

# International Comparison Program

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## Measuring the Size of the World Economy

A Framework, Methodology, and Results from the  
International Comparison Program

*Executive Summary*

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## **Executive Summary**

The International Comparison Program (ICP) in the 2005 round became the largest and most complex international statistical program in the world. It included 146 countries which provided thousands of prices and related measures used to estimate Purchasing Power Parities (PPPs) to deflate national Gross Domestic Product (GDP) expenditures into a common global currency. The resulting PPPs and volume indices made it possible to make comparisons between countries that are soundly based on economic and statistical theory. The ICP had its beginnings in the 1960's; each successive round involved more countries and innovations in methodology. The results from each round provided the building blocks leading to new theory and methods for the next rounds.

The purpose of this book is to present the challenges faced by the ICP 2005, the new theories and methods developed to address those problems, and then an assessment of lessons learned that can be applied to future rounds of the ICP. The ICP book has been prepared to ensure complete transparency in the theory and methods used, and problems encountered. Much of the analysis presented by the authors of the various chapters was made possible by providing them access to a data file containing basic heading PPPs and expenditures for the 146 participating countries.

This summary will begin with a brief description of PPPs and an overview of their uses. That will be followed by a general overview of the multiple steps required to produce PPPs at the regional and global levels. Then there will be a review of the underlying theory that leads to the choices of methods used to estimate PPPs.

### **1. What is a Purchasing Power Parity?**

In its simplest form, a PPP is a price ratio. PPPs for the total consumption aggregate of the GDP, for example, are built up from comparisons of prices of products purchased by households. The characteristics of the individual products need to be carefully defined to ensure comparable products are being priced. The data example shown in Table 1 below will be used throughout this summary to explain the concepts and methods used in the ICP<sup>1</sup>. The data come from the Ring data collection from ICP 2005. The table shows national average prices for three products and four countries for the rice basic heading. The PPP between Egypt and the United Kingdom (UK) for long grain rice-prepacked is the average price in Egypt in its national currency (Egyptian pound) divided by the average price in UK pounds sterling. The price ratio 7.54 means that takes 7.54 Egyptian pounds to purchase an amount of long grain rice in Egypt that would

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<sup>1</sup> The data for the examples to be shown come from the Ring Comparison. A global list that was a composite of the regional products was priced by 18 countries representing all regions. These countries priced both the global list and the ring list; the results were used to calibrate regional PPPs to the global level

cost 1.0 pound sterling in the UK. Likewise, it only takes 3.30 Egyptian pounds to purchase the same quantity of long grain rice sold loose that would cost 1.0 pounds sterling in the UK.

As the table illustrates, the relative prices (product PPPs) differ by product; therefore, the product PPPs are averaged to arrive at a PPP for the rice basic heading. The simple geo mean is the bilateral PPP. In practice, multilateral PPPs are computed which takes into account the relative prices between all of the countries as a group. More will be said about this in sections to follow.

Since there are no weights reflecting the quantities of each product that are purchased, the basic heading PPPs are computed with products and countries treated equally. However, expenditures are available for each basic heading, therefore, enter into the averaging of Basic Heading PPPs to major aggregates such as food. Then the PPPs for the major aggregates are averaged to the GDP, again using weights. Table 2 shows PPPs for selected basic headings in the food aggregate and the average PPP for food. The food PPP means that it takes 4.22 Egyptian pounds to purchase an amount of food in Egypt that would cost one pound sterling in the UK. More importantly this also means that the expenditures in Egyptian pounds for the food aggregate of the GDP in Egypt can be converted to the UK currency by dividing it by the PPP or 4.22. The food PPPs in the other countries can also be converted to the UK pound by dividing their food expenditures by their respective PPPs.

Another important measure is the Price Level Index (PLI) which is simply the PPP divided by the exchange rate. PLI's less than 1.0 means the products or aggregates are relatively cheap. The PLI is also a measure of the ratio of nominal expenditures (based on exchange rate) to real expenditures based on PPPs. The price level indexes for food shown in table 2 indicate that food is relatively cheap in those countries and also that the nominal expenditures for food would be .42, .64, and .54 of the real expenditures respectively in Egypt, Estonia, and the Philippines.

The PPP for the GDP is based on thousands of prices collected for about 1,000 products plus measurements for other aggregates such as housing, government, and construction that are used to first estimate basic heading PPPs, then average them to the GDP. The PPPs at each level of aggregation and for the GDP are simply a form of exchange rate to calibrate expenditures in national currencies to a common currency. While simple to say, the resulting PPPs are based on very complex statistical and economic theories presented in detail in Chapters 1, 4, 5, and 6 and summarized in a later section below.

Table 1. Prices of products in the Rice Basic Heading and their ratios to the UK Prices for selected countries

| Rice BH                | Egypt/UK    |           | Estonia/UK  |           | Philippines/UK |           | United Kingdom |      |
|------------------------|-------------|-----------|-------------|-----------|----------------|-----------|----------------|------|
|                        | Nat'l price | PPP to UK | Nat'l Price | PPP to UK | Nat'l Price    | PPP to UK | Nat'l Price    | PPP  |
| Long grain prepacked   | 5.51        | 7.54      | 11.59       | 15.87     | 32.73          | 44.83     | .73            | 1.00 |
| Long Grain Loose       | 3.47        | 3.30      |             |           | 23.35          | 22.23     | 1.05           | 1.00 |
| Basmati                | 5.69        | 5.69      | 45.68       | 20.48     |                |           | 2.23           | 1.00 |
|                        |             |           |             |           |                |           |                |      |
| Geo Mean-bilateral PPP |             | 5.22      |             | 18.02     |                | 31.56     |                | 1.00 |
| Multilateral           |             | 4.80      |             | 19.98     |                | 33.36     |                | 1.00 |
| Exchange Rate          | 10.12       |           | 22.78       |           | 90.87          |           |                |      |

Source: Ring survey ICP 2005

Table 2. PPPs for selected basic headings and countries, UK =1.00

| Basic Heading         | Basic Heading PPPs UK = 1.00 |            |                |      |
|-----------------------|------------------------------|------------|----------------|------|
|                       | Egypt/UK                     | Estonia/UK | Philippines/UK | UK   |
| Rice                  | 4.80                         | 19.98      | 33.36          | 1.00 |
| Other cereals         | 7.12                         | 18.46      | 95.28          | 1.00 |
| Bread                 | 6.80                         | 15.98      | 60.73          | 1.00 |
| Beef and Veal         | 4.60                         | 10.60      | 31.22          | 1.00 |
| ....29 basic headings |                              |            |                |      |
| Food Aggregate PPP    | 4.22                         | 14.67      | 47.32          | 1.00 |
| Exchange Rate         | 10.12                        | 22.78      | 90.87          | 1.00 |
| Price Level Index     | .42                          | .64        | .52            |      |

Source: Ring survey ICP 2005

**Uses of PPPs.** The PPP based expenditures allow direct comparisons of indicators of well being such as expenditures per capita because they are now in a common currency. Similar comparisons can be made for other aggregates such as health, education, housing, government, and the GDP. The PPPs for household consumption are the main input to the estimation of the international poverty line which is a main driver of international development efforts. Countries

with different rates of economic growth can compare their price levels and per capita expenditures to guide their development policies. PPP based expenditures allow comparisons across countries for different sectors; for example, the ICP 2005 showed that China accounted for 29 percent of global real expenditures for construction.

A major use of PPPs is for poverty assessments<sup>2</sup>. National poverty assessments differ by country because purchasing power differs. Therefore, an international poverty line is established using PPPs to hold the real value constant across countries. The international poverty line of \$1.25 in international dollars is translated to the national level using PPPs; then household survey data are used to determine the number of people living with per capita consumption below the poverty line.

The International Monetary Fund<sup>3</sup> (IMF) uses PPP based GDP to determine the quota subscriptions of member countries. This not only determines the financing each country must provide to the IMF, it also determines the amount of financing a country can obtain from the IMF and largely determines its voting power in IMF decisions. The IMF also uses PPP based GDP numbers in its World Economic Outlook that provides estimates of regional and world output and growth.

The US Federal Reserve Board<sup>4</sup> used PPP based data on the GDP and aggregates to do an empirical analysis of international price levels. Others use PPPs for international comparisons of output and productivity<sup>5</sup> at the sector level (agriculture, manufacturing, and services) which provide useful complements to comparisons of GDP or by expenditure categories.

**Why not use Exchange Rates?** First, exchange rates do not reflect the different price levels across the components of the GDP; table 2 shows the variability of selected basic headings in the food aggregate. Table 3 shows the PLI's for the GDP and major aggregates for China and India. If exchange rates were used to deflate GDP expenditures by aggregate, the same value would be used regardless of the difference in price levels. The comparisons of per capita expenditures across countries would not reflect the relative price differences. The use of the PPPs allows direct comparisons. Again using table 3, the PLI for health in both countries is several times smaller than the food price level. The PLI also shows the difference in health expenditures if they are deflated using the exchange rate instead of the PPPs. In other words, the nominal expenditures for health in China and India based on the exchange rate would be 16 and 13 percent respectively of the real expenditures based on PPPs.

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<sup>2</sup> See chapters 20 and 21

<sup>3</sup> See chapter 23

<sup>4</sup> See chapter 23

<sup>5</sup> See chapter 24

Table 3. Price level Indexes for major aggregates, China and India

|              | Price Level Indices World Equal 100 for major aggregates |      |        |           |                       |                               |
|--------------|--|------|--------|-----------|-----------------------|-------------------------------|
|              | GDP  | Food | Health | Education | Collective government | Gross Fixed Capital Formation |
| <b>China</b> | 52   | 75   | 16     | 31        | 31                    | 79                            |
| <b>India</b> | 41   | 53   | 13     | 16        | 35                    | 48                            |

Source: ICP 2005

## 2. Overview of the Collection of Data for the Estimation of PPPs

The ICP is made up of three major components. First, the conceptual framework is determined by the set of national accounts making up the GDP. The second component is the national annual average prices or quantity or value data for a basket of goods and services that are comparable across countries, and representative of purchasing patterns within each country. The third component is the methodology to compute the PPPs at the product, basic heading, aggregates of the GDP, and the GDP.

These three components are carried out under a governance structure whereby countries are grouped into regions with a regional coordinator. The ICP Global Office in the World Bank provides the overall coordination of the program across the regions and also the coordination with the Eurostat-OECD comparison<sup>6</sup>.

Figure 1 provides an overview of the different steps required to produce estimates of PPPs. The Starting point is the Gross Domestic Product (GDP). The best practice in the measurement of economic activities is the System of National Accounts (SNA 93) which forms the basis for the ICP<sup>7</sup>. The breakdown of the GDP expenditures into 155 basic headings forms the building blocks to estimate PPPs. The basic heading represents the categories into which individual products are grouped for pricing purposes, and is the lowest level for which expenditure estimates (breakdown of the GDP) are required. The use of the GDP as the main element of the conceptual framework of the ICP means that the prices to be collected need to be consistent with the underlying values in the national accounts. The prices must be national annual averages and basically represent purchaser prices that include taxes and other costs.

Basic headings fall into three main categories; first is those containing products consumers purchase in various markets. Prices for these basic headings are obtained via market surveys.

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<sup>6</sup> See Chapter 2

<sup>7</sup> See Chapter 3

Many basic headings are called “comparison resistant” because of the difficulties encountered in collecting data to estimate PPPs. These include basic headings grouped into Dwelling rents, Health, Education, Government, Construction, and Equipment. The third category includes those basic headings where the prices are either not available or too expensive to obtain; therefore, their PPPs are imputed using PPPs from other basic headings (reference PPPs.) The overview continues with a review of the steps to estimate PPPs for basic headings represented by market surveys, then returns to the comparison resistant basic headings, and those for which PPPs are imputed.

**Basic Headings with Prices collected from market surveys<sup>8</sup>.** These account for about 100 out of the 155 basic headings and account for about 60 percent of the world GDP. Each region determines the products to be priced in these basic headings and prepares their specifications using Structured Product Specifications—a new method introduced for the ICP 2005 which provides a systematic and consistent way to describe products. The regional concept meant that goods and services to be priced could be chosen to be the most representative of its countries. While this provides the best comparison between countries in the same region, say India and Indonesia, it is not possible to compare either with Brazil, or the US. For that reason, a method coined “the Ring” was adopted for ICP 2005.

The Ring concept involved creating a list of products that represented a composite of what was priced in each region. Eighteen countries representing the different ICP regions and the Eurostat-OECD program priced the set of Ring products in addition to the products in their regional list. National annual average prices were provided by all countries for their regional products and the Ring countries also provided prices for the Ring products. The prices from the regional lists were used by each region to compute **within region** basic heading PPPs for its countries. These **within region** basic heading PPPs were used to deflate the ring prices into 5 sets of **regional prices** which then were used to estimate between region PPPs. These between region PPPs were in effect scalars that calibrated each country’s within region basic heading PPPs to a common global currency. Before discussing how the within region and global basic heading PPPs were averaged to higher level aggregates and the GDP, we return to the comparison resistant basic headings.

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<sup>8</sup> See Chapters 7 and 8

### **3. Overview of Data Collected for Comparison Resistant Basic Headings**

A common feature of the comparison resistant basic headings is that **global** specifications for pricing or data collection are defined whereas each region prepares its own lists of products for which prices are collected in market surveys.

**Dwelling rents for owner occupied households<sup>9</sup>.** Household dwelling expenditures consist of market-rented housing and imputations for nonmarket rents and owner-occupied housing. The imputations create a difficulty in preparing the national accounts and as a result it is difficult to compare housing across countries because of the varying mix of rental vs. owner occupied dwellings. PPPs for dwellings in ICP 2005 were computed three different ways. Where there was a large rental market, rental surveys provided average rental rates by size and type of housing-these were also used to estimate PPPs for owner-occupied dwellings. However, there is not a sufficient rental market in many countries to provide data to impute PPPs for owner-occupied housing. The preferred method in this case is to derive PPPs based on the relationship provided by Expenditures = Prices x Quantities. Here Prices = Expenditures/Quantities, therefore an indirect PPP is the ratio of the derived prices between countries. This is called the Quantity approach because total housing quantities such as number of structures rooms, square footage, etc. from housing surveys and censuses are used as the quantity measure after they are adjusted for quality. This method was used in some of the Eurostat-OECD countries and in the CIS and South American regions because the rental market was too small to provide rents to impute for owner occupied housing. There was a similar lack of a rental market in Africa and Asia; therefore, the quantity method was also attempted in the African and Asia-Pacific regions but produced implausible results. Therefore, PPPs were imputed for countries in Africa and the Asia Pacific regions using the PPP for individual consumption expenditures by households (excluding housing.) which meant that the housing PPP likely does not reflect the true volume of housing services in those countries.

Data users, especially those doing poverty analysis, were very critical of the method used in Africa and Asia-Pacific. Therefore, in 2011 efforts are being redoubled to enable all countries to base dwelling PPPs on a combination of dwelling rents and quantities. Chapter 12 provides a detailed explanation of how the within region dwelling PPPs were linked using a set of quantity data representing each region.

**Health and Education.<sup>10</sup>** The difficulty with comparing health and education across countries is because they have different arrangements for providing their citizens with health and education goods and services. In the majority of the countries health and education are provided by a mixture of government-run and private services. PPPs for the health aggregate therefore include 7 basic headings under household consumption and 12 basic headings in the individual consumption by government aggregate. For education, there is one basic heading in household

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<sup>9</sup> See Chapter 12

<sup>10</sup> See Chapter 11.

consumption, but six basic headings under individual consumption expenditures by government. Prices are collected for pharmaceutical, therapeutic appliances, outpatient and hospital services and other medical products for household consumption health basic headings. The same prices are used for the basic headings under government health benefits. For the government basic headings for the production of health and education services, it has been assumed that the comparative value of the government output is equal to input costs as measured by employee compensation. The problem with the traditional method of using government compensation to estimate PPPs is exacerbated by developments of the use of technologies which ignores the productivity gains from the use of technology.

For ICP 2005, prices were collected for products and services purchased by consumers for health and private education, and average salaries were obtained for a selection of occupations for selected health and education basic headings. For the first time, productivity adjustments were used in two ICP regions to adjust the compensation PPPs for differences in productivity across countries. More about this follows in the next section which concerns government services.

**Government Services**<sup>11</sup> As described above, government services are compared by using government compensation as a measure of the value of output. Detailed specifications were prepared describing 50 different governmental occupations in terms of the work done. For each, annual salaries were obtained that reflect gross salaries and wages that include payments for benefits, and employee contributions for insurance and pensions. These salaries for each occupation and country were treated as national annual average prices and PPPs computed accordingly. Also as described above, the average salaries were adjusted for productivity in Africa and Asia-Pacific. Since this is the first time productivity adjustments were made, a chapter<sup>12</sup> is devoted to this issue. The adjustments were needed because the very low salaries in some countries would have resulted in levels of real expenditures that were not plausible. The assumption underlying the productivity adjustments is that the output per worker is likely to increase with more capital per worker.

The issue for 2011 is whether to make adjustments for productivity or to find output measures such as numbers of health care workers or other health outputs, and number of students and test scores for education that are comparable across countries for the estimation of PPPs. The situation becomes even more complex if different methods are used across regions because the PPPs will need to be linked. One of the outcomes of the debate is that all countries will furnish compensation data for the same set of occupations. These will be used in a global aggregation to the basic heading and aggregates that in one run will provide regional and global PPPs and real expenditures. If a region prefers to follow a different method to estimate within region PPPs, it can do so and the regional share of the world expenditures from the global aggregation will be distributed to its countries to maintain within region fixity.

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<sup>11</sup> See Chapters 15 and 16

<sup>12</sup> See chapter 16

**Construction<sup>13</sup>.** The comparison of construction across countries depends on the concept of comparability the same as for any other component of the ICP. Construction poses special problems because most construction outputs are unique. No two office buildings are identical in different countries nor are bridges, highways, dams, etc. One method to make comparisons is based on comparing input prices. Inputs are materials, labor, and equipment hire, each of which can be described so that the resulting costs are comparable between countries. The main problem with using input costs is that productivity, profits, and overhead costs are assumed to be the same relative size in each country.

Output pricing involves creating a model building or civil engineering project with detailed specifications describing the final product. Construction professionals in each country are asked to quote a price for the construction output. This output price takes into account differences in productivity and other components such as profits and overhead. The disadvantage is that it is very costly to create the model projects and then to have them priced in each country. This method is used in the Eurostat-OECD comparison, however, was considered too costly to use in the ICP regions.

Construction in the ICP 2005 was compared using an approach called the Basket of Construction Components. It involved collecting prices for a range of major construction components and basic inputs that were common across countries. Detailed specifications were prepared for components such as a column footing and the cost of labor, materials, and equipment obtained. Basic inputs costs such as a fixed quantity of cement or an amount of reinforcing steel were also obtained. Because the component prices included labor, materials, and equipment, they met the requirement for output prices (still excluding profits and overhead). The problem was that a complex set of weights was required to combine the construction components; most countries had difficulties providing them.

For the ICP 2011, 38 different kinds of materials, 7 types of labor, and 5 types of equipment will be priced based on detailed specifications. PPPs will be computed for each of these three components within each of the three basic headings. Each country will furnish weights indicating the relative shares of materials, labor, and equipment for the residential, non-residential buildings, and civil engineering basic headings to aggregate the three component PPPs to the respective basic heading PPPs.

**Machinery and Equipment<sup>14</sup>.** The procedure used for pricing machinery and equipment in ICP 2005 was similar to that used for household goods and services. Structured Product Descriptions were developed for different kinds of equipment and then used as the basis to prepare product specifications so that comparable products could be priced across countries. The major difference was that the product specifications are very technical and deal with combinations of characteristics such as torque, power, lifting capacity, etc. As a result, outside experts had to be

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<sup>13</sup> See Chapter 13.

<sup>14</sup> See Chapter 14

brought in to assist countries with the price collection to assure the products purchased were comparable across countries.

Also, a set of 108 products was defined at the global level because of the difficulty of describing the price determining characteristics. These were used in the price collection for the ICP regions. Some equipment goods are unique because they are designed for a specific location or purpose. Examples are sea vessels, oil platforms and power plants. No attempt was made to price these items; pricing was confined to standard generally mass-produced items. The set of global specifications prepared for 2005 has been updated for use in the ICP 2011.

**Basic Headings for which PPPs were imputed<sup>15</sup>.** PPPs were imputed for different reasons. One was that there are no good measures to compare government basic headings such as intermediate services, gross operating surplus, net taxes on production, and receipts from sales. Household consumption also contains basic headings for narcotics, prostitution, games of chance, and animal drawn vehicles that would be difficult to price. In addition, some regions had found it difficult to define price determining characteristics for basic headings such as repair of furniture and appliances, and maintenance of major durables and household services.

Basic heading PPPs used to impute for those that are missing are referred to as “reference” PPPs. For example, the reference PPPs for intermediate consumption for government health services was PPPs for individual consumption expenditures by households (excluding health, education, and other basic headings imputed using reference PPPs.) At the global level, the imputed PPPs accounted for 14 percent of the global real expenditures. Countries with low government expenditures had smaller amounts from imputation while those with high government expenditures had much larger amounts. The African and Asia regions had higher levels because they imputed PPPs for owner occupied housing. One outcome of this review is to set stricter standards on when PPPs would be imputed and to increase efforts to directly estimate PPPs for dwellings.

**Data Validation.<sup>16</sup>** Prices and other measurements are first validated at the national level. This review ensures that the same products were priced across the different outlets over the country. The validation then moves to the regional and global levels where the main goal is to ensure the same products were priced across countries. The validation at these levels is done by first putting the prices in each basic heading into a common currency using PPPs. Two methods were used—the Quaranta tables from the Eurostat-OECD comparison and the Dikhanov tables derived by the World Bank. The Quaranta tables incorporate both exchange rates and PPPs in the identification of outliers. The Dikhanov tables allow the validation to be across basic headings in addition to the within basic heading review. Both methods involve an iterative process because the basic heading PPPs will change as prices that are outliers are checked by the respective countries and either revised or removed. For ICP 2005, the data validation of the regional prices

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<sup>15</sup> See Chapter 17

<sup>16</sup> See chapters 9 and 10

was done region by region while the Global Office validated the prices from the Ring price survey.

Since the regions published their results first, the **within region** basic headings had to be taken “as is” for the estimation of linking factors and the global aggregation. Analysis since then indicates that the regional basic heading PPPs need to be subject to additional review when the global linking factors are being validated and estimated.<sup>17</sup> A major outcome is that the regional results will remain open for review until the global results have been finalized.

#### **4. Some Basic Concepts underlying the Estimation of PPPs**

The previous section outlined the steps for the collection and validation of the data used for the estimation of the PPPs. Before moving on to providing an overview of the next phase which is the estimation of PPPs, some basic concepts are first reviewed. There are many ways that the basic heading PPPs can be computed using the relative product prices or simply the product PPPs, each has strengths and weaknesses. There are also many methods that could be used to average the basic heading PPPs to aggregates and then to the GDP.

The first step is the estimation of basic heading PPPs. The bilateral PPP between any country and the UK is simply the geometric mean of the product PPPs which as shown in table 1 for Estonia equals 18.02. Also, the PPP between any two countries can be computed directly. First, the geometric mean of the price ratios between Egypt and Estonia is **.243**. The PPP between Egypt and Estonia can also be measured indirectly by the ratio of their respective PPPs to the UK as the base or  $5.22/18.02 = .289$ . One could also compute the PPP between Egypt and Estonia indirectly by dividing the PPP between Egypt and the Philippines by the PPP for Estonia and the Philippines. If there are n countries in the comparison, there will be a PPP obtained directly between any two countries and n-1 PPPs between the same two countries obtained indirectly through the base country.

In each case, one will get different answers. In the section to follow, it will be seen that the one way to estimate multilateral PPPs between any two countries is to take the geo mean of the direct and indirect PPPs. The PPP for Egypt to the UK goes from 5.22 (bilateral) to 4. 80 when the multilateral estimate is computed. This then means that the PPPs between any two countries are affected by their respective PPPs with each other country. This also means that the PPPs between any two countries can change if the mix of countries included in the computations changes. As shown by table 1, not all countries price every product. As will be shown in sections to follow, there are many ways to estimate basic heading PPPs; these methods would all provide about the same answer if every country priced every item. The choice of methods is based on several properties.

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<sup>17</sup> See chapter 8

Multilateral PPPs are computed so that the results satisfy two basic properties—transitivity and base country invariance. **Transitivity** simply means that the PPP between any two countries should be the same whether it is computed directly or indirectly through a third country. The second requirement is that the PPPs be **base country invariant** which means the PPPs between any two countries should be the same regardless of the choice of base country. A simple solution is to use the geometric mean of the direct and indirect PPPs.

Note that the basic heading PPPs shown in table 1 are essentially averages of the relative prices with no weights taken into account which means every product is treated equally. However, in reality, expenditure shares for each would not be equal. Note that prices for long grain rice sold loose are cheaper than prices for Basmati. It is likely that long grain rice sold loose is purchased in much greater quantities than long grain pre packed and Basmati in Egypt and the Philippines with long grain pre packed the most popular in Estonia and the UK. Since products with the greatest expenditures are likely to have the lowest prices, it would improve the quality of the estimates if some form of weighting could be introduced. This brings in the concept of representativity used by the Eurostat-OECD and CIS in ICP 2005, and attempted in the other regions.

A **representative product** is one frequently purchased by households and also has a price level consistent with all products in the basic heading. The use of this classification can be used to apply a form of weighting in the estimation of basic heading PPPs as shown in chapter 4. Most countries in the ICP regions had difficulty applying the concept, especially the meaning of price level. In order to simplify the classification of products for the 2011 ICP, a simpler concept of **importance** was adopted. Each country is asked to use expert judgment to determine which product(s) would have the largest expenditure shares. This will allow the introduction of simple weights for products deemed important and used to estimate basic heading PPPs.

Weights based on basic heading expenditures are used in the methodology to average a group of basic headings to an aggregate level. The food aggregate, for example, contains 29 basic headings. For the column of basic heading PPPs say between Egypt and the UK, there are two sets of weights; the expenditure shares for Egypt and those for the UK. Another basic concept that determines the choice of index method is that countries be treated equally. Therefore, the basic heading PPPs are first averaged using Egypt's weights, then are averaged using UK's weights. These are called the Laspeyres and Paasche indexes. Each provides a PPP between Egypt and the UK; therefore, the geo mean is taken. The result is a Fisher index. As discussed in Chapter 5, this is a superlative multilateral index that is consistent with economic comparisons of utility across countries. For each pair of countries, the multilateral PPP is the geo mean of the direct and indirect Fisher indexes. This method was used for the ICP 2005 even though it does not satisfy the **addititvity** requirement.

**Addititvity** means that, for example, the expenditures for each food basic heading (in national currency) divided by the respective PPPs should add to the sum of food expenditures (in national

currency) divided by the aggregated food PPP. The addition of major aggregate expenditures in PPP terms to the GDP should equal the real expenditures obtained by dividing GDP expenditures (in national currency) by the aggregated PPP for the GDP. However, the requirement that countries be treated symmetrically as shown above produces results that are not additive. As a result of the non additive method used for ICP 2005, the real world GDP was about 2 percent smaller than the GDP obtained by the summation of the aggregate real expenditures. These differences were many times larger at the national level. However, at each level of aggregation, the results are consistent with economic comparisons of utility and also minimize the differences between the bilateral and multilateral PPPs.

Additive methods can be used, but have the disadvantage of providing more weight to the relative prices of the larger more developed countries. As a result the real expenditures for poor countries become larger and farther away from the bilateral PPPs.

**Fixity** is another concept that determines the methodology used. This means that the relative volume (ratio of real expenditures) between any pair of countries in a region remains the same after the region has been combined with other countries or regions. This concept is critical when a region prepares its results which are then later converted from a regional currency to the global currency.

## 5. Estimation of PPPs—Within Regions

Figure 1 shows that PPPs between countries within each region are estimated in two steps. The first step is the estimation of basic heading PPPs. The next step is the averaging, or using ICP jargon, aggregating the basic heading PPPs for each country to higher aggregates and the GDP using expenditure weights. The basic requirement for each stage of aggregation is that the resulting PPPs are transitive and base country invariant as defined above.

**From Product PPPs to the Basic Heading.** This section provides a brief overview of the material presented in Chapter 4 and builds off table 1 provided above. The bilateral PPPs for each country shown in table 1 are a form of a Jevons index. If the table is full, that is if every country priced every item, then the bilateral PPPs would be transitive and base country invariant.

In practice, not every country can price every item. There are two basic methods used in the ICP to calculate basic heading PPPs. The first approach is based on the Jevons index and the Gini, Elteto-Koves and Szulc method which turns the bilateral PPPs into multilateral PPPs to make them transitive and base country invariant. The GEKS method is based on averaging the direct PPPs between any two countries with the n-1 PPPs that can be obtained indirectly. The other

method makes use of a regression model known as the Country Product Dummy (CPD) which directly estimates PPPs that are transitive and base country invariant in one step.

As discussed above, either method treats every product equally regardless of their relative expenditures. That is why the concepts of **Representativity** and **Importance** were introduced.

Table 4 below repeats the data shown in table 1 with representative products indicated by an asterisk.

Long grain rice that is prepacked is representative of the basic heading in Estonia and the UK while long grain rice sold loose is representative in Egypt and the Philippines. There are two ways that basic heading PPPs are computed using this information. The PPP between Egypt and the UK is computed first only using products representative of Egypt, the again only using products representative of the UK. The bilateral PPP between Egypt and the UK is then the geo mean of these two PPPs. Note that long grain rice sold loose is representative in two countries, thus entering in both bilateral PPPs and receiving more weight. Also note that basmati is not considered representative for any country even though prices were provided, hence, are not used in the price comparison for any countries. These bilateral PPPs are made transitive and base country invariant using the GEKS method. This method (Jevons-GEKS\*) is used by the Eurostat-OECD comparison and the CIS region.

The other regions for ICP 2005 attempted to use the Country Product Representative Dummy (CPRD) method with representativity included as another variable in the regression. However, the countries were not able to consistently provide the representativity coding because the concept required judgment about both price levels and relative expenditures. Therefore, the concept was not used in the remaining four regions. The concept has been simplified for ICP 2011 with the importance classification being used to only indicate those products with the greatest expected expenditures. Because the importance classification is based on assumptions about expenditures, the Country Product Dummy-Weighted (CPDW) method will be used in ICP 2011 with important products receiving weights greater than two.

Table 4. Prices of products in the Rice Basic Heading and their ratios to the UK Prices for selected countries

| Rice BH              | Egypt/UK    |           | Estonia/UK  |           | Philippines/UK |           | United Kingdom |      |
|----------------------|-------------|-----------|-------------|-----------|----------------|-----------|----------------|------|
|                      | Nat'l price | PPP to UK | Nat'l Price | PPP to UK | Nat'l Price    | PPP to UK | Nat'l Price    | PPP  |
| Long grain prepacked | 5.51        | 7.54      | 11.59*      | 15.87     | 32.73          | 44.83     | .73*           | 1.00 |
| Long Grain Loose     | 3.47*       | 3.30      |             |           | 23.35*         | 22.23     | 1.05           | 1.00 |
| Basmati              | 5.69        | 5.69      | 45.68       | 20.48     |                |           | 2.23           | 1.00 |

| Rice BH                | Egypt/UK    |           | Estonia/UK  |           | Philippines/UK |           | United Kingdom |      |
|------------------------|-------------|-----------|-------------|-----------|----------------|-----------|----------------|------|
|                        | Nat'l price | PPP to UK | Nat'l Price | PPP to UK | Nat'l Price    | PPP to UK | Nat'l Price    | PPP  |
| Geo Mean-bilateral PPP |             | 5.22      |             | 18.02     |                | 31.56     |                | 1.00 |
| Multilateral           |             | 4.80      |             | 19.98     |                | 33.36     |                | 1.00 |
| Exchange Rate          | 10.12       |           | 22.78       |           | 90.87          |           |                |      |

\*Products are representative of the basic heading price structure and frequently purchased.

*Source:* Ring survey ICP 2005

Table 5 shows the different methods that can be used to estimate basic heading PPPs. Jevons, Jevons-GEKS, and the CPD methods will provide the same results if every country prices every product and the representative or importance classifications are not used. However, the results between the GEKS\* and either the CPRD or CPDW will differ for one basic reason. Note in the example above that Basmati rice was not representative for any country, therefore, did not enter into the estimation of PPPs for the group of countries using the Jevons-GEKS method. The CPRD and CPDW regressions will include all data, thus becomes more robust when the price matrix is incomplete.

Table 5. Methods to estimate basic heading PPPs

| Index      | Methods to estimate basic heading PPPs         |   |   |   |   |   |
|------------|--|---|---|---|---|---|
|            | Jevons   | Jevons-GEKS   | CPD   | Jevons-GEKS*  | CPRD  | CPDW  |
| Properties | Transitive and base invariant with full matrix | Multilateral procedure to ensure transitivity and base invariance with less than full price table | Multilateral procedure to ensure transitivity and base invariance with less than full price table | Implied weights used for representative products. Results are transitive and base invariant | Implied weights used for representative products. Results are transitive and base invariant | Specific weights used for "important" products. Results are transitive and base invariant |

*Source:* ICP Book 2011

The main outcome of the analysis of the ICP 2005 data is that some classification process be used to ensure that products most widely purchased receive more weight than other products being priced. The classification of "importance" discussed above will be used in the ICP regions for 2011 and basic heading PPPs will be estimated using the CPDW.

**From Basic Headings to Major Aggregates to the GDP.** Chapter 5 provides an extensive review of the different methods used to aggregate basic heading PPPs to the GDP and their properties. Remember that expenditure weights are available for each country. Therefore, the input to the estimation process is a matrix of 155 basic heading PPPs by country in the region and another matrix of basic heading expenditures in national currencies.

There are three methods examined in the chapter. The method used in five out of the 6 regions was the GEKS. The basic heading PPP between any two countries has two weights, one for each country. Therefore, two weighted averages of basic heading PPPs to estimate the GDP basic heading are computed using the weights for each country in turn. The Fisher indexes, the geo mean of these weighted averages, are then made transitive and base country invariant using the GEKS process described above. The GEKS method has the property that each country is treated in a symmetric way. One disadvantage is that the results are not additive.

Two additive methods have been used in the ICP. The Geary-Khamis and Ikle Dikhanov Balk (IDB) methods produce results that are additive. However, the results are not consistent with economic comparisons of utility across countries. In addition, large countries have a greater impact on the final results. If large countries have higher prices, then the impact is to raise the price levels of the poorer, smaller countries. The IDB method has a smaller large country affect.

In ICP 2005, the GEKS method was used in every region except Africa where the IDB method was used because it was important that results be additive.

The IDB is a newer method, therefore chapter 5 provides an extensive review of its properties.

A problem with the EKS method is that countries at very different stages of development with very different relative prices are given the same weight as countries with similar stages of development and relative prices. Therefore, the chapter examines the Minimum Spanning Tree approach that builds up the multilateral set of comparisons starting with bilateral comparisons with countries very similar in structure. This method offers considerable promise for the future, but still contains some arbitrary aspects suggesting further analysis and research is needed. Therefore, the main method for ICP 2011 will be the GEKS to aggregate basic heading PPPs to the GDP.

**From Within Region to Global Basic Heading PPPs.** Returning to figure 1, note that at this stage there is a set of PPPs and related indices for each of the 6 regions, each in the currency of one of the countries within the region. The PPPs for each level of aggregation and the GDP in each region are transitive and base country invariant. However, at this stage, it is not possible to compute the PPPs between two countries in different regions. Therefore, the final step is to convert the within region PPPs to a common global currency. The requirements remain the same which means the concepts of transitivity and base country invariance apply to the global results.

In addition, there needs to be adherence to the principle of fixity. This simply means that the relative volumes between any two countries shown in the regional comparison remain the same after they are converted to a common global currency. This concept applies at every level of aggregation from the basic heading to the GDP.

A new method introduced for ICP 2005 meets all of these requirements and is described in chapters 6 and 8. Two sets of PPPs are required for each basic heading to convert regional PPPs to a common global currency. The first set is the within region PPPs by country for each region. The second step is a set of 6 between region PPPs or linking factors for each basic heading with one region serving as the base with between region PPP = 1.0.

For household consumption, the between region PPPs were based on separate prices (Ring as defined above) collected by 18 countries ranging from 6 African countries to two countries each from the Western Asia and South American regions. For each of these countries, there was a set of Ring product prices for each basic heading and their within region PPP in a regional currency. These Ring prices for each country were converted to the currency of the regional base country by dividing each country's basic heading ring prices by its within region PPP from the regional comparison. For each basic heading there was a set of <sup>18</sup> prices, each in a regional base country. A CPD model that treated each set of regional prices as a country provided a set of PPPs for each region that reflected the relative prices (between region PPPs or linking factors) for each basic heading. These linking factors were transitive and base country invariant.

Chapters 11-16 describe the process to link the health, education, government, construction, and machinery and equipment basic headings. Since the same set of specifications were used for every region, the between region PPPs were computed from the same data used for the regional comparisons for all basic headings except housing dwelling rentals. The between region PPPs for housing rentals were computed using quantities of housing for a large number of countries within each region. Even though each region used different methods to estimate within region housing PPPs, they were linked using the Quantity method.

The basic heading linking factors for each region were scalars used to convert the within region basic heading PPPs to the global currency. Since the within region basic heading PPP for each country was multiplied by the the same between region basic heading scalar, the fixity principle was met. The outcome was a matrix of 146 countries and 155 basic heading PPPs that satisfied the transitivity and base country requirements and all relating to the same base country.

ICP 2011 methodology will be similar but with improvements made to the linking and aggregation. First, instead of only selected countries pricing a large ring list, all countries will price a smaller set of global core products. Analysis of the 2005 results showed that the between country variability was greater than the variability from the different products. In other words,

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<sup>18</sup> The linking factors for the CIS region were based on the PPPs for Russia from the Eurostat-OECD comparison. Russia also priced the CIS products and was the base country for the region.

the optimum design calls for more countries to price fewer products for linking purposes. Therefore, a set of global core products were defined and will be part of the regional price comparisons as well. The prices for these core products from all countries will be used in the same two step process described above to first estimate between region PPPs, then use those as scalars to convert the within region PPPs to the global currency.

In ICP 2005, the representativity concept was not used for the ring prices. However, given the diversity of the economies across the world, it will be essential that the importance classification be applied to all of the prices in the set of global core. While countries will be able to price a large number of the core items, it is very unlikely all have the same price levels or the same relative expenditures. Products that are common in some countries may only be found in boutiques with higher prices in other countries; the importance classification is needed to prevent an upward bias in the price levels used to estimate the between region PPPs. The importance classified will be used on both the regional and core prices. The between region PPPs will be computed using the CPDW method.

## **6. Aggregating (averaging) Global PPPs to higher Aggregates and the GDP.**

At this stage in ICP 2005 there was a matrix of 5 regional linking factors for each of the 155 basic headings, and for each region total expenditures across the countries in the currency of the regional base country. In ICP 2005, the between region basic heading PPPs or linking factors were aggregated to the GDP and other aggregates using the GEKS. As done at the basic heading level, the aggregated linking factors at each level times the within region PPP for each country at the same aggregated level converted the regional PPP to the global currency. This preserved fixity at all levels of aggregation. Later analysis, however, showed that the linking factors at the aggregated level were not base country invariant, i.e, were dependent on the choice of regional base country.

For this reason, a global aggregation will be used for the ICP 2011. The input will be the outcome of the linking at the basic heading level which will provide a matrix of 155 basic heading PPPs for 180 countries and another for expenditures. A global GEKS aggregation of the entire matrix will directly estimate a set of PPPs to a global base country at every level of the GDP breakdown and the GDP. The resulting expenditures for each country in the global currency will be summed to regional totals. These regional totals can be distributed to each country within a region to ensure fixity is maintained with the within region results.

## **7. Imputing PPPs for missing countries and extrapolating PPPs between benchmarks.<sup>19</sup>**

The ICP 2005 included 146 countries, thus PPPs were not available for about 65 other economies for a variety of reasons ranging from resources to country interest. Data users, however, requested a complete data base, therefore, PPPs were imputed for the missing economies. For these economies, PPPs were imputed using a model based on benchmark data. The model imputed PLIs using GDP per capita in US\$, imports and exports as share of the GDP, and an age dependency ratio as explanatory variables.

This provided a data base of PPPs to the US \$ for 180+ countries for 2005. Another dilemma is posed by the fact that many data users want PPPs for succeeding years. Therefore, PPPs are extrapolated forward and published each year in the World Development Indicators (WDI.) These extrapolations are based on GDP deflators. The problem is that the extrapolated PPPs will differ from the new benchmark PPPs. The challenge is to explain to data users why CPI price changes and GDP growth rates are not consistent with the changes in PPPs between benchmarks. Chapter 18 provides an in-depth review of the reasons why the two data series will not always be consistent.

## **8. Conclusion**

While ICP 2005 was a vast improvement over previous rounds because of the significant effort to improve methodologies, much has been learned that will be taken forward to the 2011 round. A brief review of lessons learned and improvements to be made follow.

More attention will be paid to the national accounts starting with the national estimates of the GDP and then the breakdown to the 155 basic headings. The comparisons between countries are based on volume indices and per capita measures; a perfectly good PPP is of no use if the GDP it converts is of weak quality. Therefore, there is a concerted effort from the beginning to improve national accounts and make them more consistent between countries.

A most significant change is to move from the use of a Ring list priced by a few countries for linking to the development of a set of global core products that will be priced by all countries. This will greatly improve the estimation of the between region linking factors used as scalars to convert within region PPPs to the global currency. This carries with it the adoption of the principle of “importance” to classify products to give more weight to those most widely consumed in each country.

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<sup>19</sup> See chapter 18

Considerable effort is going towards improving the estimates of PPPs for the difficult to compare basic headings.

Due to the criticism from data users because dwelling rent PPPs were imputed in Africa and Asia, efforts are being redoubled to ensure direct PPPs are provided for both regional and global comparisons. The use of output measures for health and education are being explored.

The issue of productivity adjustments for government services is being addressed. In ICP 2005, productivity adjustments were not used in every region making it difficult to compare results between countries in different regions. A significant improvement for ICP 2011 will be using a global aggregation of government compensation across all countries that is adjusted for productivity differences.

The methodology for construction is being simplified so that countries can carry out the data collection without having to engage expert consultants.

Additional attention will be given to data validation at the basic heading level and above for both the regional and core comparisons. A major change is that regional PPPs will be open for review while the core prices and PPPs are being validated because the within region PPPs are an input into the estimation of linking factors.

An underlying theme to this publication and others is that all methods and procedures should be totally transparent.

In conclusion, the list of authors for the ICP book reads like a list of “who’s who” in the field of economic statistics, especially for international statistics. Their efforts contribute tremendously to the knowledge base about the ICP which leads to a continuous improvement of methodology.

**Figure 1. Overview of the Main Components of the International Comparison Program**

