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International Comparison Program

Understanding changes in PPPs over time

A proposal for the Extrapolation of PPPs for Household Consumption using CPI data

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Understanding changes in PPPs over time. A proposal for the Extrapolation of PPPs for Household Consumption using CPI data*

By

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1. Introduction

The difficulties and costs involved in the construction of Purchasing Power Parities (PPPs) for international comparisons impose restrictions on the frequency of their computation and, therefore, they are only constructed in benchmark years: for example the last two International Comparison Program (ICP) data collections took place between 1993 and 1996 and in 2005, and the next will be carried out later this year. Consequently the estimation of PPPs for non-benchmark years is highly demanded by the International Economic Organizations and researchers in various fields.

The PPPs for non benchmark years are usually estimated as simply as possible, by extrapolating the PPPs of the benchmark year using the price deflators of GDP and its components and/or the Consumer Price Indices (CPI) for each country considered if the updating refers to the PPP for household consumption.

However, when the extrapolated PPPs from a benchmark are compared with those based on the last benchmark round, there are great differences between them and therefore a great deal of debate over the consistency between the two sets of results arises.

Moreover, although the PPPs from two subsequent benchmarks are not completely comparable due to the various changes in data collection procedures and methodology used for their computation, the large differences in the results that usually emerge also in this case cast doubt on the comparability of the resulting PPPs over time and these differences need to be interpreted both from a statistical and an economic point of view.

Much research has been focused both on the methods for extrapolating the PPPs and on the interpretation of the above-mentioned differences. Some of these studies are not only aimed at explaining the consistency and the differences between the results of the PPP benchmark rounds, but also present ideas and tools for improving the methods for the extrapolation of the PPPs over time.

The aim of this paper is twofold. Firstly, to discuss the methods used and proposed for the temporal extrapolation of the PPPs. Secondly, to propose an adequate procedure and a more suitable method for extrapolating the PPPs over time in a more coherent way, at least in the case for household consumption. To this aim it is essential to analyse the differences between the formulae used for constructing the PPPs over time.

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The rest of this paper is organised as follows.

Section 2 reviews the methods used and proposed for the temporal extrapolation of the PPPs and for analysing coherence between computed PPPs in two different benchmark years and between the extrapolated PPPs and those based on the last benchmark round. The objective is to summarize the characteristics of an adequate method for extrapolating the PPPs.

Section 3 presents the proposed procedure and the various criteria and steps to be followed for implementing it. In order to carry out this procedure it is essential to define suitable extrapolation factors that must be estimated by using detailed data.

Section 4 presents a method for explaining, both statistically and economically, the divergences of the PPPs over time (without considering the differences imputed to the definition and methods of collection of data). This method decomposes the formulae into components which refer to the prices and to the system of weights respectively. The two components can be interpreted economically and their computation is also useful for extrapolating the PPPs.

In Section 5 we discuss the issues arising from the extrapolation of the PPPs for household consumption, using the data collected for the computation of the Consumer Price Indices (CPIs), and present some suggestions to solve them Finally, in section 6 some concluding remarks are drawn.

2. Methods for extrapolating PPPs over time and for analyzing the coherence between computed and/or extrapolated data

The need for annual estimates of PPPs for international comparisons has been evident since the beginning of their construction. In 1984, Krijnse-Locker and Faerberg published an important paper concerning space and time comparisons of PPPs where the theoretical problems of consistency between the spatial results and temporal indices were discussed[1] and methods for extrapolating PPPs and interpolating them between two benchmark years were presented. Although initially no attention was paid to this topic, in recent years there has been a growing interest in this issue and several papers have been published, especially concerning the coherence between PPPs and SNA based estimates of GDP.

[1] More recently, Robert Hill published (Hill, 2004) a very interesting paper on the construction of prices indexes across space and time. The author proposes methods to construct panel of price indexes combining temporal and spatial comparisons, with application and analysis to a constructed EU panel data set covering the period 1995-2000. The paper covers the problem of reconciling temporal and spatial indices, but does not consider the issue of extrapolating PPPs.

Considering the problem concerning the extrapolation of PPPs, generally speaking, we can group the methods and analyses in the following way:

i. Methods generally used for extrapolating PPPs: the inconsistencies of the extrapolated and computed PPPs and PPP based National Accounts;

ii. Methods for improving the interpolation or extrapolation of PPPs or PPP-based GDP in order to achieve consistency;

iii. Methods for analysing the coherence between the spatial and temporal measures of price changes in order to estimate the factors influencing the differences;

iv. Methods for the annual updating of PPPs using direct newly-collected data.

Below a summary of the characteristics of these methods is presented.

i. Methods generally used for extrapolating PPPs: the inconsistencies of the extrapolated and computed PPPs and PPP–based National Accounts

It is common practice (World Bank, 2008b and OECD-Eurostat, 2006) to extrapolate PPPs or PPP-based GDP and its components for a non benchmark year by using the price deflators of GDP and its components and/or the Consumer Price Index (CPI) for each country considered whenever the updating refers to the PPP for household consumption.

The formula for extrapolating PPPs at macro level from time t-1 to time t can be written as follows:

$$^{E}PPP_{t}^{lj} = PPP_{t-1}^{lj} \cdot \left(I_{t-1,t}^{j} / I_{t-1,t}^{l} \right)$$

where $^{E}PPP_{t}^{lj}$ denotes the extrapolated PPP at time t and $I_{t-1,t}^{j}$ and $I_{t-1,t}^{l}$ are the price deflators of the two countries l and j for which the parities were computed at time t-1. In order to obtain parities which refer to a numeraire country it is necessary to divide the values of each country by the data of the numeraire country.

The $I_{t-1,t}^{j}$ and $I_{t-1,t}^{l}$ used to compute the PPPs for GDP are the price deflators of national GDP, and since they are a ratio between GDP at current prices and at constant prices they are actually implicit price indices of the Paasche type.

The $I_{t-1,t}^{j}$ and $I_{t-1,t}^{l}$ used for computing the PPPs for household consumption are the national CPIs, which are usually price indices of the Laspeyres type.

Comparisons of the extrapolated PPPs with computed PPPs in the subsequent benchmark year usually differ greatly and large discrepancies are found between PPPs and PPP-based National Accounts. Therefore there has been a great deal of debate concerning the consistency of the different estimates carried out by various researchers (Krijnse-Locker and Faerber, 1984; Nuxol, 1994; Dalgaard and Sorensen, 2002; Deaton and Heston, 2010, and papers they quoted[2]).

[2] Most of the debate was carried out during the discussions concerning the correct estimates of the real growth

The researchers have underlined several inconsistencies between the different estimates that can be grouped as follows (the most important of them are also presented in the ICP and OECD Handbooks on PPPs):

- inconsistencies due to the changes in data collection procedures and methodology, in different definitions of products and baskets of goods, etc.. Moreover it is important to note that the national GDP deflators' expenditure structure does not reflect comparable baskets of goods and services among countries;

- inconsistencies due to the price index numbers used for the extrapolation (inflator/deflator): the common practice, as already mentioned, is to use implicit index from GDP deflator (Paasche type) or explicit CPIs (usually Laspeyres type), while the PPPs are based on Jevons type indices and on Fisher type index and by construction they reflect the current prices and expenditures of the benchmark years. On the other hand, temporal price indices and parities do not share the same purpose; in fact, as Krijnse-Locker and Faerber (1984, pag. 63) pointed out, different extrapolation factors should be applied when different formulas are used for the calculation of PPPs.

- inconsistency due to the fact that the extrapolation over time of the PPPs is carried out at macro or GDP level: this procedure does not allow for the structural changes in the relative prices and in the expenditures of the various countries compared[3]; in order to take into account the changes in structures of relative prices and expenditures it is necessary to compute the extrapolation starting from a detailed level, as the individual product or the Basic Headings (BH) at least[4].

ii. Methods for improving the interpolation or extrapolation of PPPs or PPP-based GDP in order to achieve consistency

Much research has been carried out with the aim of improving the extrapolation or interpolation of PPPs or PPP-based GDP by using different tools and methods than the simple price indices (see for example: Johnson et al, 2009; Feenstra et al., 2009; Ravaillon, 2010; Rao et al., 2010).

Johnson et al., 2009, presented an evaluation of the Penn World Tables and of their methodology for estimating growth rates of GDP for non-benchmark years, examining specifically the problem of data revisions across time. The paper proposed also the construction of a new chained series, with all data valued at common international prices, and based on a greater use of the disaggregated data collected for the different benchmark years.

[3] The differences in the comparisons over space are more important than time comparisons because the patterns of relative prices and of expenditure differ greatly among the contries in question.

[4] OECD-Eurostat compute the PPPs every three years using a kind of rolling benchmark approach which is a combination of "fresh" price data for the reference year with the extrapolation of the PPPs for those Basic headings for which PPPs cannot be calculated (OECD-Eurostat,2006, pag. 122). This approach does not guarantee the absolute consistency of the computed and extrapolated PPPs, but "softens" the problems.

Feenstra et al., 2009, provided a framework for making real income comparisons across countries and over time that satisfy transitivity in the field of consumption, by means of an empirical experiment using data from the 1980 and 1996 ICP.

Rao et al., 2010, presented an econometric framework for the construction of a consistent panel of PPPs which enable us to combine all the PPP benchmark data from various rounds. A regression model along with data on country specific price movements are combined using state-space formulation and optimum predictions of PPPs were used. The procedure was applied for deriving inter-temporal estimates for the PPPs and GDP, for the period from 1970 to 2005. The method allows for a coherent projection based on all the data from all the benchmarks.

Ravaillon, 2010, focused on the changes observed in PPPs between ICP rounds, analysing the reasons for these changes and found that they "made sense". The paper presents a model for the changes in PPPs (actually for the Price Level Index derived from them) and taking into account the results of the empirical analysis, proposes the inclusion of the dynamic Penn effect explicitly into the extrapolation of PPPs for non-benchmark years.

iii. Methods for analysing the coherence between spatial and temporal measures of price changes in order to estimate the factors influencing the differences

Following the analysis of Dalgaard and Sorensen (2002), Rhoades (2003) proposed a method for checking the coherence of the changes in PPPs over a period of time and the changes in the implicit deflators of GDP over the same period. This method was also evaluated and applied by researchers of the Australian Bureau of Statistics (Tessema and Rossiter, 2009). Rhoades proposed a framework for making a comprehensive and exact reconciliation between SNA-based real growth and PPP-implied real growth by analyzing the differences in the respective formulae employed, in order to identify the sources of inconsistencies. The differences between the ratio of implicit deflators and the ratio of PPPs have been explained in terms of various factors and particularly in terms of differences in weights, relative prices and index formula substitution effects. By using the framework suggested it is possible to compute the impact of the variations of basic input data and of the different treatment and revisions of weights. An empirical application of the method using the European Comparison Program (ECP)[5] data from 1996 to 2000 is presented.

The ABS study discusses the method proposed by Rhoades (2003) and presents an empirical analysis to data extracted from the 1999 and 2002 aggregate databases of the ECP. The study pointed out that the relative contributions of prices remained as a dominant factor and that the results of the analysis and the estimation of the different effects appear to have good practical implication for post hoc analysis to improve the calculation of future PPP projections.

[5] That is the ICP for the OECD region.

iv. Methods for the annual updating of PPPs using direct newly-collected data .

Recently, Dikhanov et al (2011) proposed a method for estimating PPPs for non-benchmark years that is an extension of the last calculated PPP benchmark using additional data collected for "core products" in the next year of prediction and some inter-product and intra-country price correlations made against the benchmark year exercise. The method, which is substantially of the "inferential" type, uses a limited number of core products for which the necessary data are collected mainly in the capital cities. In this way it is impossible to compute all the requested PPPs and therefore the estimation of the "missing" PPPs and the computation of the PPPs for the full list of products are carried out by means of adjustment procedures. The method has been applied in the Asia and Pacific Regions on an experimental basis.

At the end of this presentation of the research concerning PPP extrapolation it is clear that the reasons of the inconsistencies between the extrapolated and computed PPPs and PPP–based National Accounts have been very carefully examined. Some studies showed that is important to measure the factors that affect the inconsistencies, but these measures have never been used for the extrapolation of PPPs and in most cases the analyses have only been carried out at macro level and for some of GDP components.

The proposal made by Dikhanov et al. (2011) is the only direct updating of PPPs with a clear meaning and in which the coherence between the PPPs in benchmark and non benchmark years is obtained by construction. However, it is necessary to collect price data in the year of prediction for the core items at least but it is difficult to estimate the reliability of an extrapolation of this type. Besides it may not be possible to carry out the exercise for all the countries involved in the ICP.

The methods presented should undergo further investigation, but in our opinion it is not only necessary to study the way to give the two benchmarks of PPP consistency y means of price index numbers, but also to carry out the extrapolation procedure avoiding the inconsistencies mentioned above and to find a new methodological tool for the extrapolation using consistent "extrapolation factors" which should be applied when different formulas are used for the calculation of PPPs.

3. A procedure for extrapolating the PPPs in a more coherent way

According to the above illustrated analyses, in order to avoid or reduce the inconsistencies between the computed PPP_t and the extrapolated ${}^{E}PPP_t$ that are not caused by definition problems and collection of data (that must be considered separately), it is necessary to: i) carry out the extrapolation of PPPs at a very disaggregated level; ii) use adequate price index formula to obtain coherent extrapolation; iii) define and estimate the factors that may affect the differences of PPP formulae in two different years (t-1 and t) to get more precise extrapolations; iv) find already existent data or collect new data to implement the estimations.

The procedure we suggest in this paper is aimed at obtaining a precise extrapolation of the benchmark PPP_t. The most important aspect in this process is to carry out the extrapolations starting from the

Basic Heading (BH) level to avoid bias due to the structural changes in the relative prices and in the share of expenditures of the various countries compared.

Below is a summary of the procedure to be followed.

1 – Carry out the extrapolations for each of the two binary PPPs at BH level, which are usually calculated with Jevons indexes (Laspeyres and Paasche types).

In this way it is possible to avoid extrapolating the "effect" of the adjustments introduced in the computed PPPs for obtaining transitive bilateral and multilateral PPPs. In fact the value of those adjustments depends on the data used for the computation of PPPs in the different years for the various countries involved. The extrapolation must be carried out for each element of the two matrices of the Laspeyres and Paasche type indexes of the countries involved in the comparisons.

2 – Find and estimate adequate "extrapolation factors" to be used for obtaining a coherent extrapolation of the two binary Jevons indexes from time t-1 to time t.

The extrapolation factors must be defined considering the differences concerning the formulae used for binary comparisons between countries in two different years t-1 and t. Then, the necessary data must be obtained to estimate the identified extrapolation factors

3 – Compute the extrapolation of each element of the matrices of the two binary Jevons indices by using the estimated extrapolation factors.

4 -.Compute the matrix of Fisher type indexes and than the matrix of multilateral PPPs, using the EKS adjustment method or other methods.

5 - Compute the aggregated PPPs, using the chosen system of weights.

The last two steps are usually followed in the ICP benchmark rounds as well.

It is worth noting that the most important issues that can arise from the proposed procedure concern mainly the point 3.

First of all, it is essential to decompose the differences in order to find components that: 1) should satisfy the consistency of the extrapolation exercise, which would not otherwise be possible using CPIs or the implicit deflator (Paasche index) and 2) can be more easily estimated with the data collected for the computation of the CPIs.

For this reason, the analyses described in the following sections have a general value even if they should refer to the PPPs computed for household consumption.

4. A methodological approach for explaining the divergences of the PPPs over time

With the aim of identifying factors to be used for extrapolating PPPs for non benchmark years, we analyse the relationship between the formulae used for calculating two PPPs, referring to years t-1 and t. As already mentioned above, we only consider the binary PPPs at the basic heading level.

In order to illustrate our analyses we refer to the method currently used in the Eurostat-OECD comparison for calculating and aggregating PPPs known as the asterisk method[6] or EKS* (Éltetö-Köves-Szulc). At the basic heading level the method proceeds by calculating two separate Jevons indices for each pair of countries. One Jevons index (called the Laspeyres type PPP) covers products that are representative in the first country, considered as the base country. The other (called the Paasche type PPP) covers products that are representative in the second country. Naturally, some products may be representative in both countries and therefore are included in both indices. The geometric mean of these two PPPs is then taken to derive a single binary PPP between the two countries (called the Fisher type PPP). Once all of these bilateral parities have been constructed for each pair of countries in the region, the EKS formula is used to make them transitive. The EKS adjustment is not of interest at this stage of extrapolation but will be considered later[7].

Taking two countries j and l and considering country l as the base country, the first Jevons index, PPP_L^{lj} is expressed by:

$$PPP_L^{l,j} = \prod_{k=1}^{{}^R n_l} \left(\frac{p_k^j}{p_k^l} \right)^{w_k^l} = \frac{\prod_{k=1}^{{}^R n_l} \left(p_k^j \right)^{w_k^l}}{\prod_{k=1}^{{}^R n_l} \left(p_k^l \right)^{w_k^l}} \qquad [1]$$

Where ${}^R n_l$ is the number of products that are representative in country l (or representative in both countries) and priced in both l and j; the weights are defined as $w_k^l = 1/{}^R n_l$ if product k is representative in country l and $w_k^l = 0$ if product k is not representative in country l; p_k^j is the price of item specification k in country j and p_k^l the price of the same specification in country l.

[6] The EKS* method is so called because it makes use of the distinction between representative and unrepresentative products, the representative products being identified in the product lists by an asterisk *

[7] Three observations are important for our aims. First, the EKS method is applied with the constraint that the results obtained must differ as little as possible from the original binary Fisher type PPPs. Second, the EKS adjustment could be considered an additive element in the decomposition of formula (Cfr. Roades, 2003, pag. 3). Third, in our proposal for the extrapolation of PPPs, the EKS method – or other methods for obtaining consistent multilateral PPPs can be applied subsequently.

In the most common situation, where the number and type of representative products in the base country l change throughout the time period considered, the temporal variation from time t-1 to time t of the binary PPP referring to countries j and l is expressed by:

$$\frac{PPP_{L,t}^{lj}}{PPP_{L,t-1}^{lj}} = \frac{\prod_{k=1}^{R_{n_l}} \left(p_{k,t}^{j} \right)^{w_{k,t}^{l}} \Big/ \prod_{k=1}^{R_{n_l}} \left(p_{k,t}^{l} \right)^{w_{k,t}^{l}}}{\prod_{k=1}^{R_{n_l}} \left(p_{k,t-1}^{j} \right)^{w_{k,t-1}^{l}} \Big/ \prod_{k=1}^{R_{n_l}} \left(p_{k,t-1}^{l} \right)^{w_{k,t-1}^{l}}} \qquad [2]$$

Following the idea developed in the paper by Biggeri and Laureti (2009) by taking the natural logarithms and by adding and subtracting the ratio between the hybrid index (for countries j and l) obtained by using the weights of the base period t-1 and the price of the each country at time t, after simple algebra, we can state that:

$$\frac{PPP_{L,t}^{lj}}{PPP_{L,t-1}^{lj}} = \frac{\prod_{k=1}^{R_{n_l}} \left(p_{k,t}^{j} / p_{k,t-1}^{j} \right)^{w_{k,t-1}^{l}}}{\prod_{k=1}^{R_{n_l}} \left(p_{k,t}^{l} / p_{k,t-1}^{l} \right)^{w_{k,t-1}^{l}}} \cdot \prod_{k=1}^{R_{n_l}} \left(\frac{p_{k,t}^{j}}{p_{k,t}^{l}} \right)^{w_{k,t}^{l} - w_{k,t-1}^{l}} \qquad [3]$$

The first product on the right hand side of [3] represents the divergence between the movement in price changes from time t-1 to time t in the two countries compared ("price effect"). In fact, this factor is the ratio between two consumer price indices in the two countries j and l, calculated according to the weighted Jevons index using the weights of country l at time t-1.

The second product, which refers to the "weight effect", is related to the impact of the difference in the consumption structures of the two countries.

These decompositions give us a better understanding of the temporal variation of the formulae used for constructing PPPs from an economic point of view based on the distributions of price changes and the consumption expenditure shares in the two countries[8]. (Biggeri and Laureti, 2009)

Moreover, it is clear that $PPP_{L,t-1}^{lj}$ can be extrapolated at time t by multiplying it by the two factors on the right hand side of the formula [3] thus obtaining:

$${}^{E}PPP_{L,t}^{lj} = PPP_{L,t-1}^{lj} \cdot \frac{\prod_{k=1}^{R_{n_l}} \left(p_{k,t}^{j} / p_{k}^{j,T-1} \right)^{w_{k,t-1}^{l}}}{\prod_{k=1}^{R_{n_l}} \left(p_{k,t}^{l} / p_{k}^{l,T-1} \right)^{w_{k,t-1}^{l}}} \cdot \prod_{k=1}^{R_{n_l}} \left(\frac{p_{k,t}^{j}}{p_{k,t}^{l}} \right)^{w_{k,t}^{l} - w_{k,t-1}^{l}}$$

[8] Appendix 1 contains methodological details on a further decomposition of the "price" and "weight" components which can give interesting economic interpretation.

It is worth noting that in the unlikely event that the product basket in country l does not change from time t-1 to time t the PPP time variation can be expressed by[9]:

$$\frac{PPP_{L,t}^{lj}}{PPP_{L,t-1}^{lj}} = \frac{\prod_{k=1}^{{}^{R}n_l}\left(p_{k,t}^{j}/p_{k,t-1}^{j}\right)^{w_{k,t-1}^{l}}}{\prod_{k=1}^{{}^{R}n_l}\left(p_{k,t}^{l}/p_{k,t-1}^{l}\right)^{w_{k,t-1}^{l}}} \qquad [3bis]$$

Therefore, in this case the variation of the binary PPP formulae is only explained by the price effect since the weight effect is equal to one due to the fact that there is no variation in the weights.

A similar decomposition can be obtained for the difference between basic heading PPPs, at time t-1 and t by using the second Jevons index (the Paasche type PPP) for countries j and l. Let ${}^{R}n_j$ be the number of products that are representative in country j (or representative in both countries) and priced in both l and j. Therefore the weights are defined as $w_k^l = 1/{}^{R}n_j$ if product k is representative in country l. We can state that:

$$PPP_P^{lj} = \prod_{k=1}^{{}^{R}n_j}\left(\frac{p_k^j}{p_k^l}\right)^{w_k^j} = \frac{\prod_{k=1}^{{}^{R}n_j}\left(p_k^j\right)^{w_k^j}}{\prod_{k=1}^{{}^{R}n_j}\left(p_k^l\right)^{w_k^j}} \qquad [4]$$

$$\frac{PPP_{P,t}^{lj}}{PPP_{P,t-1}^{lj}} = \frac{\prod_{k=1}^{{}^{R}n_j}\left(p_{k,t}^{j}/p_{k,t-1}^{j}\right)^{w_{k,t}^{j}}}{\prod_{k=1}^{{}^{R}n_j}\left(p_{k,t}^{l}/p_{k,t-1}^{l}\right)^{w_{k,t}^{j}}} \cdot \prod_{k=1}^{{}^{R}n_j}\left(\frac{p_{k,t}^{j}}{p_{k,t}^{l}}\right)^{w_{k,t}^{j}-w_{k,t-1}^{j}} \qquad [5]$$

$$\frac{PPP_{P,t}^{lj}}{PPP_{P,t-1}^{lj}} = \frac{\prod_{k=1}^{{}^{R}n_j}\left(p_{k,t}^{j}/p_{k\,t,-}^{j}\right)^{w_{k,t}^{j}}}{\prod_{k=1}^{{}^{R}n_j}\left(p_{k,t}^{l}/p_{k,t-1}^{l}\right)^{w_{k,t}^{j}}} \qquad [5bis]$$

where the factors “weight effect” and “ price effect” in [5] and [5bis] are equivalent to those identified in [3] when the number and type of representative products in country j change during the time period considered and [3bis] when the product basket of country j remains unchanged.

[9] Although at present the BHs are the lowest level aggregates for which expenditure data are available, it is worth noting that the importance attached to the different items in terms of consumer expenditure may change from time t-1 to time t. Therefore, in order to precisely estimate the different factors in [3]-[3bis] and [5]-[5bis] it is necessary to collect data on expenditure weights for the products and services belonging to each BH.

Although we do not focus on the extrapolation issue of PPPs above the basic heading level, where expenditure weights are available, it is worth noting that it may be advisable to use the Tornquist index instead of the Laspeyres index for aggregating BHs. Indeed by using the Tornqvist index a similar decomposition to [3]-[3bis] and [5]-[5bis] may be obtained. The two factors expressing the "price effect" and the "weight effect" could be used to extrapolate PPPs for household consumption or other GDP aggregates. We must underline that for computing consistent (or unbiased) PPPs at macro or GDP level it is essential to calculate the extrapolation of country parities starting from the BH level.

5. Discussion of the issues arising in the extrapolation of PPPs for Household Consumption over time based on CPI data

In this section we briefly examine the data required for implementing the various phases of the extrapolation procedure and the issues that can arise, using CPI data.

The starting point of the extrapolation procedure is the matrix of the binary PPPs at BH level in the benchmark year t-1. In order to obtain the extrapolated PPPs at time t, ${}^{E}PPP_t^{lj}$, it is necessary to gather appropriate data regarding prices and weights at product level for estimating the extrapolation factors, derived from formula [3]-[3bis] and [5]-[5bis], and then get a suitable system of weights for aggregating the extrapolated PPPs above the BH level.

Regarding the estimation of the extrapolation factors, from the above formulae, it is clear that the price indices to be used must be of the Jevons type. The CPIs usually computed by the National Statistical Institutes (NSIs) cannot be used directly because they cannot provide an exact extrapolation of the binary BH PPPs, and their use always cause bias, even if in same cases this bias could be marginal. On the other hand it could be possible to use the detailed price data collected for computing the CPIs in l and j countries (and in all countries involved in the computation of the PPP program) at time t-1 and t in order to calculate the "price" and "weight" factors.

Nevertheless, we have to deal with some operational issues.

The main problem is related to the differences between PPP and CPI definition of baskets of products and the collection of data, even if we were in an optimal situation in which the countries involved in the PPP computation have a similar economic structure (from an expenditure point of view) and have sufficiently detailed and codified data in their CPI data set.

Therefore a complicated analysis of CPI data must be carried out with the aim of checking the possibility of using them for the estimation of the extrapolation factors[10].

[10] A work of reconciliation between the PPP and CPI definition of baskets of products is already partially carried out by Eurostat. In fact, for consumer products that are priced every three years, Eurostat extrapolate the BH PPPs using corresponding sub-indices from

However, not all PPPs could be extrapolated using CPI data because a part of the necessary prices required for updating the PPPs may not be included in the CPI surveys. In this case "missing" PPPs could be obtained using the methods suggested in ICP and ECP exercises for solving the problem of the missing PPPs and the reference PPPs could be used. Many useful suggestions for this aim can also be found in the paper by Dikhanov et al. (2011).

This fact confirms once again that we cannot postpone the development of a complete integration of the PPP activity with the CPI compilation in order to achieve an increased coherence between the results of the PPP and CPI calculations. The integration would also enable us to compute the PPPs at reduced intervals of time (for example each year), taking into account the high frequency of collection of data for CPI purposes, thus overcoming the difficulties linked to the use of CPIs for the temporal updating of the PPPs (Rao, 2001; Biggeri and Laureti, 2009; Ward et al., 2008).

Another major issue is the lack of adequate information on weights below the BH level. The estimation of the extrapolating factors in formulae [3] and [5], when the representative products in country l and j change over time, or in formulae [3bis] and [5bis], when the number and type of representative products remain the same in the period in question, requires information on weights associated with the various product categories reflecting the importance attached to different items in the two countries in the years t-1 and t.

In this context the suggestions of some authors for introducing "indicators" of expenditure weights for the products considered into parity estimation at BH level could be useful even if these weights are based on qualitative information for each item.

Let us assume that it is possible to obtain a quite reliable estimation of the factors reported in formula [3]-[3bis] and [5]-[5bis] and carry out the extrapolation from time t-1 to time t of all binary BH PPPs of the Laspeyeres and Paasche types for the countries involved in the Comparison Programme. As already mentioned in section 3, the geometric mean of these two PPPs for each pair of countries can then be used for obtaining a single binary PPP between each pair of countries – that is the Fisher type PPP. Moreover as the Fisher type PPPs are intransitive, an adjustment to achieve transitivity will be easily carried out using the EKS method thus obtaining transitive multilateral PPPs.

Subsequently the aggregation of PPPs above the level of BHs up to the level of household consumption can be carried out using the methods suggested by ECP, which requires the computation of a weighted average using the expenditure on the BHs of each pair of countries as weights at time t. In this case, the data available, used as system of weights for the computation of CPIs, should be rearranged to be employed for the aggregation of the PPPs above the BHs. However, since the CPIs are usually of the "chained" Laspeyres type, the system of weights may refer to the base period of one or more years before. In this case it may be necessary to wait a few years in order to obtain the data for period t.

CPI.

On the other hand, for economies which have sufficiently detailed and codified data in their CPI data set – like the European countries where the CPIs are of the yearly chained Laspeyres type, with the base period and system of weights renewed every year - it might be possible to acquire the expenditure system of weights for computing the aggregation of PPPs above the BHs and obtain the extrapolated PPPs for household consumption in a yearly consistent series, that will certainly improve their estimation and also assess their effectiveness for measuring and comparing the "real" household consumptions in different countries .

6. Concluding remarks

The main findings of our study can be summarized as follows.

Firstly, in our opinion to correctly extrapolate PPPs for GDP and/or household consumption it is necessary to start from the extrapolation of the matrix of binary PPPs of the Laspeyeres and Paasche types at the level of basic heading. In fact, the subsequent phases can be easily computed by using the estimated matrices. To this aim, we propose a procedure for extrapolating the PPPs in a more coherent way.

Secondly in order to obtain consistent extrapolation of PPPs at BH level for household consumption it is essential to estimate the factors that influence the time variation of PPPs according to the formula used, which are called "extrapolation factors". These factors can be estimated by referring to the formulae [3]-[3bis] and [5]-[5bis] and using the data collected in the CPI survey by rearranging them.

Finally, the proposed procedure for extrapolating PPPs for household consumption is time-consuming and costly, but it is applicable to the EU countries as well as many other countries by integrating it with the procedure proposed by Dikhanov et al. (2011) if necessary.

In order to check the practical problems and difficulties for the implementation of the proposed procedure for the yearly extrapolation of PPPs, some empirical small-scale exercises must be carried out.

Appendix 1

In order to improve our interpretation of the factors that influence the temporal variation of the formula used for constructing PPPs, we suggest a further decomposition of the price and weight effect in formula [3], which highlights various statistical measures concerning the characteristics of price and weight distributions in the two countries in question.

Let's consider the decomposition in formula [3]

$$\frac{PPP_{L,t}^{lj}}{PPP_{L,t-1}^{lj}} = \frac{\prod_{k=1}^{{}^{R}n_l}\left(p_{k,t}^{j}/p_{k,t-1}^{j}\right)^{w_{k,t-1}^{l}}}{\prod_{k=1}^{{}^{R}n_l}\left(p_{k,t}^{l}/p_{k,t-1}^{l}\right)^{w_{k,t-1}^{l}}} \cdot \prod_{k=1}^{{}^{R}n_l}\left(\frac{p_{k,t}^{j}}{p_{k,t}^{l}}\right)^{w_{k,t}^{l}-w_{k,t-1}^{l}}$$

By introducing the variables $\eta_k = \left[\ln\left(\frac{p_{k,t}^{j}}{p_{k,t-1}^{j}}\right) - \ln\left(\frac{p_{k,t}^{l}}{p_{k,t-1}^{l}}\right)\right]$ and $g_k = \left(w_{k,t}^{l} - w_{k,t-1}^{l}\right)$ which express the differences between the set of logarithms of elementary price indices in countries *j* and *l* and the difference between expenditure weights of country *l* in the two years *t* and *t*-1, respectively, after simple algebra, decomposition [3] can be equivalently expressed as:

$$\frac{PPP_{L,t}^{lj}}{PPP_{L,t-1}^{lj}} = \exp\left(\bar{\eta}\right)\exp\left({}^{R}n_l \cdot s_{w_{k,t-1}^{l}} \cdot s_{\eta} \cdot R_{w_{k,t-1}^{l},\eta}\right) \cdot \exp\left({}^{R}n_l \cdot s_{\ln\frac{p_{k,t}^{j}}{p_{k,t}^{l}}} \cdot s_{g_k} \cdot R_{\ln\frac{p_{k,t}^{j}}{p_{k,t}^{l}},g}\right)$$

Therefore it is possible to identify the factors that influence the price effect, that is $s_{w_{k,t-1}^{l}}$ the standard deviation of the weighing system of the base country *l* in the base year, s_{η}, the standard deviation of the differences of elementary price indices in countries *j* and *l*, $R_{w_{k,t-1}^{l},\eta}$ the linear correlation coefficient between the differences of log price ratios of countries *j* and *l* and the weights of country *l* at time *t-1* .

Similarly, the weight effect is influenced by $s_{\ln\frac{p_{k,t}^{j}}{p_{k,t}^{l}}}$, the standard deviation of the logarithms of price ratio concerning item *k* in country *j* and *l* at time *t*, s_{g_k}, the standard deviation of the differences between the weighting system of country *l* in the two years *t-1* and *t* and $R_{\ln\frac{p_{k,t}^{j}}{p_{k,t}^{l}},g}$, the linear correlation coefficient between these two distributions.

Obviously, it is possible to obtain a similar decomposition form considering formula [5].

The most important aspect is that we obtain statistical measures (standard deviation, central tendency and correlation coefficient) concerning the variability of price changes and the consumers' behaviour in the two countries over the period in question which can be interpretable from a statistical and economic point of view.

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