Measuring inflation when prices change slowly

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1. Introduction

Inflation is currently low and falling in the OECD area, even after the recent tragic events in USA. As a matter of fact, this is not a short run occurrence, but the result of several structural changes, mainly concerning markets flexibility and increasing competitiveness. Globalisation, privatisation, liberalisation, fiscal consolidation and tight monetary policies worked together to achieve such results.

A side effect of these facts is that they made harder the task of price index compilers, since the demand for information about inflation is evolving. The transformation is twofold and, in a sense, is contradictory as well. On the one hand, increasing integration of international markets pushed for harmonised measures of inflation, to be used in international comparisons. On the other hand, researchers and analysts are moving their attention from aggregate price dynamics to price differentials (among products, markets, consumers groups, and countries), since relative differences among single prices did not tend to narrow as inflation falls. Thus the distribution of price changes (and underlying price dispersion) has become more and more relevant for users.

In the European countries, HICP provided an answer to the first request. While, until now, the breakdown of national CPIs for markets and consumers groups sometimes satisfied the demand for information on price differentials within few countries.

Figure 1 below tries to summarise the current awkward condition of price compilers. First of all, they have to cope with some practical, but not trivial, problems raised by low inflation itself, such as rounding. Secondly, statistical agencies must devote huge resources to ensure international comparability of national price indexes. Actually, international organizations are capable of harmonising national indexes *ex-post* only up to a point, since data collection, definitions and data processing can be harmonised only *ex-ante* at national level. The complex regulatory process behind the compilation of HICP exemplifies how hard this task can be. On its turn, a fine breakdown of price indexes requires comparable classifications as well.

In addition, important factors, such as market segmentation and consumers stratification, should be taken into account both in CPIs and in harmonised indexes, above and beyond usual "consumption purpose" of goods and services, underlying COICOP classification. For instance, the relation between price level, on the one side, and price dynamics cannot be disregarded as well, as Section 4 below will show. Furthermore, price dispersion requires the dissemination of new indicators on inflation dynamics, notably those based on the concept of "core" inflation.

Of course, this paper can only touch upon few of these points. In the following section the "trivial" problem of rounding is considered. Section 3 provides some empirical evidence concerning price changes dispersion and its effects on economic analysis. Section 4 deals with the dependency of inflation from initial price level.

2. New outcomes of an old problem: rounding

Price index rounding is a very old problem, but never solved as well. Usually only rounded inflation figures are disseminated to the public and to the researchers. This may be a relic of times when computation was a heavy duty, and dealing with one decimal figure made far simple the task of statistical agencies. In addition, during mid or high inflation, rounding did not turn out so disturbing for analysts, since monthly price index changes largely exceeded rounding approximation. Hence rounding "noise" did not conceal the signal of inflation. Nowadays the noise to signal ratio is much more unfavourable. Provided that index figures are usually rounded up to the first decimal place, it implies an "extra" variance of price index of $0.01/12 \approx 0.001$ percentage

points[1], which seems apparently negligible, compared to sample variance and Boskin-type systematic bias. However, it implies, for instance, that in 50% of cases the true index differs from the rounded one more than ±0.025 percentage points. If a fixed base index is compiled, this error has only transitory effects, but if a chained index is used, then the rounding inaccuracy occurred in the chaining month (usually December) potentially carries over forever. If statistical agencies are unlucky enough, one half decimal point drift may occur in 10 years.

What is more, inflation rate is usually computed by using rounded index, and the result is rounded again. Hence, in 50% of cases the published inflation rate diverges from the unrounded one more than ±2×0.015 = ±0.03 percentage points, that is one third of monthly price changes currently observed in many countries. Such inaccuracy seems unimportant again, and it might be in fact if it was a random noise added to the true figures. Unfortunately this is not the general case, since the double rounding creates pseudo-periodic oscillations around the true inflation rate. As a consequence, the turning points of inflation, if any, may be moved, and further spurious cycles are introduced in the time series of inflation. It is easy to show that rounding produces a series of "saw-tooth" waves around the true inflation rate whose width is 0.1 percentage points, and the period changes over the time according to a highly non –linear function of annual inflation rate. Non-linearity implies that even a small change of long run inflation rate may change dramatically the pattern of spurious waves. For instance, even considering the very simple case of three constant inflation rates (i.e.: 1.5%, 2%, and 2.5% per year), it is apparent in Figure 2 that shapes and periods of spurious waves induced by rounding vary completely from one case to the other. Hence it is almost impossible to deduce from rounded data the "true" underlying inflation dynamics. This is enough to confuse every analyst.

Furthermore, noise and cycles added to price index may disturb usual seasonal adjustment procedures. First of all, it is possible that such cycles have a near-seasonal period, but this is only a minor problem (and a lucky chance, indeed), since in this case seasonal adjustment is generally able to cancel out rounding influence from adjusted time series. Nevertheless, sometimes the noise component added by rounding may hinder the detection and estimation of seasonal pattern. Specifically, rounding may worsen the estimation and projection of time series models on which most seasonal adjustment methods are based.

Of course there is a trivial remedy to these drawbacks: namely to publish unrounded data, or at least data with 2 or 3 decimal places, in order to make negligible the size of rounding noise. It is not by chance that other indexes, widely used by analysts, such as the stock market indicators, have a base near 10,000, that makes almost negligible rounding effect on decimal places, and nevertheless the daily changes of these indexes are published by using 2 decimal places at least. However, only few statistical agencies adopt this convention, and even the recent agreements on HICP compilation suggest rounding indexes and inflation rates to the first decimal place. Notably, the base of HICP has been fixed to 100 in 1996. Furthermore, in most cases, European statistical agencies are allowed to adopt different compilation procedures, other than the agreed one (e.g.: they may use a different aggregation formula), under the condition that the results differ from the baseline less than one tenth of a percentage point. Only in computing average yearly changes of HICP it is required to use unrounded figures of annual index averages.

3. Price changes dispersion

To compile a price index means necessarily computing average prices for a number of products. On their turn, products sub-indexes are aggregated by using a system of weights, derived from households' budget surveys, national accounts, and other wide-ranging sources. Of course this

[1] By the way, this result was reported by Sheppard more than a century ago in his article published in the Proceeding of the London Mathematical Society, 1989, vol. 29: "On the calculation of the most probable values of frequency constants for data arranged according to equidistant divisions of a scale".

practice provides an accurate measure of average price changes from the viewpoint of a representative consumer, who has average preferences, average income, and so on. As a matter of fact, this average inflation applies to other consumers as well, if price dynamics of different goods and services do not differ too much from the average one. Unfortunately, it has been remarked that this is not the most frequent case nowadays; hence different consumers groups bear very different purchasing power reductions.

Of course this is a well known (and maybe unavoidable) drawback of every aggregate statistical measure. According to the mainstream economic theory, market enlargement and improved competition should narrow the differences within every product market, while the same factors could widen the divergence of price changes among different products as well. In fact, general equilibrium requires that prices adjust very fast in each market. As a result, global competition lowers general inflation, on the one hand, while it tends to increase prices dispersion on the other.

Figure 3, reporting some distribution indicators for HICP compiled for the European Monetary Union, provides a very rude exemplification of this fact. Specifically, the breakdown in 89 product groups has been used to compute each month the second and eighth deciles of 12-month price changes distribution.

First of all, it is worth noticing that price dispersion does not increased too much during the oil crisis: the distance between second and eighth deciles remained by 2-2.5 percentage points, as during the previous period. It means that price dispersion does not depend mainly on transitory shocks on special prices, but is determined essentially by structural factors. One reason may be the fast and strong adjustment of prices on markets that become more and more flexible and reactive. If it is so, analysts need some measures of overall price dynamics that are less sensitive to changes in price distribution than the headline average inflation rate. Otherwise, it would be very difficult understanding the true signals coming from the markets. Hence statistical agencies should make an effort to provide researchers and analysts also with some indicators about price changes distribution, such as quantiles, median, trimmed mean, and the like. Incidentally, the last two indicators are standard core inflation measures as well.

It can be argued that average European inflation almost always stayed within the aforementioned quantiles, even during the latest oil price rise. Nevertheless, the distribution of price changes became pretty asymmetrical since the mid of 1999. It implies that, at the same time as the average inflation speeded up by 2.5 percentage points from the end of 1998 to April 2001, the large majority of prices, included between the second and the eighth deciles, accelerated by less than 2 percentage points. What is more, until September 2000, the prices of one fifth of products fell or rose less than 0.5% per year, as the dynamics of the second decile shows. Namely inflation, in its narrowest definition, regarded only 80% of products. On the other hand, even when average European inflation was below 1%, one fifth of products displayed annual price increases over 2% (as the level of eighth decile confirms), that is more than twice the average inflation rate.

Adopting a narrow statistical viewpoint, an estimated average associated to such dispersion might not differ from zero significantly. Of course, nobody questions seriously that inflation was, and still will be, a problem for European countries. However, it should be stressed that deflating consumers' expenditure by using a single average inflation indicator could be misleading. Furthermore, headline inflation rate may provide a poor (noisy) signal about general price dynamics. As a consequence, analysts need, first of all, very disaggregate price sub-indexes in order to evaluate properly purchasing power of different consumer groups and, secondly, they would appreciate some "robust" measure of inflation, such as "core" indicators.

4. Market competitiveness, price convergence, and price index compilation

Increasing market integration, competitiveness and flexibility play a crucial role in determining price dynamics. The so-called "law of one price" states that in a perfect competitive

market the same commodities must be exchanged at the same price. If this were not the case, the market would not be in equilibrium, there would be a scope for arbitrage, and therefore the price would not be stable. This law holds also in most of actual markets, even though they are far from being competitive. For instance, in the case of indifferianciate monopoly, the monopolist sets a single price in order to maximise his profits. The same happens in collusive oligopolistic markets for commodities that can be hardly be differentiated (such as fuels).

In other cases the law of one-price holds because of the strategies followed by firms. For instance, sometimes the same price is set on different markets in order to "fidelise" clients. This is the case of several brands such as McDonald, Swatch and Benetton, that sometimes make use of a rude PPP rule too. Occasionally, firms use one-price policies to reinforce the look of their products. For instance, most luxury goods producers impose a single highest price in all shops, to the aim of granting customers about quality and originality of their products. In other cases, prices tend to follow a reference benchmark, set by the price leader, which can be a true dominant firm or a "barometric" one, which simply has better information about the market. Furthermore, in each instant of time prices could differ only owing to the staggering of price variations among the firms and outlets. Anyway, even in a perfect competitive market, the prices of the same commodity are allowed to diverge if consumer incurs in search costs. Thus the law of "one stable structure of price" holds instead.

In any case, it could be put forward the general hypothesis that prices variations exhibits a negative correlation with the initial level of prices, or, specifically, with the difference between initial price and the average (or reference) one. Figure 3 illustrates this hypothesis in the case of six models of a given product, whose prices differ in the beginning, but tend to converge in the long run. To do so, higher initial prices must rise at a slower pace, while lower prices must increase speedier. Of course, price variations should also depend on the usual structural factors, such as the nature of goods, the place of selling, type of outlet.

If convergence hypothesis is not false, a series of consequences for the estimation of inflation rates follow. First of all, price changes are not independent from price levels, as price index compilers usually assume. Thus surveyed products should be chosen taking into account also the price frequency distribution in the market. Specifically, the selection of "best selling" products only could bias the inflation rates. As far as "best selling" items have the best quality price ratio (otherwise rational consumers did not prefer them), this class of products has also a price above the average (taking into account quality and other relevant characteristics). Thus, if the one price law holds, then bestseller prices tend to rise faster than the others. As far as I know, this possible upward bias of CPI (not only of COLI) has not been regarded yet in Boskin Report and related literature.

Furthermore, it is likely that the adjustment of prices toward some equilibrium configuration is faster as price stickiness lessens. Notably, this is the case when search costs incurred by consumers decrease, and when "menu costs" for firms reduce. The next changeover in Europe is likely to cut both types of costs: consumers will be able to compare prices of the same item all over Europe, without incurring in any exchange fee; and firms may take advantage of the changeover to adjust their prices exactly to the optimal level, since in any case they have to bear (not trivial) menu costs to switch their national prices in euros. As a consequence, the selection of price sample for 2002 will be crucial. Inflation measures in Europe could be biased if the sample provided an out of focus picture of current prices structure.

Namely, some statistical evidence in favour of one price hypothesis is provided by the analysis of Italian data collected in order to estimate HCPI during 1995 and 1996 in 9 cities, for over 400 products. The author will be happy to provide further details about this study to the interested people. Table 1 reports the price changes of different classes of items, grouped according to the difference between their own price level and the related average price (computed for the same item sold in the same city and in the same type of outlet). Price changes are given as difference to the average inflation rate, which was by 6%. It is self evident that items that are sold at a higher

price show price increases far lower than the others, and vice versa. In addition, the effect of initial price on future price dynamics seems to be substantial.

By using the same data, the half-life of a prices divergence has been estimated approximately in 13 years, which is slightly longer than convergence time found among general price levels in several US cities. Sharp differences in convergence rates hold among various outlet categories. Notably, mean reversion effect seems stronger in big commercial centres and in street markets, maybe because these are the (polar) cases in which competition is stronger and search costs for consumers are negligible. Quite the reverse, convergence is slower in traditional, specialised, one brand and chained outlets, where product differentiation is a common practice. Furthermore, goods prices tend to revert toward the average faster than services do, and this fact is consistent with the scarce competition in most service markets in Italy.

5. Some conclusive remarks

Of course this paper expresses the views of a user, rather than a data producer. Statistical agencies usually complain with analysts and economists for their insatiable demand for new and more detailed data. Furthermore, they grumble for the variety and volatility of such demand. It should be acknowledged that statistical agencies improved dramatically their capability to satisfy the demand for information during the last few years. They emulated firms, which have got used to cope with such problems for a long time now.

As a matter of fact, the additional burden demanded to statistical agencies by this paper does not seem so heavy. Nevertheless, the gain in accuracy and pertinence of information about inflation would not be negligible, as it has been shown above. In the very end, the main requests concern: the dissemination of indexes rounded to the second decimal place; a fine breakdown of price indexes, which enables analysts to compute almost every non-standard indicator by themselves; and possibly the computation of some core inflation indicators. In addition, section 4 suggests some practicable improvements to the current sampling strategy, which could be very relevant during the changeover in Europe, as far as prices adjustment will speed up.

It should be pointed out that such requests are neither extemporaneous or a short run curiosity. They basically derive from a consensus analysis about long-term tendency of word economy. Thus one can expect that information demand on inflation outlined above will not change dramatically in the next years. In a sense, this is the “core” demand faced to the statistical agencies. In addition, a fine breakdown of price indexes potentially satisfies in advance most on the spot requests put forward by analysts. Hence investment required to statistical agencies on this project is likely to have a good and durable return. Last, but not least, some warnings and suggestions about price index compilation seem to be relevant right now, in view of the European changeover.

FIGURE 1 – THE CHALLENGES FOR PRICE INDEX COMPILERS

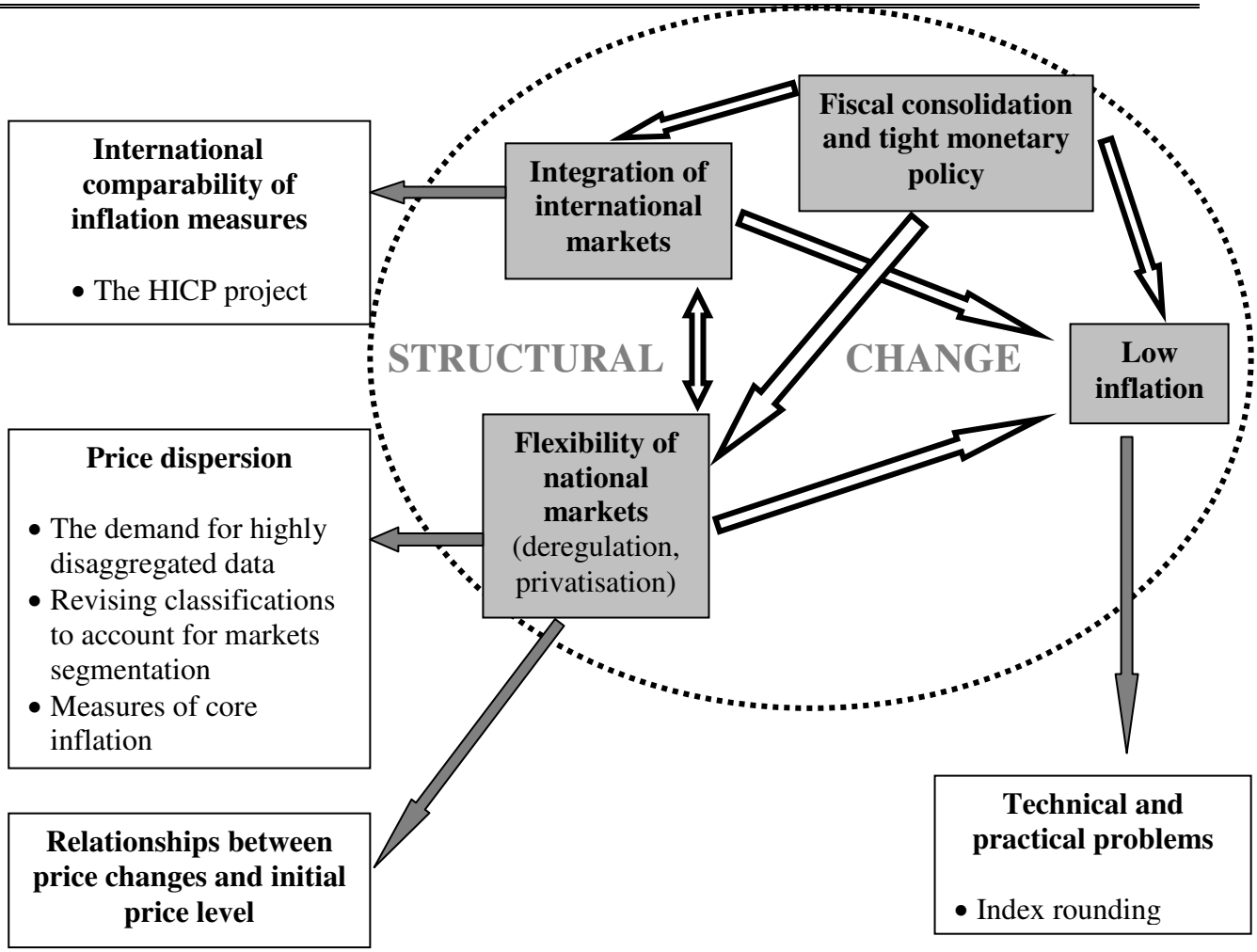

FIGURE 2 – EFFECTS OF ROUNDING ON PUBLISHED INFLATION RATE

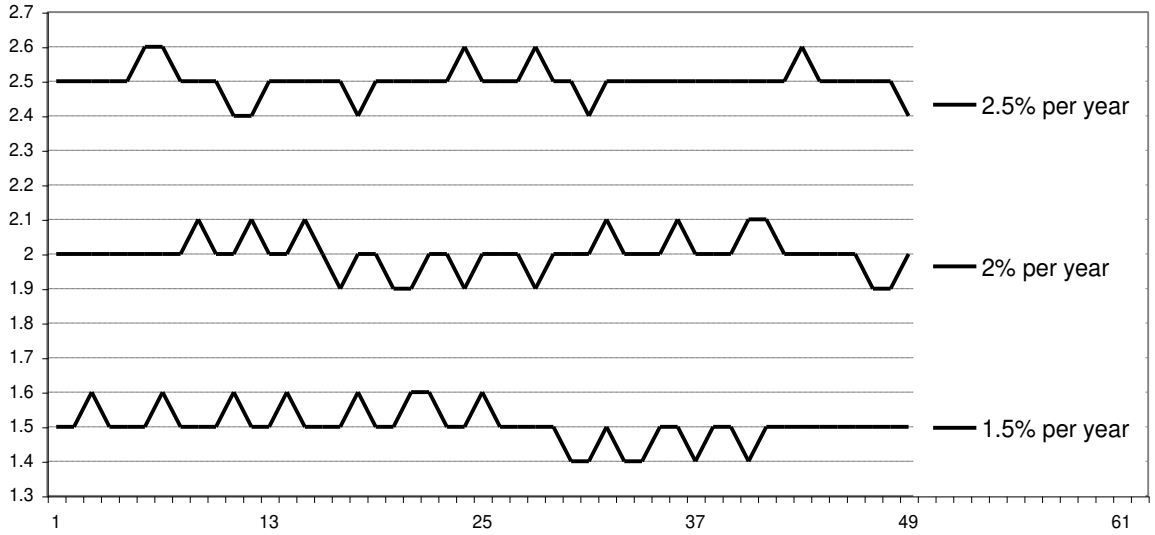

FIGURE 3 – DISTRIBUTION OF SECTORAL 12-MONTH PRICE CHANGES IN THE EURO AREA

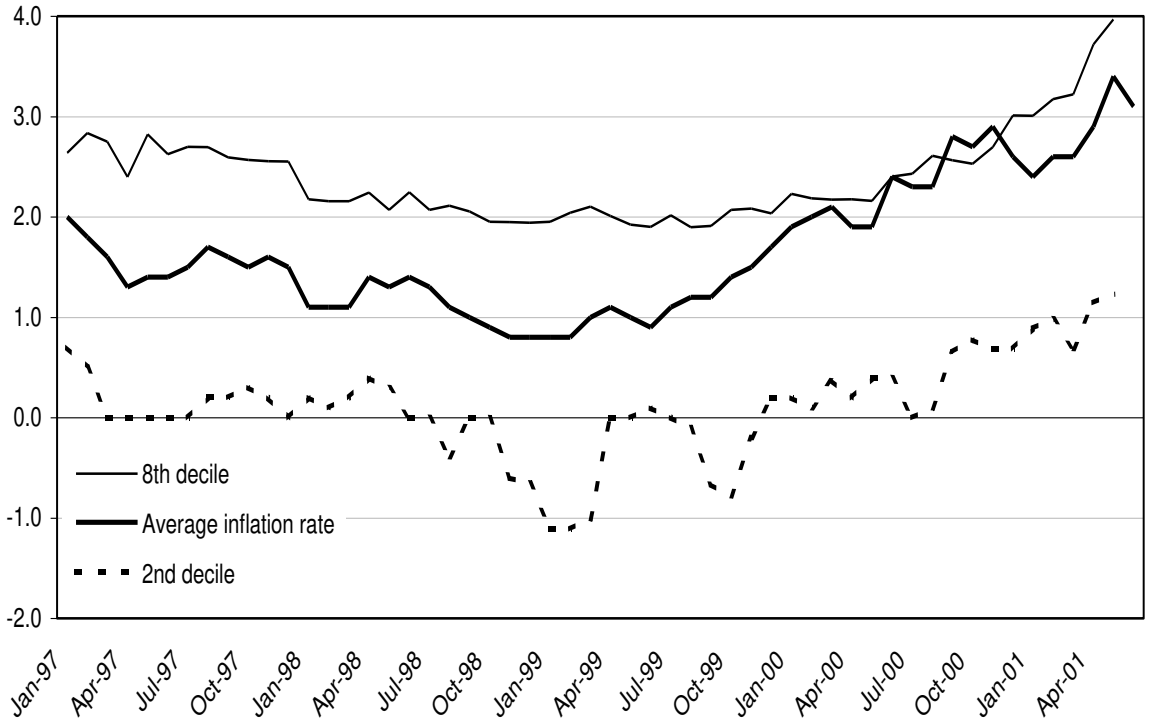

FIGURE 4 – PRICES CONVERGENCE AND PRICE CHANGES

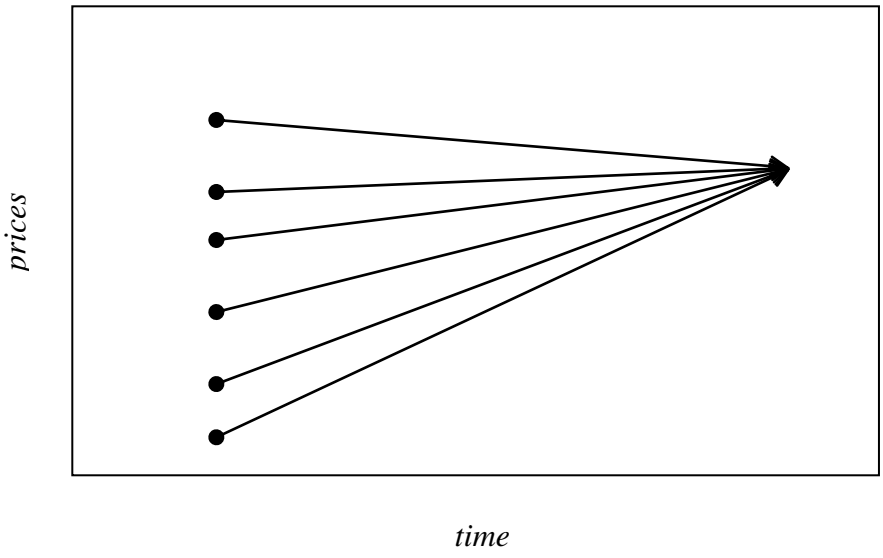

TABLE 1 – RELATIVE LEVEL OF PRICES AND THEIR RATE OF CHANGE

Percentage difference respect to the average price	Difference respect to the average annual rate of inflation
more than 30% lower	+3.94%
from 20% to 30% lower	+2.91%
from 10% to 20% lower	+1.98%
from 0% to 10% lower	+0.92%
from 0% to 10% higher	-1.34%
from 10% to 20% higher	-2.54%
from 20% to 30% higher	-2.68%
more than 30% higher	-2.02%