ICP PPP Time Series Implementation

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This note is a companion piece to the conceptual paper by Inklaar and Rao,[1] which provides a broader set of principles and methods for constructing PPP time series. This note discusses several specific issues relevant for constructing time series of PPPs and real expenditures for the years 2012 to 2016 based on the ICP data available for 2011 and 2017, regional benchmarks for interim years, National Accounts (NA) expenditure data for interim years, and CPI and NA deflator time series.

1. General approach

Table 1 outlines for which of the regions there is regional benchmark (RBM) data in the 2012-2016 period.

Table 1. Availability of ICP and Regional benchmark data, 2011–2017

	Africa	Asia-Pacific	CIS	Eurostat-OECD	Latin America	Caribbean	Western Asia
2011	ICP	ICP	ICP	ICP	ICP	ICP	ICP
2012				RBM			RBM
2013				RBM			RBM
2014			RBM	RBM			RBM
2015				RBM			RBM
2016				RBM			RBM
2017	ICP	ICP	ICP	ICP	ICP	ICP	ICP

[1] "ICP: Extrapolation and Interpolation of PPPs and Real Expenditures for the Years 2012 tot 2016" Paper prepared for the October 28-29 TAG Meeting.

Given this structure and, more in general, the need for a flexible system to incorporate regional data when available and maintain fixity of those results with respect to other regions, the time series estimation is done in two steps:

1. Interpolate the linked basic heading PPPs between 2011 and 2017,
2. Use the CAR-PPP approach to incorporate the regional benchmarks.
3. Aggregation using standard 2011/2017 methods.

This means the PPP are computed at the same level of detail (basic headings) and using the same method in the global benchmark years (2011 and 2017) as in the off-benchmark years (2012–2016). Implementing these steps requires inflation and expenditure data for all countries and years at the basic-heading level, both of which are discussed below.

Step 1:

Interpolation follows the 'geometric PWT' approach discussed in Inklaar and Rao, Section 4. The linked basic heading PPPs $PPP_c^{L,t}$ for country c and time t between the first benchmark ($t = 1$) and the subsequent benchmark ($t = T$) is then estimated as:

$$PPP_c^{L,t} = \left[PPP_c^{L,1} \times \frac{P_c^t / P_c^1}{P_{USA}^t / P_{USA}^1}\right]^{1-w^t} \times \left[PPP_c^{L,T} \times \frac{P_c^t / P_c^T}{P_{USA}^t / P_{USA}^T}\right]^{w^t} \quad (1)$$

Here P_c^t is the deflator in country c and the weight given to the benchmark at time T is given by $w^t = \frac{t-1}{T-1}$. The reference country for the linked PPPs is taken to be the United States, so the price changes are given relative to the United States as well, but the procedure is base-country independent. A more extensive discussion of this method and alternatives is given in Inklaar and Rao, Section 4.

Step 2:

Start from an RBM basic heading PPP for, say, Western Asia (i.e. Oman=1) denoted by $PPP_c^{R,t}$. Then $PPP_c^{F,t}$ is linked to the global comparison but with fixity of the regional comparison and is computed as:

$$PPP_j^{F,t} = PPP_j^{R,t} \times \left[\prod_{c \in R} PPP_c^{L,t}\right]^{\frac{1}{N_R}} \Big/ \left[\prod_{c \in R} PPP_c^{R,t}\right]^{\frac{1}{N_R}} \quad (2)$$

With N_R the number of countries in the region. In this procedure the regional PPPs are multiplied by an adjustment factor given by the geometric average of linked PPPs for the region divided by the geometric average of the regional PPPs for the region. This is known as the **CAR-PPP method** and it ensures fixity, i.e. that the within-region price relatives carry over to the global level, and the method is base-country independent.

Step 3:

From Step 1 we have linked basic heading PPPs for all regions without regional benchmarks and in Step 2 we have integrated the basic heading PPPs from the regional benchmarks. We then calculate aggregate PPPs using the same methods as in the benchmark years. For a given aggregate we calculate within-region GEKS PPPs—if not already provided in the regional benchmark. We then link the regions as follows:

1. The core regions (Africa, Asia-Pacific, Eurostat-OECD, Latin America and Western Asia) using the CAR-Volume method,
2. CIS to Eurostat/OECD using the CAR-PPP method,
3. The Caribbean to Latin America using the CAR-Volume method,
4. Georgia and Ukraine (in 2017) using the CAR-PPP method to Eurostat-OECD, and
5. Iran (in 2017) using the CAR-PPP method to Western Asia.

The **CAR-Volume** method in linking step 1 involves estimating within-region aggregate PPPs, PPP_c^R and an aggregate PPP across the core regions, PPP_c^G. The within-region PPPs, combined with nominal expenditure E_c, are used to calculate real expenditure $q_c^R = \frac{E_c}{PPP_c^R}$ and from that the share of each country in real regional expenditure, $s_c^R = \frac{q_c^R}{\sum_{c \in R} q_c^R}$. The across-region PPP is used to calculate total regional real expenditure for each region $q_R = \sum_{c \in R} \frac{E_c}{PPP_c^G}$. The CAR-Volume PPP for each country is then computed as: $PPP_c^F = \frac{E_c}{s_c^R \times q_R}$. In a final step, these PPPs are normalised to USA=1 (though any other reference country could be used). The

CAR-Volume method in linking step 3 is similar but is used to link the countries in the Caribbean region to Latin America.

The CAR-PPP method was introduced in equation (2) and is applied by calculating within-region aggregate PPPs and an aggregate PPP for the broader group of countries. For example, in linking step 2, aggregate PPPs are calculated for the countries in either the Eurostat-OECD region or the CIS region, $PPP_c^{EUO+CIS}$. Then the PPPs for the CIS countries are adjusted to link to the fixed Eurostat-OECD set:

$$PPP_j^F = PPP_j^{EUO+CIS} \times \left[\prod_{c \in EUO} PPP_c^{EUO}\right]^{\frac{1}{N_{EUO}}} \Big/ \left[\prod_{c \in EUO} PPP_c^{EUO+CIS}\right]^{\frac{1}{N_{EUO}}} \quad (3)$$

Equation (3) applies only to the CIS countries, $j \in CIS$ as the Eurostat-OECD countries PPPs have been calculated within the region. The same approach is taken in linking steps 4 and 5 for the special participation countries.

Beyond this general setup, there are a number of specific issues that come up. One issue is how to deal with productivity adjustment, namely whether to interpolate the productivity-adjusted basic heading PPPs or the non-adjusted PPPs and apply a productivity adjustment in every year. A second issue relates to reference headings. Most notable is the issue of how to treat countries that are 'regional switchers', i.e. those that move between region (notably Columbia and Costa Rica that move from Latin America to Eurostat-OECD), from participating to non-participating (e.g. Guatemala, Macao) and from non-participating to participating (e.g. Argentina, Guyana).

2. Constructing the inflation data

As argued in our conceptual paper, estimation of PPPs for years not covered by official ICP data or regional benchmarks, the principle should be to use the most detailed price data available. This led to concerns about the relevance of more detailed price series given possible mismatches between ICP and CPI samples. In practice, though, NA deflators are not available below the level of Main Aggregates and CPI indexes are not available below the level of Categories, i.e. the COICOP-12 level.

A more practical challenge is that data coverage varies across countries and over the years. For instance, COICOP-12 CPI indexes may be available for some years but not others or Main Aggregate deflators are missing. To construct a complete inflation dataset, we apply the following rules:

1. All CPI and deflator data are converted to annual changes, so $P_{i,c}^{t}/P_{i,c}^{t-1}$ for index i.
2. Since CPIs are always based directly on price observations, while NA deflators may be estimated in a variety of ways, CPI data is given preference over NA deflators
3. For a basic heading in a year, the most detailed price change is used, so for Rice, the Food and Non-Alcoholic Beverages CPI is used when available, otherwise the total CPI, otherwise the NA deflator for Individual Consumption Expenditure by Households, and otherwise the GDP deflator.
4. Whenever the change in the GDP deflator is missing for a country/year, the change in the total CPI is used.
5. Whenever the change in the total CPI is missing for a country/year, the change in the GDP deflator is used.
6. The annual price changes for each basic heading/country/year combination are transformed into an index with 2011=1.

Following these steps results in a complete set of inflation data, i.e. covering 155 basic headings for 7 years and 213 countries, including non-benchmark countries.

3. Constructing the expenditure data

To construct a complete set of expenditure data at the basic-heading level, we also start from data at varying levels of detail. For instance, Eurostat-OECD provides annual basic-heading level data, while in the CIS region, coverage is restricted to the Main Aggregate level (except in 2014). For 2011 and 2017, data is available at the level of basic headings. This allows for computing expenditure shares of each basic heading within their Group, Category, Main Aggregate or GDP in (at least) those two years. These benchmark shares are interpolated using a formula similar to that in (1) – giving greater weight to share data closest to the year for which interpolation is made. and applied to the more aggregate expenditure data at the most detailed level available.

4. Productivity adjustment

For the compensation basic headings, there are two possible approaches. Option 1 would be to use the PPP post productivity adjustment, i.e. post-PA PPPs, and interpolate those between 2011 and 2017. Option 2 would use the pre-PA PPPs, interpolate those between 2011 and 2017 and then apply the PAFs for each year. For both options, the PA would be done separately within the region (where applicable) and for the linking across regions.

For the interpolation, it seems probable that both options will yield similar results, because the beginning and endpoints are given, and the only matter is how the change between these two points is distributed over the years. But especially when the current computation framework will be used to extrapolate to 2018 and beyond, the two options will likely yield different results.

To the extent that countries outside Eurostat-OECD currently rely on input-based deflators rather than (implicit) output-based deflators, Option 2 would be preferable, because the extrapolation will be done using changes in labour compensation (and possibly other costs), so the extrapolated (pre-PA) PPP will still conceptually be a compensation PPP that should be adjusted for productivity differences. Given the likely widespread prevalence of input-based deflation, we will therefore follow Option 2.

5. Reference headings

In the benchmark years, we apply reference PPPs to headings where direct price observation is not practical or feasible. This includes using the exchange rate as the reference PPP for (amongst others) the balance of exports and imports, but also combinations of other headings, such as the PPP for narcotics, which is a combination of tobacco and pharmaceutical products. In the 2012–2016 period, we apply the same reference PPP scheme and method as in ICP 2017 taking the interpolated basic heading PPPs (for the regular headings) as inputs.

6. Regional switchers

Countries that switch region, which includes those that move from participation to non-participation and vice versa are a special case. Table 2 sketches the situation for Colombia and Argentina, as examples. Colombia was a member of the Latin America region in 2011 and of Eurostat-OECD in 2016 and 2017. Argentina did not participate in 2011 and participated as part of Latin America in 2017.

Table 2. Schematic representation of the regional classifications for Colombia and Argentina

2011	2012	2013	2014	2015	2016	2017
Colombia						
LAT					EUO	EUO
Argentina						
NBM						LAT

At the basic heading level, we use the linked PPPs for the benchmark(s) and interpolate as discussed in Step 1, above. In the case of countries that participated only in 2011 or 2017 we extrapolate from the available benchmark using relative inflation.

For aggregation above the basic heading level, we distinguish two groups of countries in each region, namely the *continuing countries* and the *switchers*. Take the case of Argentina. For the results in 2017, Argentina should be part of Latin America, but the estimate for Argentina's PPP in 2011 (based on extrapolation from 2017) should not affect the PPPs for the continuing countries.

We therefore compute aggregate PPPs for the years 2012 to 2016 within the region:

1. For the continuing countries, $PPP_c^{CN,t}$
2. For the set of countries based on the 2011 regional classification, $PPP_c^{2011,t}$, and
3. For the set of countries based on the 2017 regional classification, $PPP_c^{2017,t}$.

The aggregate PPPs used for continuing countries are based on the aggregation over continuing countries, $PPP_c^{CN,t}$. Those PPPs will also be linked across regions as detailed in Step 3, above. To avoid overly cumbersome notation, we let $PPP_c^{CN,t}$ denote the aggregate PPPs linked across regions, with within-region fixity imposed, while $PPP_c^{2011,t}$ and $PPP_c^{2017,t}$ are purely within-region aggregate PPPs.

For the switchers we use the PPPs from the aggregation over the relevant set(s) of countries. So, in the case of Argentina, we only have $PPP_{ARG}^{2011,t}$. We link Argentina to the continuing countries in Latin America ($PPP_{ARG}^{L11CN,t}$) using a CAR-PPP approach:

$$PPP_{ARG}^{L11CN,t} = PPP_{ARG}^{2011,t} \times \left[\prod_{c \in CN} PPP_c^{CN,t}\right]^{\frac{1}{CN}} \Big/ \left[\prod_{c \in CN} PPP_{ARG}^{2011,t}\right]^{\frac{1}{CN}} \quad (4)$$

In the case of Colombia and based on equation (4), we have the country linked to Latin America based on the 2011 regional classification, $PPP_{COL}^{L11CN,t}$, and linked to Eurostat-OECD based on the 2017 regional classification, $PPP_{COL}^{L17CN,t}$. We interpolate between these two linked series so that in 2011, all weight is on $PPP_{COL}^{L11CN,t}$ and in 2016, when Colombia was first part of the Eurostat-OECD region, all weight is on $PPP_{COL}^{L17CN,t}$. The benchmark observations for 2011, 2016 and 2017 are left unchanged, so the interpolation is for the 2012–2015 years.

Below is a table of all switching countries, including the year in which they moved to a different regional classification if this is different from 2011 or 2017. As indicated, all (regional) benchmark observations are left unchanged. Note that for Georgia and Iran, we use the 2017 linking approach for the full 2012–2016 period. This linking is to an entire region, so more robust than the 2011 bilateral linking.

Table 3. Switching countries and their regional classifications

	2011 Region	2017 Region
Argentina	NBM	LAT
Colombia	LAT	EUO (from 2016)
Costa Rica	LAT	EUO (from 2016)
Guatemala	LAT	NBM
Georgia	SNG (via ARM)	SPP (EUO)
Guyana	NBM	CAR
Iran	SNG (via TUR)	SPP (WAS)
Macao	ASI	NBM
Morocco (dual participation)	AFR (until 2013)	WAS (from 2014)
Ukraine	CIS	SPP (EUO, from 2014)
Yemen	WAS (until 2013)	NBM (from 2014)