence $P_{jl,t}$, $P_{jl,t+1}$,…, $P_{jl,t+k-1}$, with $P_{jl,t+s} = P_{jl,t}$ for $s=1,...,t+k-1$. A price spell is therefore an episode of fixed price, which can be fully described by three elements: the date of the first quote (t),its price ($P_{jl,t}$) and the duration of the spell (k), that is $\{P_{jl,t}, t, k\}$.

- Price trajectory: a sequence of s successive price spells for the product (j,l), that is ($\{P_{jl,t}, t_1, k_1\}, \{P_{jl,t+k1}, t_2, k_2\}$, $\{P_{jl,t+k1+k2}, t_3, k_3\}$,….,$\{P_{jl,t+k1+...+ks-1}, t_s, k_s\}\}$. By computing L_{jl}= (k_1 +... +k_s) we can define the trajectory length for the elementary product (j,l), which is just the sum of the individual price spells.

These definitions are represented in Figure 3.

- Trajectory 1 can be described as:

($\{P=1, t_0=1,k_1=2\};\{P=2, t_0=3, k_2=3\};\{P=3, t_0=6, k_3=3\};\{P=2, t_0=9, k_4=1\}$)

- similarly, Trajectory 2 can be described as

($\{P=5, t_0=1, k_1=3\};\{P=6, t_0=4, k_2=3\};\{P=5, t_0=7, k_3=3\}$)

Trajectory 1 has four price spells (with durations of 2, 3, 3 and 1 month), while Trajectory 2 has three price spells (all with a duration of 3 months).

3. PRICE DURATION AND THE FREQUENCY OF PRICE CHANGES

The first aim of our analysis is to characterise price behaviour across products and outlets. Two methodological approaches can be used: the first is based on duration between two price changes, the second on the frequency of price changes. The former, which is denoted as <u>duration</u>

approach, measures the duration of a price spell (the number of months in which a price remains unchanged) directly and derives an "implied" frequency of price changes indirectly, as the inverse of duration. The <u>frequency approach</u> first computes the frequency of price changes as the proportion of all quotes that change in a given period and then derives an indirect measure of "implied" duration of the spells. If the sample does not have censored price spells, the two approaches give the same results.

Under both approaches, in order to determine synthetic estimates of average duration and of average frequency of price changes we need to aggregate statistics on elementary products. As Baharad and Eden (2004) show the method of aggregating can change the results for the overall statistic substantially. Here we take a "bottom-up" approach (see below), assuming that products are more homogeneous within certain subgroups (for instance in a given price trajectory or in a given product category).

3.1 The duration approach

The duration approach is illustrated in Figure 3. The average duration of price spells in Trajectory 1 (the uncensored one) is the simple average of the spells durations (2, 3, 3 and 1). The same result is obtained by dividing the number of observations (9) by the number of price spells (4).

An important issue arises in aggregating price spells over different trajectories. Consider again Figure 3; it is clear that we can either ignore the information on the trajectory to which each spell belongs and then compute a simple average over the entire pool of spells, or else take the information on the trajectory into account. The latter approach entails first computing average spell duration within trajectories and then aggregating over trajectories. While the results in this example differ, they will be similar if the number of price spells is large enough to presume that duration processes are fairly homogenous.

We can compute average duration using a number of different formulas.

- If we pool all price spells, we obtain the <u>unweighted average duration of all price spells</u> (all spells have equal weight), that is:

$$\bar{d} = \frac{1}{N_{spells}} \sum_{j=1}^{n_j} \sum_{s=1}^{N_{sj}} d_{js} = \frac{N_{elementary\ price\ quotes}}{N_{spells}} \qquad (1)$$

where j refers to the product (n_j =48), s identifies a specific spell, d_{js} is the duration of spell s of product j, N_{sj} refers to the number of price spells for product j.

- Obviously, products which exhibit more frequent price changes and thus more spells (typically, energy and unprocessed food) will have a greater weight in the formula for $\bar{d}$. This problem can be overcome by computing the <u>unweighted average duration of price spells, averaged by product</u>, obtained by first computing the average duration for each product j, $\bar{d}_j = \frac{N_{elementary\ price\ quotes\ for\ product\ j}}{N_{spells\ for\ product\ j}}$ (averaging over all its spells, across outlets and time), and then averaging it over products, that is:

$$\bar{\bar{d}} = \sum_{j=1}^{n_j} \frac{1}{n_j} \bar{d}_j \qquad . \qquad (2)$$

- If CPI product weights *(ω_j, $j=1,...,n_j$)* are used in calculating the previous statistics, we obtain the <u>weighted average duration of price spells, averaged by product,</u> defined as:

$$\overline{\overline{d}}^{\,\omega} = \sum_{j=1}^{n_j} \omega_j \sum_{j=1}^{N_s} \overline{d}_j \qquad\qquad\qquad (3)$$

- A further possibility is first averaging price spells in a given trajectory and then averaging over products, obtaining the <u>unweighted average duration of price spells, averaged by individual trajectory</u>:

$$\overline{\overline{d}}^{\,traj} = \sum_{j=1}^{n_j} \frac{1}{n_j} \sum_{r=N_{traj;1}}^{N_{traj;j}} \frac{{}_j\overline{d}_r^{\,traj}}{N_{traj;j}} \qquad\qquad\qquad (4)$$

where $N_{traj;j}$ is the number of price trajectories for product j, and ${}_j\overline{d}_r^{\,traj}$ represents the average duration of the spells in the rth trajectory of product j.

- Similarly, the <u>weighted average duration of price spells, averaged by individual trajectory</u> is given by:

$$\overline{\overline{d}}^{\,traj,w} = \sum_{j=1}^{n_j} \omega_j \sum_{r=N_{traj,1}}^{N_{traj,j}} \frac{\overline{d}_r^{\,traj}}{N_{traj;j}} \qquad\qquad\qquad (5)$$

In our analysis we mostly aggregate the individual durations according to expression (3), but as a robustness check we also present those based on (5).

The main advantage of the duration approach consists in the possibility of reporting the full distribution of price durations in each period (in our analysis we focus on the median and the inter-quartile range of the distribution of durations). Moreover, only under this approach we can compute the *hazard* and *survival functions*. In the empirical section we present the standard non-parametric estimate of the *hazard function* based on the Kaplan-Meier product limit estimator. The estimator is based on the number of spells ending at period t, h_t ("failures"), divided by the number of spells still in the risk set (R_t, which at each time t consists of the number of spells lasting *at least* until t):

$$\hat{\lambda}(t) = \frac{h_t}{R_t} \qquad\qquad\qquad (6)$$

3.2 The frequency approach

The frequency approach, used by Bils and Klenow (2002) among others, defines the frequency of price changes, given for each product j as the number of price changes in each period (denoted by NUM_{jt}, for the jth product at time t, where $t=2,\dots T$) over the total number of price quotes for that product in that period (DEN_{jt})[8], that is:

$$F_j = \frac{\sum_{t=2}^{T} NUM_{jt}}{\sum_{t=2}^{T} DEN_{jt}} \qquad\qquad\qquad (7)$$

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[8] See Appendix 1 for details.

Under certain conditions of stationarity of the process determining price spells both cross-sectionally and over time (see Lancaster, 1990)[9], the data on average spell duration for product j can be recovered as the inverse of the frequency of price changes (<u>implied average spell duration</u>):

$$\overline{T}_j = \frac{1}{F_j} \qquad (8)$$

Equation 7, and consequently equation 8, are appropriate when retailers change their price only at discrete intervals. We can also assume, like Bils and Klenow (2002), that prices are changed in continuous time: in such an environment, and under a constant hazard model, the implied average duration can be computed by

$$\overline{T}_j = \frac{-1}{\ln(1 - F_j)} \qquad (9)$$

and the median time elapsing between two price changes is equal to:

$$T_j^{50} = \frac{\ln(0.5)}{\ln(1 - F_j)} \qquad (10)$$

As these formulas show, the frequency approach has some clear advantages. First it does not require a long span of data; in principle, the observation window may even be shorter than the average duration of a price spell. Second, if some months are deemed to be exceptional due to specific events (like a VAT change), in principle they could be easily be dropped in computing the average frequency of price changes. Finally, the approach also allows to use the maximum amount of information from the dataset, not discarding all the observations from censored price spells (as in the duration approach; see below) but only those observations that involve transitions from or to unobserved prices.

Nonetheless, as pointed out in Baudry *et al.* (2004), the frequency approach too requires sufficiently homogenous products (and sub-periods). In our analysis this means that in aggregating frequencies over products we first compute statistics at the product level and then average different goods and services; at this stage, in computing aggregate weighted statistics (i.e. averaging the F_j) we use CPI weights.

The frequency approach can also be used to calculate the frequency of price increases (decreases) for each product, where the expression in the numerator of equation 7, NUM_{jt} is replaced by $NUMUP_{jt}$ ($NUMDW_{jt}$), indicating the number of positive (negative) price changes in each period t (see Appendix 1 for details).

4. THE EMPIRICAL ANALYSIS

4.1 How to deal with censoring.

On these definitions we now illustrate two main problems faced in the empirical analysis - censoring and attrition - both arising in the process of price collection.

The issue of censoring can be introduced by turning again to the example in Figure 3. The first price spell in Trajectory 2 is left-censored because collection only begins at time t=2, even though the price was also available at time t=1; the last is right-censored, as collection ends in

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[9]   The stationarity assumption regards the process determining the sample of price spells: this ensures that the probability of a price spell's starting in each period is stable over time. Lancaster (1990), in the context of the theory of renewal processes, provides a formal argument for the convergence of the inverse of the frequency of price changes with the mean spell duration.

period t=7. Hence, the true time of beginning (ending) of the first (last) price spell does not correspond to that one observed in the dataset, as it comes before (after) the first (last) price observation.[10] It is worth remarking that if the start of the collection period coincided with the first time a price is set in the outlet (as in Trajectory 1), then the price trajectory would not be censored; this occurs, for instance, if a shop sells a product for the first time in the same month as that in which the statistical agency starts to observe it. As a consequence, any measurement of the average duration of the price spells in such a trajectory that ignored censoring in the first and in the last spell would be biased.[11]

In practice, the frequency of price changes can be computed on the basis of different sets of price quotes. Two "extreme" strategies are the following:

Strategy 1: No censoring: the statistics completely disregard the issue of censoring, therefore using all price spells.

Strategy 2: Full censoring: the first and last price spells within each price trajectory are considered as censored (thus obtaining full symmetry between the number of right- and left-censored price spells), and the statistics on price duration and on the frequency of price changes are computed only on the basis of the remaining uncensored observations. This approach, as is pointed out in Baudry *et al*. (2004) and in Aucreamanne and Dhyne (2004), has the disadvantage of excluding far too many spells, especially when considering products (such as clothing and footwear) subject to very few price changes in their lifecycle.

Intermediate strategies to overcome these difficulties can be devised. If the price of a specific product can always be observed in the same outlet and for the whole time interval, then at most the spells at the start and at the end of each trajectory are censored; our dataset is truncated on the left in January 1996 and on the right in December 2003. In practice, however, when the statistical institute re-bases the index (every December for the Italian CPI) generally drops and adds some products and outlets. This cause of censoring is motivated by statistical considerations and can be considered as an optional replacement (a choice by the statistical institute).

The price collector may also have to replace a product variety or an outlet in order to continue to follow a given product if the price observed to that point ceases to be available (on shelf) or the outlet has closed. This situation is also known as "attrition" and gives rise to a type of censoring that is considered as a forced replacement, since the statistical agency must undertake specific actions independently of its wishes.

In practice, on our information the distinction between forced and optional replacements is not possible, since we have only a flag signalling whether there was a product substitution, independent of sources. We shall soon see that the two different sources of censoring can affect how we estimate our statistics. We can distinguish between the two situations using two *auxiliary* assumptions:

Assumption 1 - Nature of the replacement. Since the CPI is re-based in December each year, we assume that the replacements effected in January are optional, part of the CPI revision and do not coincide with the start/end of the price spell. Replacements in other months are assumed to be forced. On this basis we devise an intermediate strategy to compute the frequency and the size of price changes:

Strategy 3: Intermediate censoring. We consider as uncensored also the first and the last price spell of a price trajectory that starts/ends due to a forced replacement (i.e. it occurs in non-rebasing months). Hence, price spells are considered as left-censored only if they belong to a trajectory beginning in January, and right-censored when they are the last in a trajectory ending in December.

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[10] In terms of the example of product "Coffee", in the case of Trajectory 1 we are considering the price of, say, 1 kg. of coffee of a specific brand sold for the first time in period t=1 in a given store, or which is no longer sold in that shop from time t=9 onwards. In the case of Trajectory 2, this product was sold before t=1 and it will continue to be sold after t=9.

[11] For an extensive review of duration analysis and the various methods of dealing with censoring, see Kiefer (1996).

The main advantage of Assumption 1 is that it increases the number of price spells characterised as uncensored. However, it also introduces an asymmetry in the number of left- and right-censored spells and in some situations it can be too extreme. In our "coffee" example suppose that up to March a given retailer was selling 1 kg. of "Lavazza" brand coffee which was in the list of prices to be collected in that shop, and that in April he/she has decided to sell only 1 kg. of another brand. In this case the new price is not left-censored, so our assumption is appropriate. But if a shop where the price of 1 kg. of "Lavazza" is observed closes in March and is replaced by a similar shop that also sells 1 kg. of "Lavazza", we consider this new price spell not to be left-censored, though as a matter of fact we are facing a situation similar to that depicted by Trajectory 2 in Figure 3.

In computing the frequency of price changes, the consequences of replacement can be severe for some products, leading to very low estimated frequencies. This holds, in particular, for clothing and footwear items. New fashion models are typically introduced at the beginning of each season; they are sold at a price that remains unchanged until a slightly different model replaces the previous one on the market. Hence, under strategy 3 the price for that product never changes, since as long as the product is on the shelf its price is unchanged. To mitigate this effect, a specific assumption concerning products which at some point in time are no longer available is made:

Assumption 2 - Pseudo price-change: when a new variety of a given product (for instance a new pair of trousers) replaces a variety that is no longer sold and whose price has been collected through a given month, the price of the new variety is likely to be different, and the two prices cannot be directly compared. However, we can assume that the price of the old model would have changed in the same month in which it was replaced. On this basis we can device a fourth intermediate strategy.

Strategy 4: Intermediate censoring with pseudo price-change. We still rely on Assumption 1 to distinguish between forced and optional replacements, but for the former we now assume that the implied price change (the difference between the prices for the old and the new models, collected in periods t-1 and t) is an actual price change (as if the two prices referred to the same item), which is taken into account when computing the frequency of price changes. Since we are actually referring to two different goods, however, we disregard this information in computing the average size of the price change, which thus remains the same as under strategy 3.

In conclusion, the treatment of censoring can be crucial for the results, though on the basis of the available metadata an optimal strategy does not exist. To assess robustness, we compute all the relevant frequency statistics under the four different strategies described above, focusing in particular on strategy 4.

4.2 Price trajectories and price spells

To allow for the impact of the euro cash changeover on the duration and frequency of price changes, we computed all the main statistics both for the time interval excluding the changeover (1996-2001, 19,000 observations) and for the entire one (1996-2003, 23,600 price trajectories). The analysis that follows focuses on the former, on the assumption that the euro cash changeover at most exerted a temporary impact on price-setting behaviour. Appendix 2 provides the main results for the whole time interval.

The unweighted mean length of price trajectories is 36 months (Table 5), ranging from an average of 30 months for non-energy industrial goods to 49 for services. As for individual items, some quotes are observed over the entire time horizon (96 months), others for just two months. The median trajectory has a duration of 30 months for the whole dataset, ranging from 24 months for non-energy industrial goods to 47 months for services.

Price spells (without any assumption on censoring) are about four times as numerous as trajectories (Table 6). The weighted average duration of all price spells (equation 1), with no censoring (strategy 1), is 10 months; it falls to 8 months under the assumption of intermediate

censoring (strategy 3), and to 6 months under full censoring (strategy 2). As for the five sub-indices, average duration is much longer for non-energy industrial goods and services (14 and 15 months, respectively) and very short for energy products (2 months). The longer than expected duration for unprocessed foods (9 months) is entirely due to "meat" and "milk", whereas "fruit and vegetables" prices have much shorter duration. These results suggest that the impact of censoring on estimated average duration is not dramatic. For the full sample, the difference between the no censoring and strategy 3 estimates is only 2 months.

For the whole period 1996-2003, average duration falls to 8 months, suggesting that the euro cash changeover did in fact induce more price adjustments[12] (Table A2.1 in Appendix 2).

Fact 1: the weighted average duration of price spells is between 6 and 10 months, depending on estimation strategy. It is longer for non-energy industrial goods and services and very short for energy products.

The distribution around the mean duration is markedly asymmetrical, as is suggested by comparison with the median of 5 months (2 and 4 by the other two methods; Table 6). For around 35 per cent of the spells the duration is 1 month (Figure 4), as some unprocessed food and especially energy prices change very often indeed. The distribution of spell duration shows also a peak at 6, 9 and 12 months.

The overall average tends to overweight the products with very short price duration (quite significant in our database), since for given trajectory length more spells are observed. Therefore, we also compute the weighted average duration of price spells averaged by individual trajectories (equation 5 in section 3.1), which increases average duration to 14 months (13 for the whole period; Table A2.1 in Appendix 2) and the median to 8 months (Table 6).

Finally, we compute the hazard function of price spells for the overall sample (Figure 5), which describes the probability of a price spell to end (vertical axis) in a given month (horizontal axis). The hazard function is a decreasing function of time, as found in other country studies (e.g. in Dias (2004)). Interestingly, it is characterised by local modes at durations of 12 and 24 months, a strong indication that firms apply yearly pricing rules: this result is in line with the survey evidence on Italian firms described in Fabiani et al. (2004). Furthermore, when distinguishing items according to their nature (Appendix 4), we find that the shape of the hazard function is either moderately decreasing, or flat, for services and food products, while it displays an increasing shape for energy products after a 12 months period.

4.3 Price adjustment in Italy: the frequency approach

In this section we describe some basic features of consumer price adjustment in Italy adopting the frequency approach. We investigate the frequency of price changes, their direction and size and their degree of synchronisation. The analysis relies on the statistics described in section 3.2.

The weighted average frequency of monthly price changes is 9% with no censoring; it rises to 10% if either of the two intermediate approaches to censoring is adopted (Table 7). This is lower than in France (19%; Baudry *et al*., 2004), Belgium (17%; Aucremanne and Dyhne, 2004) and Portugal (22%; Dias *et al*, 2004). The percentage for Italy, as expected on the basis of the results on duration, rises marginally when the period covered is extended to include 2002-03 (Table A2.2 in Appendix 2). The weighted average implied duration, which is approximated by the inverse of the average frequency, ranges from 9 to 11 months.

Fact 2: On average, in Italy, 9% of prices are changed each month. The implied average duration of price spells is 9-11 months, depending on calculation method.

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12   All sub-indices have shorter average duration including 2002-2003.

The analysis across different goods and services shows pronounced heterogeneity, which makes it difficult to provide a single answer to the question of how often prices change. The disaggregated analysis provides useful insights, however. Under our preferred intermediate strategy (censoring, with pseudo price-change; strategy 4) most energy prices change every month (Table 7). Unprocessed food prices also change quite often, with an implied average duration of 5 months. The prices of other goods and services change less frequently. Processed food's and beverages change, on average, almost once a year, with modest differences between products. The dispersion of the implied average duration of non-energy industrial goods prices is also quite moderate (the average is 17 months). Service prices change very seldom, on average every 21 months, with some remaining fixed for more than 2 years. The euro cash changeover decreased the frequency of price changes for all sub-indices (Table A2.2 in Appendix 2).

Fact 3: Results on the frequency of price changes are rather heterogeneous across the five product groups. Energy prices change every month, while non-energy industrial goods and services prices last longest, about 17 and 21 months, respectively.

Considering the direction of price changes, the weighted average frequency of price increases ranges from 5.6% to 6.8% depending on the strategy used (Table 7); under strategy 4 it is 10.5% for unprocessed food, 34.1% for energy products and around 5% for non-energy industrial goods and for services. Price changes are asymmetrical, the average frequency of reductions ranging from 3.2% to 4.4% (depending on approach). The asymmetry is more pronounced for services and for non-energy industrial goods, for which price increases are, respectively, three times and twice as frequent as decreases.

Fact 4: Price changes tend to be asymmetrical, as one expects given positive inflation; under strategy 4 the average frequency of price increases is 7%, compared with 4% for decreases.

The average size of price increases and decreases is about the same (7.5% and –8.4%, respectively; Table 7); this symmetry broadly holds for all components. This result is robust to sample period and is thus not affected by the euro cash changeover (Table A2.2 in Appendix 2).

Fact 5: The average percentage change is about the same, whether prices are adjusted upwards or downwards.

As for type of outlet, traditional outlets tend to change the price of non-energy industrial goods and food products significantly less often than large outlets; with frequencies of 7.1% and 10.8%, respectively (Table 8). The behaviour of prices with respect to the direction of the change is more symmetrical in large modern outlets than in traditional ones.

Fact 6: The frequency of price changes differs significantly by type of outlet, being higher for larger stores.

In general the degree of synchronisation of price changes (see Appendix 1 for the formula), is rather low except for energy prices (Table 9). For the other items, the lack of synchronisation may result from the fact geography is not considered. In fact, price changes for individual products are likely to be more similar within each town than in a pool of observations from all towns. To adjust, we compute our statistics separately for each item and each town and then aggregate the results in an average for the whole country using two weighting schemes, one based on the weight of each town in the national CPI, the other on the price quotes for each item in a town as a percentage of all the observations for that product nation-wide. The results show that for a number of items price movements are actually quite highly synchronised, in particular for services.

Fact 7: Price movements of individual products are not highly synchronised at the national level, but they are much more so if geographical location is taken into account.

4.4 Factors affecting the frequency and the size of price changes

In this section we perform a regression analysis to assess the quantitative importance of the main factors determining variations in the frequency and size of price changes over time (Figure 6). Note that the size of price changes decreases steadily from 1996 to the end of the nineties, then stabilising at 3%. As regards frequency, it fluctuates around 10% until the end of 2001, it spikes in January 2002 and then fluctuates around values higher than 10%. The explanatory factors considered are as average inflation, seasonal factors, the incidence of threshold prices, and the impact of indirect tax changes[13]. This can shed some light on firms' pricing strategies, especially on the prevalence of time-dependent and state-dependent rules. Under both strategies firms can be seen to hold their prices stable for some period of time. Following a significant shock (to costs, to demand etc.) we will observe an immediate response if firms follow state-dependent rules; if time-dependent rules dominate, firms will have to wait to be in a position to reset prices.

The variables examined can help explain variations in the frequency and the size of price changes over time as follows.

Average inflation - From a firm's point of view, the cost of not changing its price is likely to rise with the rate of inflation. Under time-dependent rules, the duration of prices should rise as inflation falls, so we would expect a positive correlation between the frequency of price changes and the inflation rate. Under state-dependent rules what matters is the magnitude of the shock, i.e. whether it is large enough to warrant a change in the price; effects of nominal variables (money, interest rates, etc.) on the real side of the economy are less likely to vary with the rate of inflation.

Seasonality - A strong seasonal pattern in the data could be interpreted as evidence in favour of time-dependent pricing. Such a pattern could have several causes: weather, the timing of sales, institutional factors, such as changes in regulated prices typically coming in specific periods of the year. In the case of the Italian CPI, part of the seasonal pattern is related to the fact that for some items prices are collected only quarterly (remaining unchanged for the other two months; Cubadda and Sabbatini, 1997).[14] However, the seasonal pattern remains quite significant even if this statistical factor is accounted for.

Threshold prices - There is substantial empirical evidence for Italy[15] and for other countries in the euro area that a large percentage of consumer prices are set at "attractive" levels. Attractive prices are of three types: (i) "psychological" (e.g., €1.99 instead of €2.00), aiming at gaining additional buyers[16]; (ii) "fractional" prices (e.g., €1.70, not €1.67), to simplify payments; and (iii) "exact" prices, typically for large amounts (€50) to avoid the use of coins and small banknotes. With attractive prices, a retailer might decide not to change the price until the adjustment brings a new attractive level. This results in longer price duration.

In our database, the share of attractive prices is indeed quite large[17], almost 80%[18] in the years before the euro cash changeover. In January 2002 the percentage falls sharply and then progressively recovers to near the previous level. This denotes a gradual adjustment of prices to the euro, as documented in other analyses as well (Mostacci and Sabbatini, 2003). There are significant differences by sector: attractive prices are most important for services and non-energy industrial

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[13]   In principle, the substantial heterogeneity we find across sectors could also result from product characteristics, market structure, degree of competition within the sector, and so on. Unfortunately, this type of information is not available to us.

[14]   In our sample, the items whose prices are collected on a quarterly basis are mostly services (maintenance and repair of the dwelling, maintenance and repair of personal transport equipment, hairdressing, etc.) and non-energy industrial goods (TV, furniture and furnishings, electric household appliances, etc.).

[15]   See Mostacci and Sabbatini (2003).

[16]   This is explained by the fact that the buyer may unconsciously undervalue the last digit, so that €0.99 is "assimilated" to €0.90. The objective in setting these prices depends on consumers' limited ability to memorise information; for a discussion see Mostacci and Sabbatini (2003).

[17]   These prices have been identified by the same methodology of Mostacci and Sabbatini (2001, 2003). The percentage in the two studies is similar, the differences being due to the fact that Mostacci and Sabbatini (2003) considers a larger set of items.

[18]   This share is similar to that computed in Mostacci and Sabbatini (2003) on monthly elementary CPI price quotes in 2002; their coverage of the index is much larger, though data are referred only to 2002.

goods (around 90%), a bit less for unprocessed food (80%) and significantly less (50%) for processed food. We expect that the higher this share, the lower the frequency and the greater the size of price changes.

VAT changes - Changes in value added tax rates are likely to induce a sudden increase in the frequency (and size) of price changes, as firms pass the tax on to the consumer. Over the sample period there was only one major change in VAT rates, in October 1997; in the years considered by our analysis other episodes of VAT changes concerned only a fraction of goods and services and their impact was very moderate.

Empirically, we evaluate the importance of the above factors by regressing the frequency (F_t) and the size (S_t) of price changes, respectively, on the following variables:

- D_i *(i=1, 2, ..., 12)* = seasonal dummies.

- *VAT9710* = VAT change dummy, equal to 1 in October 1997 and 0 elsewhere.

- $Cptot_t$ = headline consumer price inflation (year-on-year rates) at month t.

- $Attr_t$ = percentage of attractive prices in month t.

In other words, the following two regressions are run with reference to the whole set of data over the period 1996-2001 and, separately, for the sub-indices:

$$F_t = \alpha + \sum_{i=2}^{12} \beta_i D_i + \gamma \, VAT9710 + \delta \, Cptot_t + \phi \, attr_t + \varepsilon_t$$

$$S_t = \alpha + \sum_{i=2}^{12} \beta_i D_i + \gamma \, VAT9710 + \phi \, attr_t + \varepsilon_t$$

Tables 10 and 11 report the estimated coefficients.[19] The main findings can be summarised as follows:

Headline inflation increases the frequency of price changes, in line with our *a priori*. The low value of the coefficient might depend on the fact that the variability of price dynamics over our time horizon is fairly small. As for the share of attractive prices, in our sample a higher share is correlated with lower frequency of price changes.[20] This is evidence that firms indeed change attractive prices less frequently, waiting until a new attractive level can be set. The increase in VAT rates in October 1997 induced a higher frequency of price changes. Under the "extreme" assumption that this VAT change was fully and immediately passed on to prices, its impact on overall average inflation for our subset of items would have amounted to around 0.1 percentage points.[21] Seasonal dummies help explain the frequency of price changes, while they are never significant in explaining the size of price changes.

As Table 11 shows, the size of price changes seems not to be significantly affected by any of the above factors.

As for the various sub-indices, average sectoral inflation always has a positive impact on the frequency of price changes, except for services, where the coefficient is not significant. The share of attractive prices affects frequency significantly and negatively for unprocessed food and services. The frequency of price changes of processed food, non-energy industrial goods and services is highly seasonal.

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[19] Results for upward and downward changes are not reported in the Tables but are available from the authors on request.
[20] This holds for both upward and downward changes, although the impact is greater for increases.
[21] At least part of the adjustment is likely to have taken place gradually over the months following the VAT change, in a pattern that might be impossible to distinguish from the other factors in price developments; nevertheless, in October 1997 an impact should be recorded.

4.5 Factors affecting the probability of a price change

Next, we report the results of a logit regression of the probability of observing a price change. Our dependent variable is a dummy indicating whether a price change has been recorded or not in each month. The explanatory variables include: the number of months since the last price change, to capture the degree of duration dependence; seasonal dummies; the type of item (non-energy industrial good, service, energy product, etc.); a dummy for attractive price; the inflation rate; and a dummy equal to 1 in October 1997 (change in the VAT rate).

The results reported in Table 12 show that the longer the duration of a price spell is, the lower is the probability of a price change. The VAT change significantly and positively impacts on the probability of a price change, suggesting that state-dependent factors also matter. Average inflation is highly significant, positively affecting the probability of price change.[22] And the higher the share of attractive prices, the lower the probability of a price change. Although the related coefficients are not shown in the Table, seasonal dummies are always significant. As mentioned in Section 4.4, this is only partly due to statistical effects related to the data collection procedure. Hence, this evidence could signal the presence of some form of time-dependency.

Finally, the results confirm the sectoral differences; the probability of a price change is much higher for energy and unprocessed food products than for non-energy industrial goods and services. There are no major differences with respect to the direction of the price change.

5. CONCLUSIONS

We investigated the characteristics of consumer price changes in Italy by analysing price behaviour at the most disaggregated level, namely items of a specific brand sold in a specific outlet. The empirical analysis mirrors that of other euro area central banks within the *Inflation Persistence Network*.

We adopted both a duration approach, directly tracking the number of months for which a price remains unchanged, and a frequency approach, computing the proportion of price quotes that change in a given period. We used a variety of empirical strategies to assess the robustness of the results with respect to censoring and attrition.

The average duration of price spells, which captures how long prices tend to remain unchanged, is between 6 and 10 months, depending on how censoring is treated. It is much longer for non-energy industrial goods and services (14 and 15 months, respectively) and very short for energy products (2 months). The average duration slightly falls including in the sample the years 2002-03, suggesting that the euro cash changeover did induce a larger number of price adjustments.

Turning to the frequency approach, every month 9% of prices are changed, on average, which implies an average duration of 9-11 months. Again, results are rather heterogeneous across products. At the two extremes, energy prices change every month and services prices last almost two years.

Price changes tend to be asymmetrical, as is only to be expected given inflation. Under our preferred strategy on censoring, the average percentage of price increases each month is 7%, that of decreases 4%. The asymmetry is most pronounced for services and non-energy industrial goods, for which increases are respectively three and two times as frequent as decreases. However, the size of the average increase and decrease is approximately the same, a symmetry that broadly holds for all components.

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[22]   Note that the coefficient of this variable in the regression for price decreases is wrongly signed.

As for type of outlet, traditional outlets tend to change the price of non-energy industrial goods and food products significantly less frequently than large stores (7.1% *versus* 10.8%). Price changes tend to be more symmetrical in mass than in traditional retailing.

In general, synchronisation of price changes is rather low (except for energy prices). However, when the statistics measuring synchronisation are computed separately for each item and each town and then aggregated in a national average, there is a much greater synchronisation for a number of items (in particular in the service sector).

In a regression analysis we investigated the main factors (average inflation, seasonal factors, attractive pricing thresholds, indirect tax changes) determining variations over time in the frequency and size of price changes. Frequency is positively related to the headline inflation rate and to the increase in VAT rates in October 1997 and negatively related to the share of attractive prices; seasonal effects are present. As for the size of price changes, none of the considered factors seems to significantly affect it.

Finally, the probability of changing prices is positively correlated with the increase in VAT rate and with average inflation; it is negatively correlated with the share of attractive prices and with the duration of the price spell. Seasonal dummies are always significant. There is evidence of differences with respect to sectors but not to the direction of the price change.

All in all, the analysis offers relevant evidence on pricing behaviour in Italy, confirming and significantly extending results found in previous studies based on different data and approaches (Fabiani *et al.*, 2003 and 2004).

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FIGURES AND TABLES

Figure 1 – CPI official inflation and 48 items inflation
(percentage changes on the year-earlier period)
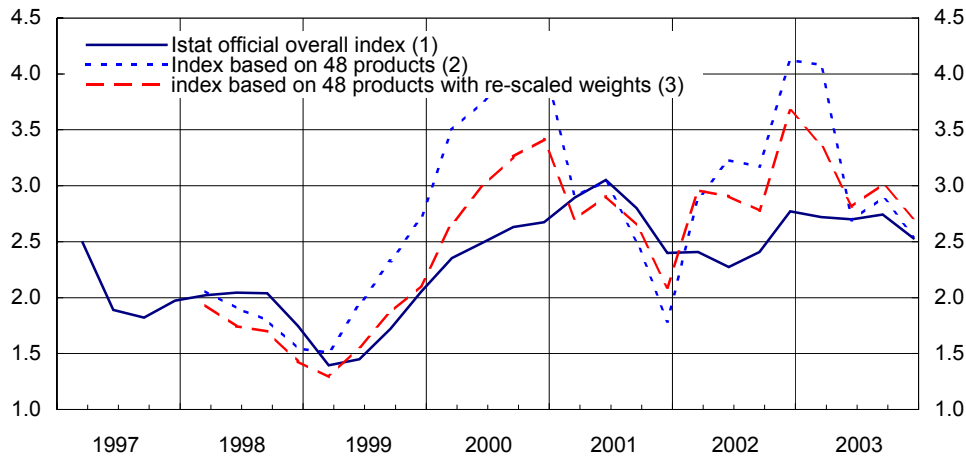
Source: Based on Istat data.
(1) Index of consumer prices for the entire resident population. – (2) Each of the 48 items has the same weight as in the overall CPI basket. – (3) The weight of each item is re-scaled so that the sum of all items belonging to the same category of expenditure (e.g. unprocessed food) is equal to the weight that the category has in the overall index.

Figure 2 – 48 items inflation – Official and reconstructed price index from elementary price data in our sub-sample
(percentage changes on the year-earlier period)
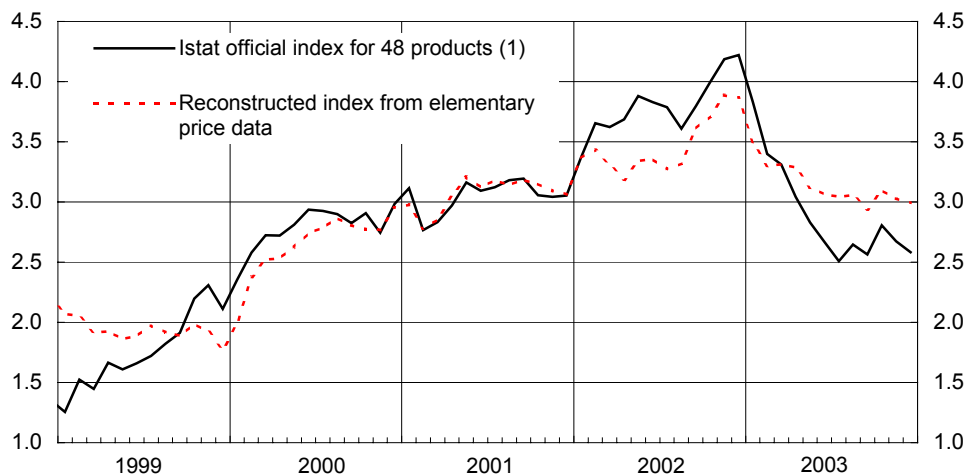
Source: Based on data.
(1) Each of the 48 items has the same weight as in the overall CPI basket and the price index which is considered is the official one released by Istat.

Figure 3 -A typical price trajectory
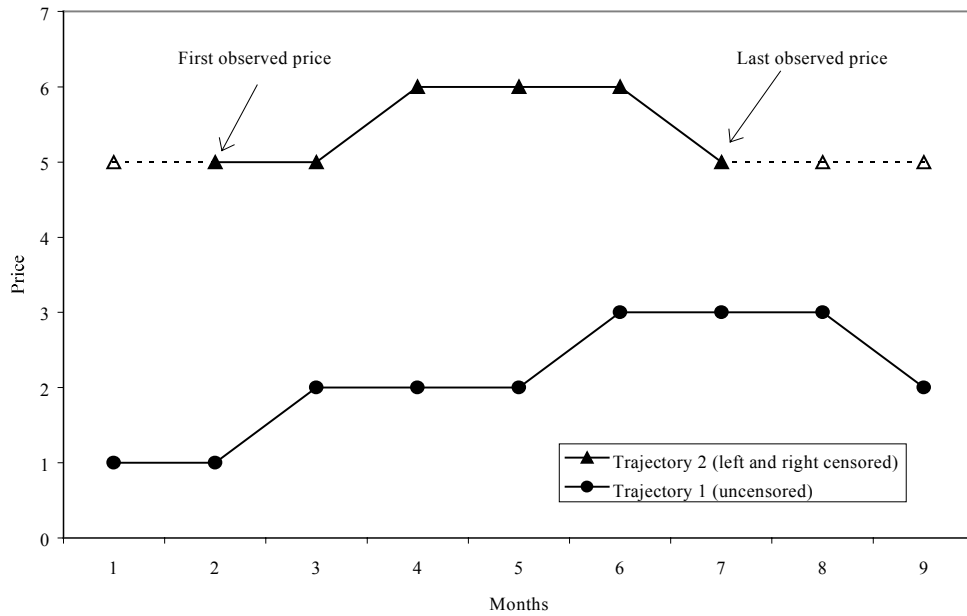
Figure 4 - Distribution of spells duration
(*unweighted statistics)*
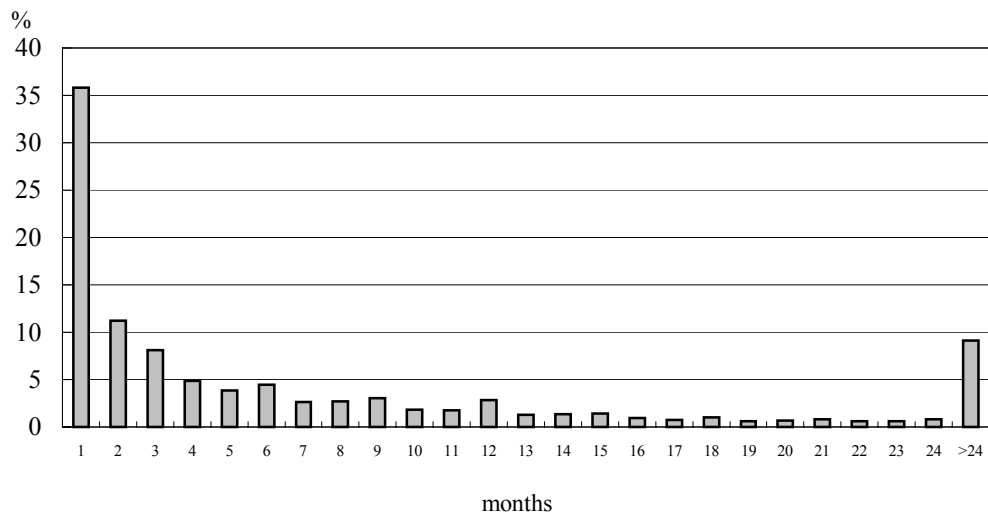
Source: Based on Istat data.

Figure 5 – Hazard function for the whole sample *(1)*
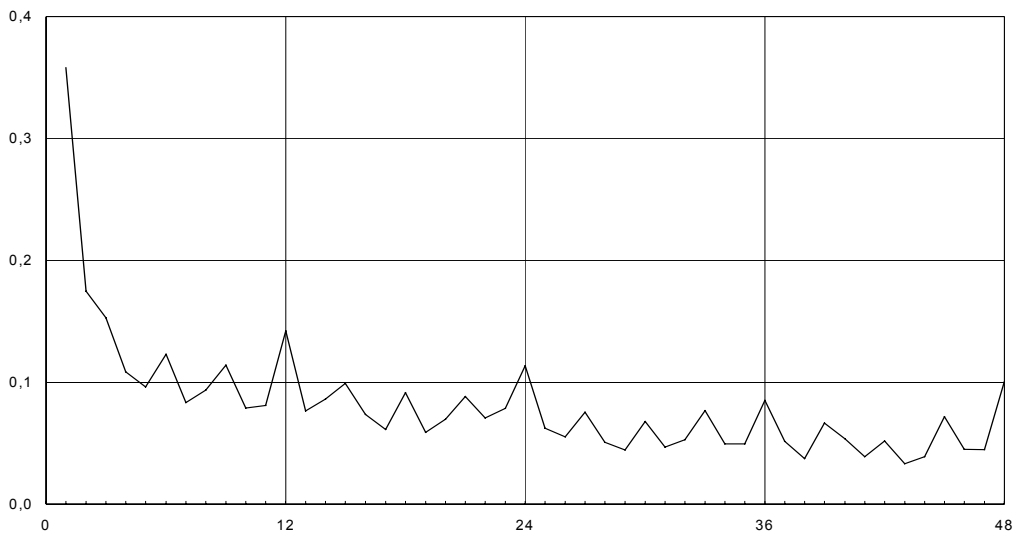
Figure 6 – Frequency and size of price changes
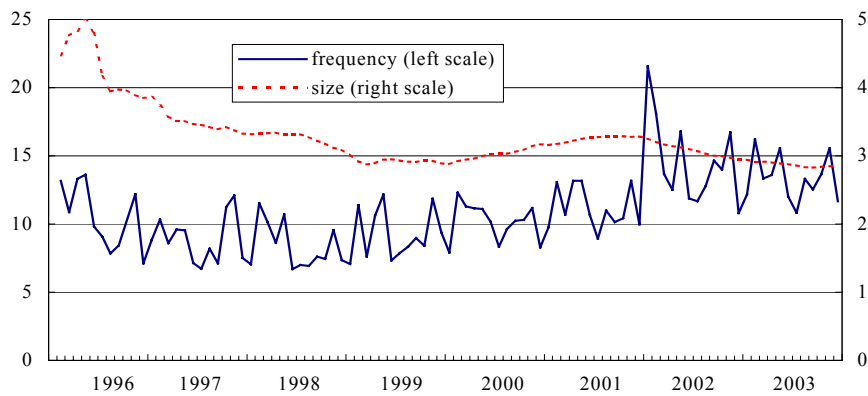
Table 1 – Items included in our dataset

Item	Frequency of collection	Item	Frequency of collection
Steak	Monthly	Dog food	Quarterly
1 fresh fish	Twice a month	Football	Quarterly
Tomato	Twice a month	Construction game (Lego)	Quarterly
Banana	Twice a month	Toothpaste	Monthly
Fresh milk	Monthly	Suitcase	Monthly
Sugar	Monthly	Dry cleaning (suit)	Monthly
Frozen spinach	Monthly	Hourly rate of an electrician	Quarterly
Mineral water	Monthly	Hourly rate of a plumber	Quarterly
Coffee	Monthly	Domestic services	Quarterly
Whisky	Monthly	Hourly rate in a garage	Quarterly
Beer in shop	Monthly	Car wash	Quarterly
Gasoline (heating)	Monthly	Balancing of wheels	Quarterly
2 fuels	Twice a month	Taxi	Monthly
Socks	Monthly	Movie	Monthly
Jeans	Monthly	Videotape hiring	Quarterly
Sport shoes	Monthly	Photo development	Quarterly
Shirt (men)	Monthly	Hotel room	Monthly
Tiles	Monthly	Glass of beer in a café	Monthly
Iron	Quarterly	1 meal in a restaurant	Monthly
Electric bulb	Monthly	Hot dog	Monthly
Furniture	Quarterly	Cola based lemonade in a café	Monthly
Towel	Monthly	Haircut (men)	Quarterly
Car tyre	Quarterly	Hairdressing (ladies)	Quarterly
Television set	Quarterly		

Table 2 – Classification of the elementary price quotes by type of items

	Frequency	Percentage	Percentage weight of the items included in our sample in the CPI basket (2002=100)		Percentage weight in the official CPI basket (2002=100)
			weights	weights re-scaled to 100	
COICOP category					
01 - Food and non-alcoholic beverages	195,452	26.26	1.71	8.47	15.94
02 - Alcoholic beverages and tobacco	98,819	13.28	0.82	4.06	2.68
03 - Clothing and footwear	87,851	11.81	1.46	7.23	10.53
04 - Housing, water, electricity, etc.	26,724	3.59	1.32	6.53	9.16
05 - Furnishings, household equipment, etc.	48,871	6.57	2.59	12.82	10.25
06 - Health	-	-	0.00	0.00	7.25
07 - Transport	63,349	8.51	4.07	20.12	13.24
08 - Communication	-	-	0.00	0.00	3.20
09 - Recreation and culture	83,385	11.21	0.52	2.57	8.42
10 - Education	-	-	0.00	0.00	1.07
11 - Restaurants and hotels	76,727	10.31	6.48	32.06	10.94
12 - Other goods and services	62,988	8.46	1.24	6.14	7.33
Type of product					
Unprocessed food	94,023	12.63	0.88	4.34	6.94
Energy	32,374	4.35	2.87	14.18	5.94
Processed food	204,376	27.46	1.66	8.19	11.68
Non-energy industrial goods	221,787	29.8	3.36	16.61	35.33
Services	191,606	25.75	11.47	56.68	40.11
Total	**744,166**	**100.00**	**20.23**	**100.00**	**100.00**

Source: Based on Istat data.

Table 3: Information available for each elementary price quote (metadata)

Date	Reference year and month
Outlet code	Each outlet has a numeric code
City	Name of the city
Area of the outlet	Code describing whether the location of the outlet is in a residential area, city center, etc.
Type of Outlet	Code describing the type outlet (supermarket, hard discount, small retailer…)
Brand	Description of the brand
Product code	Coicop or Istat code
Istat trajectory code	Numeric code which identifies univocally each price trajectory: i.e. it changes with any of the following characteristics: brand, variety, outlet, quantity.
Variety	Description of the product
Collected price	Price of the item actually collected by the surveyor
Collected price per unit	Price for a reference quantity. E.g. the price of 1 egg, computed on the basis of the price collected for a pack of 6 eggs.
Sale price	Starting from 2002 both the sale and the full price are collected. Before 2002 only one of the two was collected and no information was given on the nature of the price.
Base period price	The price in the base period (e.g. in October 2003 the base price refers to December 2002)
Switch of brand	Flag variable =1 if the price collected is referred to a different brand, 0 otherwise.
Switch of variety	Flag variable =1 if the price collected is referred to a different variety, 0 otherwise.
Switch of quantity	Flag variable =1 if the price collected is referred to a different quantity, 0 otherwise.
Switch of outlet	Flag variable =1 if the price collected is referred to a different outlet, 0 otherwise.

Table 4 – Classification of the elementary price quotes by type of outlet and frequency of price collection

Distribution channel	**Percentage of the elementary price quote in our sample**	
Modern	27.0	
Traditional	56.8	
Other	16.2	
Total	100.0	
Category of expenditure	**Frequency of price collection (%)**	
	Monthly	Quarterly
Unprocessed food	100	0
Energy	100	0
Processed food	100	0
Non-energy ind.goods	60.33	39.67
Services	46.75	53.25
Total	74.36	25.64

Source: Based on Istat data.

Table 5 – Duration of trajectories – Period 1996-2001
(unweighted statistics; months)

	Number of obs.	Mean	Median	Standard deviation
Total sample	**18858**	**36**	**30**	**28**
By nature:				
Unprocessed food	1297	48	46	29
Processed food	6304	33	25	26
Non energy industrial goods	6815	30	24	24
Energy	717	43	36	27
Services	3725	49	47	31
By COICOP:				
Food and non-alcoholic bev.	4562	40	36	29
Alcoholic bev. and tobacco	3039	29	25	23
Clothing and footwear	2364	34	26	26
Housing, water, electricity, etc.	561	45	45	29
Furnishings, household equipment, etc.	1218	38	32	29
Health				
Transport	1369	44	37	30
Communication				
Recreation and culture	2443	31	23	26
Education				
Restaurants and hotels	1643	43	38	29
Other goods and services	1659	35	30	27

Source: Based on Istat data.

Table 6 - Duration of price spells – Period 1996-2001
(weighted statistics; months)

	Number of obs.	Mean	Median	Standard deviation
1. No censoring				
Total sample	**69308**	**10**	**5**	**13**
Unprocessed food	13447	9	3	14
Processed food	19689	9	5	11
Non energy industrial goods	13505	14	10	13
Energy	14845	2	1	1
Services	7822	15	11	16
Averaged by individual trajectory [1]				
Total sample	**18858**	**14**	**8**	**16**
Unprocessed food	1297	12	4	18
Processed food	6304	11	6	12
Non energy industrial goods	6815	15	10	15
Energy	717	2	1	2
Services	3725	23	14	22
2. Full censoring				
Total sample	**43886**	**6**	**2**	**9**
3. Intermediate censoring				
Total sample	**58397**	**8**	**4**	**11**

Source: Based on Istat data.
(1) See equation (5) in the text.

Table 7 – Frequency and size of price changes and duration - Period 1996–2001
(weighted statistics)

	Frequency of price changes			Duration implied by average frequency (months)			Frequency of price increases			Frequency of price decreases			Average price increase (%)		Average price decrease (%)	
	1. no cens.	3. interm. cens.	4. pseudo price-changes	1. no cens.	3. interm. cens.	4. pseudo price-changes	1. no cens.	3. interm. cens.	4. pseudo price-changes	1. no cens.	3. interm. cens.	4. pseudo price-changes	1. no cens.	3. interm. cens.	1. no cens.	3. interm. cens.
By COICOP:																
1. Food and non-alcoholic bev.	14.0	15.1	14.6	6.6	6.1	6.3	7.9	8.5	8.5	6.1	6.5	6.8	6.4	6.4	-6.7	-6.5
2. Alcoholic bev. and tobacco	7.6	8.5	10.0	12.6	11.2	9.5	4.9	5.3	7.3	2.7	3.3	5.2	8.4	7.9	-7.6	-7.6
3. Clothing and footwear	3.8	3.8	5.4	25.7	25.6	18.0	3.2	3.3	4.9	0.6	0.6	2.2	7.6	6.6	-7.4	-8.1
4. Housing, water, electricity, etc.	21.2	22.0	21.8	4.2	4.0	4.1	12.6	13.2	13.3	8.6	8.8	9.3	5.6	4.8	-5.6	-4.6
5. Furnishings, household equip.	3.1	3.0	4.4	32.1	33.2	22.1	2.8	2.6	4.1	0.3	0.3	1.8	7.0	5.3	-5.5	-4.8
7. Transport	24.2	24.7	24.8	3.6	3.5	3.5	13.4	13.9	14.2	10.8	10.8	11.6	6.4	6.4	-7.1	-5.7
9. Recreation and culture	5.2	6.0	7.7	18.9	16.2	12.5	2.5	2.8	5.2	2.7	3.2	5.4	6.4	6.8	-8.2	-8.0
11. Restaurants and hotels	5.0	6.0	5.8	19.7	16.1	16.7	4.0	4.6	4.9	1.0	1.4	1.9	9.1	9.5	-13.5	-11.8
12. Other goods and services	3.3	3.6	4.3	29.9	27.5	22.7	2.6	2.7	3.6	0.7	0.8	1.8	8.8	7.8	-9.4	-9.4
By Product type																
Unprocessed food	19.1	21.0	19.5	4.7	4.2	4.6	10.2	11.4	10.5	9.0	9.6	9.4	7.5	7.5	-8.0	-8.2
Processed food	7.8	8.3	9.4	12.4	11.6	10.1	5.0	5.2	6.7	2.7	3.1	4.4	6.8	6.5	-6.3	-6.1
Energy	61.3	62.6	61.6	1.1	1.0	1.0	33.3	34.7	34.1	27.9	27.9	28.5	1.9	2.0	-1.5	-1.5
Non-energy industrial goods	3.9	4.0	5.7	25.2	24.6	16.9	3.0	3.0	4.9	0.9	1.0	2.9	6.9	6.1	-6.9	-6.7
Services	4.0	4.6	4.6	24.7	21.1	21.1	3.3	3.7	3.9	0.7	1.0	1.4	9.1	8.8	-11.5	-10.2
Total - 48 products	**8.8**	**9.4**	**10.0**	**10.8**	**10.1**	**9.5**	**5.6**	**6.0**	**6.8**	**3.2**	**3.4**	**4.4**	**7.5**	**7.1**	**-8.4**	**-7.8**

Source: Based on Istat data.

Table 8 – Frequency of price changes of non-energy industrial goods and food products by type of outlet (strategy 4)

(weighted statistics)

Distribution channel	Frequency of price changes	Frequency of price increases	Frequency of price decreases
Period 1996-2003			
Modern	11.8	8.1	6.4
Traditional	7.6	5.7	3.5
Other	6.4	4.4	3.8
Period 1996-2001			
Modern	10.8	7.5	5.9
Traditional	7.1	5.3	3.3
Other	6.1	4.0	3.2

Source: Based on Istat data.

Table 9 - Synchronisation ratio of price changes, with intermediate censoring and pseudo price- change (strategy 4) - Period 1996-2001

(weighted statistics)

Product	Synchronisation ratio of price changes	Synchronisation ratio of price increases	Synchronisation ratio of price decreases	Average of the synchronisation ratio of price changes by cities *(weighted with the weight of the cities)*	Average of the synchronisation ratio of price changes by cities *(weighted with the number of observations)*
Unprocessed food					
Steak	11.9	11.1	14.3	27.6	29.0
1 fresh fish	14.1	17.3	15.9	42.7	41.5
Tomatoes	23.3	53.2	52.8	53.9	47.5
Banana	12.8	21.8	18.8	36.9	35.2
Energy					
Gasoline (heating)	40.3	56.5	44.5	67.6	69.2
Fuel type 1	52.7	75.3	71.1	70.5	70.0
Fuel type 2	60.1	77.0	72.6	75.4	74.6
Processed food					
Milk	28.2	31.5	9.0	58.2	58.5
Sugar	13.1	10.2	16.6	30.1	29.9
Frozen spinach	18.9	20.8	7.1	34.7	36.2
Mineral water	34.9	11.5	9.7	41.6	43.3
Coffee	14.5	20.7	10.9	30.0	29.5
Whisky	13.3	16.0	5.7	27.9	28.7
Beer in a shop	11.6	13.0	7.7	29.4	29.2
Non-energy ind. goods					
Socks	14.2	14.7	6.7	35.4	34.3
Jeans	20.7	19.8	8.4	39.7	39.8
Sport shoes	18.7	16.5	13.4	43.5	42.5
Shirt (men)	18.4	15.7	6.6	34.8	35.8
Tiles	31.0	26.4	10.1	53.6	54.2
Toaster	37.3	30.2	19.4	62.4	59.2
Electric bulb	15.2	16.0	8.8	39.9	39.1
1 type of furniture	36.6	27.0	12.4	53.6	55.0
Towel	13.6	13.2	7.7	35.5	35.7
Car tyre	45.7	29.4	27.1	62.3	64.4
Television set	47.4	23.1	29.4	59.3	59.0
Dog food	38.8	26.8	21.2	53.9	50.6
Football	25.4	16.7	13.7	45.2	46.2
Construction game (Lego)	27.6	17.8	11.7	47.3	48.1
Toothpaste	8.3	8.3	6.9	27.5	26.5
Suitcase	33.1	23.0	17.2	53.6	54.5
Services					
Dry cleaning	23.8	20.9	15.1	40.0	44.1
Hourly rate of an electrician	28.8	26.4	12.5	57.3	58.6
Hourly rate of a plumber	29.3	27.7	13.0	61.0	61.0
Domestic services	33.7	33.3	15.4	84.8	70.5
Hourly rate in a garage	28.6	26.3	10.9	54.1	55.1
Car wash	26.2	22.1	13.6	54.1	55.8
Balancing of wheels	26.1	21.4	14.8	51.4	53.9
Taxi	24.1	23.3	-	67.4	70.6
Movie	45.3	28.3	56.4	84.4	84.9
Videotape hiring	19.8	16.2	16.5	46.0	41.2
Photo development	27.8	20.9	18.3	46.7	45.4
Hotel room	24.3	25.8	14.8	55.5	56.1
Glass of beer in a café	12.6	9.5	7.2	37.8	38.7
1 meal in a restaurant	10.5	10.2	11.4	44.0	41.6
Hot-dog	10.2	9.6	8.8	38.8	38.4
Cola based lemonade in a café	11.7	10.8	8.8	35.1	36.6
Haircut (men)	32.0	17.7	9.4	49.2	54.4
Hairdressing (ladies)	17.7	17.4	10.6	44.9	42.8

Source: Based on Istat data.

Table 10 – Determinants of the time-series variation of the frequency of price changes (1)

	All items		Unprocessed food		Processed food		Energy		Non-energy industrial goods		Services	
	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value
Intercept	0.567	*0.00*	0.298	*0.02*	-0.026	*0.75*	0.555	*0.00*	0.131	*0.53*	-1.241	*0.00*
VAT	0.025	*0.02*	0.019	*0.48*	0.018	*0.38*	0.278	*0.17*	0.009	*0.30*	-	-
CPTOT	0.011	*0.00*	0.006	*0.00*	0.009	*0.00*	0.016	*0.11*	0.006	*0.00*	-	-
ATTR	-0.708	*0.00*	-0.277	*0.10*	0.102	*0.48*	0.131	*0.72*	-1.145	*0.52*	1.351	*0.01*
Number of observations	71		71		71		71		71		71	
R^2	0.80		0.28		0.56		0.22		0.94		0.66	
Wald joint significance test	16.21		1.53		5.10		1.14		63.90		7.80	
p-value	*0.00*		*0.13*		*0.00*		*0.35*		*0.00*		*0.00*	
Wald seasonality test (2)	13.85		0.74		3.30		1.35		77.85		9.01	
p-value	*0.00*		*0.70*		*0.00*		*0.22*		*0.00*		*0.00*	

Source: Based on Istat data.
(1) All the regression include monthly seasonal dummies and are performed under the assumption of first order autocorrelated errors, using the Prais-Winsten estimator. (2) Test of the joint significance of the monthly seasonal dummies.

Table 11 – Determinants of the time-series variation of the size of price changes (1)

	All items		Unprocessed food		Processed food		Energy		Non-energy industrial goods		Services	
	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value	coeff.	p-value
Intercept	0.848	*0.68*	-3.151	*0.39*	1.490	*0.20*	0.195	*0.18*	-1.104	*0.88*	3.926	*0.76*
VAT	0.516	*0.49*	0.057	*0.82*	0.006	*0.95*	-0.008	*0.96*	0.033	*0.79*	0.002	*0.99*
ATTR	3.975	*0.17*	4.996	*0.32*	1.316	*0.51*	0.203	*0.57*	6.469	*0.41*	1.702	*0.90*
Number of observations	71		71		71		71		71		71	
R^2	0.67		0.13		0.56		0.05		0.72		0.52	
Wald joint significance test	8.82		0.67		5.63		0.23		11.33		4.68	
p-value	*0.00*		*0.79*		*0.00*		*0.99*		*0.00*		*0.00*	
Wald seasonality test (2)	0.89		0.82		0.15		0.89		0.50		1.75	
p-value	*0.55*		*0.62*		*0.99*		*0.55*		*0.89*		*0.09*	

Source: Based on Istat data.
(1) All the regression include monthly seasonal dummies and are performed under the assumption of first order autocorrelated errors, using the Prais-Winsten estimator. (2) Test of the joint significance of the monthly seasonal dummies.

Table 12 – Logit model - Conditional probability of a price change (all items) (1)

	Price changes				Price increases				Price decreases			
	coeff.	p-value	marginal effect	p-value	coeff.	p-value	marginal effect	p-value	coeff.	p-value	marginal effect	p-value
Unprocessed food	1.886	*0.00*	0.339	*0.00*	1.293	*0.00*	0.149	*0.00*	2.405	*0.00*	0.226	*0.00*
Processed food	0.460	*0.00*	0.562	*0.00*	0.256	*0.00*	0.020	*0.00*	1.019	*0.00*	0.046	*0.00*
Non-energy ind. goods	0.279	*0.00*	0.034	*0.00*	0.173	*0.00*	0.013	*0.00*	0.623	*0.00*	0.027	*0.00*
Energy	2.809	*0.00*	0.563	*0.00*	1.990	*0.00*	0.292	*0.00*	2.773	*0.00*	0.316	*0.00*
DUR	-0.019	*0.00*	-0.002	*0.00*	-0.007	*0.00*	-	*0.00*	-0.048	*0.00*	-0.002	*0.00*
VAT	0.502	*0.00*	0.069	*0.00*	0.686	*0.00*	0.069	*0.00*	-0.134	*0.11*	-0.005	*0.09*
CPTOT	0.418	*0.00*	0.048	*0.00*	0.392	*0.00*	0.030	*0.00*	0.200	*0.00*	0.008	*0.00*
ATTR	-0.374	*0.00*	-0.045	*0.00*	-0.245	*0.04*	-0.019	*0.00*	-0.382	*0.00*	-0.015	*0.00*
Intercept	-3.350	*0.00*			-3.848	*0.00*			-4.018	*0.00*		
Number of observations	291048				291048				291048			
Pseudo R^2	0.18				0.10				0.17			
Wald joint significance test	41285				19784				20814			
p-value	*0.00*				*0.00*				*0.00*			

Source: Based on Istat data.
(1) All the regressions include monthly seasonal dummies.

APPENDIX 1: DEFINITIONS AND FORMULAS

- Variables. We define the following binary variables for each product j:

(1) $\quad DEN_{jt} = \begin{cases} 1 & \text{if } P_{jt} \text{ and } P_{j,t-1} \text{ are observed} \\ 0 & \text{if } P_{jt} \text{ exists but not } P_{j,t-1} \end{cases}$

(2) $\quad NUM_{jt} = \begin{cases} 1 & \text{if } P_{jt} \neq P_{j,t-1} \\ 0 & \text{otherwise} \end{cases}$

(3) $\quad NUMUP_{jt} = \begin{cases} 1 & \text{if } P_{jt} > P_{j,t-1} \\ 0 & \text{otherwise} \end{cases}$

(4) $\quad NUMDW_{jt} = \begin{cases} 1 & \text{if } P_{jt} < P_{j,t-1} \\ 0 & \text{otherwise} \end{cases}$

On the basis of the above variables we analyse the frequency of price changes.

- Basic statistics for each product j:

  - frequency of price changes :

  (5) $\quad F_j = \dfrac{\sum_{t=2}^{\tau} NUM_{jt}}{\sum_{t=2}^{\tau} DEN_{jt}}$

  - implied median price duration (continuous time):

  (6) $\quad T_j^{50} = \dfrac{\ln(0.5)}{\ln(1 - F_j)}$

  - implied mean price duration (continuos time):

  (7) $\quad \overline{T}_j = \dfrac{-1}{\ln(1 - F_j)}$

  - frequency of price increases:

  (8) $\quad F_j^+ = \dfrac{\sum_{t=2}^{\tau} NUMUP_{jt}}{\sum_{t=2}^{\tau} DEN_{jt}}$

  - average price increase in p.c.

  (9) $\quad \overline{\Delta P}_j^+ = \dfrac{\sum_{t=2}^{\tau} NUMUP_{jt}\left(\ln P_{jt} - \ln P_{j,t-1}\right)}{\sum_{t=2}^{\tau} DEN_{jt}}$

- frequency of price decreases:

$$(10) \quad F_j^- = \frac{\sum_{t=2}^{\tau} NUMDW_{jt}}{\sum_{t=2}^{\tau} DEN_{jt}}$$

- average price decrease in p.c.:

$$(11) \quad \overline{\Delta P_j^-} = \frac{\sum_{t=2}^{\tau} NUMDW_{jt}\left(\ln P_{j,t-1} - \ln P_{jt}\right)}{\sum_{t=2}^{\tau} DEN_{jt}}$$

- Price synchronisation. We rely on the synchronisation ratio proposed by Konieczny and Skrzypacz (2002), which is based on the standard deviation of the proportion of price changes (increases and/or decreases) evaluated each month t. In case of perfect synchronisation, the proportion of price changes at time t is either equal to 1 or to 0. As the average frequency of price changes over the sample period is equal to Fj, it means, in the case of perfect synchronisation, that all firms change their price simultaneously in Fj per cent of the cases and do not change their price in (1- Fj) per cent of the cases. Using the probability of price changes, it is then possible to compute the theoretical value of the standard deviation of the proportion of price changes over time in case of perfect synchronisation. This standard deviation associated to perfect synchronisation is:

$$(12) \quad SDMAX_j = \sqrt{F_j\left(1 - F_j\right)^2 + \left(1 - F_j\right)\left(0 - F_j\right)^2} = \sqrt{F_j\left(1 - F_j\right)}$$

This theoretical value is an upper limit for the standard deviation of the proportion of price changes. Similarly, in the case of perfect staggering, a constant proportion F_j of firms changes its price each month and the standard deviation of the proportion of price changes over time is equal to 0. The true standard deviation of price changes for product classification j is:

$$(13) \quad SD_j = \sqrt{\frac{1}{\tau - 1}\sum_{t=2}^{\tau}\left(F_{jt} - F_j\right)^2}$$

The <u>synchronisation ratio</u> of product classification j is then given by:

$$(14) \quad SYNC_j = \frac{SD_j}{SDMAX_j}$$

The closer the ratio is to one, the higher is the degree of synchronisation. Similar expressions can be derived for $SYNC_j^+$ and $SYNC_j^-$, the synchronisation ratio of price increases and price decreases.

APPENDIX 2: RESULTS INCLUDING 2002-2003

Table A2.1 - Duration of price spells – Period 1996-2003
(weighted statistics; months)

	Number of obs.	Mean	Median	Standard deviation
1. No censoring				
Total sample	**101888**	**8**	**4**	**11**
Unprocessed food	22935	7	3	12
Processed food	25431	8	5	10
Non-energy industrial goods	18954	12	9	12
Energy	22784	1	1	1
Services	11784	12	9	14
Averaged by individual trajectory (1)	**23566**	**13**	**8**	**15**
2. Full censoring	**63955**	**5**	**2**	**8**
3. Intermediate censoring	**81871**	**7**	**3**	**9**

Source: Based on Istat data.
(1) See equation (5) in the text.

Table A2.2 – Frequency and size of price changes and duration – Period 1996-2003
(weighted statistics)

	Frequency of price changes			Duration implied by average frequency (months)			Frequency of price increases			Frequency of price decreases			Average price increase (%)		Average price decrease (%)	
	1. no censoring	3. intermediate censoring	4. pseudo price-changes	1. no censoring	3. intermediate censoring	4. pseudo price-changes	1. no censoring	3. intermediate censoring	4. pseudo price-changes	1. no censoring	3. intermediate censoring	4. pseudo price-changes	1. no censoring	3. intermediate censoring	1. no censoring	3. intermediate censoring
By COICOP:																
1. Food and non-alcoholic bev.	15.0	16.3	15.6	6.2	5.6	5.9	8.6	9.3	9.2	6.4	7.0	7.1	6.4	6.4	-6.6	-6.5
2. Alcoholic bev. and tobacco	8.5	9.5	10.7	11.2	10.0	8.8	5.4	5.7	7.6	3.2	3.8	5.5	8.1	7.7	-7.3	-7.4
3. Clothing and footwear	4.6	4.5	6.4	21.3	21.6	15.2	3.8	3.7	5.6	0.8	0.8	2.7	7.5	6.6	-7.3	-7.8
4. Housing, water, electricity, etc.	22.6	23.2	23.2	3.9	3.8	3.8	13.6	13.9	14.3	9.0	9.3	9.8	5.7	4.9	-6.4	-7.2
5. Furnishings, household equip.	3.5	3.2	4.7	28.3	30.8	20.7	3.1	2.8	4.3	0.4	0.4	1.8	6.8	5.3	-5.6	-4.9
7. Transport	28.1	28.4	28.6	3.0	3.0	3.0	15.5	16.0	16.3	12.5	12.4	13.2	6.2	6.3	-6.3	-5.3
9. Recreation and culture	5.3	5.9	7.8	18.2	16.4	12.2	2.5	2.8	5.3	2.8	3.1	5.5	6.4	6.7	-8.1	-8.0
11. Restaurants and hotels	6.3	7.8	7.2	15.3	12.3	13.4	4.9	5.7	5.8	1.4	2.1	2.4	8.8	9.3	-12.7	-11.4
12. Other goods and services	3.9	4.0	4.9	25.2	24.7	19.9	3.0	3.0	4.1	0.9	0.9	1.9	8.5	7.7	-9.2	-9.4
By Product type																
Unprocessed food	20.4	22.7	20.9	4.4	3.9	4.3	11.2	12.6	11.6	9.3	10.1	9.7	7.5	7.6	-8.1	-8.2
Processed food	8.5	9.2	10.1	11.2	10.4	9.4	5.4	5.6	7.0	3.1	3.6	4.8	6.6	6.4	-6.0	-5.9
Energy	68.9	70.0	69.2	0.9	0.8	0.8	37.5	38.8	38.1	31.5	31.2	32.0	2.0	2.0	-1.6	-1.7
Non-energy industrial goods	4.5	4.5	6.4	21.7	21.9	15.2	3.4	3.3	5.3	1.1	1.1	3.1	6.8	6.1	-6.9	-6.9
Services	5.0	5.8	5.7	19.5	16.7	17.1	4.0	4.4	4.7	1.0	1.4	1.7	8.9	8.6	-10.7	-9.8
Total - 48 products	**10.1**	**10.7**	**11.2**	**9.4**	**8.8**	**8.4**	**6.4**	**6.8**	**7.6**	**3.7**	**3.9**	**4.9**	**7.4**	**7.0**	**-8.1**	**-7.7**

Source: Based on Istat data.

APPENDIX 3: RESULTS FOR INDIVIDUAL ITEMS

Table A3.1 - Frequency of price changes and duration, with intermediate censoring and pseudo price-change (strategy 4) - Period 1996-2001
(weighted statistics)

Product	Frequency of price changes	Implied median duration (months)	Implied average duration
Unprocessed food	**19.5**	**3.2**	**4.6**
Steak	7.7	8.6	12.5
1 fresh fish	51.7	1.0	1.4
Tomatoes	76.2	0.5	0.7
Banana	34.0	1.7	2.4
Energy	**61.6**	**0.7**	**1.0**
Gasoline (heating)	59.1	0.8	1.1
Fuel type 1	64.4	0.7	1.0
Fuel type 2	62.3	0.7	1.0
Processed food	**9.4**	**7.0**	**10.1**
Milk	7.1	9.5	13.7
Sugar	7.9	8.4	12.2
Frozen spinach	10.0	6.6	9.5
Mineral water	10.2	6.5	9.3
Coffee	13.8	4.7	6.7
Whisky	9.0	7.4	10.6
Beer in a shop	12.2	5.3	7.7
Non-energy ind. goods	**5.7**	**11.7**	**16.9**
Socks	4.5	15.0	21.7
Jeans	5.7	11.9	17.1
Sport shoes	5.8	11.5	16.6
Shirt (men)	4.9	13.7	19.8
Tiles	4.1	16.7	24.1
Iron	5.3	12.7	18.3
Electric bulb	5.6	12.1	17.4
1 type of furniture	4.9	13.8	19.8
Towel	4.4	15.4	22.2
Car tyre	8.6	7.7	11.1
Television set	9.7	6.8	9.8
Dog food	6.9	9.8	14.1
Football	4.0	17.0	24.5
Construction game (Lego)	5.5	12.3	17.7
Toothpaste	10.1	6.5	9.4
Suitcase	5.5	12.4	17.8
Services	**4.6**	**14.7**	**21.1**
Dry cleaning	2.4	28.4	41.0
Hourly rate of an electrician	3.4	19.8	28.5
Hourly rate of a plumber	3.5	19.7	28.4
Domestic services	3.5	19.3	27.9
Hourly rate in a garage	3.1	21.8	31.4
Car wash	2.7	25.0	36.1
Balancing of wheels	2.3	29.4	42.5
Taxi	2.2	31.3	45.2
Movie	7.4	9.0	13.0
Videotape hiring	1.5	45.9	66.2
Photo development	3.2	21.5	31.1
Hotel room	8.6	7.7	11.2
Glass of beer in a café	2.5	27.5	39.7
1 meal in a restaurant	4.2	16.1	23.3
Hot-dog	2.7	25.4	36.7
Cola based lemonade in a café	2.4	29.0	41.9
Haircut (men)	3.1	22.1	31.8
Hairdressing (ladies)	2.7	25.1	36.2
Total	**10.00**	**6.6**	**9.5**

Source: Based on Istat data.

Table A3.2 - Frequency and size of price increases (decreases), with intermediate censoring and pseudo price-change (strategy 4) - Period 1996-2001

(weighted statistics)

Product	Frequency of price increases	Average price increase (%)	Frequency of price decreases	Average price decrease (%)
Unprocessed food	**10.5**	**7.5**	**9.4**	**-8.0**
Steak	4.8	5.7	3.4	-6.2
1 fresh fish	25.0	10.1	26.7	-10.7
Tomatoes	38.7	16.8	37.6	-18.1
Banana	17.8	10.1	16.2	-11.1
Energy	**4.9**	**1.9**	**2.9**	**-1.5**
Gasoline (heating)	33.3	2.5	26.5	-2.0
Fuel type 1	34.8	2.3	30.7	-1.7
Fuel type 2	34.4	1.7	29.1	-1.3
Processed food	**6.7**	**6.8**	**4.4**	**-6.3**
Milk	6.2	4.9	1.6	-4.4
Sugar	3.9	5.1	5.0	-5.5
Frozen spinach	8.1	5.9	4.2	-6.4
Mineral water	7.0	8.6	6.0	-7.9
Coffee	7.5	6.2	8.0	-6.3
Whisky	7.5	8.3	3.7	-6.8
Beer in a shop	8.5	7.4	5.4	-7.9
Non-energy ind. goods	**4.9**	**6.9**	**2.9**	**-6.9**
Socks	4.2	6.9	1.6	-9.4
Jeans	5.2	7.9	2.0	-6.1
Sport shoes	4.9	8.0	3.0	-8.5
Shirt (men)	4.5	6.8	2.0	-7.3
Tiles	3.9	7.9	1.3	-2.9
Toaster	4.0	6.8	3.4	-6.8
Electric bulb	4.6	8.2	2.4	-9.2
1 type of furniture	4.6	6.3	2.4	-5.1
Towel	4.2	8.9	1.8	-8.3
Car tyre	5.6	5.8	5.3	-12.7
Television set	6.3	4.1	7.8	-5.8
Dog food	4.9	7.3	4.0	-10.3
Football	3.7	8.7	2.5	-12.2
Construction game (Lego)	5.0	7.6	3.7	-5.9
Toothpaste	7.4	7.1	5.0	-7.7
Suitcase	4.6	5.7	3.1	-8.9
Services	**3.9**	**9.1**	**1.4**	**-11.5**
Dry cleaning	1.8	7.5	0.8	-11.4
Hourly rate of an electrician	3.3	6.1	0.6	-10.0
Hourly rate of a plumber	3.3	6.5	0.6	-12.4
Domestic services	3.4	8.4	0.3	-5.0
Hourly rate in a garage	2.8	8.1	0.8	-8.5
Car wash	2.5	11.6	1.1	-16.3
Balancing of wheels	1.9	11.7	0.9	-10.6
Taxi	2.2	7.5	0.2	0.0
Movie	4.6	13.1	3.3	-12.6
Videotape hiring	1.1	15.3	0.5	-25.9
Photo development	2.2	6.8	1.4	-9.4
Hotel room	6.9	9.8	2.7	-15.3
Glass of beer in a café	2.4	12.8	0.8	-14.5
1 meal in a restaurant	3.7	8.3	1.4	-12.4
Hot-dog	2.6	12.3	0.6	-11.4
Cola based lemonade in a caf	2.2	12.2	0.5	-8.9
Haircut (men)	2.9	9.8	1.3	-8.4
Hairdressing (ladies)	2.4	10.2	0.6	-10.7
Total	**6.8**	**7.5**	**4.4**	**-8.4**

Source: Based on Istat data.

Table A3.3 - Frequency of price changes and duration, with intermediate censoring and pseudo price-change (strategy 4) - Period 1996-2003

(weighted statistics)

| Product	Frequency of price changes	Implied median duration (months)	Implied average duration (months)
Unprocessed food	**20.9**	**3.0**	**4.3**
Steak	9.2	7.2	10.4
1 fresh fish	52.6	0.9	1.3
Tomatoes	77.1	0.5	0.7
Banana	35.2	1.6	2.3
Energy	**69.2**	**0.6**	**0.8**
Gasoline (heating)	61.9	0.7	1.0
Fuel type 1	73.0	0.5	0.8
Fuel type 2	71.6	0.6	0.8
Processed food	**10.1**	**6.5**	**9.4**
Milk	8.2	8.1	11.6
Sugar	8.0	8.3	12.0
Frozen spinach	10.8	6.1	8.7
Mineral water	10.9	6.0	8.7
Coffee	13.5	4.8	6.9
Whisky	9.7	6.8	9.8
Beer in a shop	13.1	5.0	7.1
Non-energy ind. goods	**6.4**	**10.5**	**15.2**
Socks	4.9	13.8	19.9
Jeans	6.8	9.8	14.2
Sport shoes	6.6	10.2	14.7
Shirt (men)	6.1	11.1	16.0
Tiles	5.2	12.9	18.6
Iron	5.3	12.7	18.4
Electric bulb	6.4	10.4	15.1
1 type of furniture	5.2	13.0	18.7
Towel	5.5	12.2	17.6
Car tyre	9.2	7.2	10.3
Television set	9.7	6.8	9.8
Dog food	7.1	9.4	13.6
Football	4.6	14.7	21.3
Construction game (Lego)	5.8	11.7	16.9
Toothpaste	10.7	6.1	8.8
Suitcase	6.2	10.8	15.6
Services	**5.7**	**11.9**	**17.1**
Dry cleaning	3.1	22.3	32.2
Hourly rate of an electrician	4.0	17.0	24.6
Hourly rate of a plumber	3.8	17.8	25.6
Domestic services	3.7	18.2	26.3
Hourly rate in a garage	3.8	17.9	25.8
Car wash	3.4	20.1	29.0
Balancing of wheels	3.4	20.1	29.0
Taxi	3.3	20.7	29.9
Movie	7.7	8.7	12.5
Videotape hiring	2.8	24.4	35.2
Photo development	3.6	18.7	27.0
Hotel room	10.3	6.4	9.2
Glass of beer in a café	3.5	19.3	27.9
1 meal in a restaurant	5.4	12.4	17.9
Hot-dog	3.6	19.0	27.4
Cola based lemonade in a café	3.3	20.7	29.9
Haircut (men)	3.7	18.3	26.4
Hairdressing (ladies)	3.2	21.2	30.6
Total	**11.2**	**5.8**	**8.4**

Source: Based on Istat data.

Table A3.4 - Frequency and size of price increases (decreases), with intermediate censoring and pseudo price-change (strategy 4) - Period 1996-2003
(weighted statistics)

| Product	Frequency of price increases	Average price increase (%)	Frequency of price decreases	Average price decrease (%)
Unprocessed food	**11.6**	**7.5**	**9.7**	**-8.1**
Steak	6.1	5.7	3.7	-6.2
1 fresh fish	26.1	10.5	26.5	-11.0
Tomatoes	38.5	17.5	38.6	-18.3
Banana	18.4	10.1	16.7	-11.0
Energy	**38.1**	**2.0**	**32.0**	**-1.6**
Gasoline (heating)	35.2	2.5	27.5	-2.1
Fuel type 1	39.4	2.3	34.3	-1.8
Fuel type 2	39.0	1.8	33.4	-1.4
Processed food	**7.0**	**6.6**	**4.8**	**-6.0**
Milk	6.7	4.8	2.3	-4.1
Sugar	4.2	5.0	4.7	-5.5
Frozen spinach	8.5	5.7	4.5	-6.2
Mineral water	7.3	8.4	6.3	-7.6
Coffee	7.3	6.0	8.0	-5.9
Whisky	7.9	7.8	3.9	-6.7
Beer in a shop	8.4	7.2	6.0	-7.5
Non-energy ind. goods	**5.3**	**6.8**	**3.1**	**-6.9**
Socks	4.4	6.7	1.8	-9.2
Jeans	6.1	7.7	2.5	-6.0
Sport shoes	5.6	7.9	3.3	-8.5
Shirt (men)	5.3	6.7	2.5	-6.9
Tiles	4.7	8.0	1.8	-6.6
Toaster	4.0	6.8	3.4	-6.8
Electric bulb	5.1	8.0	2.6	-9.1
1 type of furniture	4.8	6.1	2.4	-5.0
Towel	4.9	8.8	2.5	-8.0
Car tyre	6.1	5.9	5.3	-11.8
Television set	6.2	4.2	7.9	-6.0
Dog food	5.1	7.5	4.0	-9.8
Football	4.0	8.7	2.8	-11.4
Construction game (Lego)	5.2	7.4	3.8	-6.8
Toothpaste	7.5	6.9	5.4	-7.3
Suitcase	5.2	5.5	3.5	-8.6
Services	**4.7**	**8.9**	**1.7**	**-10.7**
Dry cleaning	2.4	7.4	0.8	-11.5
Hourly rate of an electrician	3.7	6.2	0.8	-8.6
Hourly rate of a plumber	3.6	6.6	0.7	-10.9
Domestic services	3.6	8.2	0.3	-5.2
Hourly rate in a garage	3.4	8.0	1.0	-7.7
Car wash	3.1	11.3	1.0	-15.1
Balancing of wheels	2.7	11.2	1.3	-10.0
Taxi	2.7	7.6	0.7	-0.4
Movie	4.9	11.9	3.3	-11.6
Videotape hiring	2.0	14.5	1.1	-21.4
Photo development	2.5	6.6	1.5	-9.8
Hotel room	7.8	9.9	3.7	-15.6
Glass of beer in a café	3.3	12.2	1.0	-12.6
1 meal in a restaurant	4.7	7.8	1.6	-10.8
Hot-dog	3.4	12.0	0.7	-10.8
Cola based lemonade in a caf	3.0	11.9	0.7	-8.6
Haircut (men)	3.4	9.7	1.2	-8.1
Hairdressing (ladies)	2.9	9.8	0.6	-10.5
Total	**7.6**	**7.4**	**4.9**	**-8.1**

Source: Based on Istat data.

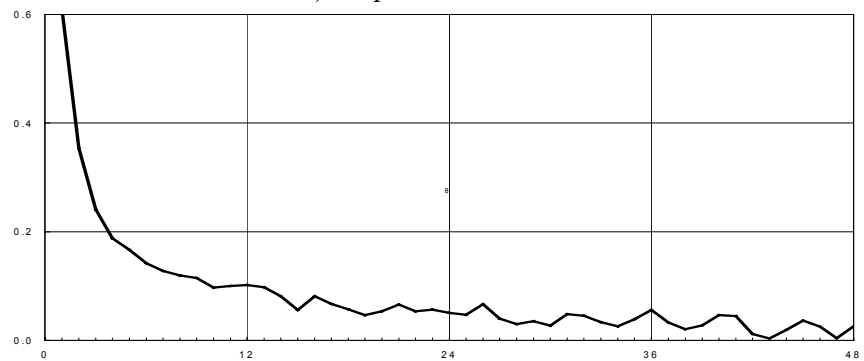# APPENDIX 4: HAZARD FUNCTIONS FOR SUB-INDICES (1)
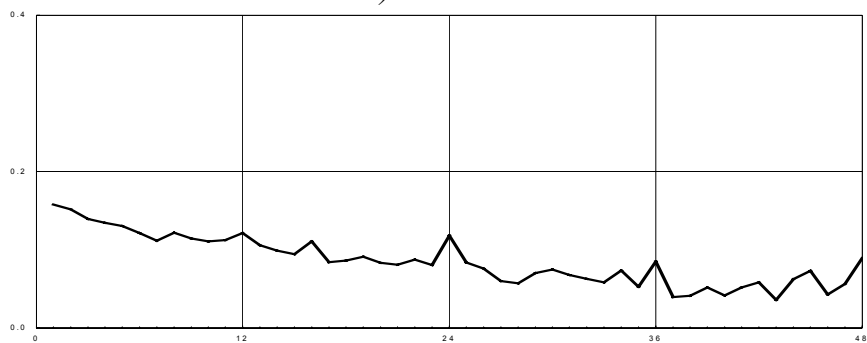
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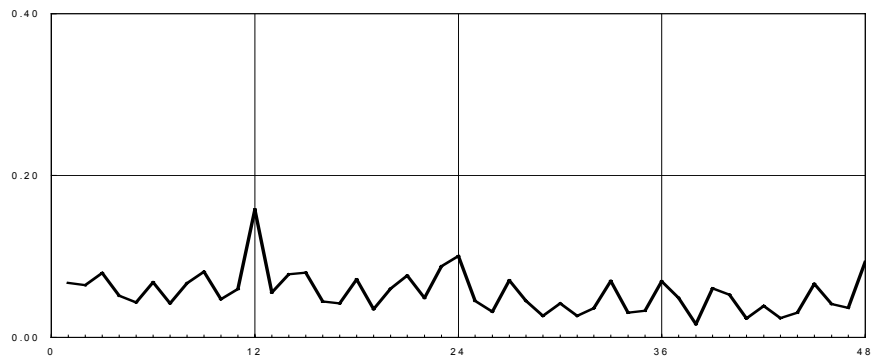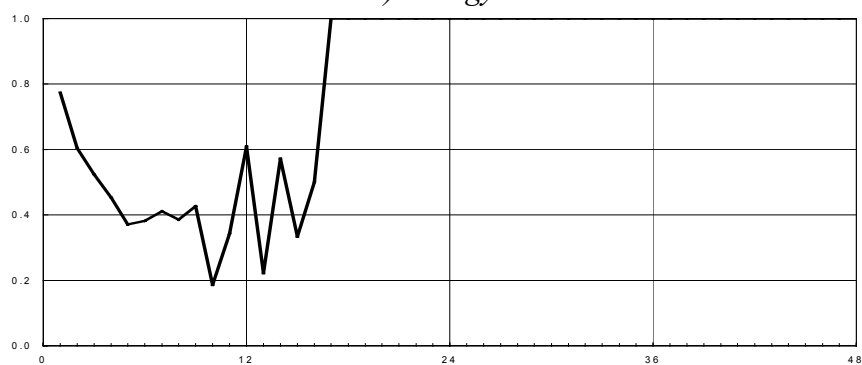

b) Non Energy Industrial Goods
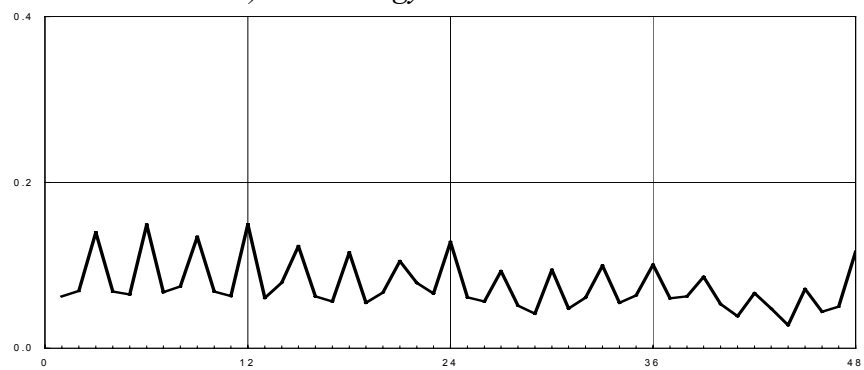
c) Unprocessed Food

d) Processed Food

e) Energy

Source: Based on Istat data.
(1) Hazard function estimates are estimated using the Kaplan-Meier method.

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