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Family of Consumer Price Indices for Different Purposes - The CPIs for Sub-groups of Population

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The CPIs for sub-groups of population[1]

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Introduction

The problem of constructing a family of price index numbers – and especially of Consumer Price Indices (CPIs) – has noteworthy theoretical and applied importance. In fact, during the recent debate over the relevance and reliability of CPIs constructed by the National Statistical Institutes (NSIs), the discussions and controversies on the sources of possible bias in a specific CPI originated mostly from the fact that some discussants often sought a specific «true» or «unique» formulation for the index, to be utilised for all kinds of purposes and uses. In order to settle the controversies, many users are asking for different CPIs to be used for different purposes. Moreover, it is widely recognized that differences in the structure of expenditure and in consumers' behavior of sub-groups of population may result in strong differences in the variation of the amount of money requested for the purchase of their specific set of goods and services. Therefore many users are asking especially for a family of indices to measure the variation of consumer prices also for sub-groups of population.

The paper first recalls, in Section 2, the main purposes for constructing consumer price indices and focuses on the need to construct a cost of living index (COLI) - as a measure of change in the cost of living -, and different CPIs, for the other purposes. In Section 3, the need for computation of different CPIs for sub-groups of population, to be used for price inflation adjustments or for assessing the impact of price changes on the disposal incomes of households, is analysed. The problems of the practical construction of these CPIs is then examined, showing that the indices usually compiled to this aim are not very adequate and useful. Finally, in the concluding Section 4, some suggestions are given in order to carry out analyses and pilot surveys to compute more adequate CPIs for sub-groups of population.

I. The main purposes of the consumer price indices and the related family of indices

The different purposes of the consumer price indices: COLI and CPIs

There is a wide variety of purposes for constructing consumer price indices (Turvey, 1989; Hill, 1996; EUROSTAT, 1996 and 2002; Australian Bureau of Statistics, 1997a; Cook and Lewington,1997; Stott, 1998; OECD, 2002 and ILO, 2003), that can be summarised as follows:

- as a measure of change in the cost of living;
- as a measure of inflation (including the analysis of the inflation process);
- as a measure for income adjustment process;

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- for general indexation of public and private sector contracts (in particular for indexation by government, prices, wage and salary adjustment in contracts);

- as a measure for the deflation of consumption aggregates in the national accounts.

There are further different specifications within the five main groups of purposes.

From a practical point of view, we can agree that the so-called Cost of Living Index (**COLI**) is to be used for the first purpose, whereas the so-called **CPIs**, computed with different specifications of Laspeyeres formula, are used for the other purposes.

COLI is used for the first purpose because its objective is to measure the effects of price changes on the cost necessary to maintain the same level of standard of living (i.e.: utility or welfare). As it is well known, a general COLI derived from this approach consists of the ratio between two expenditures or values borne in different situations (of prices) but referred to the same level of utility. Hence, the index is obtained in the following manner:

$$ {}_r\mathbf{P}_t^E = C\,(p_{1t},\ldots, p_{kt},\ldots, p_{nt};\, U)/\, C\,(p_{1r},\ldots, p_{kr},\ldots, p_{nr};\, U) \qquad (1) $$

where $(\ldots p_{kt}\ldots)$, with $t = 1,\ldots,T$, and $(\ldots p_{kr}\ldots)$, with $r = 1,\ldots T$, are two correctly defined and technically comparable price vectors of n goods and services at time t and r, respectively the current and the base period; C is a cost function and U the level of utility. However, the computation of this index is not easy, because COLI cannot be directly calculated. Many approximations have been proposed (Diewert, 2001a), but very few NSIs actually produce this kind of index. The US Bureau of Labor Statistics has been trying to do it, and has recently started to calculate an index on an experimental basis, introducing for this purpose the so-called Chained Consumer Price Index (**C-CPI-U**), that employs a superlative Tornquist formula (Cage et Al., 2003).

Due to ease of computation, timeliness and clear meaning, the most widely used formulae for calculating the CPIs are of the Laspeyres type and have the following structure:

$$ {}_r\mathbf{P}_t = \sum_k {}_r\mathbf{w}_k \; {}_rP_{k,t} \qquad (2) $$

where k denotes, in this case, the generic modality of any classification (for example of goods and services). These indices are then obtained by weighted arithmetical averages of elementary indices (${}_rP_{k,t} = p_{kt}/p_{kr}$) or aggregate indices with weights w_k (usually the expenditure share), such that $\sum_k w_k = 1$. Obviously, this kind of indices have different meanings depending on the choices and decisions made, on a case-by-case basis, with reference to the purpose for which the index is constructed (definition of the concept to be measured, of the reference population, of the goods and services acquired, used or paid for, of outlets and so on) and therefore every formula satisfies particular needs (Turvey,1989; Biggeri, 1996 and 1998a; OECD,2002; ILO, 2003).

The constructions of CPIs: the desired and computed formulae

In general terms, to locate the problem of the construction of an adequate CPI, let us assume that all the necessary information is available, namely the complete matrices of prices and weights at the various time periods in which we are interested.

The index formula coming from an adequate detailed function of expenditure or value that is necessary to acquire, use or pay for a fixed basket of commodities and services could be, for example, specified as follows:

$$ {}_r\mathbf{P}_t = \prod_{j,\,s\,c\,g\,d\,i\,l} {}_r\mathbf{w}_{j,\,s\,c\,g\,d\,i\,l} \; {}_r\mathbf{P}_{j,\,s\,c\,g\,d\,i\,l;\,t} \qquad (3) $$

where we use

s to indicate the s-th ‘specific object’, i.e. a pre-established quality of commodity (s=1,…,S);

c to indicate the c-th commodity or service acquire, used or paid for (c=1,…,C);

g to indicate the g-th group of commodities or services (g=1,…,G);

d to indicate the d-th distribution channel or specific type of outlets (d=1,…,D);

i to indicate the i-th municipalities or lower level (i=1,…,I);

l to indicate the l-th territorial area as province or region (l=1,…,L);

j to indicate the j-th household (j=1,…,J);

and where in (3) the relatives or elementary indices for the household j-th should be computed jointly with reference to specific quality of commodities, commodity groups, distribution channels, municipalities and territorial areas. The choice of the subscripts depends also on the variability of the relatives or elementary indices. Obviously, a different order in the variables could be chosen, but in any case the content of the index formula should be based on the different purposes specifying adequately the contents of the variables and subscripts (in terms of type of expenditure and behaviour of the consumers).

It is clear that sub-indices can be computed for each subscript as well as for various combination of subscripts and obviously there are many ways of obtaining the general index ${}_r\mathbf{P}_t$ through direct calculation from the elementary indices or by means of successive aggregations of sub-indices following different “paths”. The meaning of the ${}_r\mathbf{P}_t$ depends on the choices made on variables and subscripts and the resulting index will be adequate for the specific purpose for which it has been computed (as a measure of inflation or for the indexation).

An important consequence of the consideration outlined above is that when collecting elementary data - which obviously can be based only on samples - and in the procedure for estimating indices, it is necessary to make reference to a kind of *stratified sample*. This sample should be representative with respect to the characteristics chosen (regarding the

goods and services, distribution channels, households, etc.) so as to assure reliable and pertinent estimates of the price changes (Biggeri and Giommi, 1987).

In the practical application of what has been stated above, the main problem to be faced is the lack of adequate and detailed statistical information which prevents the exact computation of the desired index (suggested by the theory).

Often, NSIs carry out separate surveys for prices and for weights both with complex sampling designs and, frequently, with sometimes the so-called 'judgement samples' or partial surveys which provide inaccurate and analytically insufficient information. It is obvious that the lack of adequate data may require the use of 'substitute' indicators (mainly for weights) and may have bearing upon the approach to follow for the aggregation of the indices, with possible bias of the estimates. Moreover, data coming from several sources are combined in rather complex and often diverse ways in the various stages of the process.

In practice, a CPI is constructed in two stages. The first stage is represented by the calculation of the price relatives by 'specific object' (i.e. a pre-established quality of the commodity) and, subsequently, the calculation of elementary indices for each commodity or commodity group (using an adequate arithmetical average, weighted or not, formula or a geometric average formula). The second stage consists of aggregating the relatives and elementary indices into the higher-level indices.

It is obvious that when a computed CPI is different from the desired CPI it is important to disseminate metadata to explain the characteristics and the meaning of the computed index and to carry out analyses to have a guess of the difference between the two indices and of the factors that affect this difference.

II. Family of Consumer Price Indices for sub-groups of population

The construction of CPIs for sub-groups of population

NSIs are continuously faced with requests from different users asking to compute different price indices to measure the inflation process and to use them for wage and salary adjustment, and, especially, for assessing the impact of price changes on the disposal incomes of sub-groups of population (or households).

In Biggeri (1998b), we have already tackled the issues concerning the inflation measures and the need to built up a system of price indices (consumer, producer, export, import, etc. price indices and national accounts implicit price deflators) and satellite or sub-consumer price indices (by groups of goods and services, by geographical areas, etc.), including a measure of “core inflation”. A good analytical framework for price indices can be found in an information paper of the Australian Bureau of Statistics (1997a).

As far as the computation of different *CPIs for sub-groups of population* is concerned there are issues both related to their usefulness and to the difficulties in computing them.

Most NSIs and International Statistical Organisations suggest to clearly state the principal (primary) purpose to compute the CPI and to produce an index strictly devoted to it. This

would make the meaning and the methods of the index construction more understandable and would avoid confusion and lack of confidence from the users (see for example Australian Bureau of Statistics, 1997b; Cook and Lewington,1997; OECD, 2002; ILO, 2003).

In any case, if we would like to compute adequate CPIs for sub-groups of population, we need to start, at least, from the following base formula, coming from (3):

$$ {}_r\mathbf{P}^h_t = \sum_{j,\, s\, c\, g\, d\, i\, l} {}_r\mathbf{w}_{j,\, s\, c\, g\, d\, i\, l} \; {}_rP_{j,\, s\, c\, g\, d\, i\, l;\, t} \qquad (4) $$

where h indicates the h-th type or sub-group of households (h=1, ,H) and the h-th sub-group includes a certain number of households (therefore in (4) the j-th household belongs only to one group of households, that is $j=1,\ldots,J_h$).

Thus, the CPIs for different sub-groups must assure that the system of weights and relatives or elementary indices fulfil the <u>condition of characteristicity</u> (Biggeri and Giommi, 1987); that is to say, they must be as typical or characteristic as possible with reference to all the subscripts for the groups of households the indices refer to (in term of consumers' behaviour as far as quality of commodity, distribution channel, etc.).

The computation of CPIs for sub-groups of population by NSIs

Because of the difficulties and costs in collecting all the requested information (on prices and expenses on quality of commodities purchased and outlets preferred by different sub-groups of population), none of the NSI computes adequate CPIs for sub-group of households or population, using the formula (4).

Few NSIs are computing and publishing specific CPIs for given socio-economic groups, (usually for the sub-group of employees, OECD, 2002), or have conducted experiments to compute CPIs for elderly consumers and for the poor (Amble and Stewart, 1994; Garner and Al., 1996) or for selected types of households (Australian Bureau of Statistics, 2001 and 2004). Also Istat (2003), conducted experiments to assess the impact of price changes on the disposal incomes of different types of households. However all the resulting sub-indices are not adequate to the purpose because they do not satisfy the above-mentioned condition of characteristicity.

Actually, NSIs - or the authors of experiments- because of the difficulties in collecting the necessary data, usually compute indices for the h-th sub-group of households applying the following formula:

$$ {}_r\mathbf{P}^h_t = \sum_{c} {}_r\mathbf{w}^h_{c^h} \; {}_rP_{c,\, t} \qquad (5) $$

where c^h indicates the c-th commodity or group of commodities acquired, used or paid for by a specific sub-group of households ($c=1,\ldots,C_h$) as a whole. In other words, indices for different sub-groups of households are computed by using the same vector of elementary price indices (computed for the general CPI at national level) aggregated through system of weights differentiated for each sub-group of households; that is assuming that the difference between two different indices depends only on the different system of weights, or more

clearly assuming that every sub-group of households faces the same price or the same relative variation of price for each commodity (Australian Bureau of Statistics, 2001, constructed the CPIs for different selected households types using also lower level price data for few elementary price indices).

This is obviously not true, because usually the different sub-groups of households face different prices and different variations of prices when purchasing commodities of different quality, in different kind of outlets or distribution channels, in specific municipalities and territorial areas.

Moreover, frequently, the sub-groups of households considered for the computation of ${}_{r}\mathbf{P}^{h}_{t}$ are predefined by demographic (number of components, occupational status of the head of the household, etc.) or economic (average amount of total expenditure, etc.) characteristics. However, we have to point out that usually the households belonging to those predetermined groups of households are greatly heterogeneous from the point of view of their consumer behaviour. For example the sub-groups of pensioner households or poor households include households with different number of members, with different level of disposal income, etc. that have different structure of the expenditures. This fact produces that the differences between the average system of weights of different sub-groups of households are sometimes not very large. Moreover, if there is high heterogeneity in the consumer behaviour of the households included in a sub-group, the average variation of the referred CPI not necessarily reflects the experience of most households of the sub-group. Obviously, these CPIs are computed to reflect the experiences of population group as a whole, however, when the heterogeneity of the units in the group is higher their utility is lower.

For the mentioned reasons the usually computed CPIs for sub-groups of population are to be considered not adequate.

The divergence between the computed CPIs for different sub-groups of population

Actually, with reference to the previous considerations, it is important to point out that the results obtained in the above mentioned experimental indices showed minimal differences (of decimals) and therefore a very similar dynamics among the different CPIs for the sub-groups of households and among them and the overall CPI as illustrated in the following examples.

a) USA (source of data: Garner and Al., 1996)

The indices computed with the base period 1984=100 provided the following results, in 1990, 1993 and 1994: for All Consumer Units, respectively 125.4, 137.6, 141.1; for Expenditure Poor, respectively 126.2, 137.4, 140.8.

b) Australia (source of data: Australian Bureau of Statistics, 2001 and ABS website, www.abs.gov.au)

The indices computed with the base period 2nd quarter of 1998=100 provided the following results , in 2nd quarter of 2000, 2002, 2003 and 2004: for the All households (CPI), respectively 104.3, 113.7, 116.8, 119.7; for the Employee households, respectively 104.1, 112.4, 115.8, 119.6; for the Age pensioner households, respectively 104.1, 114.0, 117.2, 120.0; for the Other government transfer recipient households, respectively 104.8, 113.5,

116.7, 119.7; and for the Self-funded retiree households, respectively 103.2, 113.0, 116.1, 118.6.

c) Italy (source of data: Istat, 2003 and Istat web site www.istat.it)

The indices computed with the base period average 2001=100, for households grouped by typology and by deciles of equivalent expenditure, provided the following results for the average 2002 with reference to the lowest and highest values: Couples without children with reference person < 35 years hold 102.6; Single ≥ 65 years hold 102.2; Households of 1st decile of equivalent monthly expenditure 102.3; Households of 10th decile of equivalent monthly expenditure 102.6; All households 102.4.

From these results it seems that the different systems of weights have very small effect on the variation of the amount of money requested for the purchase of the specific set of goods and services by the sub-groups of population, while that effect is usually considered very strong. Certainly the differences among the different systems of weights used to compute the mentioned CPIs are small, but it is necessary to deepen the reasons of these results.

In order to understand why the divergence between the different indices for sub-groups of populations, obtained with the same elementary indices and alternative baskets, is small and which are the factors that affect the divergence it is useful to decompose it using the general methods proposed in Biggeri and Giommi,1987 and Biggeri, 1998b (different decomposition of those divergences have been proposed by Schultz, 1997).

Let us consider two different indices ${}_r\mathbf{P}^{h=1}{}_t$ and ${}_r\mathbf{P}^{h=2}{}_t$ referring to the same time interval, when the divergence depends only on the differences in the weighting system referred to the groups of households 1 and 2.

With reference to formula (5), if by $d_c = {}_rw_c^{h=1} - {}_rw_c^{h=2}$ we denote the difference between the standardised weights used to calculate the two indices; by s_p and s_d respectively the standard deviations of elementary (or partial) indices and of differences between weights d_c ; by R_{pd} the linear correlation coefficient between the elementary (or partial) price indices ${}_rP_{c,\,t}$ and the difference in the corresponding weights (that is $R_{pd} = \square_c\ ({}_rP_{c,\,t,} - {}_r\mathbf{P}_t^m)\ (d_c - d^m) / n\ s_p\ s_d$, where n is the number of commodities and services (or commodity groups), ${}_r\mathbf{P}^m{}_t$ and d^m are the arithmetic means of ${}_rP_{c,\,t}$ and d_c), then the difference between the two indices can be decomposed as follows:

$$ {}_r\mathbf{P}^{h=1}{}_t - {}_r\mathbf{P}^{h=2}t = \square_c\ {}_rP_{c,\,t}\, d_c = n\ s_p\ s_d\ R_{pd} \quad . \qquad (6) $$

It is important to emphasise that in practice the difference between the two indices vanishes when there is no relationship between the price variations of commodities and the differences between the weights attributed to them, and when one of the standard deviations of elementary indices or of the differences between weights is equal to zero.

Furthermore, sometimes, the CPIs for sub-groups of population are computed excluding some commodities and/or services included in the overall CPI. In this case it can be useful to know how much the exclusion of the commodities or services affects the results of the computed indices. Actually, if an index ${}_r\mathbf{P}^s{}_t$ has a smaller coverage in term of commodities

and services than a more complete ${}_r\mathbf{P}^n_t$, it is possible to measure the factors that influence the difference between them.

If by ${}_r\mathbf{P}^{n-s}_t$ we denote the index for the commodities excluded from ${}_r\mathbf{P}^s_t$ in comparison with ${}_r\mathbf{P}^n_t$ and by ${}_rw^s_{k,t}$ and ${}_rw^{n-s}_{k,t}$, the normalised weights for the commodity groups of the two indices (or sub-sets of elementary indices), the more complete index will be equal to:

$$
{}_r\mathbf{P}^n_t = {}_rw^s_t\,{}_r\mathbf{P}^s_t + {}_rw^{n-s}_t\,{}_r\mathbf{P}^{n-s}_t = (1-{}_rw^{n-s}_t)\,{}_r\mathbf{P}^s_t + {}_rw^{n-s}_t\,{}_r\mathbf{P}^{n-s}_t =
$$

$$
(1-{}_rw^{n-s}_t)\,[\square_{\square\square 1}{}^{s}\,{}_rw^s_{k,t}\,{}_r\mathbf{P}^s_{k,t}] + {}_rw^{n-s}_t\,[\square_{\square\square s+1}{}^{n}\,{}_rw^{n-s}_{k,t}\,{}_r\mathbf{P}^{n-s}_{k,t}] \qquad (7)
$$

and then

$$
{}_r\mathbf{P}^n_t - {}_r\mathbf{P}^s_t = ({}_r\mathbf{P}^{n-s}_t - {}_r\mathbf{P}^s_t)\,{}_rw^{n-s}_t \qquad (8)
$$

Therefore, the difference will depend on the weights of the excluded commodities and on the difference between the two indices; that is on the different evolution of the set of elementary indices included in the computed index and of the set of elementary indices excluded from the computation. Moreover, taking into account what shown above, (8) it may be decomposed as in (6) thus providing interesting information on its characteristics.

In any case, in conclusion, using the formula (5) to compute the sub-indices, the component s_d, that is the standard deviations of the differences between the weights, is frequently very small for the reasons explained in the sub paragraph 3.1. Sometimes also the mentioned linear coefficient R_{pd} is small and near to zero, and in this case with very frequent changes from positive to negative sign and viceversa. For example, for the mentioned computations made by Istat we have computed the decomposition of the divergence among the indices and found that the s_d are very near to 0 (only the fourth figure after the 0 is different from zero) and the R_{pd} showed a range from 0.02 to 0.11. Therefore, it is obvious that the resulting indices for different population groups are quite similar, with small differences among them as showed from the previous reported results.

Moreover using formula (5) instead of the correct formula (4) to compute the sub-indices, it is clear that, as it is said above, the sub indices do not take into account the actual consumer behaviour of the different groups of households. Meanwhile they purchase commodities of different quality with different level of price, in different kind of outlets or distribution channels, in specific municipalities and territorial areas. And it is known that the variability and the relative variation of prices (of elementary price indices) referred to the quality of commodities, type of outlets and geographical areas is usually rather high (this clearly happen in Italy).

Therefore the divergence between two sub-indices for different groups of households, decomposed by formula (6), is surely underestimated in comparison with the real one. In fact, first the measure of s_p is lower than the real one because not every variability of the elementary price indices is computed. Second, in any case, the divergence does not take into account the different evolution of the different set of elementary (or partial) indices of the two groups of households.

In conclusion, the usually computed indices for sub-groups of households are not so useful because they do not provide an accurate measure of price changes (inflation) as experienced by different population groups.

Concluding remarks: needs for more analyses and pilot surveys

In order to improve the computation, also on an experimental basis, of CPIs for sub-groups of population, it is surely important to carry out more analyses and evaluations and adequate pilot surveys.

First, the NSIs that calculate those CPIs have to conduct the analysis, using the formulae (6) and (7) to get information on the potential magnitude of the components of the differences among different CPIs. Obviously, this kind of study requires more detailed information than that normally used for the computation of the indices for sub-groups of households. Yet, NSIs have the elementary data and moreover they could undoubtedly obtain such information through the new technology used for data capture (for example using scanner data), at least on the occasion of the so called 'benchmark' surveys.

Secondly, to try to compute more adequate CPIs for sub-groups of households using the formula (5), that is using the same vector of elementary price indices and different system of weights, it is important to try to carry out specific researches to verify the real differences in the consumer behaviour of the various sub-groups of households, in terms of purchase of commodities of different quality with different level of price, in different kind of outlets or distribution channels, in specific municipalities and territorial areas. Using the data coming from the Survey on Household Expenditures, it is also necessary to verify if the units included in a sub-group of households are homogenous enough or most heterogeneous. In the latter case, as probably happens for the predetermined sub-groups of households, it could be convenient to try to identify - through the cluster analysis - homogeneous sub-groups of households from the structure of the expenditures point of view and to check if the located sub-groups can also have a clear demographic or economic meaning. If the results of the analyses are satisfactory, the experimental CPIs should be computed for those new sub-groups of households.

Finally, if we want to compute adequate CPIs for sub-groups of households it is necessary to carry out pilot surveys to collect information on outlets or distribution channels used by the different sub-groups of households. This information could be collected during the Survey on Household Expenditures. Other very limited pilot surveys could be carried out to collect the expenses and the prices supported for each commodity and services by the different sub-groups of households. These latter pilot surveys could be useful also to verify the cost of the collection of so detailed data.

As the cost of this kind of surveys is surely too high to be extended to the overall computation of the general CPI and sub-groups of CPIs, the results of the pilot surveys could be used to make adequate assumptions to compute indices that can be good estimates of the desired CPIs, as specified in formula (4).

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